NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION
NORTHERN ILLINOIS UNIVERSITY
TEAM ADVISOR: GHAZI MALKAWI
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Northern Illinois University

Team Introductions

- Frame and Mechanical

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Colton Smeltzer

Brandon Humpal

Riley Bell

Team Introductions

- Electrical and Controls

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Team Introductions

- Hydraulics

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Previous Year Frame vs This Year Frame

Last Years Vehicle

This Year Vehicle

Old Frame vs New Frame

Last Year

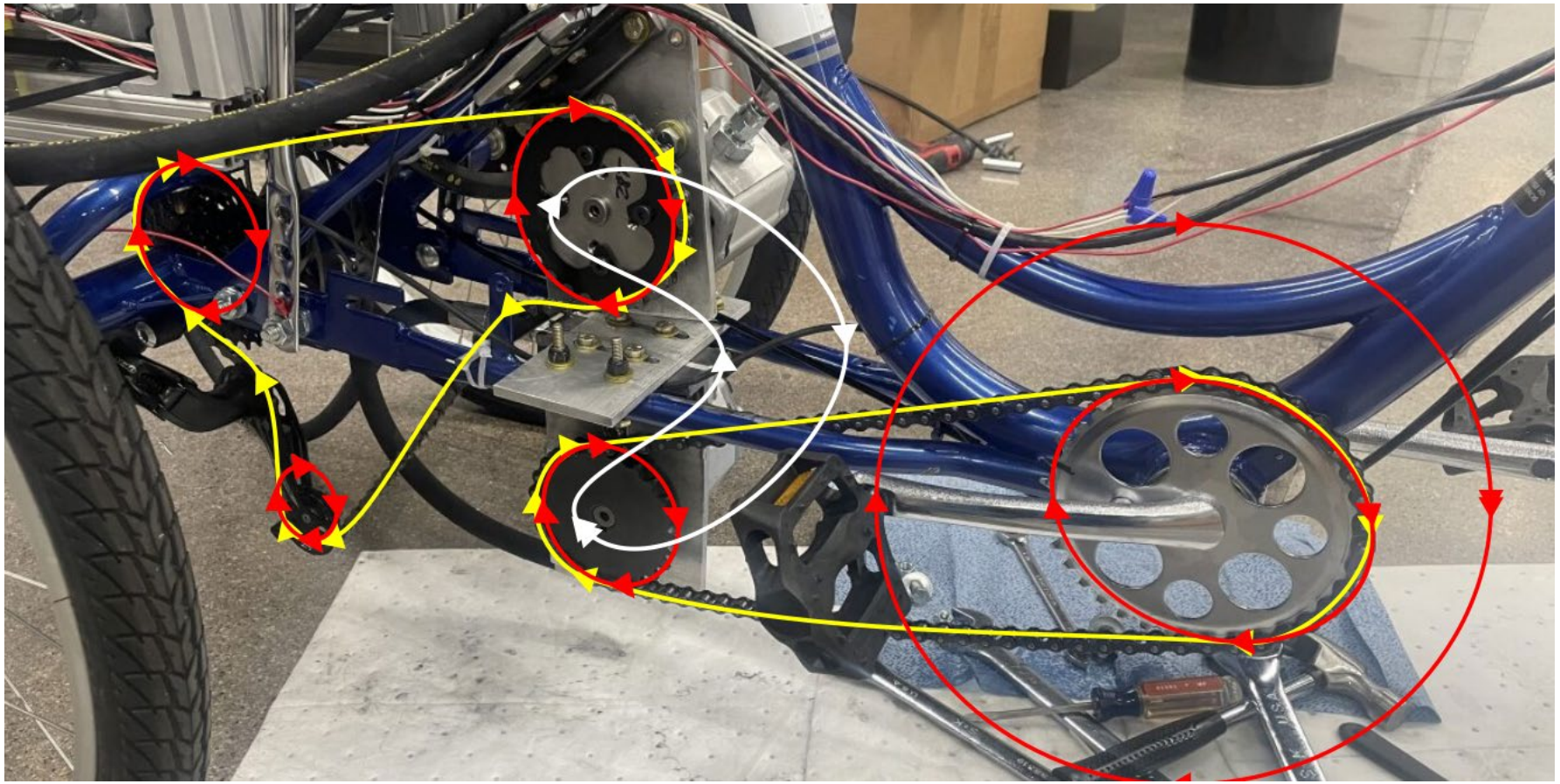
- Poor handling
- Excessive weight
- No speed ratio options
- Sprocket alignment issue - chain derailing from sprocket
- Pedal positioning

