

N F P A

Fluid Power **VEHICLE** ***Challenge***



NFPA
Education and
Technology
Foundation

FINAL PRESENTATION
Iowa State University
04/7/2025



Team Introductions



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Overview

- Failures and Improvements
- Goals and Design Choices
- Vehicle Construction
 - Component Design
 - Component Installment
- Hydraulic & Pneumatic Circuits
- Bike Changes & Improvements
- Electronic Controls & Instrumentation
- Lessons Learned

Failure Investigation

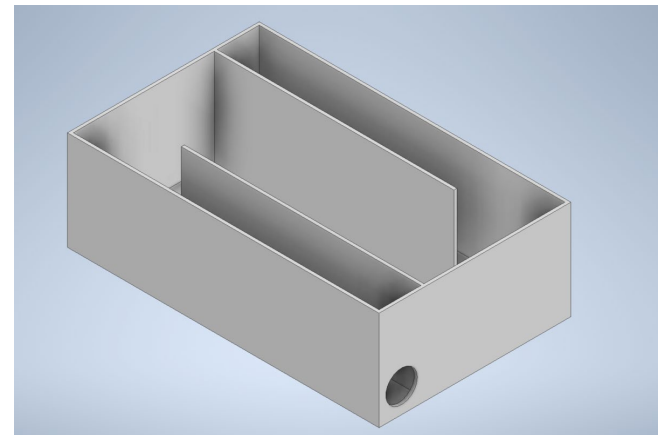
- During last years competition we discovered some design flaws
- Introduction of new frame, bad reservoir
- Also had a lot of lessons that we learned about timeframes and collaboration that we hope do improve on

What we did to Improve



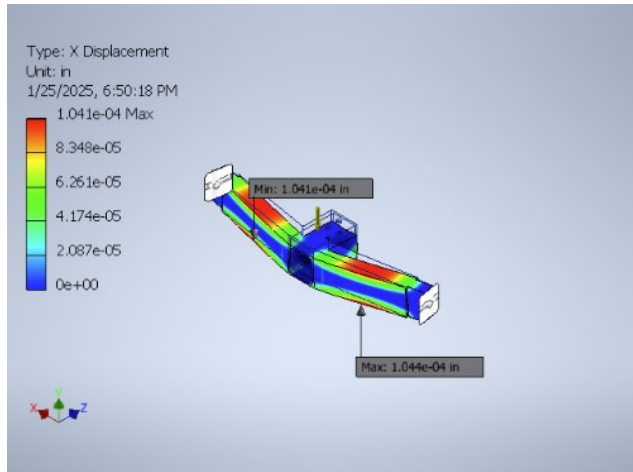
- Redesigned our reservoir to have internal baffles between the entrance and exit orifices
- Designed the front of the bike with a focus on strength to withstand bending

Old Reservoir

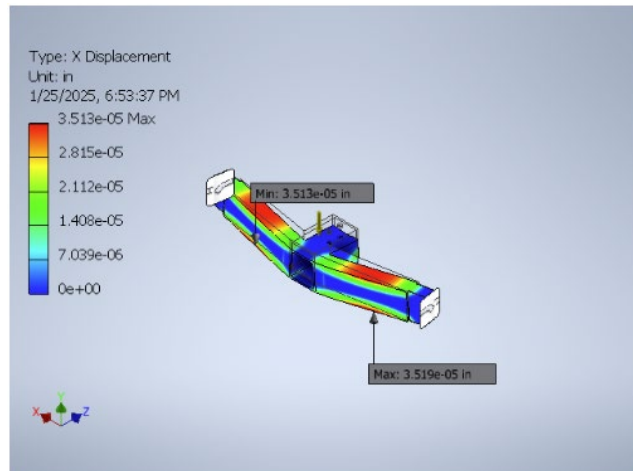


New Reservoir

What we did to Improve



Solid Metal Support



Bolted Multi Part Metal Support



Final Construction

Goals



- Reduce Weight by removing Bent Axis Motor
 - Change circuit to incorporate the use of just one motor
- Reduce flexure of frame and chain popping during the competition
 - Switch from bike chains for direct drive to poly chains
 - Strengthen the frame connections with gusset plates and bolts
- Improve the Safety and Appearance of Bike
 - Installed safety guards and new spots
 - Finished the bike with clean bend metal lines

