NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION
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MURRAY STATE UNIVERSITY

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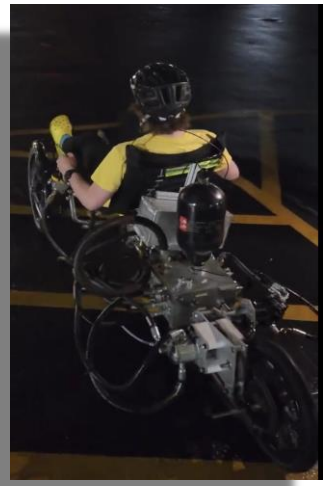
Midway Review

- Design objectives
  - -Upgraded frame for stiffness & mounting.
  - -Reduced Weight.
  - -Smooth human input.
  - -Refined hydraulic schematic.
- Vehicle Design
  - -New rear frame.
  - -Center-Based.
  - -More Aerodynamics.
- Fluid Power Circuit Design
  - -Continued simplification and safety-centered design.



Design Progression

- Changed component layout.
- Made changes to controls.
- Upgraded frame.
- Proportional valve.
- Planetary transmission.
- Use of back-up bottle.

Vehicle Components

- Carbon Fiber Back-up bottle.
- Carbon Fiber Accumulator.
- Planetary Base Transmission.
- Variable Displacement Pump.
- Dynamic Regeneration.

Vehicle Components

Selection of Hardware:

- Toro 103-1942.
- Hydroleduc M5.
- Marzocchi Alm 1a-R-6-E2.
- Custom-made manifold from Sun-Hydraulics.
- Carbon Fiber accumulator & back-up bottle from Steelhead Inc.
- ESP8266 for controler choice.

Design Feedback

- Nate Heady (Design and troubleshooting of electrical components).
- Josh Scarborough (Component selection & optimization of hydraulic system and manifold).
- Communication with Ernie Parker about use of our back-up bottle system.
- Communication with Steelhead Inc for a diagnostic on our back-up bottle.

Vehicle Construction

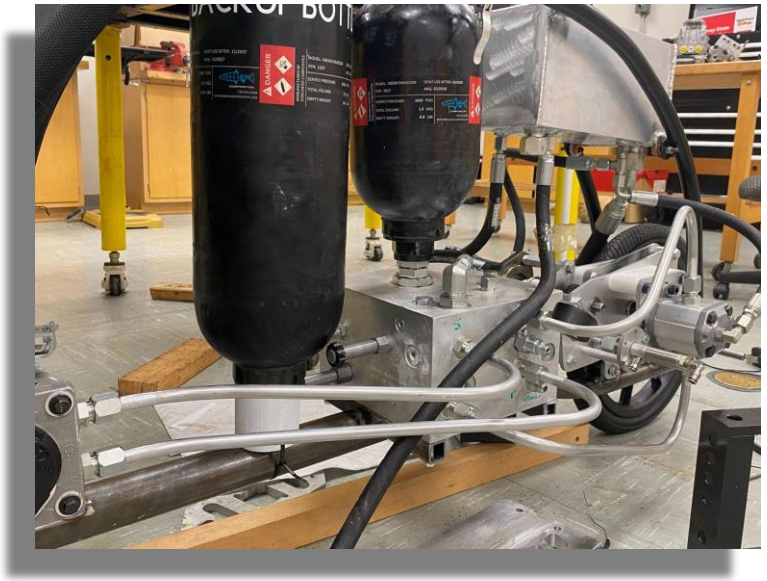
We are using a chromoly rear fork with the same front assembly as last years design with arch supports for overall stiffness and seat support.

- Designed with the ability to weld to frame for mounting components.
- Allows for flexibility when there were design changes .
- Confidence in material strength.

Hydraulics

Hardlines

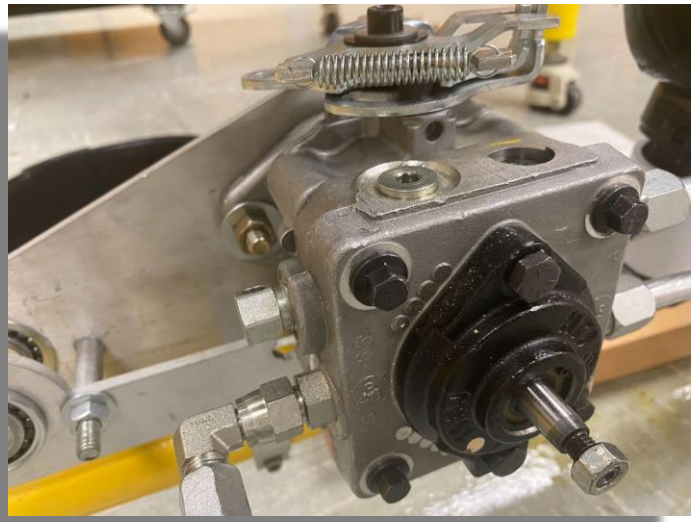
- Generates less turbulent flow than softlines.
- Reduces weight and size.



Hydraulics

Variable Displacement Pump

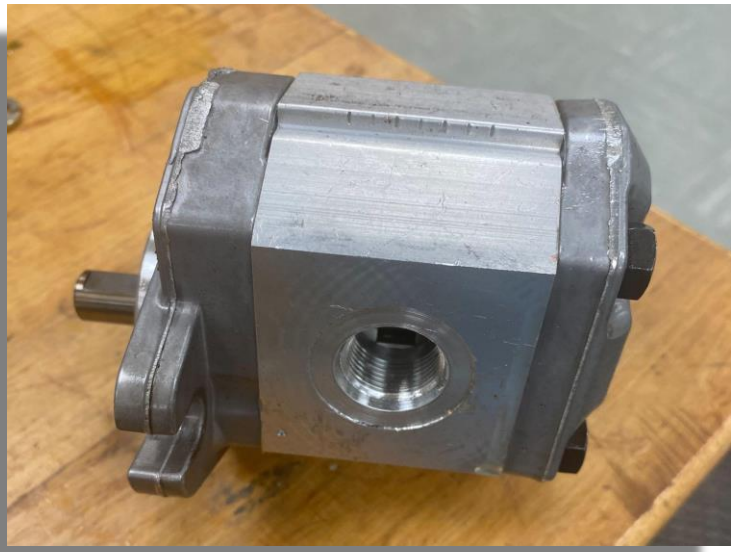
- Allows for consistent pedal force.
- Manual control of displacement.



Hydraulics

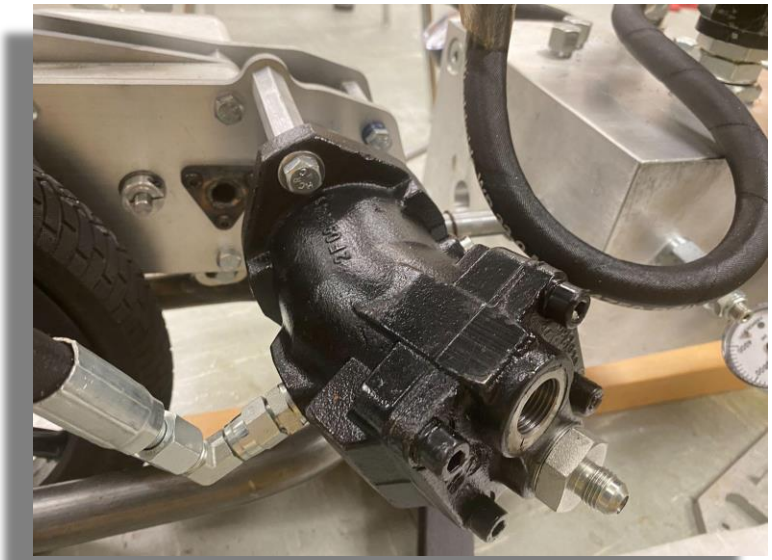
Gear Pump

- Creates the optimal flow for human power fluid power.
- Compact for its displacement and flow.