This Year

7-speed Tricycle from Sun Bikes utilized:

- Decreased the overall weight of the bike from 204 lb to 170 lb
- Optimized rider position
- Enhanced steering for improved handling
- Utilized the existing derailleur transmission for versatile gearing options

Drivetrain Layout

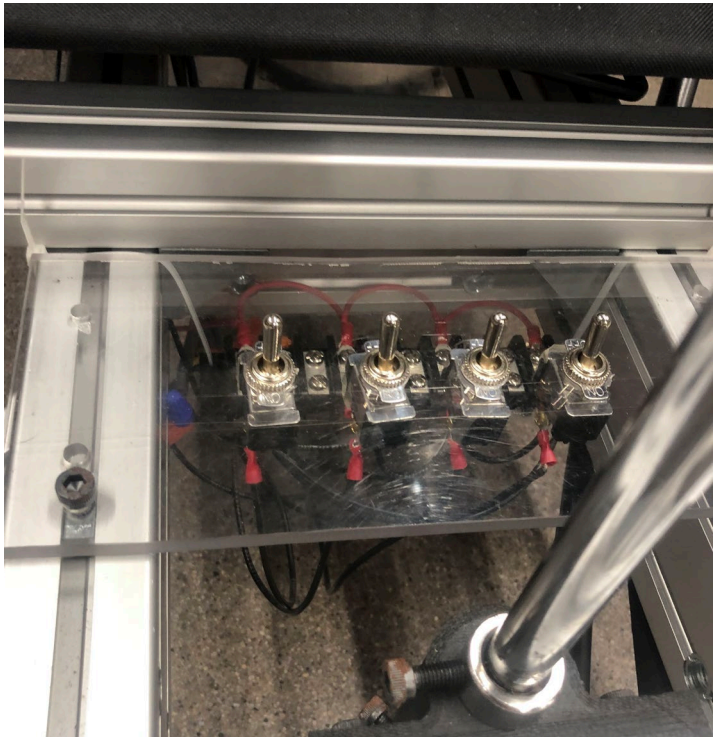


- Pedaling input powers sprocket, driving a hydraulic pump
- Pump drives fluid to a hydraulic motor, powering the rear axle

