NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION
MURRAY STATE UNIVERSITY

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MURRAY STATE UNIVERSITY

Team Members

Fluid Power Vehicle Challenge

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Design Progression

- Design objectives
  - Simplify operation and design
  - Reduce vehicle weight
  - Greater focus on rideability while pedaling
  - Design for all races
- Vehicle Design
  - Compact components and frame
  - More aluminium construction
- Hydraulic system design
  - Reduced complexity from previous design
  - Minimal complex hydraulic systems
  - Improve on previous ideas

Front Mount

- In last years design, the majority of the components were placed in the rear end of the bike.
- To maximise available space, we decided to mount the human powered pump in the front of the bike.
- In addition to the the mount, we also decided to incorporate oval sprockets to help smooth out pedaling.

Front Mount

When deciding how to mount it, we had two options, one was to mount under the bike, and other was to mount it in the direct front of it.

Pros

Underneath

- A simple mount that attaches
- Doesn't increase the length of the bike

Front

- Will not disturb the rider
- Would allow for better adjustability.

Cons

Underneath

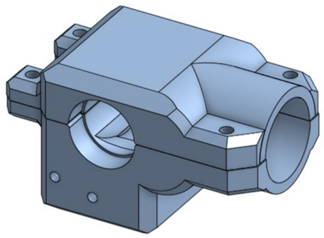
- Limits the adjustability of paddles
- Will possibly, disturb the rider

Front

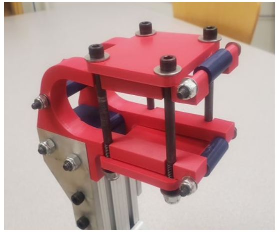
- Complex mount design
- Will increase the length of the bike

Front Mount

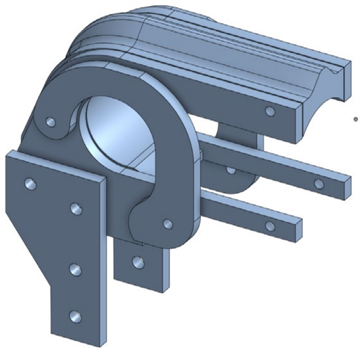
- First versions were 3D printed prototypes that had some issues