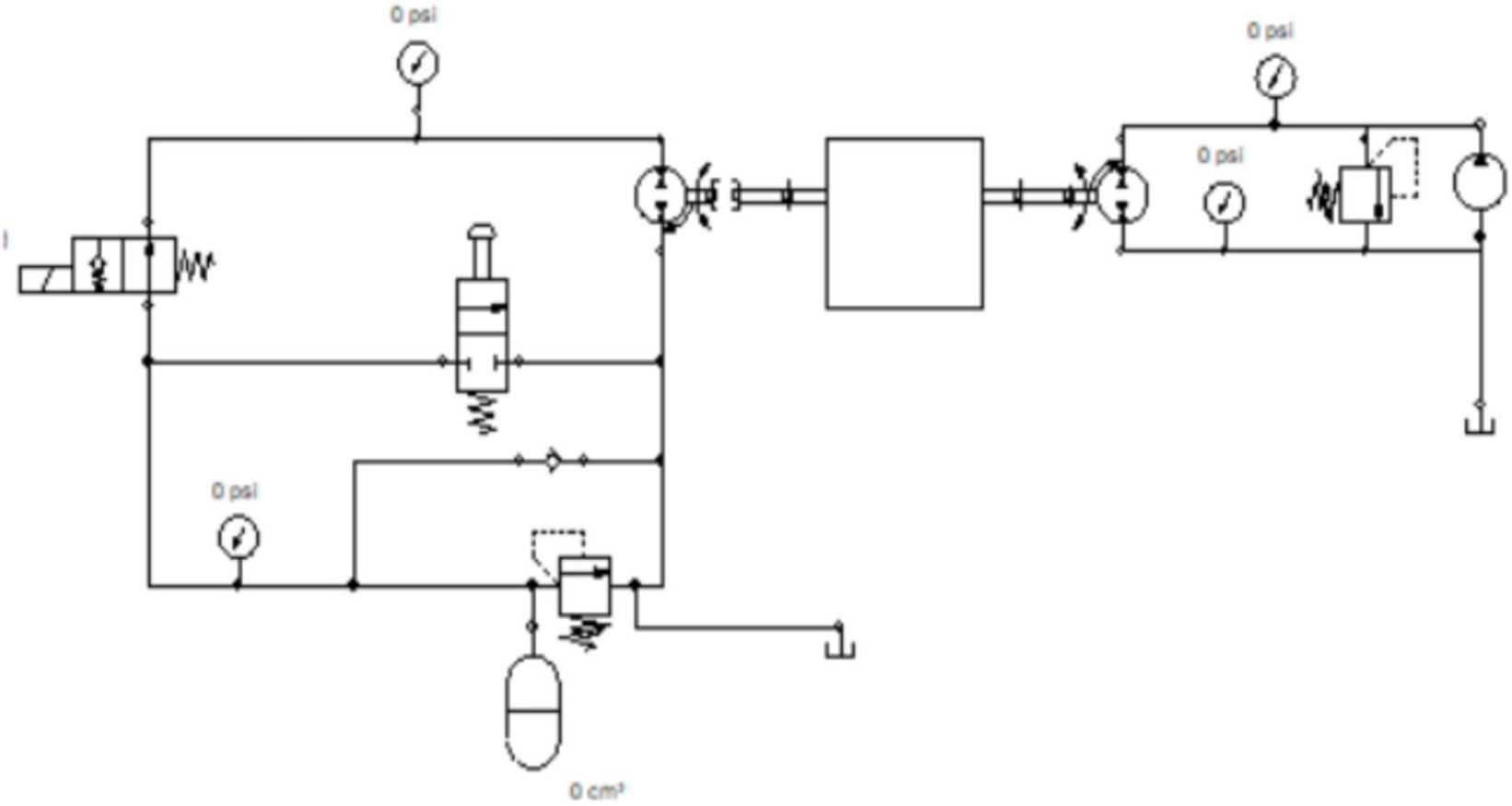


Hydraulics

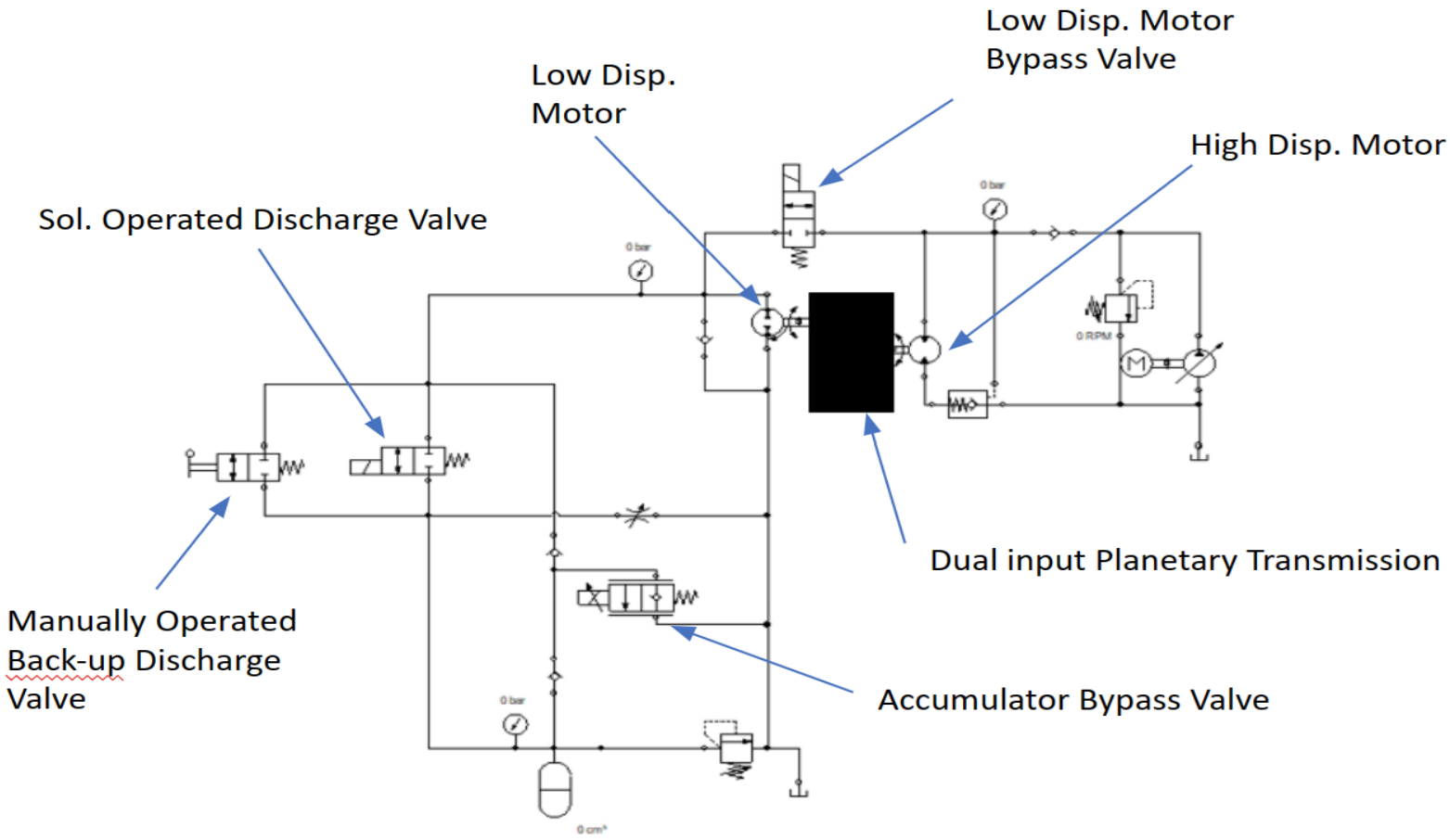
- Hydroleduc
  - Bidirectional - pump and motor.
  - One direction for regeneration.
  - One direction for discharge.
  - Optimized gear ratios in the transmission.