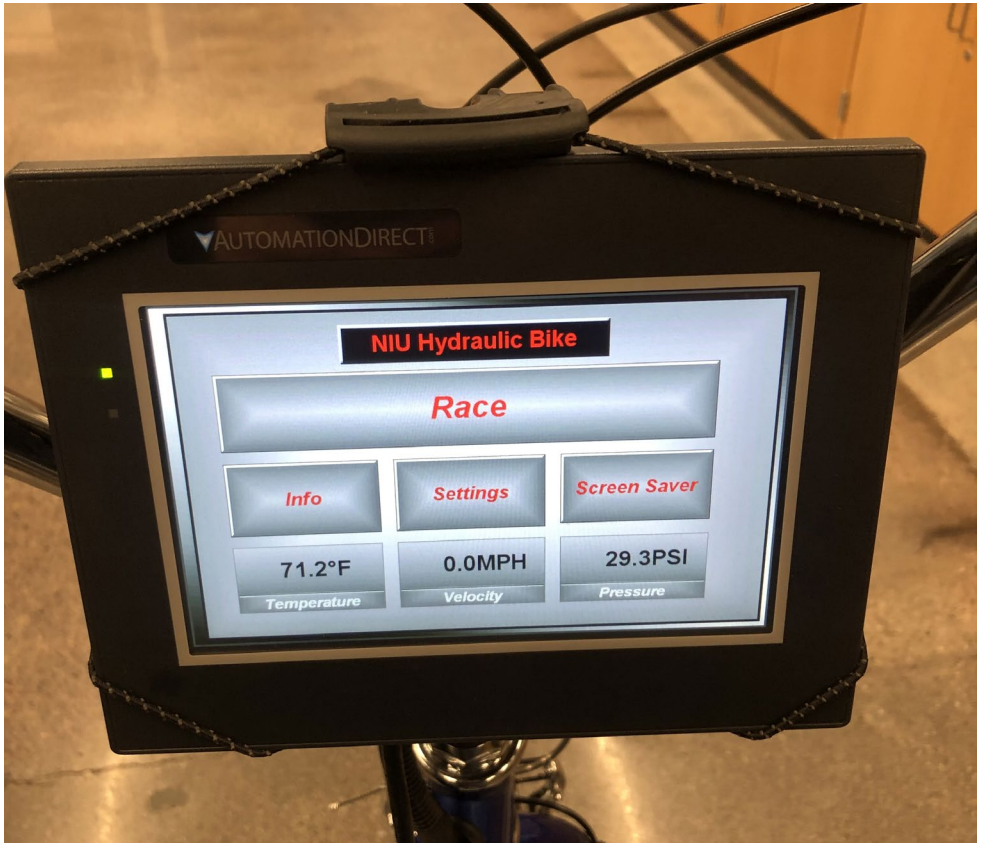
Frame Modification

Incorporated mounting plates for hydraulic components. Modified chain position and added sprocket for proper chain guidance.

Controls, Previous System vs New System



Last Year



New

Controls, Previous System vs New System

Last Year

- Requires multiple inputs to control each drive mode
- Extremely rudimentary system, uses switches
- Difficult to access and operate while driving.
- Inability to examine hydraulic system

New

- Requires one touch on the touch screen to control each drive modes
- Complex system with room for future improvements (data analytics)
- Good placement
- Displays wheel speed, pressure, and temperature

Controls System

- Automation Direct C-more EA9-T7CL Touch Screen
  - Display temperature, pressure, wheel speed
  - Communicates what solenoids to control by touch

Controls System

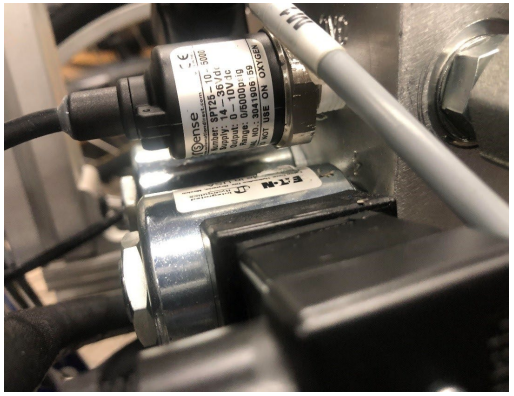
- Automation Direct Click C0-12DD2E-2-D PLC
  - Controls solenoid valves
  - Communicates inputs for temperature transmitter, pressure transmitter, and hall effect sensor to touch screen

Sensors

- Hall Effect
  - NJK-5002C
- Pressure
  - SPT25-10-5000A
- Temperature
  - XTP25N-100-0300F