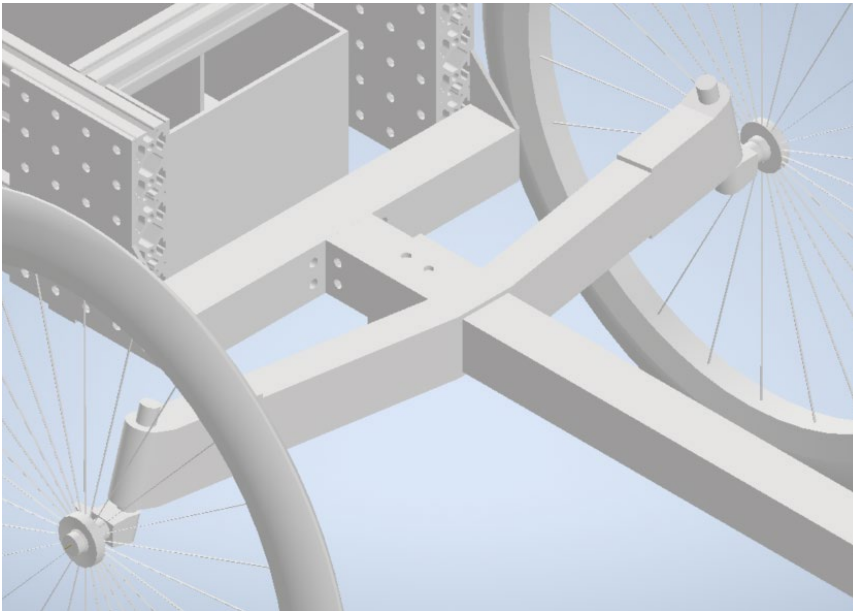
Design Choices

- Design of Front Axle Support
 - 2" x 2" square tube with a wall width of .25"
 - Enhanced rigidity where it was needed to maintain wheel alignment
 - 2" x 1" solid aluminum bolted to 2" x 2" tube with gusset plate
 - Reuse of axel connections from previous bike
- Design of New Circuit
 - Use of 2 2/2 normally closed DCV's (4 used last year)
 - Use of 1 2/2 normally open DCV's
 - Allows for the use of one motor/pump for all operations
- Use of Poly Chains
 - Requested several pulley and belt sizes from I-Motion

