NFPA Fluid Power Vehicle Challenge

NFPA
Education and
Technology
Foundation

FINAL PRESENTATION &
DESIGN REVIEW
Texas A&M University
Team GATR
Professor Gary Bradley
4/24/2025

Meet the Team

			
Garrett Schlepphorst	**Austin Oden**	**Taten Thompson**	**Reid Boegler**
Hydraulics Design Team	Mechanical Design Team	Electronics Design Team	Mechanical Design Team
Design the hydraulic circuits and ensure the circuits work efficiently. Test and simulate the circuits Ensure Hydraulic design is compatible with both Electronic and Mechanical Design	Design the mechanical components for the bike utilizing Fusion 360. Ensuring compatibility of the mechanical design to both Hydraulic and Electronic Design	Design electronic circuits and components and ensure circuits work efficiently. Test and simulate the circuits. Ensure Electronic Design is compatible with other systems.	Design the mechanical components for the bike utilizing Fusion 360. Ensuring compatibility of the mechanical design to both Hydraulic and Electronic Design

Advisors and Mentors

Professor Gary Bradley
Capstone Advisor

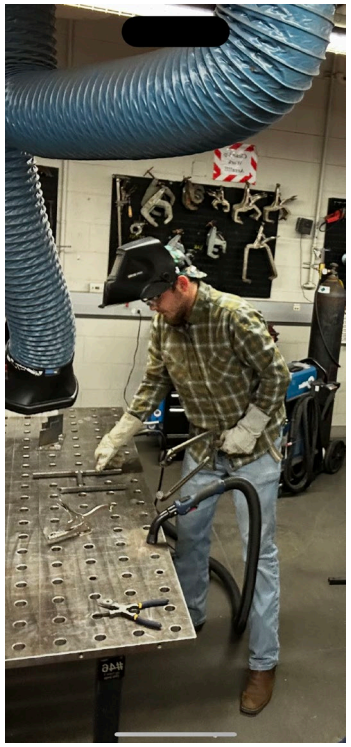
Mr. Calvin Rivas
Mr. Todd Townsend
Industry Mentors

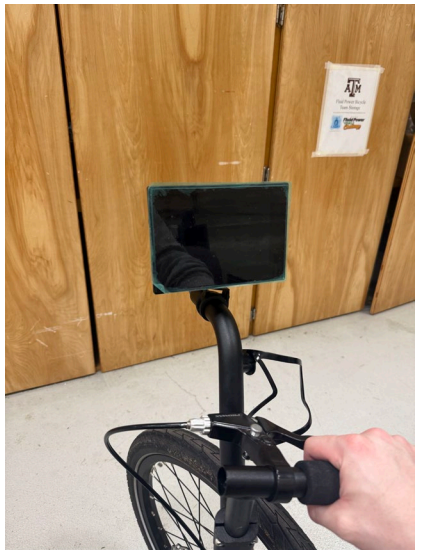
Dr. Bhaskar Vajipeyajula
Faculty Advisor

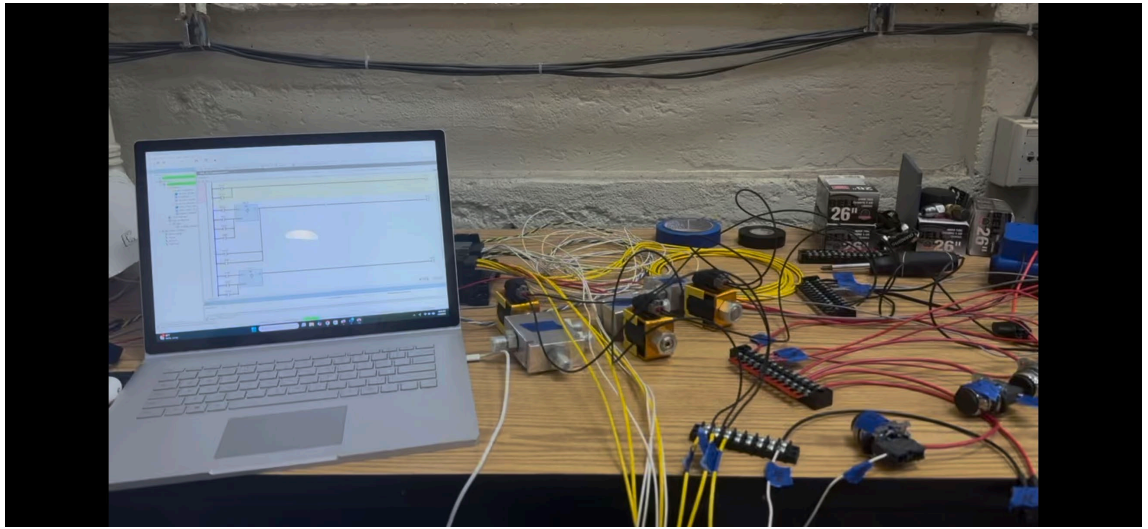
Vehicle Construction

- Started with water-jetting components from sheet metals, cutting tubing for frame, and machining on manual mill/lathe.
- Welded H-frame on bike frame and spliced/welded boom arm with boom extension.
- Welded reservoir and water-tested to ensure waterproof.
- Designed and 3D printed components to house electronics, and to hold HMI.
- Assembled bike components to bike frame.
- Assembled hydraulic system to bike.
- Wired and programmed.