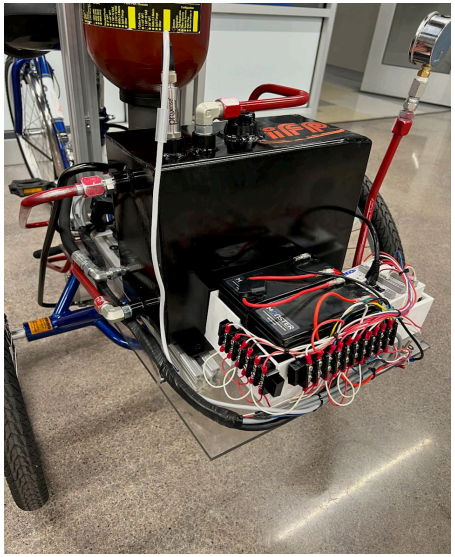
Sensors

Temperature sensor



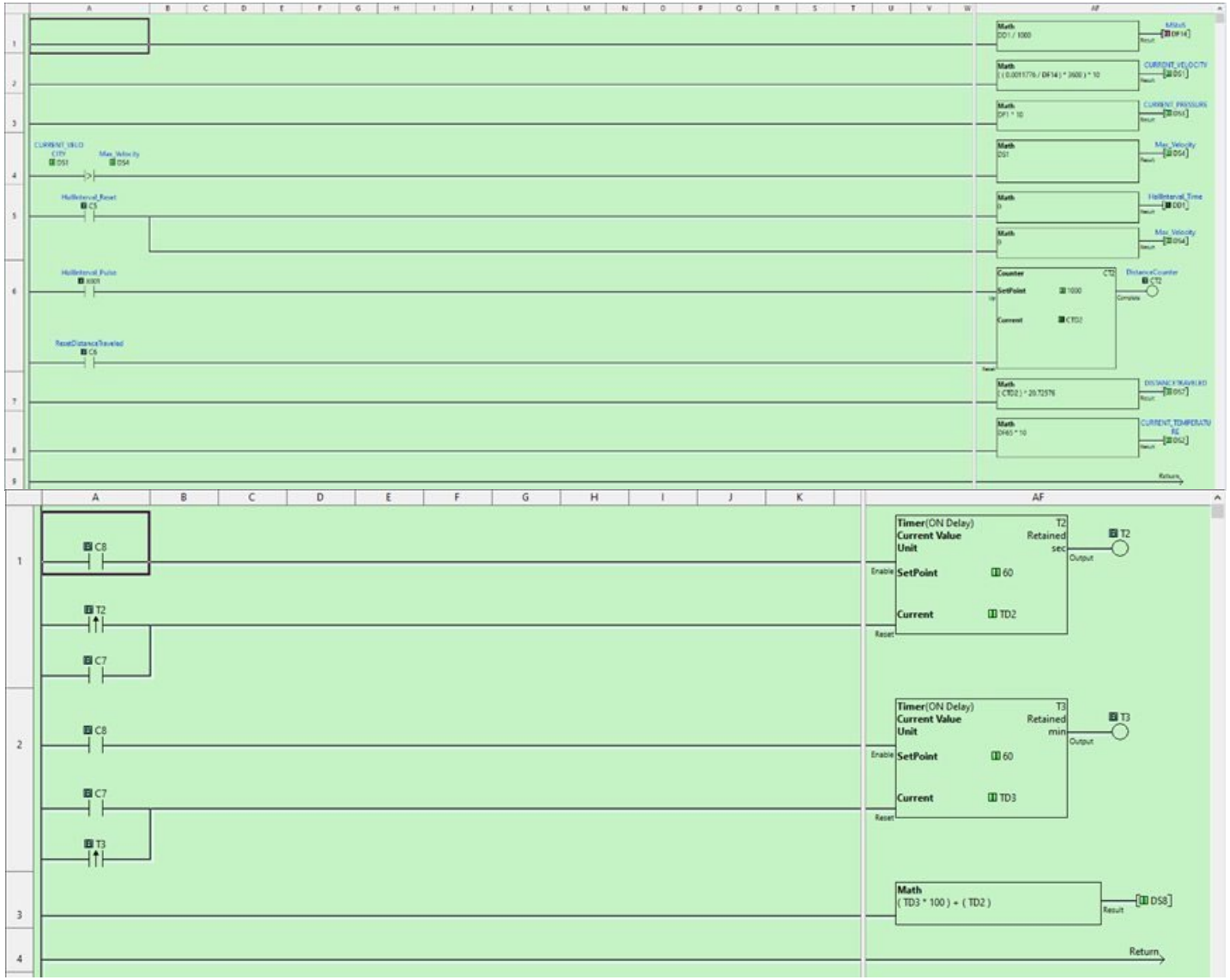
Pressure sensor

Speed sensor



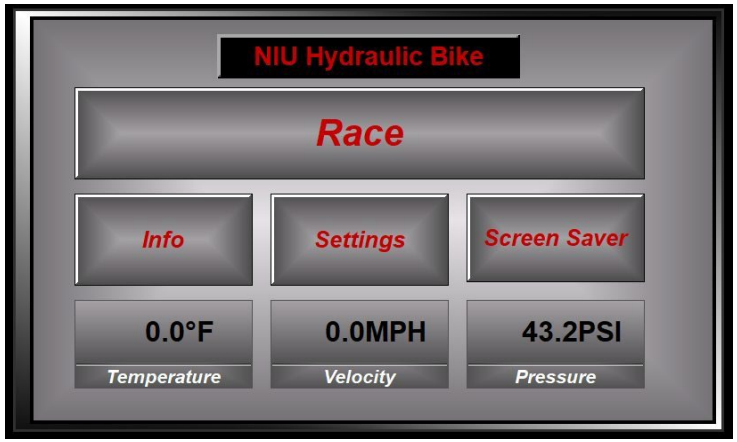
Wiring Harness

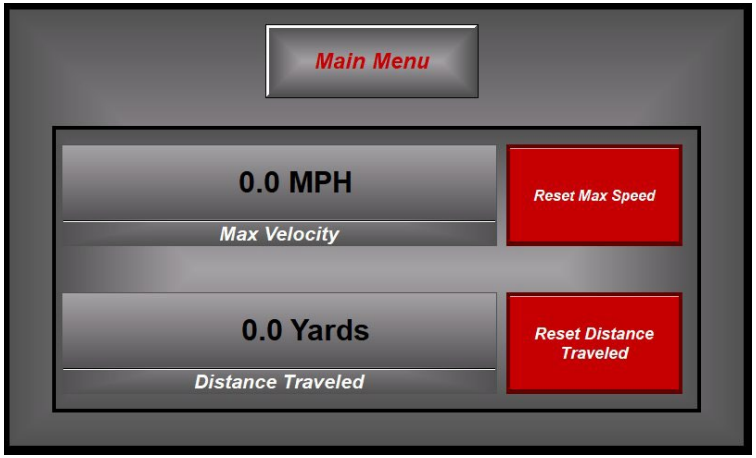
Ladder Logic Code for Sensors and Timer