Vehicle Construction

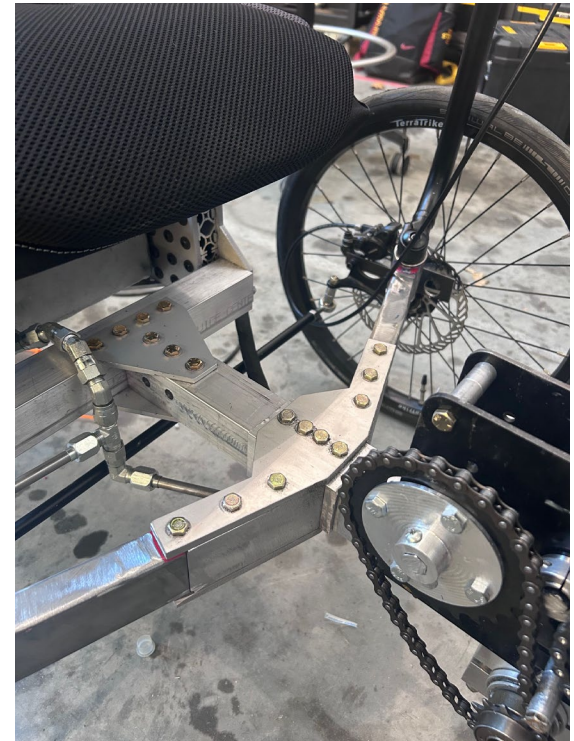


New Front Support Design

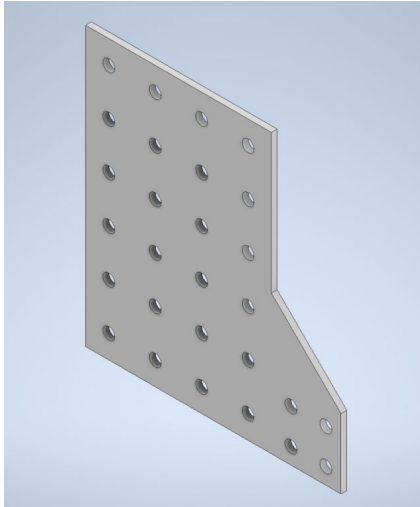


- Members as outlined in the last slide

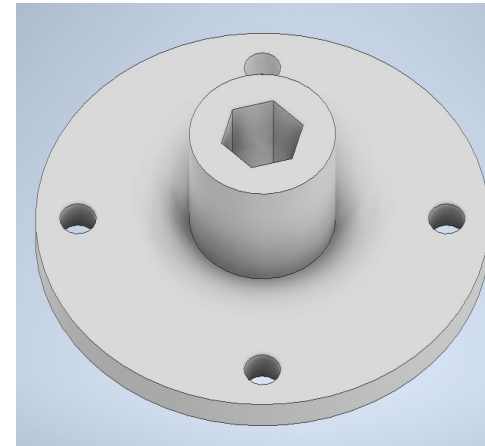
Construction in progress



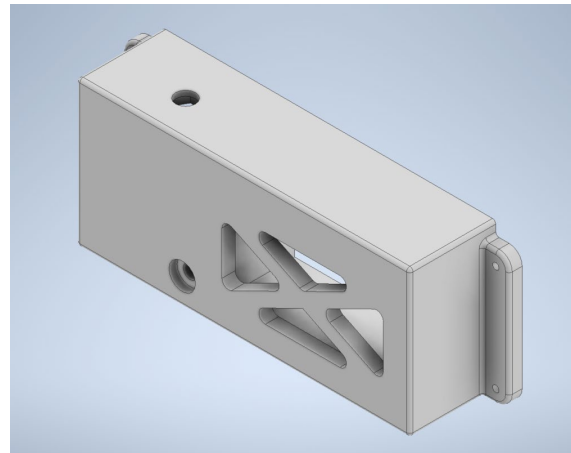
Designed Components



80-20 Bracket



Bike Sprocket
Adapter



Battery Box

Designed Components Installed



Battery Box

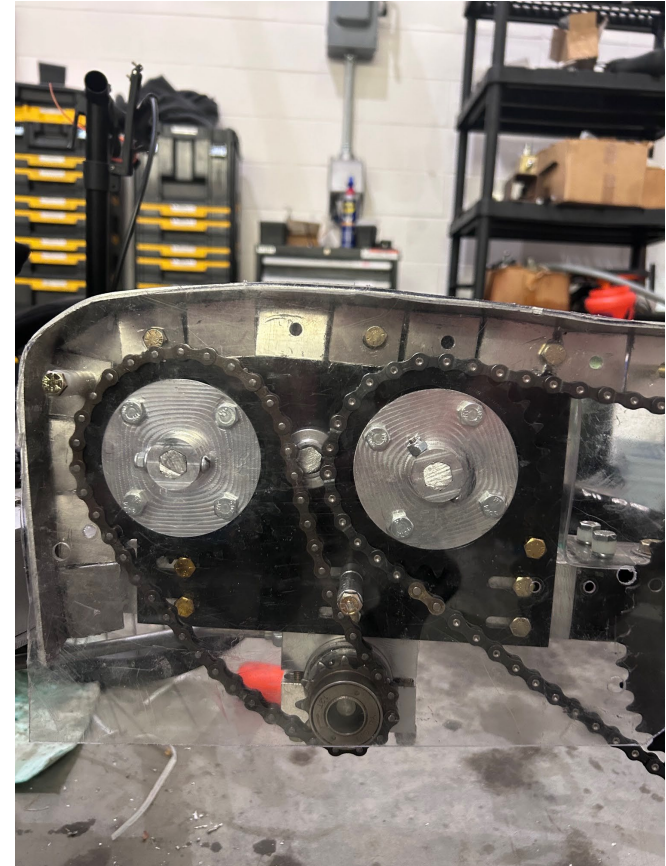


Pulleys and Polychain

Improvements on Safety



Guard Installed on Gearbox



Guard Over Front Chains

Component Selection