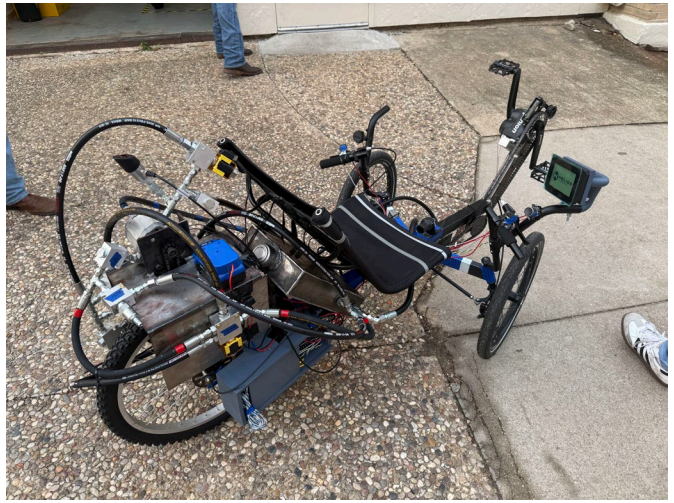
Vehicle Construction







Vehicle Construction



Final bike prior to testing

Vehicle Testing

- Tests ran:
  - Tested each hydraulic/electric system mode to ensure that each mode works properly and as intended.
    - Made sure designated solenoids were getting power when intended.
    - Made sure designated valves were actuating and hoses were properly connected.
  - Used the graphs to monitor pressure buildup in the motor and accumulator overtime.
  - Used indicator lights on the HMI screen to monitor which mode and which solenoids are activated in each mode.

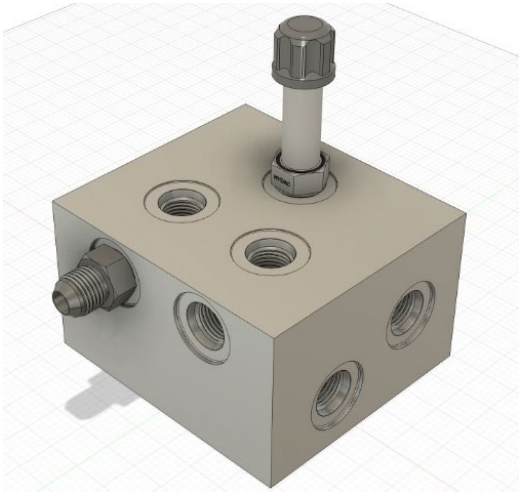
Problems Encountered

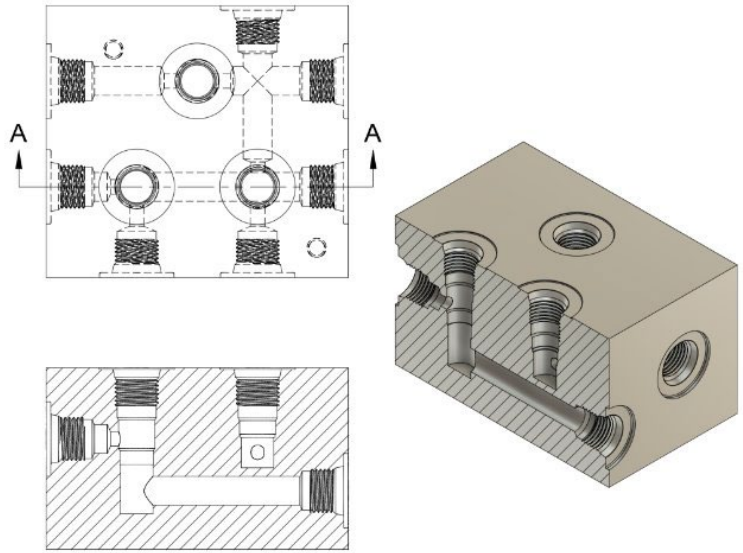
- Bearing connecting the belt and chain from the pedals to the pump broke while riding.
- Nut holding the sprocket on the gear box was stripped, causing the pedals to slip.
- Assembly issues with the hydraulic lines causing fluid to back up in unwanted places.
- Component spacing issues.
- Chain tensioning/slippage issues.
- HMI programming issues.
- Manufacturing issues.