- This version Is a simple prototype to finalize dimensions and fit

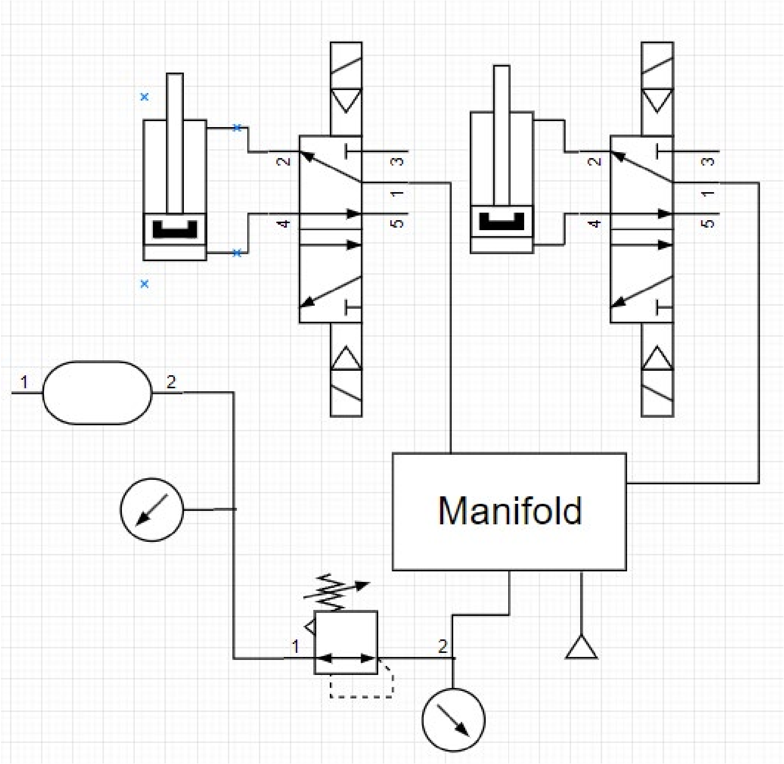


- Final version is a combination of the other designs



Pneumatics

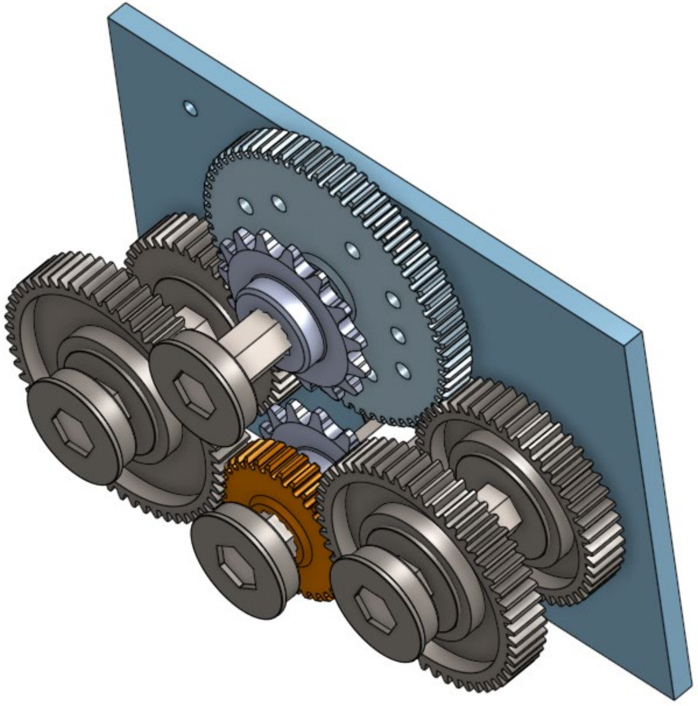
- Pneumatics for transmission shifting
- 100 PSI for tank pressure
- Regulated pressure at 50 PSI
- Custom reservoir to be inside the frame for design and safety



Transmission

Our transmission is a 4-speed transmission that is pneumatically shifted and controlled by our PLC

- Simplified from previous years
- Optimal gearing for each race and efficient operating range for our motor
- Regen system is incorporated into the transmission design
- One way bearing to allowing smooth coasting

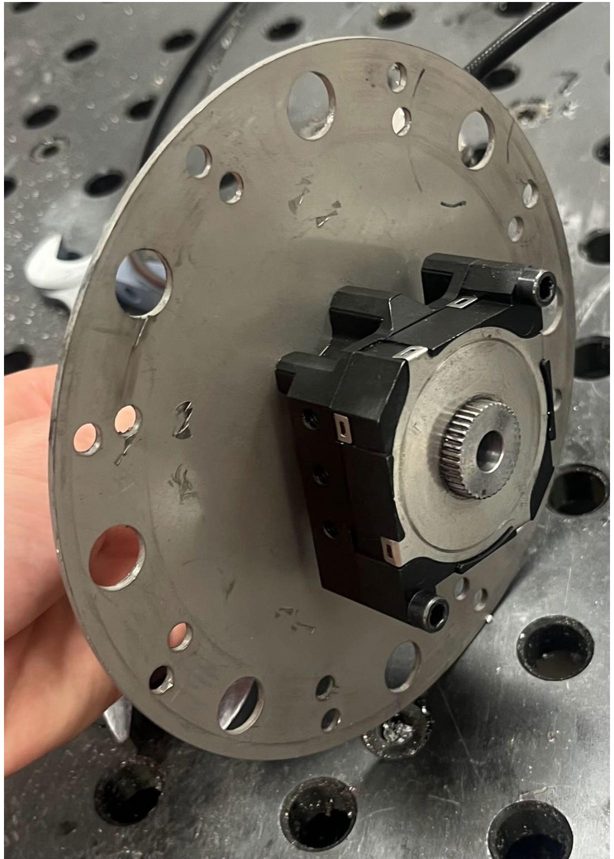


Regeneration

- Using a dynamic braking system to allow the rider to have a more practical brake

- The regenerative disk brake was designed and manufactured in house

- The planetary hub makes it a more compact and allows the system to be dynamic.