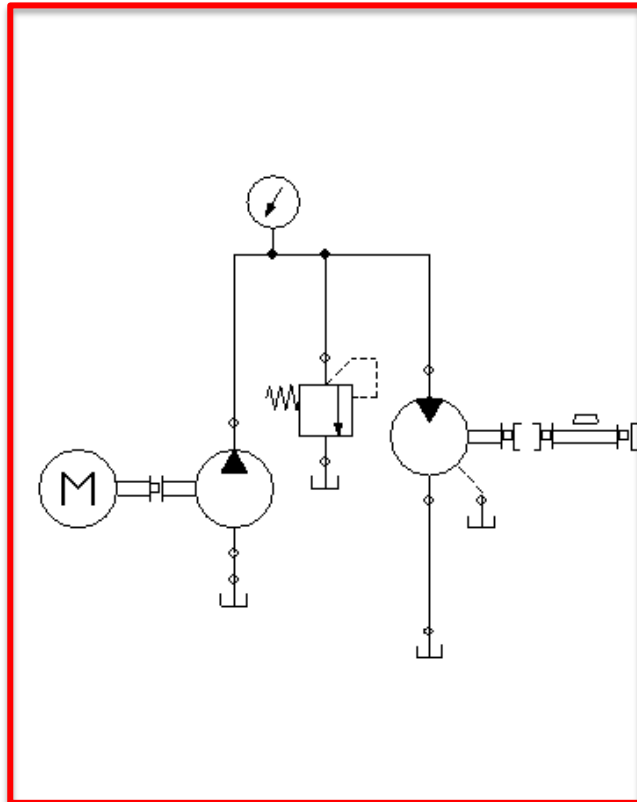
Resistance	Force (lbf)	Calculation	
Grade Resistance	28	Weight * sin(% grade)	
Rolling Resistance	2	Weight * rolling resistance * cos(% grade)	
Wind Resistance	1.1	Drag Coefficient * Density of Air * Cross sec Area * Velocity Square	@ 6 mph
	13		@20 mph
Acceleration	13	@1 ft/s^2	
	26	@2 ft/s^2	
Total	69		

Torque (wheel) lbf*ft	
Force (lbf)	69
Radius (wheel)	0.75
Torque (wheel)	51.75
Torque (motor)	
Gear Ratio	2
Torque (wheel)	51.75
Torque (motor)	25.875
Motor Displacement	
Torque (motor)	310.5
PSI	2250
Mech. Eff.	0.9
Motor Displacement	1.0