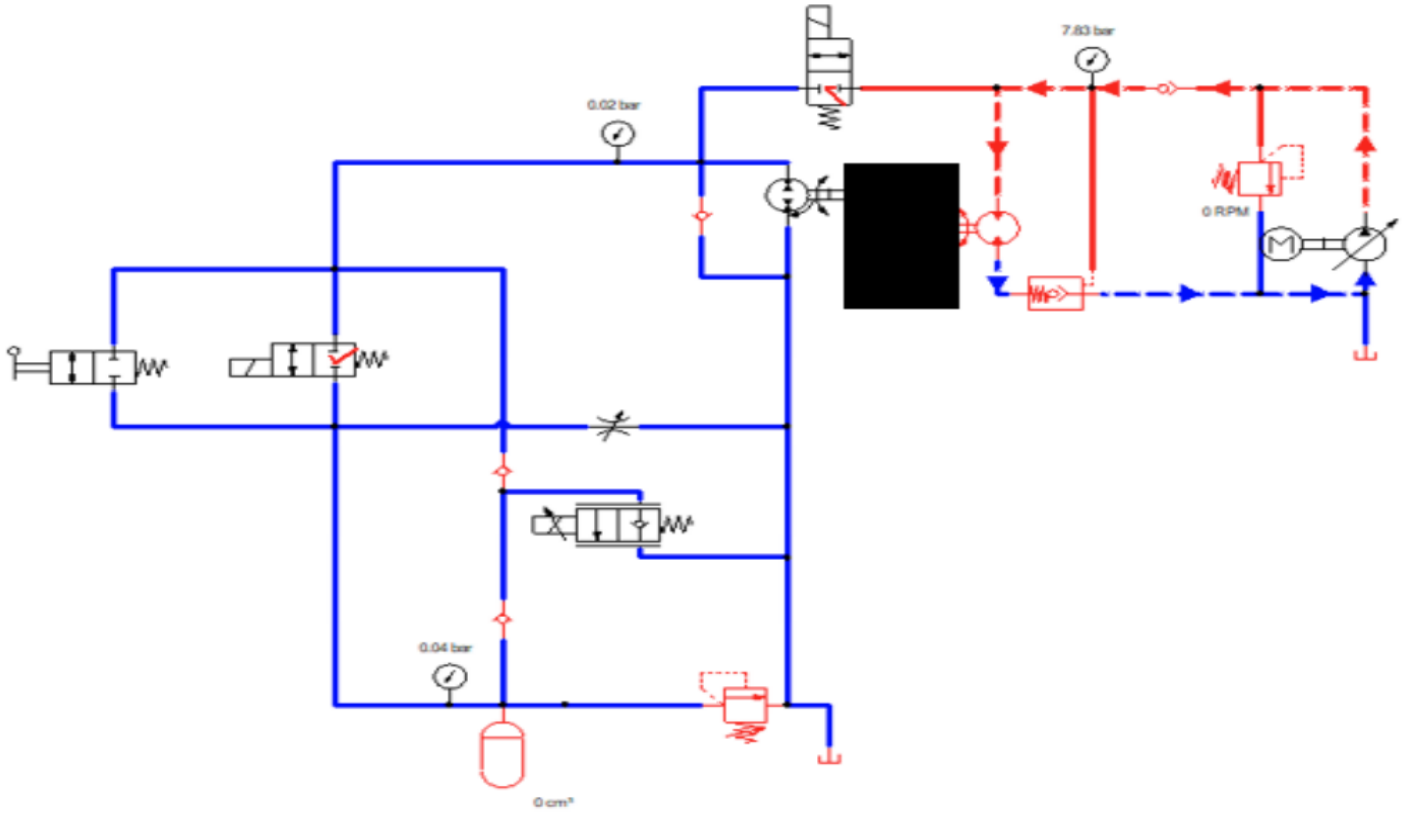
Old Schematic



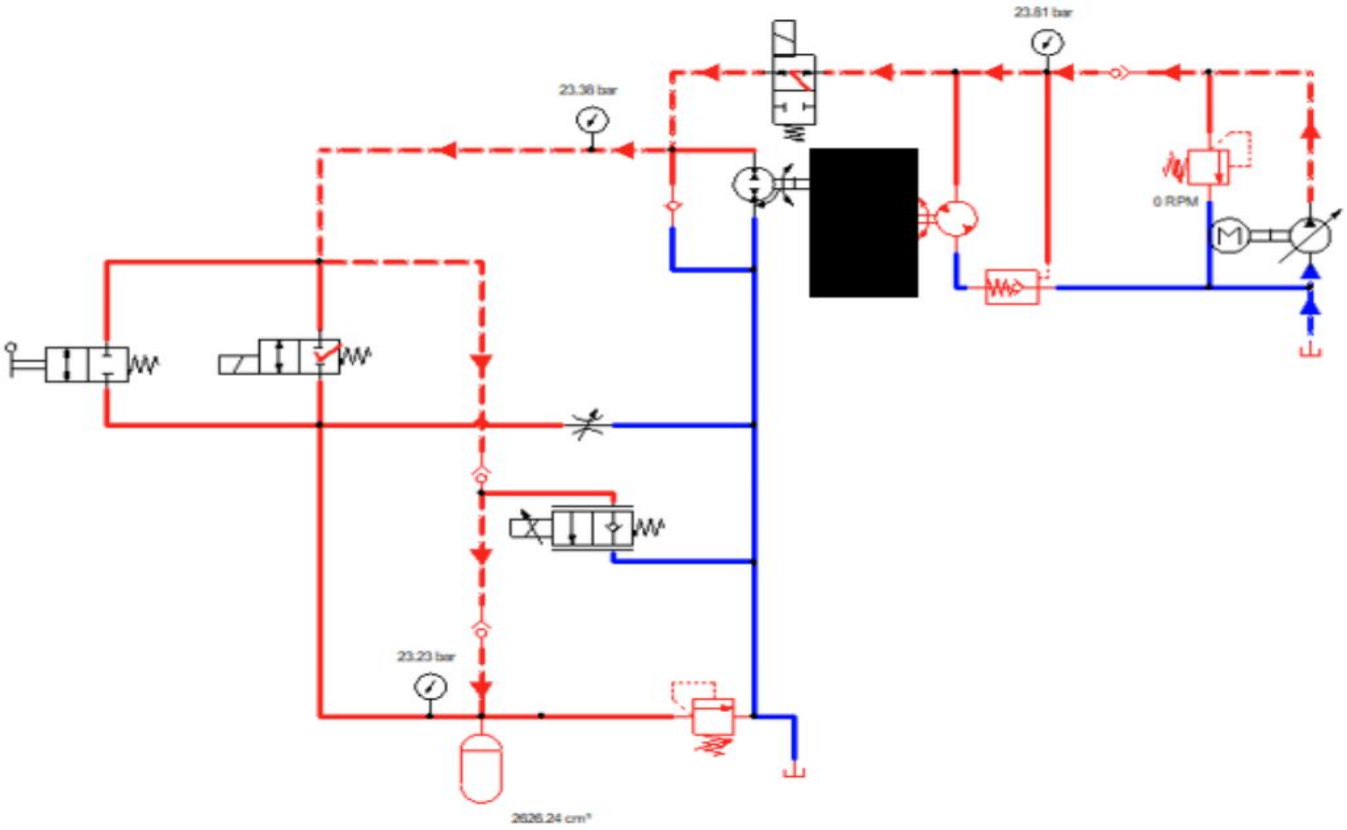
New Schematic