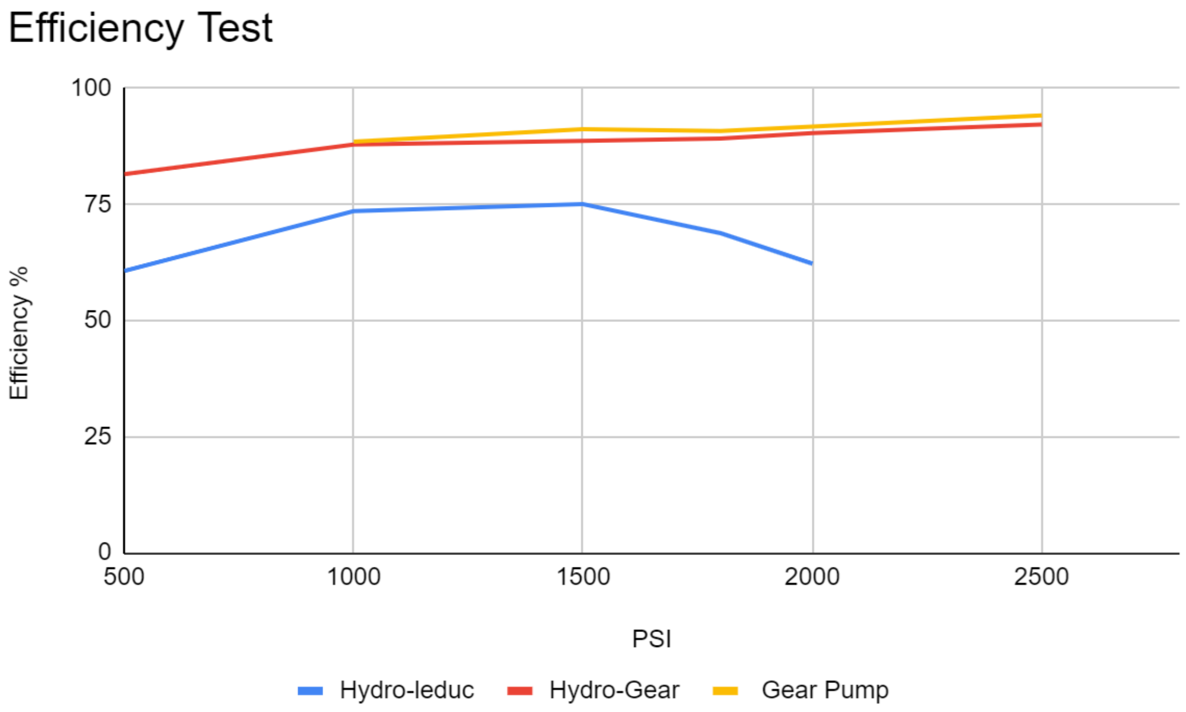


Hydraulic System

- Hydro-Gear HEM10's
  - Used for our pumps and motors
- Accumulator
  - One gallon Steelhead carbon fiber accumulator
- Reservoir
  - We made our own reservoir with a capacity of 1.24 gallons
- Manifold
  - Simplified the hydraulic schematic to reduce weight and size
- Directional valve
  - Using Rexroth DCV valve because of it's high flow rate

Hydraulic Testing

- We tested three different pumps for mechanical efficiency:
  - Hydro-Gear
  - Hydro-LeDuc
  - Marzocchi gear pump