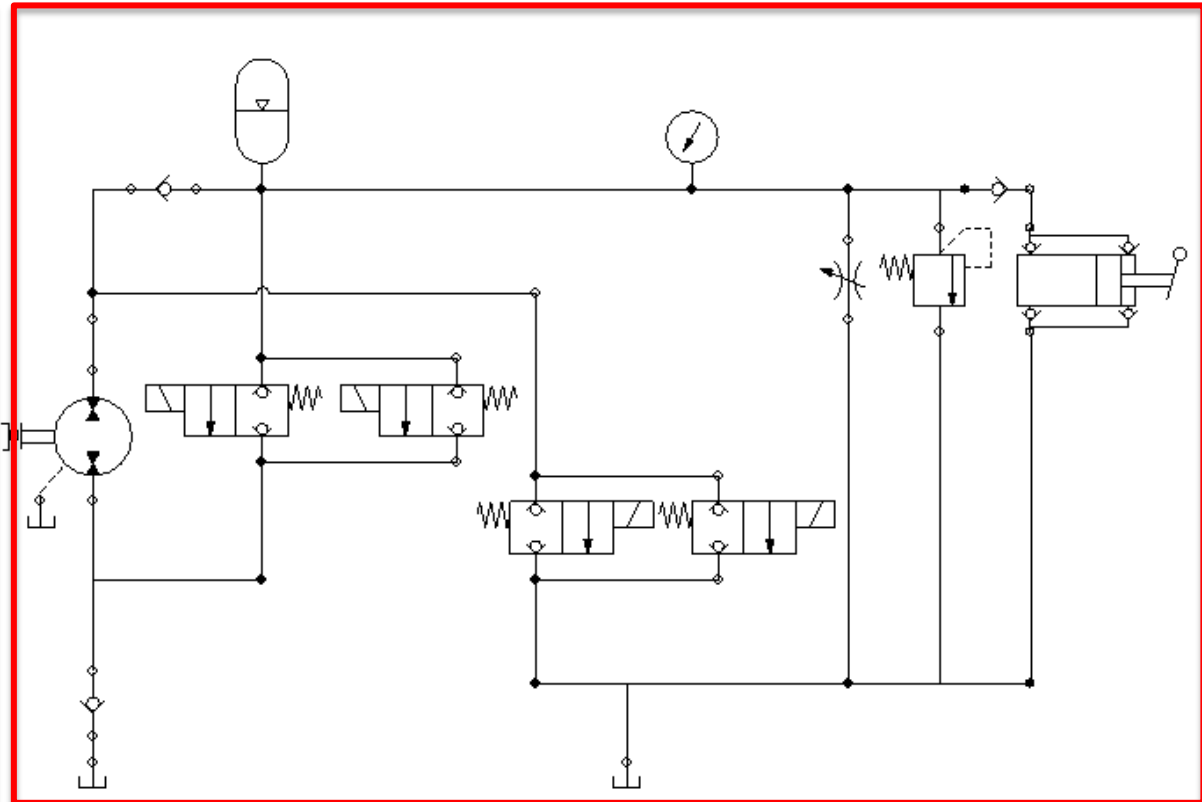
These calculations lead to our decision to select the 1.21cc Danfoss Type J motor