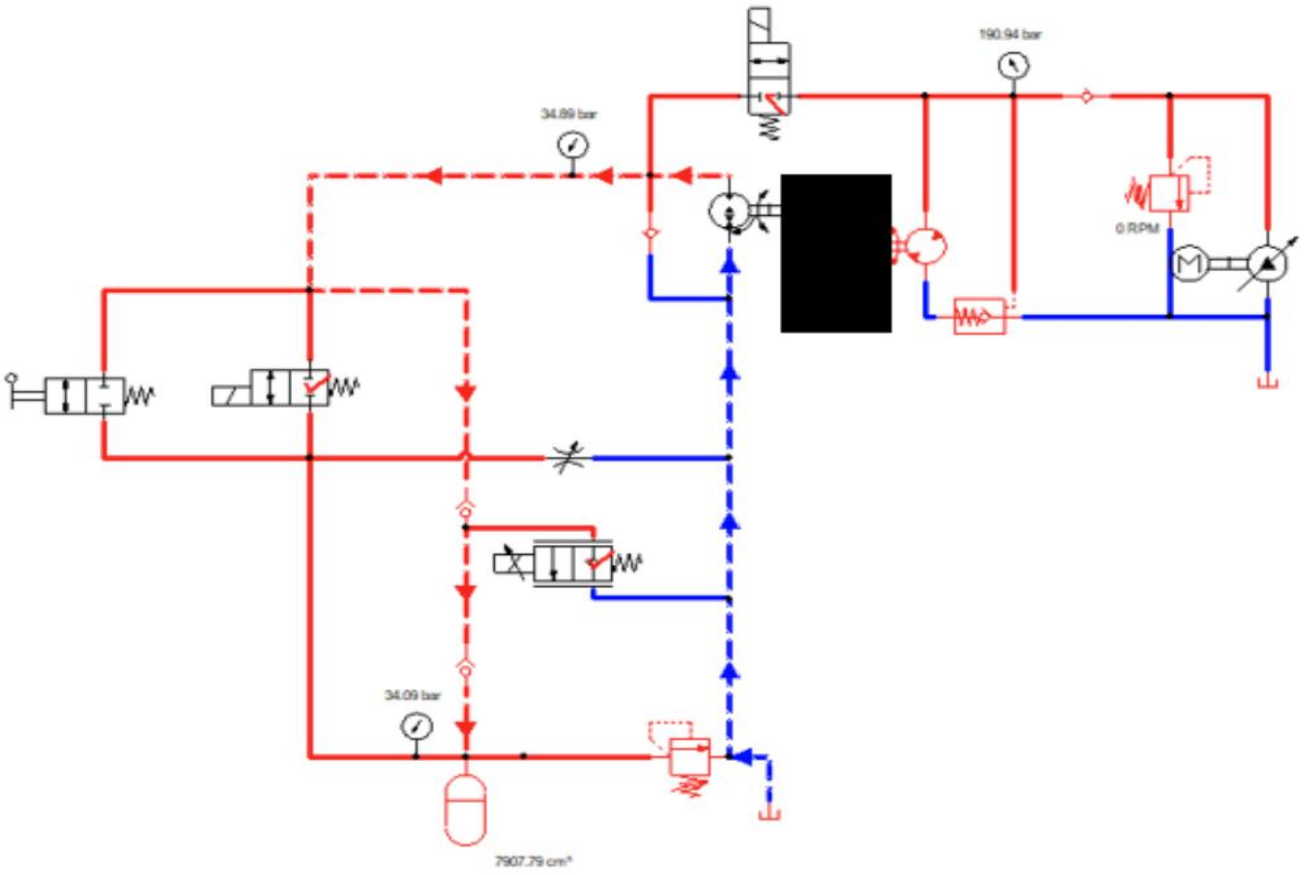
Normal Pedaling Operation



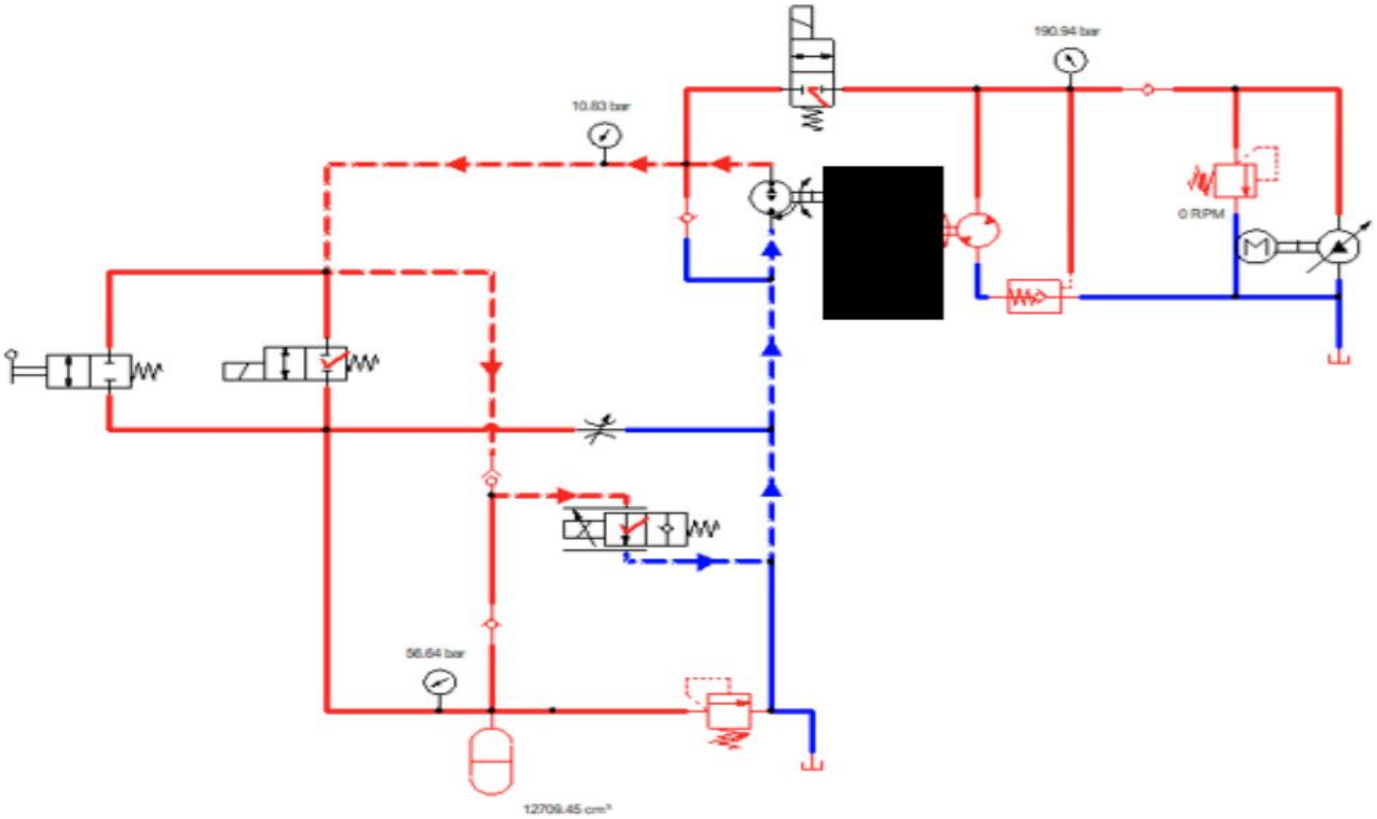
Direct Charging (Stationary)