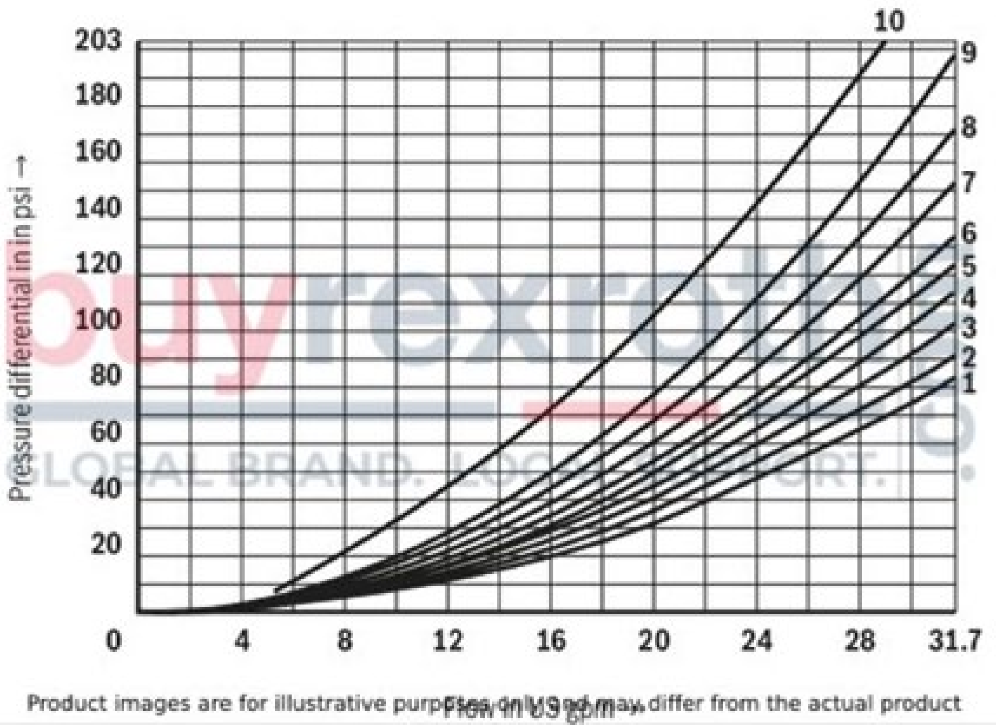
What we decided Post Testing

- From testing and manufactures information we chose the Hydro-Gear pumps for our bike to serve as both the pumps and motor.
  - High efficiency at low pressure
  - Can act as pump or motor
  - Built in RPM sensor
  - Lightweight

Rexroth Directional Valve

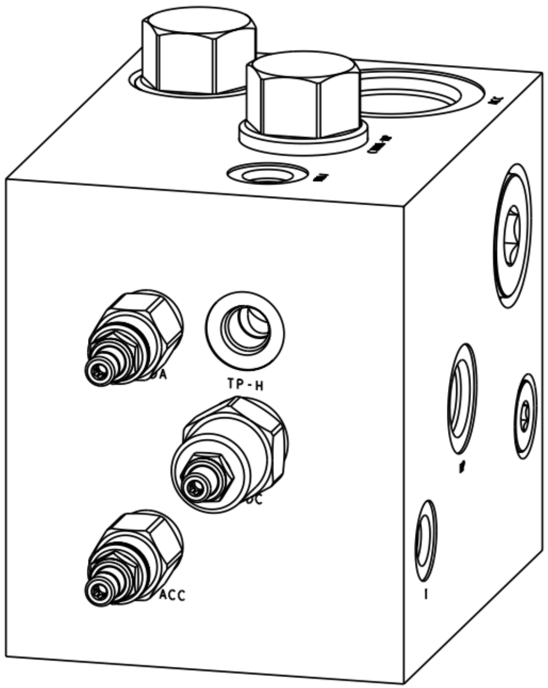
- Heavier valve at eight pounds

- More efficient flow pressure (higher flow rate)