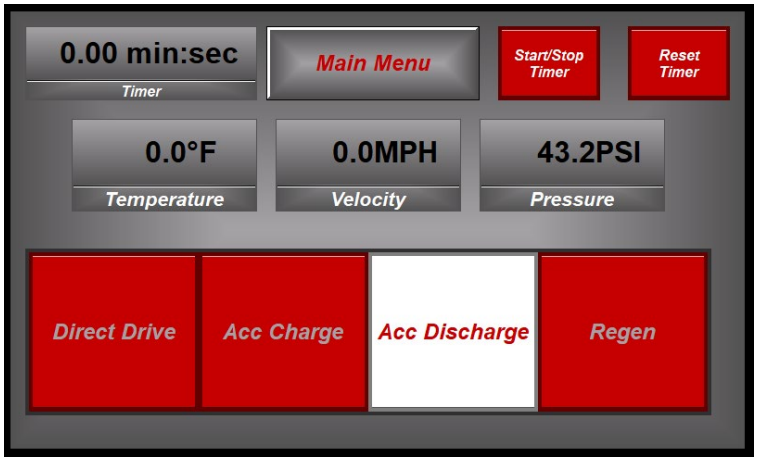


New System Improvements

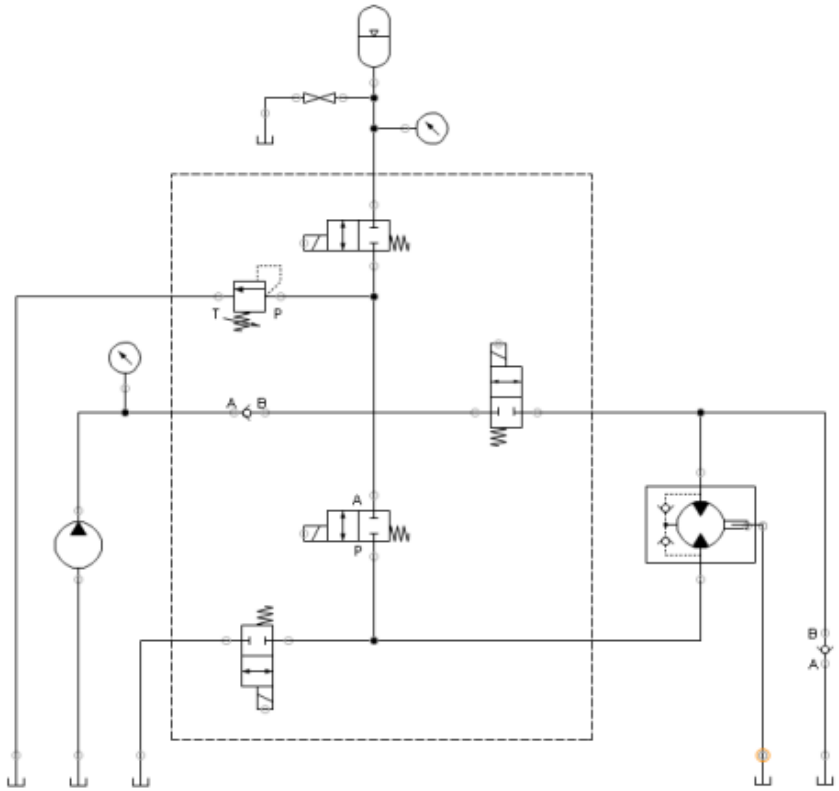
- Displays temperature, pressure, and bike velocity
- Can store max velocity and distance values
- Only requires one input to control drive modes