Previous Hydraulic Circuit

Pedal Circuit

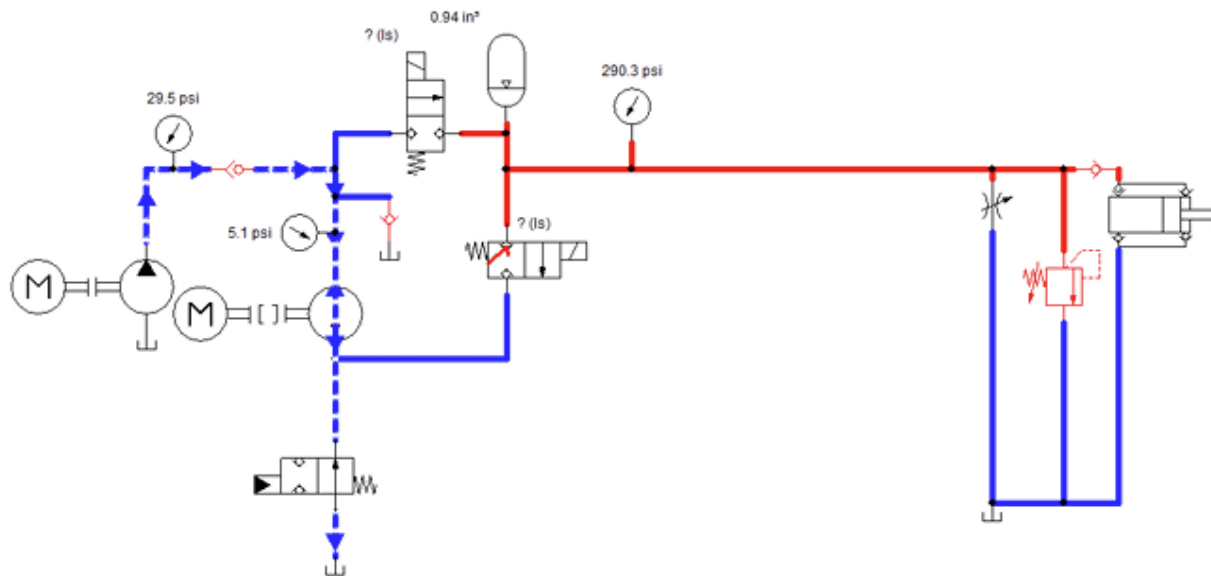


Accumulator and Regen Circuit



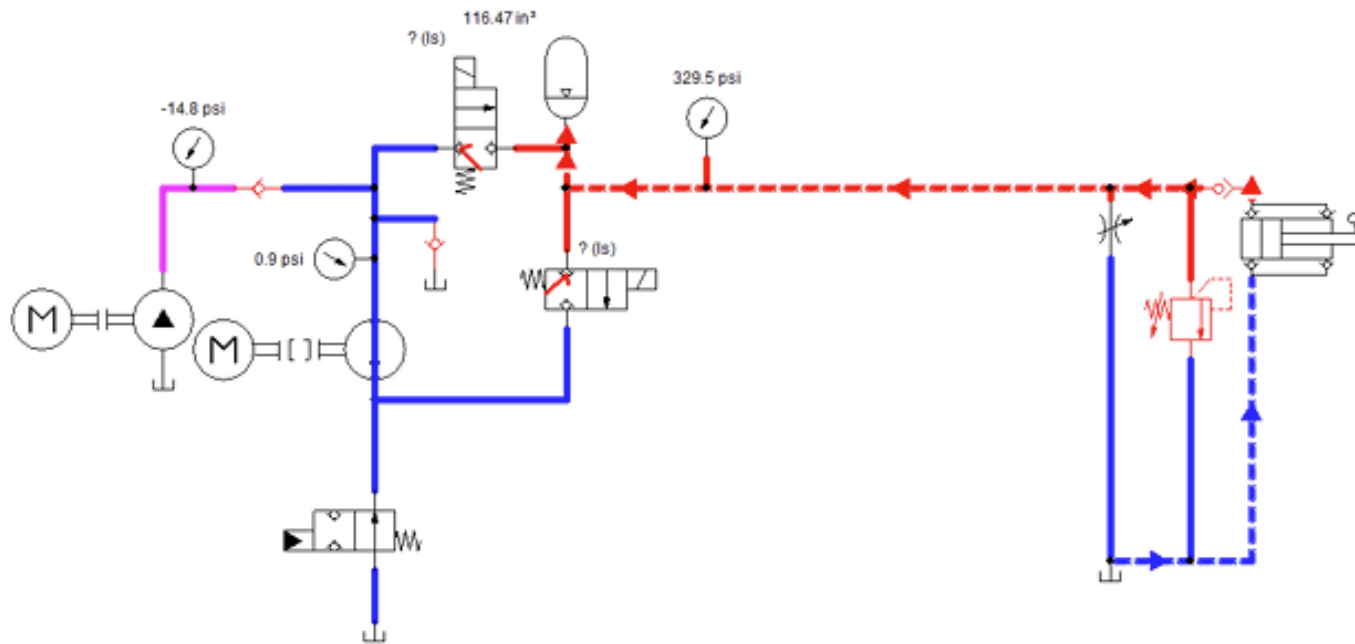
- 4 2/2 DCV in parallel
- Manual hand pump
- Micro pump, 2.8cc Gear Motor, 5.1cc Bent Axis Pump Motor

Current Hydraulic Circuit (Direct Drive)