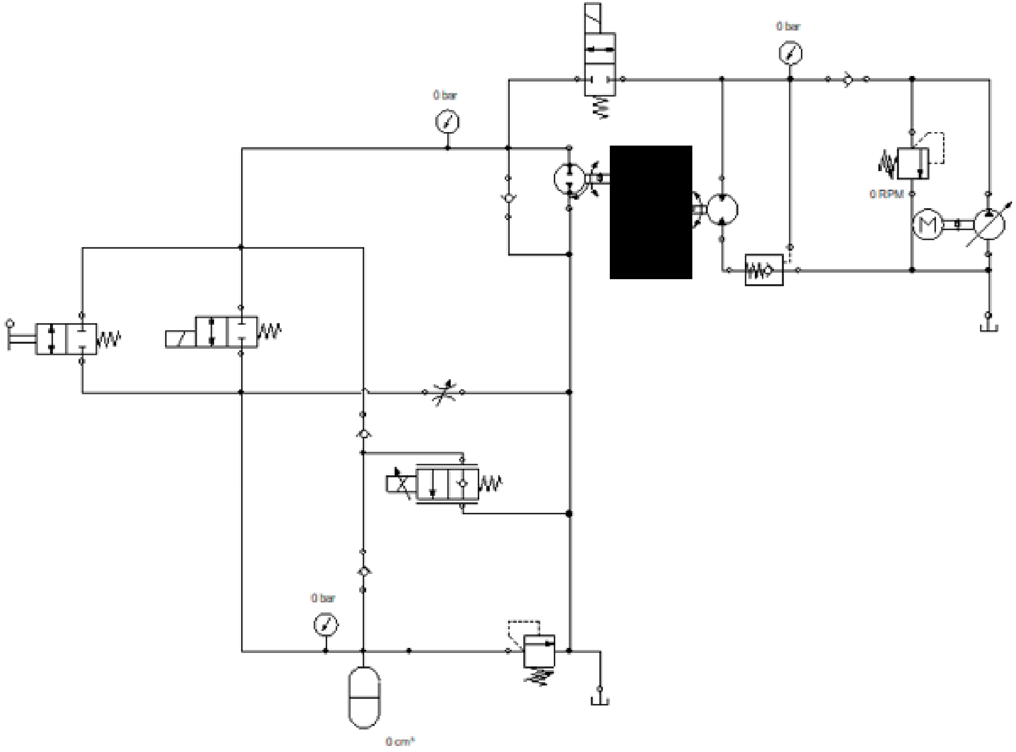


Manifold Design

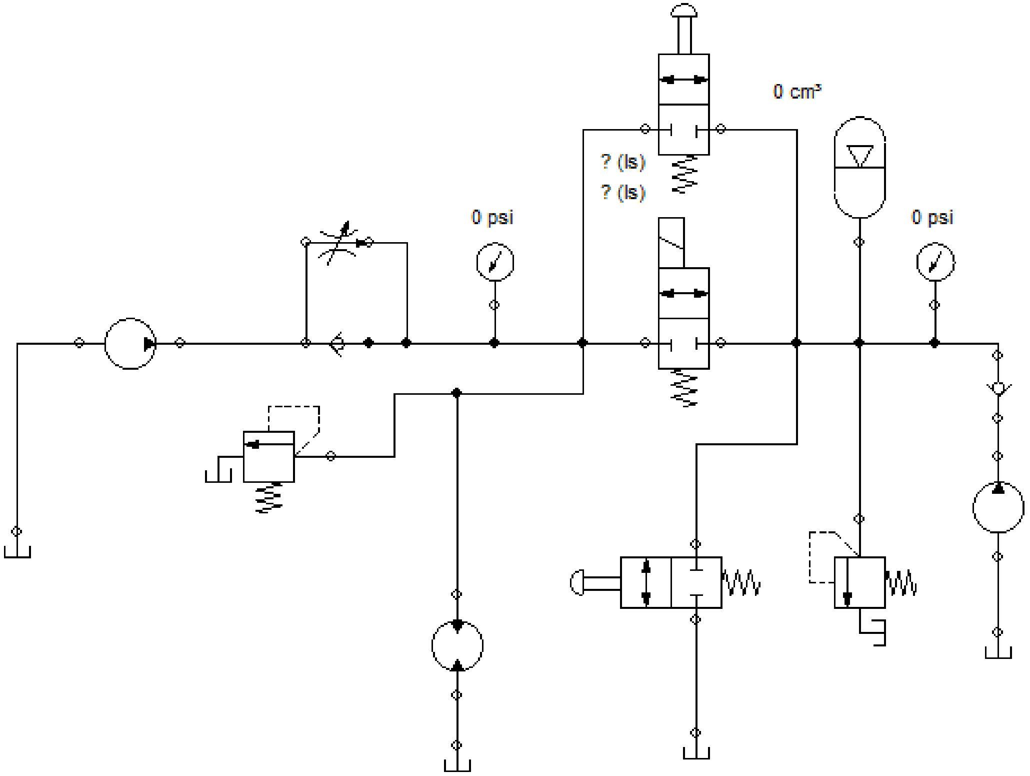
- We reduced the complex design of last year
- 40 lb manifold to 18 lb manifold
- Surface mount valve compared to a cartridge valve