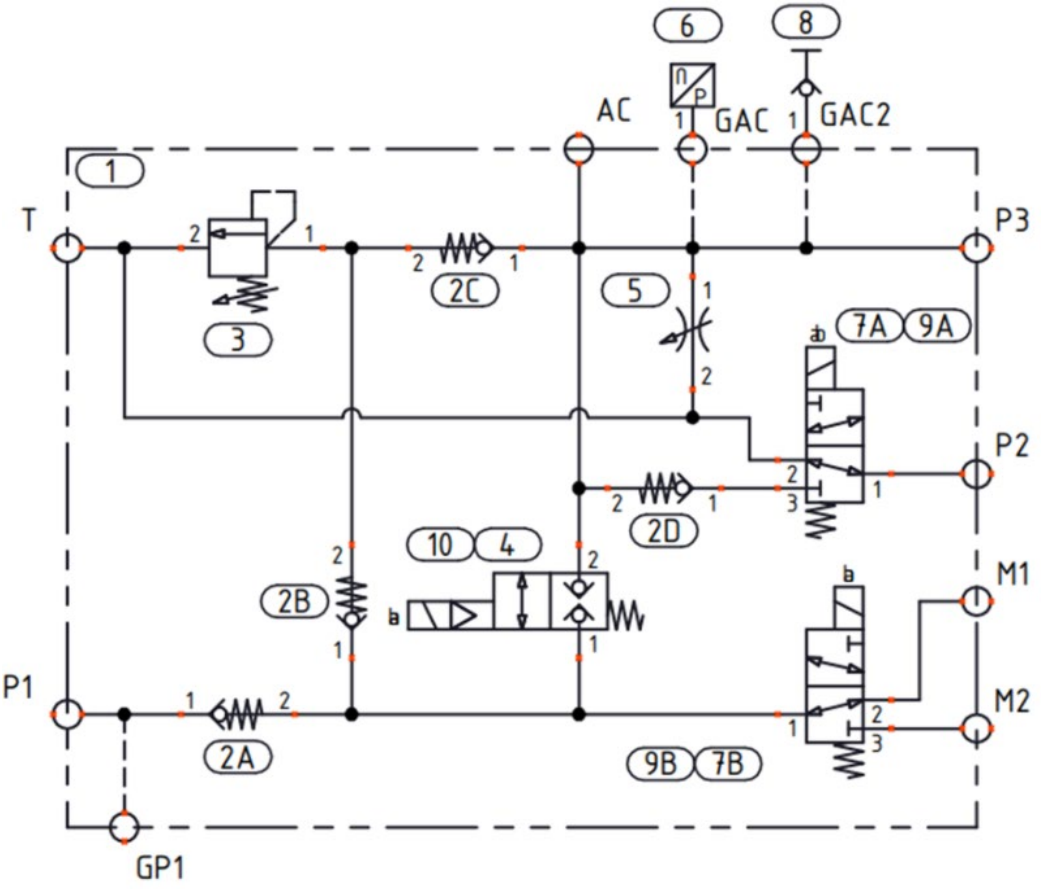




Old vs New Hydraulic System



Old Circuit

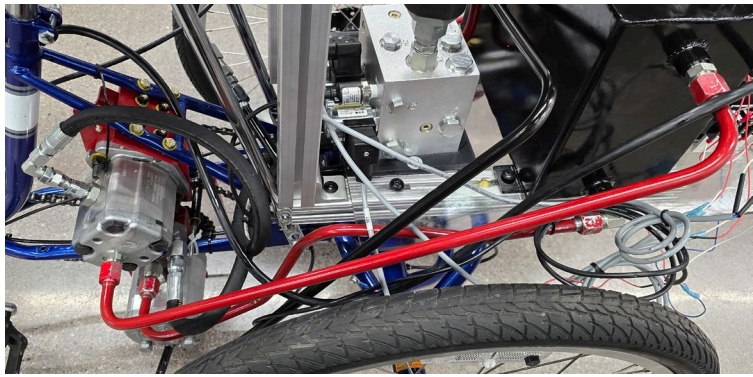


New Circuit

Tubing Info

Six custom-fabricated tubes were utilized.

- OD: 0.5", ID: 0.334"
- Wall thickness of 0.083"
- Pressure rating of 3100 psi
  - Factor of safety 6-1
- Material is Stainless steel
- Flare size is 37 degrees



Custom Tubing

Old vs New Hydraulic System

Old System	New System
Four solenoid valves	Three solenoid valves
Direct drive requires two valves to be energized	Direct drive is the neutral driving mode (no valves energized)
No hand pump support for accumulator charge	Hand pump circuit was added to support for accumulator charge
Plastic reservoir	New durable Steel tank

Pump and Motor

Old System	New System
0.67 CIR gear pump	Same pump was used (Gerotor pump and 1.025 CIR pump were tested)
0.67 CIR gear motor	1.025 CIR gear motor was used (Tested old motor)
1:2 gear ratio pedal:pump	1:1 gear ratio pedal:pump (Tested bigger gear ratios)
One fixed ratio of 1:1	Variable 5 gear ratios (1.17 to 2.15)

Hydraulic Motor

Hydraulic Pump

Accumulator

Old System	New System
600 psi pre-charge for all races	Sprint: 1400 psi pre-charge Regen: 600 psi pre-charge Efficiency: 1400 psi pre-charge
Max hydraulic pressure of 2100 psi	Max hydraulic pressure of 3000 psi