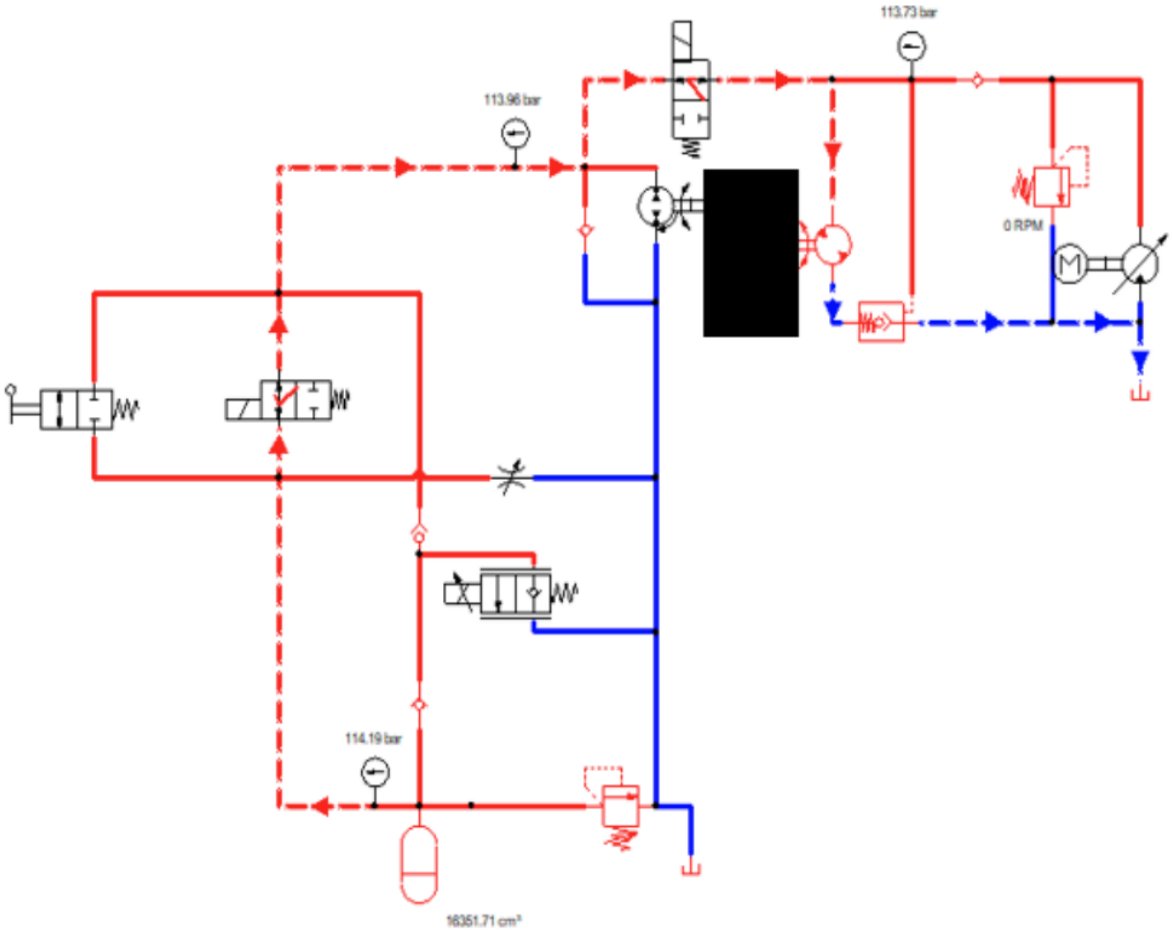
Braking (Regeneration)



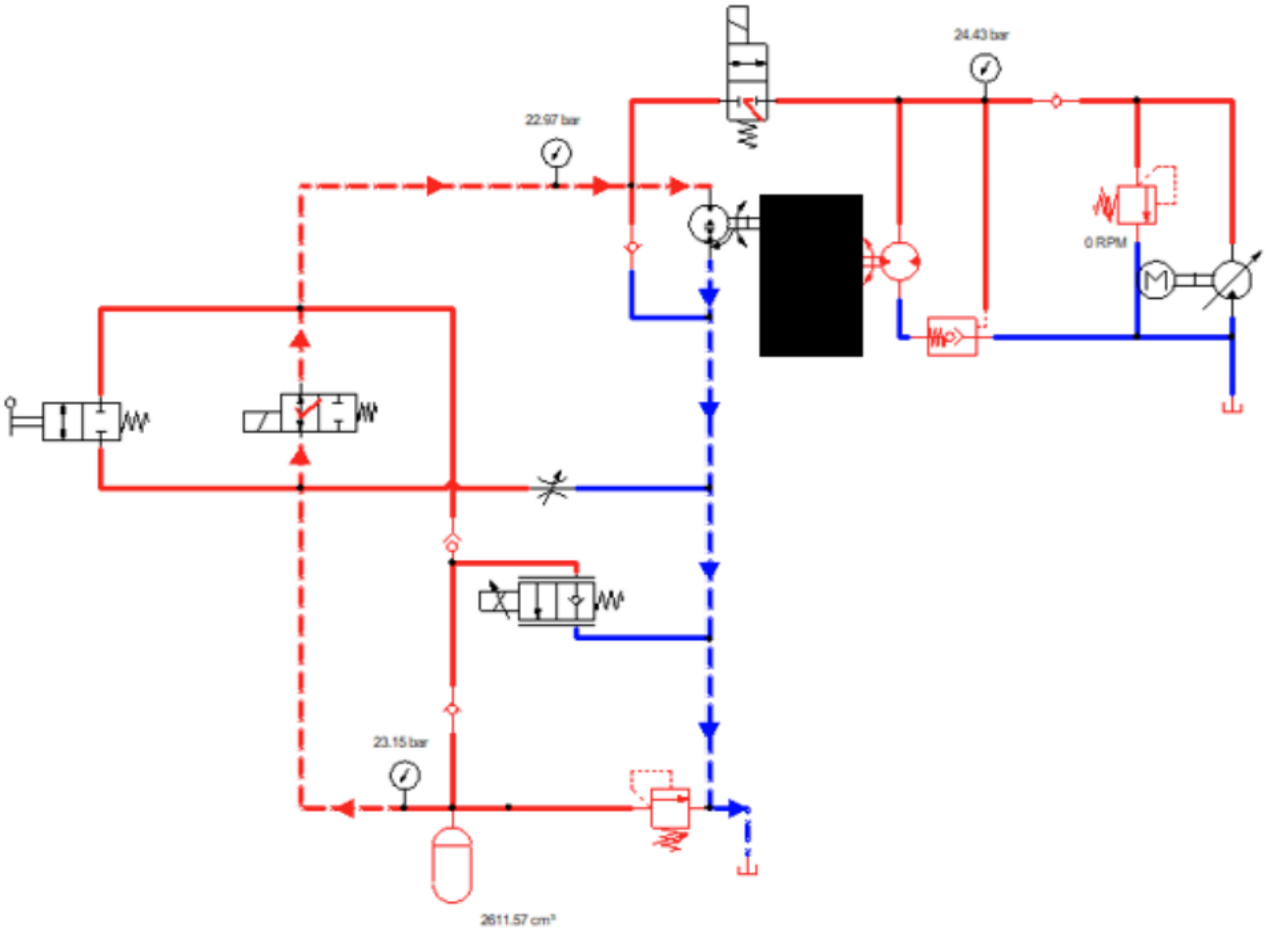
Braking (Full Bypass)