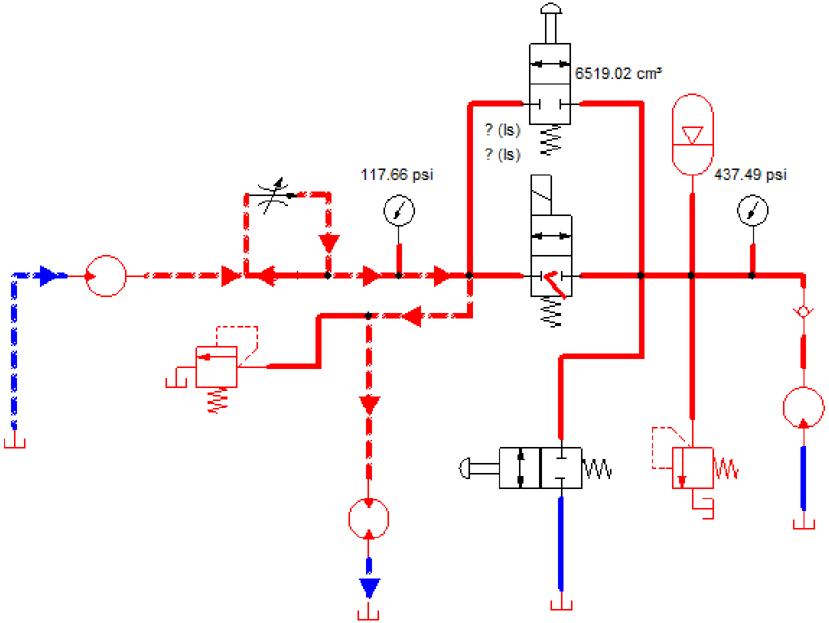
Old Schematic



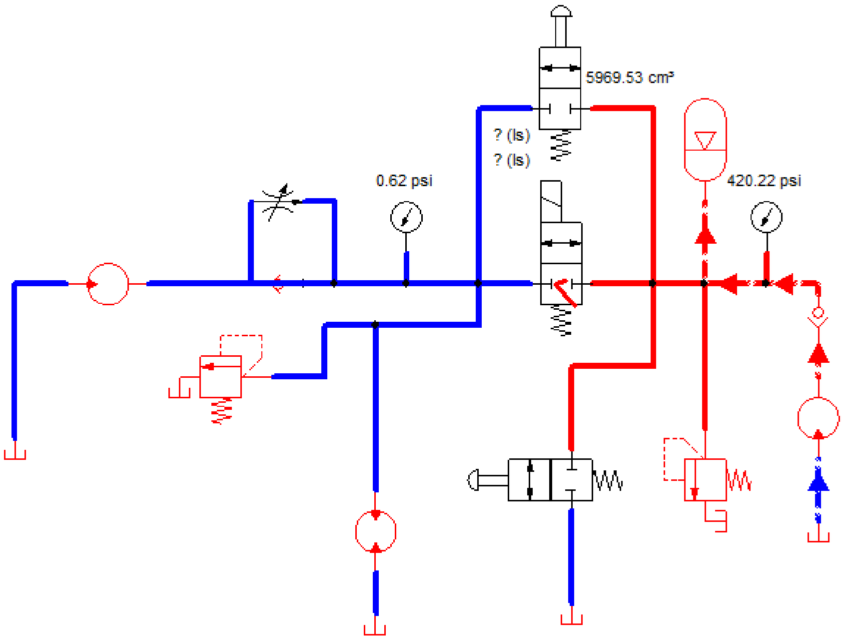
New Schematic



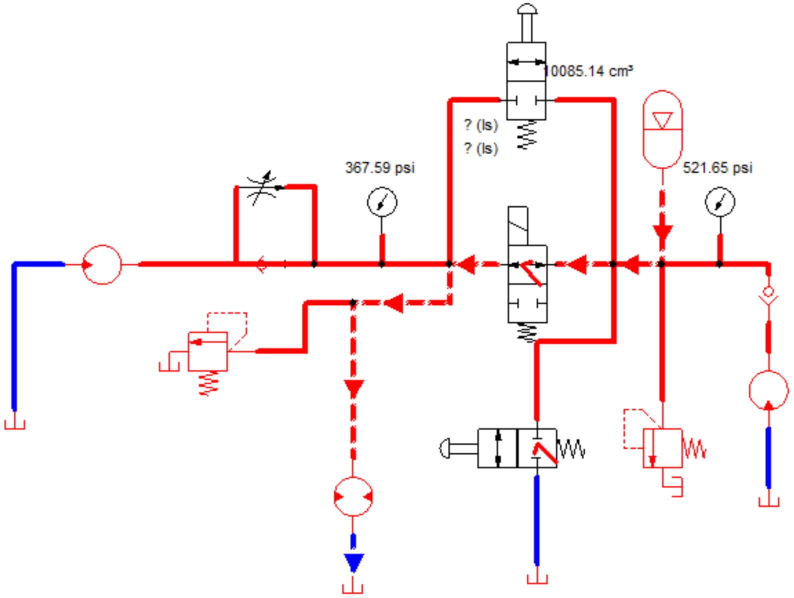
Human Powered



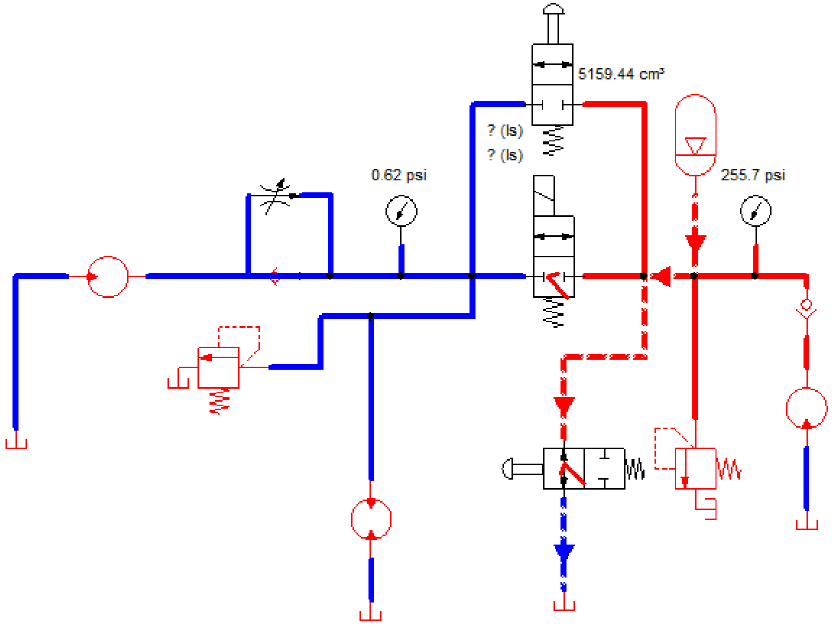
Regeneration



Discharge



Emergency Dump



Electrical Systems

Electronic components overview

- Click PLC C0-00D1-D
  - 6 sinking outputs per module
  - 4-30 VDC output
  - Up to 0.4 Amp output
  - Up to 120 mA power consumption