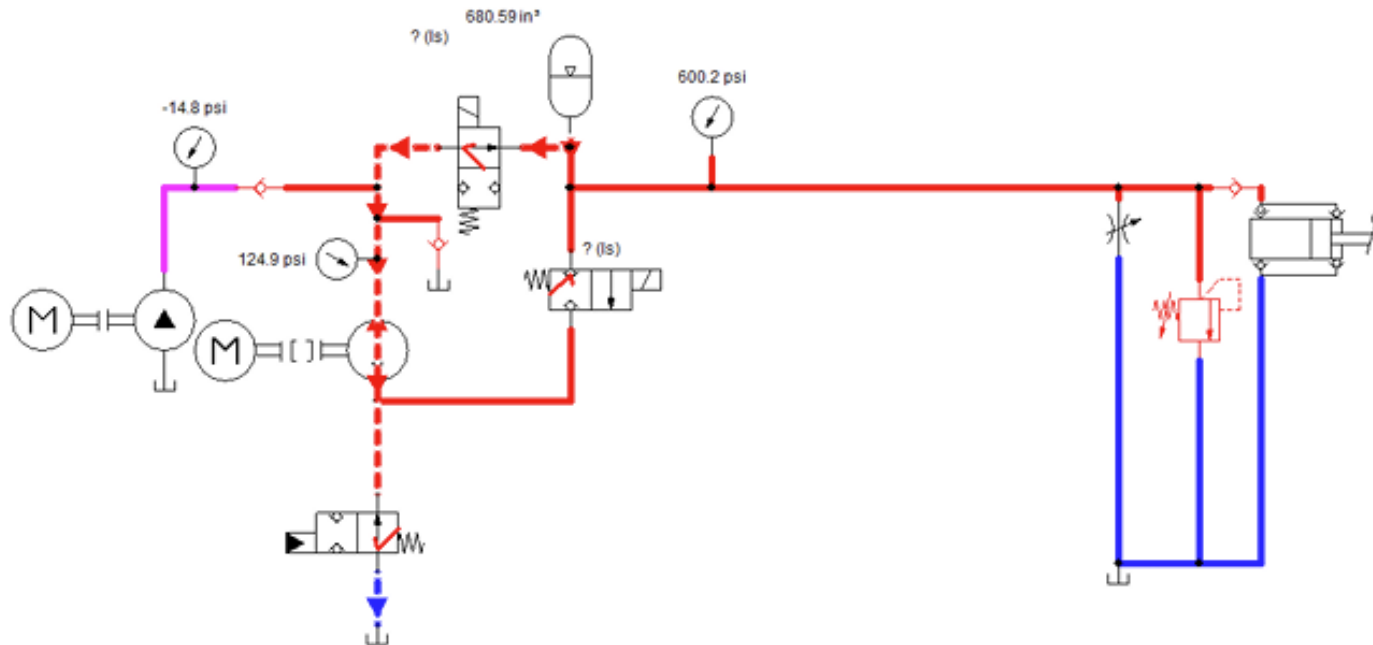


- 2 2/2 DCV normally closed, 1 2/2 DCV normally opened
- Manual hand pump
- Replaced 2.8cc motor and 5.3cc bent axis pump motor with 1.21cc motor