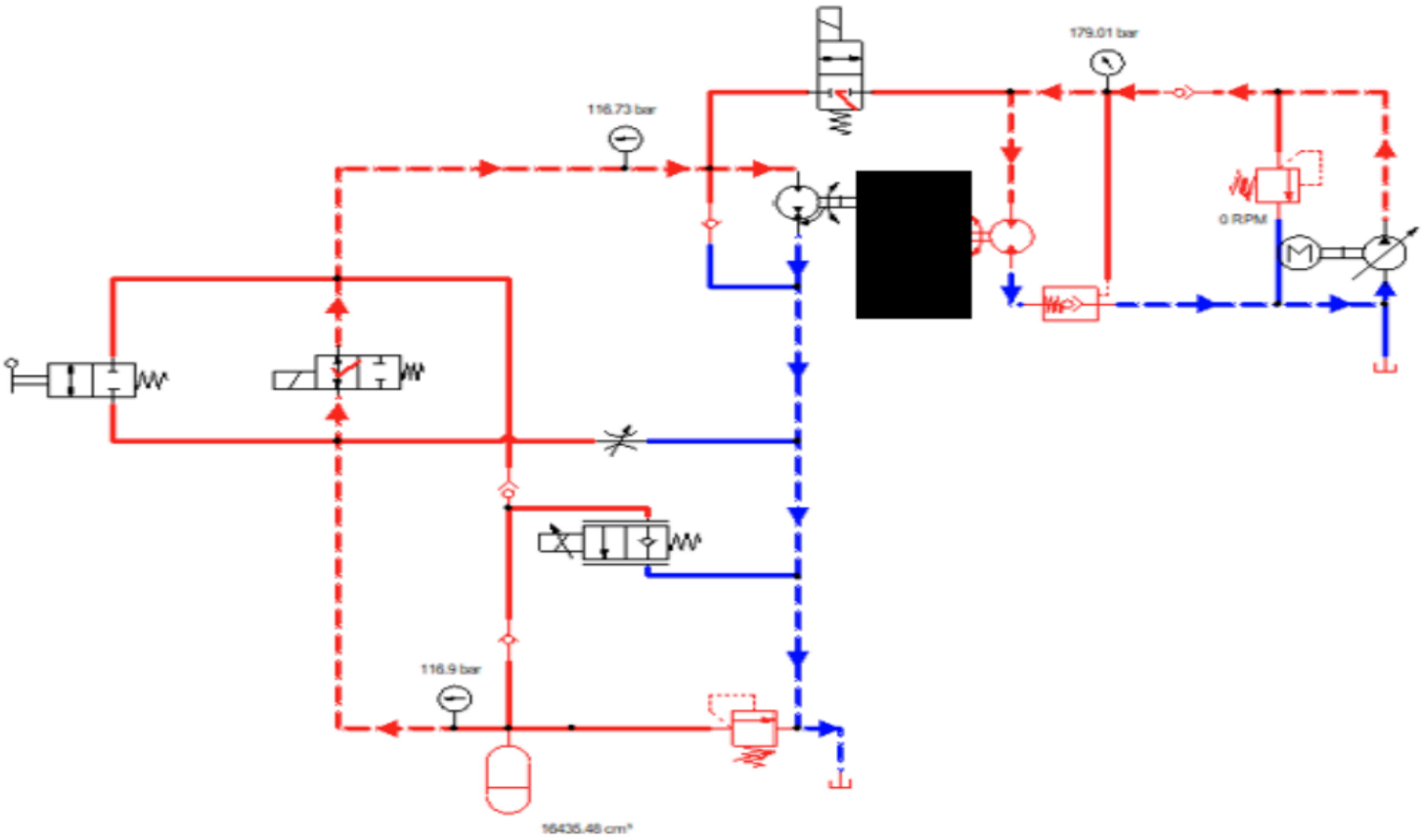
Accumulator Discharge “Low Gear”