Vehicle Testing

- Endurance test
  - Optimal results were 13150 ft in 15 minutes (average speed 10 mph, 1:1 pump-pedal ratio, motor variable gear ratio of 1.17-2.15)
- Sprint test
  - Top speed was 23.1 mph (1400 psi pre-charge at 3000 psi hydraulic pressure).
  - Pedal:pump gear ratio 1:1, motor gear ratio of 1.17

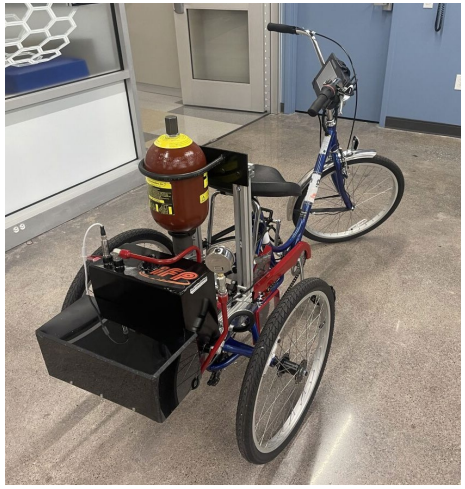
Vehicle Testing Cont.

- Efficiency test
  - Optimal efficiency 24%.
  - Accumulator pre-charge of 1400 psi, hydraulic pressure of 2000 psi
  - Distance traveled of 1015 ft

- Regen test
  - Accumulator pre-charge of 1000 psi
  - Distance traveled of 835 ft

Lessons Learned

- Controls:
  - Understanding of basic wiring
  - In depth understanding of coding with ladder logic
  - Greater understanding of long-term teamwork
  - How to problem solve using mechatronics



- Hydraulics:
  - Designing hydraulic circuits
  - Piping installation
  - Functionality of hydraulic components

- Drivetrain:
  - Derailleur mechanism crucial; durable, effective, and easy to adjust.
  - Downsides: The chain may skip sprockets due to rerouting.
- Frame:
  - Custom-built is not always the most effective; prebuilt reduces cost.
  - Provides a solid foundation for equipment integration.
  - Downsides: Limits control over design.