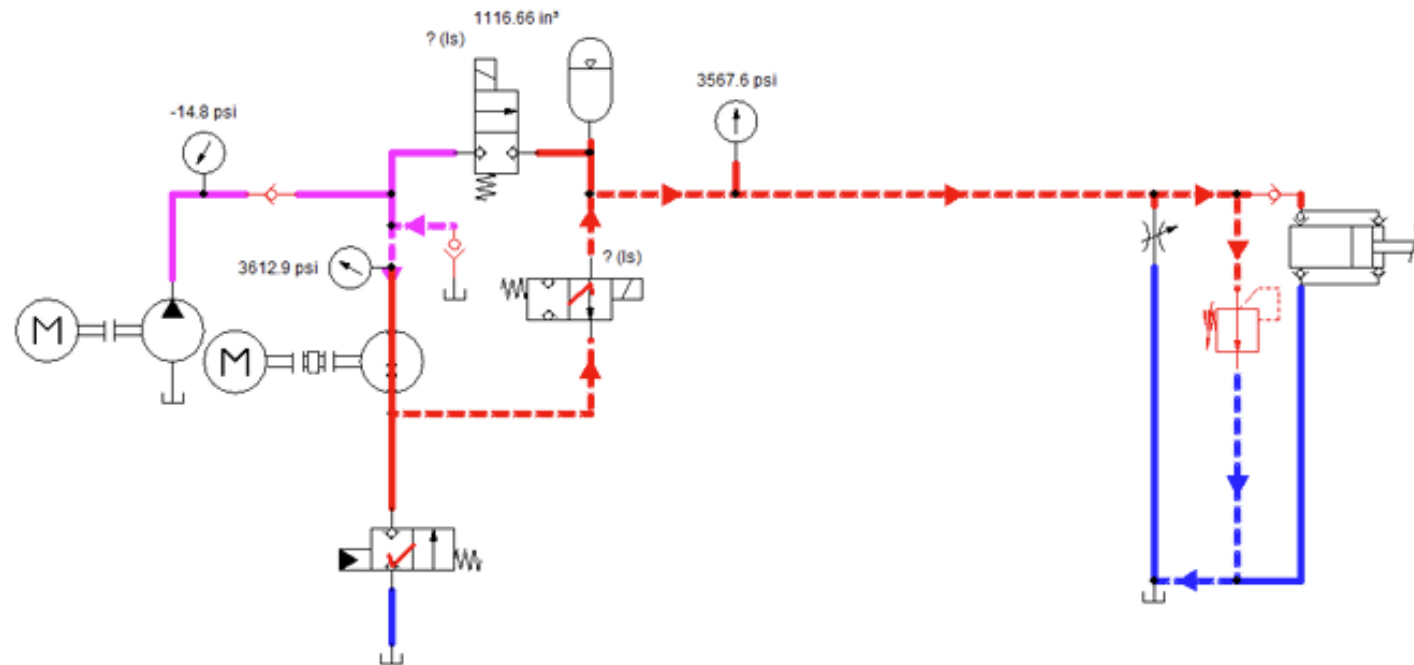
Accumulator Pressurization



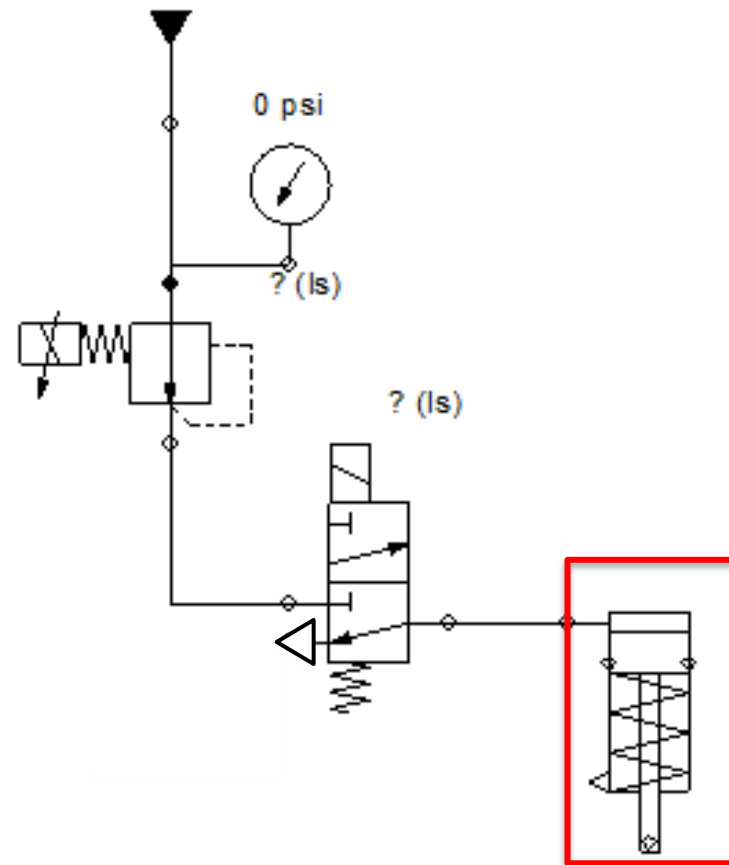
Accumulator Power



Regen Power



Pneumatic Circuit revised?



Nexen Friction Clutch actuated
by pneumatic pressure

Electronics

- 2 – 12-volt interstate batteries (total 24 volt) powering three solenoids on the manifold connected by switches on the handle of the bike.
- Our original plan was to utilize the controller from previous team designs but have faced issues with software and time constraints. The use of the switches achieved the same goal with a simpler approach.



Misc Component Selection



Lessons Learned

- Long lead times for components
- Collaboration is important for team success
- Utilize knowledge of industry professionals
 - Establishing mentors
 - Fostering relationships
- Setting deadlines is essential
 - Planned worktimes and meetings
- Analysis before design is one of the most important steps of the design process

Special Thanks You's!!



- Our mentor Tony Hennum
- Safety coordinator Hoa Chi
- Professor John Sheriff
- Fabricators at Sargent Metal Fab

Thank you!