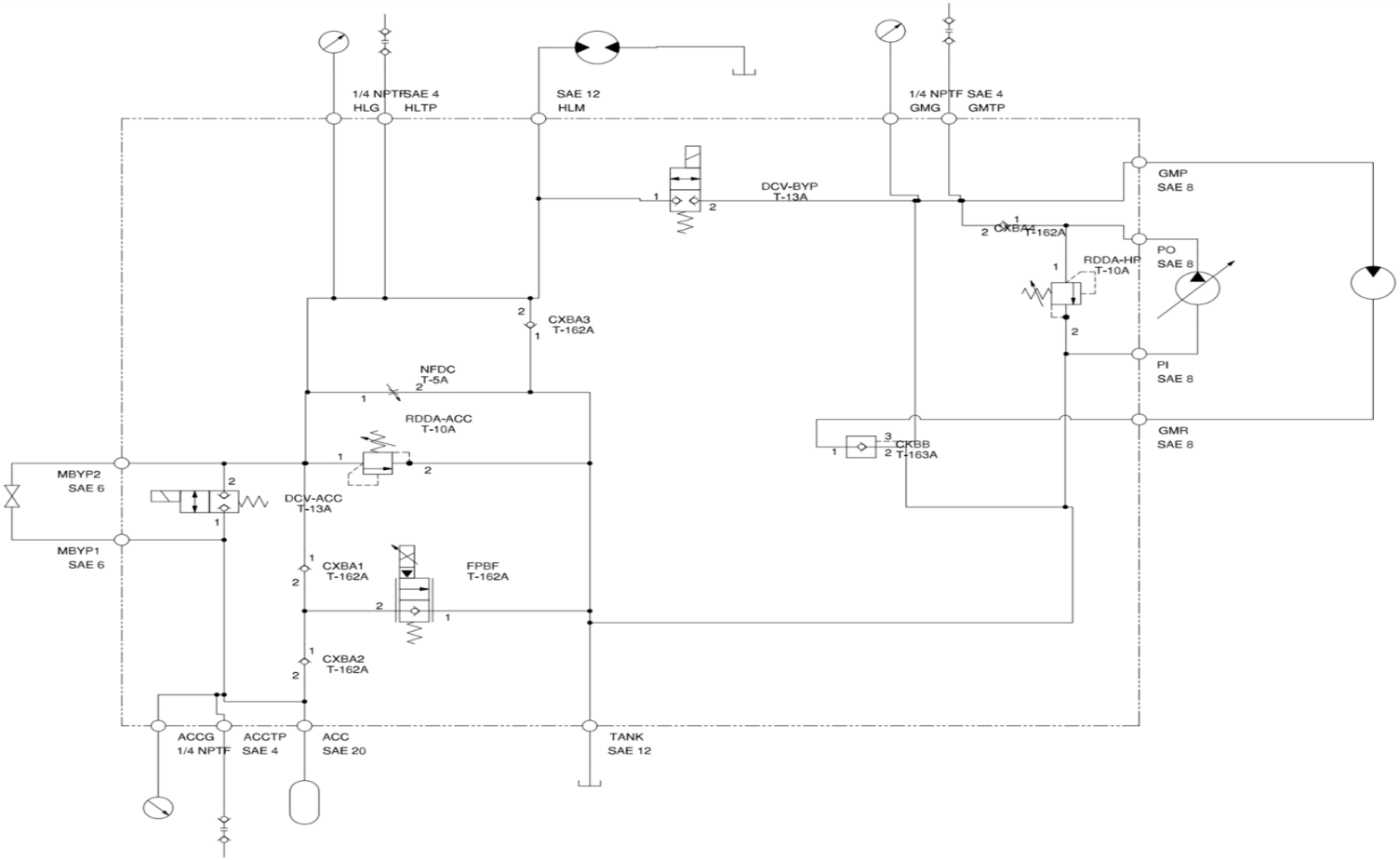
Accumulator Discharge "High Gear"