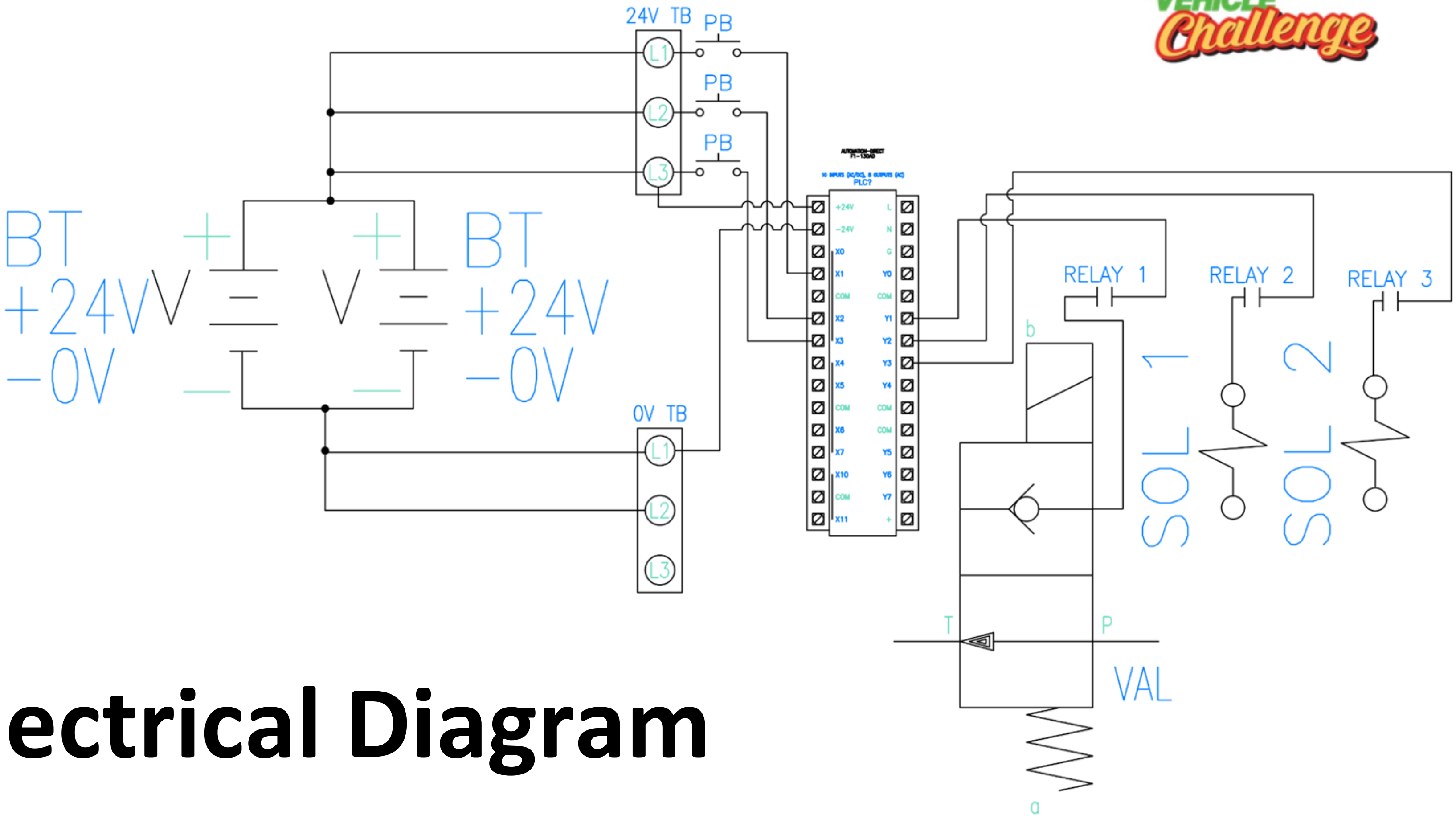
Electrical Systems

Why that PLC

- Price point
  - Cost effective with free software
- Availability
  - easy to acquire
- Experience with using it
  - Multiple team members have used it

Electrical Systems

- Pneumatic DCV
  - Gear shifting via solenoid
- Rexroth DCV Valve
  - Accumulator dump to motor via user
- Relay block
  - Control high amp outputs with PLC
- 24V Lipo Battery
  - Reliable and cost effective power so



Electrical Diagram

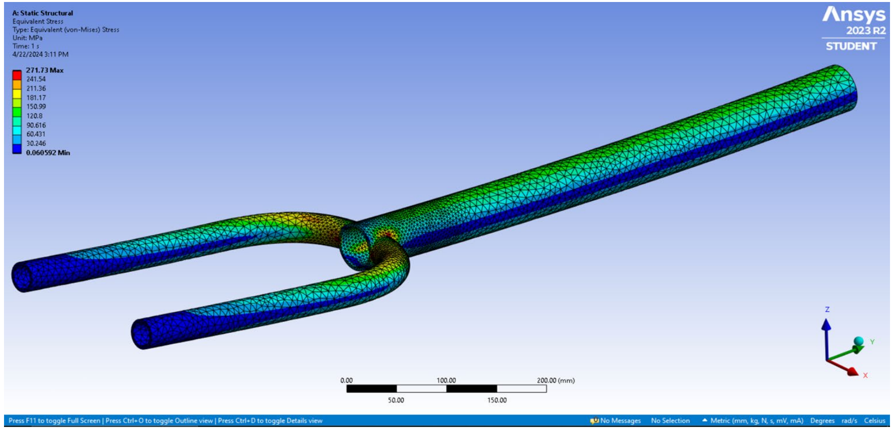
Frame

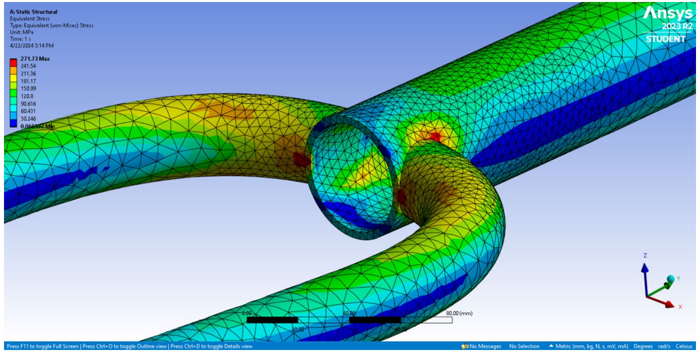
NFPA Fluid Power VEHICLE Challenge

- Aluminum frame
  - Lightweight
  - Shorter
  - Utilizes empty space
  - Narrow
- Mounting components
  - Welded main plates

Frame

- Finite Element Analysis
  - Ansys simulation software
  - Refined mesh around expected failure point for more accurate results
  - Expected for fork not to exceed 440 lbs of weight
  - Maximum stress = 271 MPa
  - 6061 aluminum ultimate tensile stress = 310 MPa





Lessons Learned

- Planning ahead for component selection
- Custom frame requires strong components location planning
- Team communications are difficult with a large team
- Have more firm deadlines for progress stages
- Preparing for new members