Hybrid Propulsion



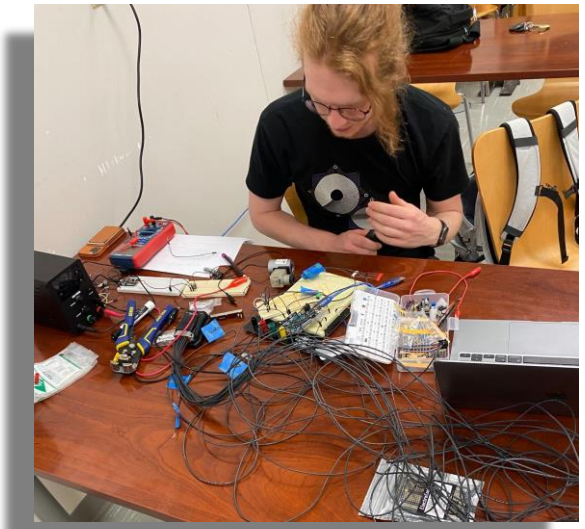
Manifold Schematic

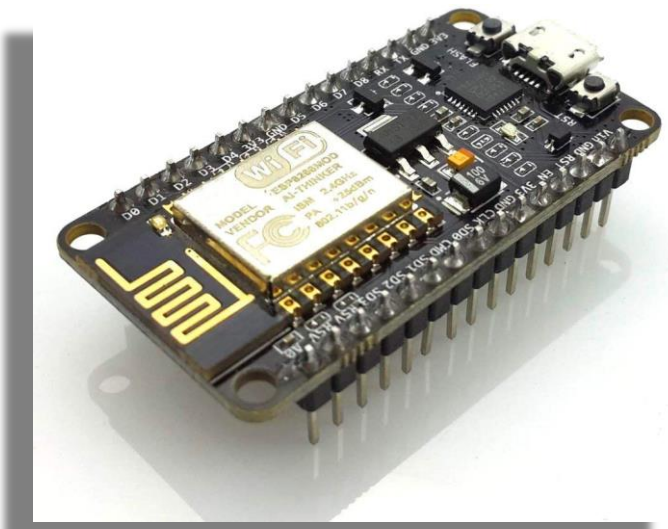


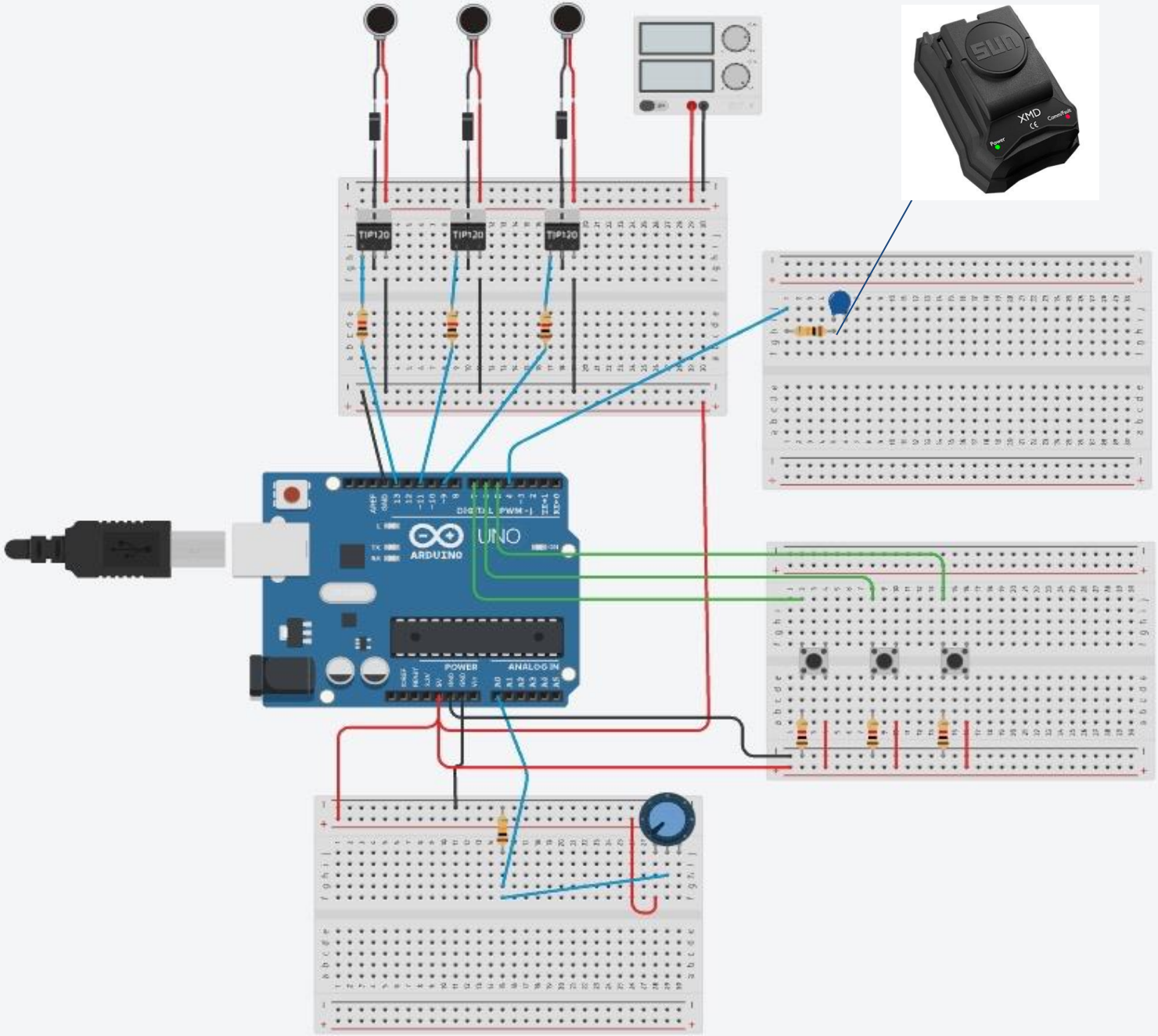
Controls

Controls system: ESP8266 (Arduino + wifi)

- Monitor inputs and outputs wirelessly.
- Replaces HMI with Smartphone.

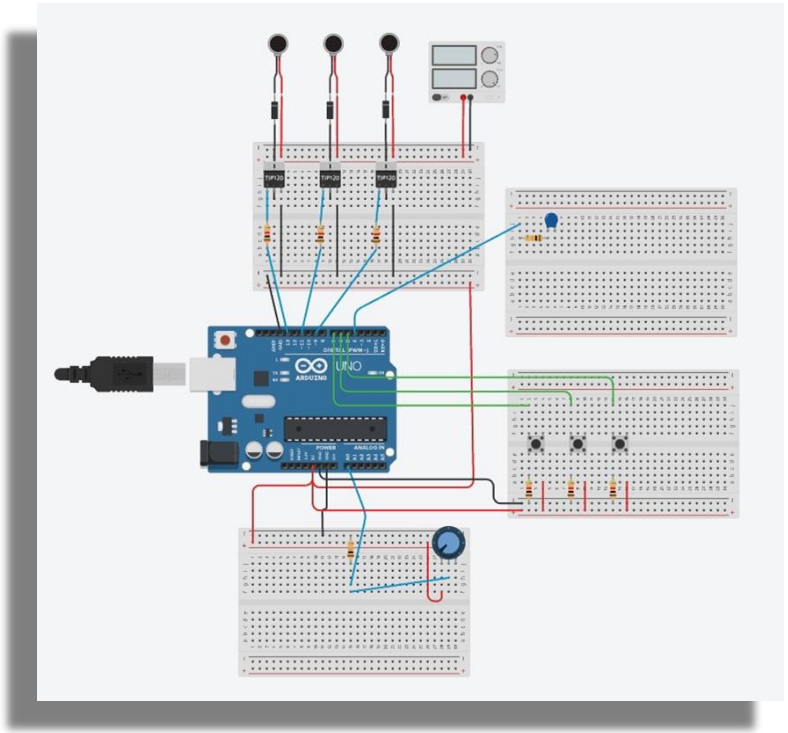





TIP120
TIP120
TIP120
UNO
ARDUINO
POWER
ANALOG IN
XMD
Power

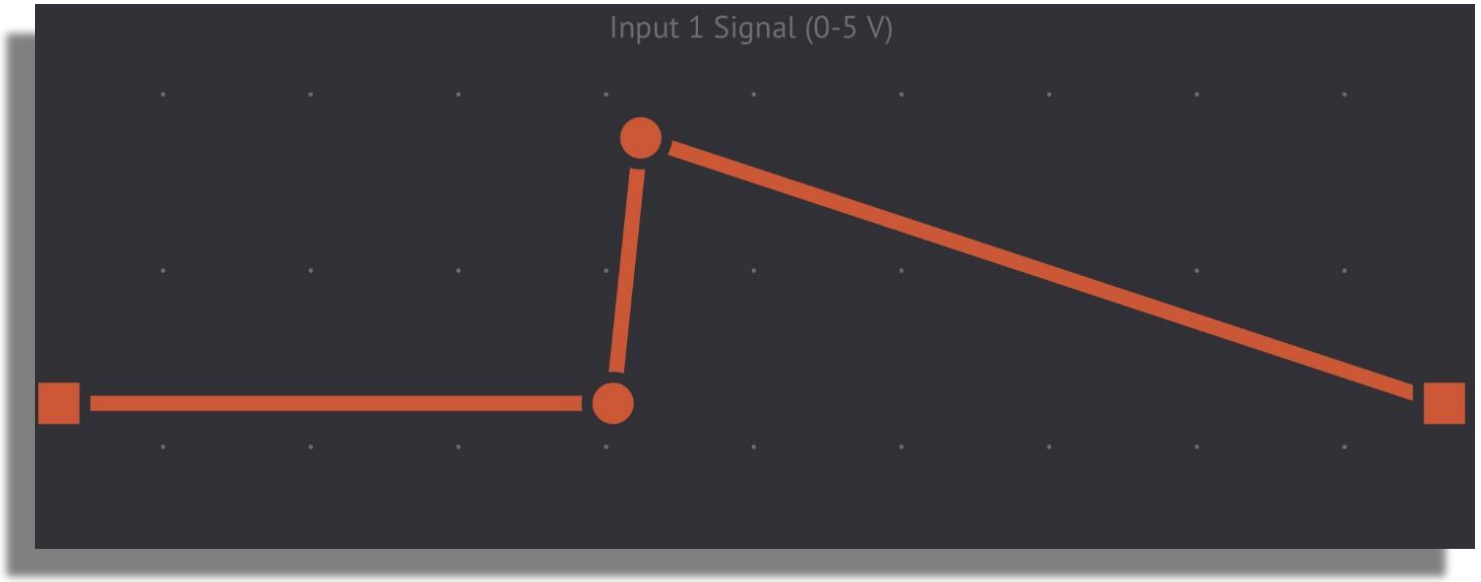
Controls Diagram

- Transistors for 24v.
- Potentiometer for variable braking.
- PWM high pass filter.



Variable Regen Braking

- Similar to an EV or Hybrid vehicle.
- Using XMD-02.



Powertrain

- We designed a dual input transmission for compact gearing and dual motor inputs and designed the manifold to make use of it.

  -Variable flow to both motors.
  -Designed to be efficient for each race.
  -Options for optimal performance.

- Our regenerative circuit is controlled by an air actuator mechanically and electronically in parallel for more control and ease of operation.

Transmission

- We designed the transmission using a planetary gear hub internally allowing for two motor inputs at different ratios for optimal torque and speed.
- Mechanical reversing gearbox for our regeneration circuit.
- Different gearing ratios for regen and normal operation.
- Ability to coast with minimal powertrain losses.

Final Vehicle

- Ability to manually control the bike if power is lost as a safety precaution.
- Designed for redundancy and reliability in operation.
- Constructed to reduce rider strain.
- Back-up bottle to increase overall pressure throughout races.
- Used controls to optimize regeneration and discharging.

Lessons Learned

- We had issues reusing a previously used accumulator as a back-up bottle (Cross threaded).
- Consider size of manifold when designing.
- Commit to designs earlier.