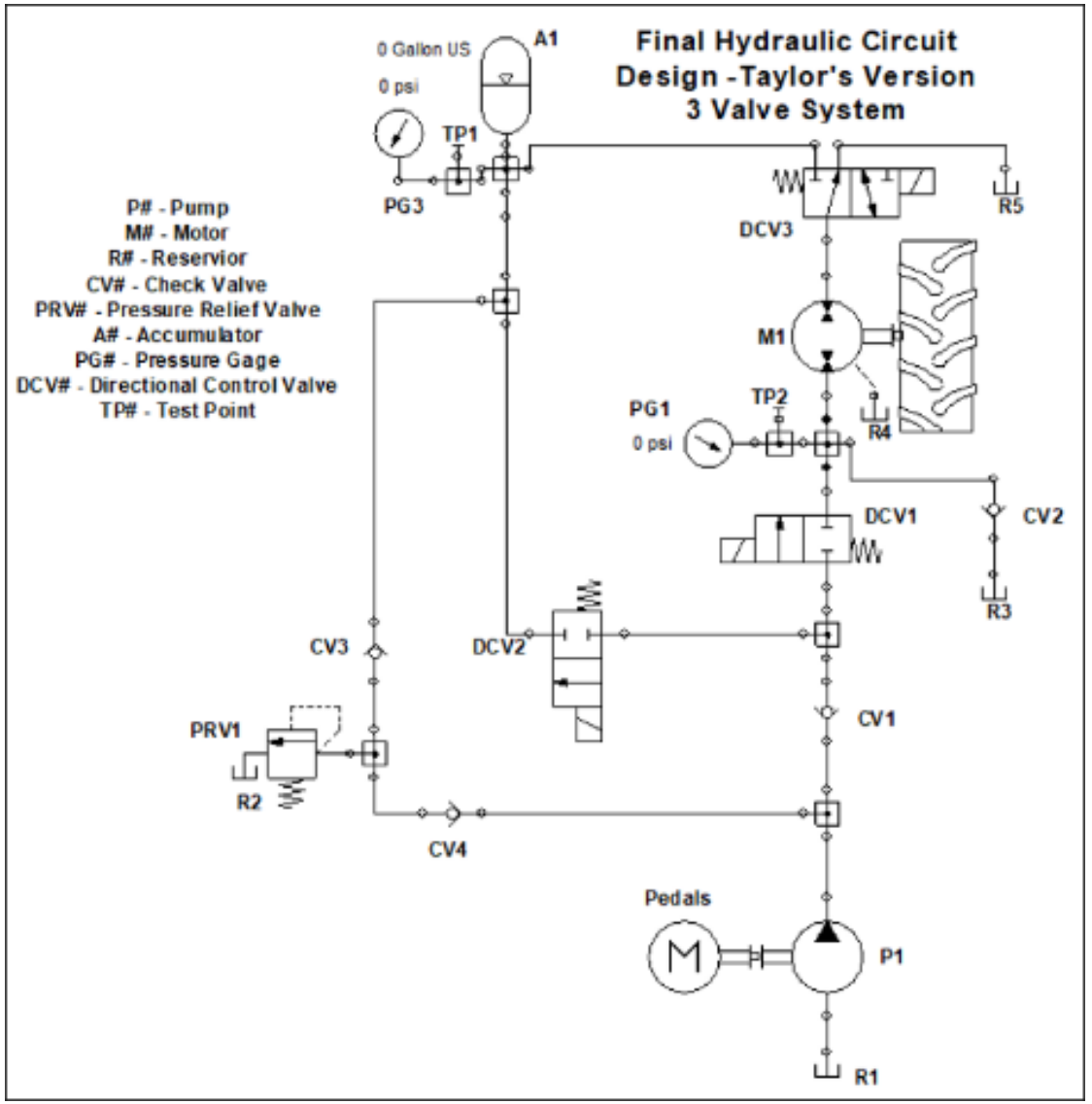
Vehicle Testing

- Changes made or to be made after testing:
  - Modified the hydraulic circuit
  - Added a belt guard to protect the rider.
  - Tensioned the gear box shifter knob to allow for gear changes while riding.
  - Fabricated a new tachometer plate with bigger but less openings.
  - Modified the back wheel axle to prevent the wheel from backing itself off the frame.
  - Added a bushing instead of a bearing to the front plate that connects the belt to the chain from the pedals to the pump.

Previous Year's Hydraulic Design

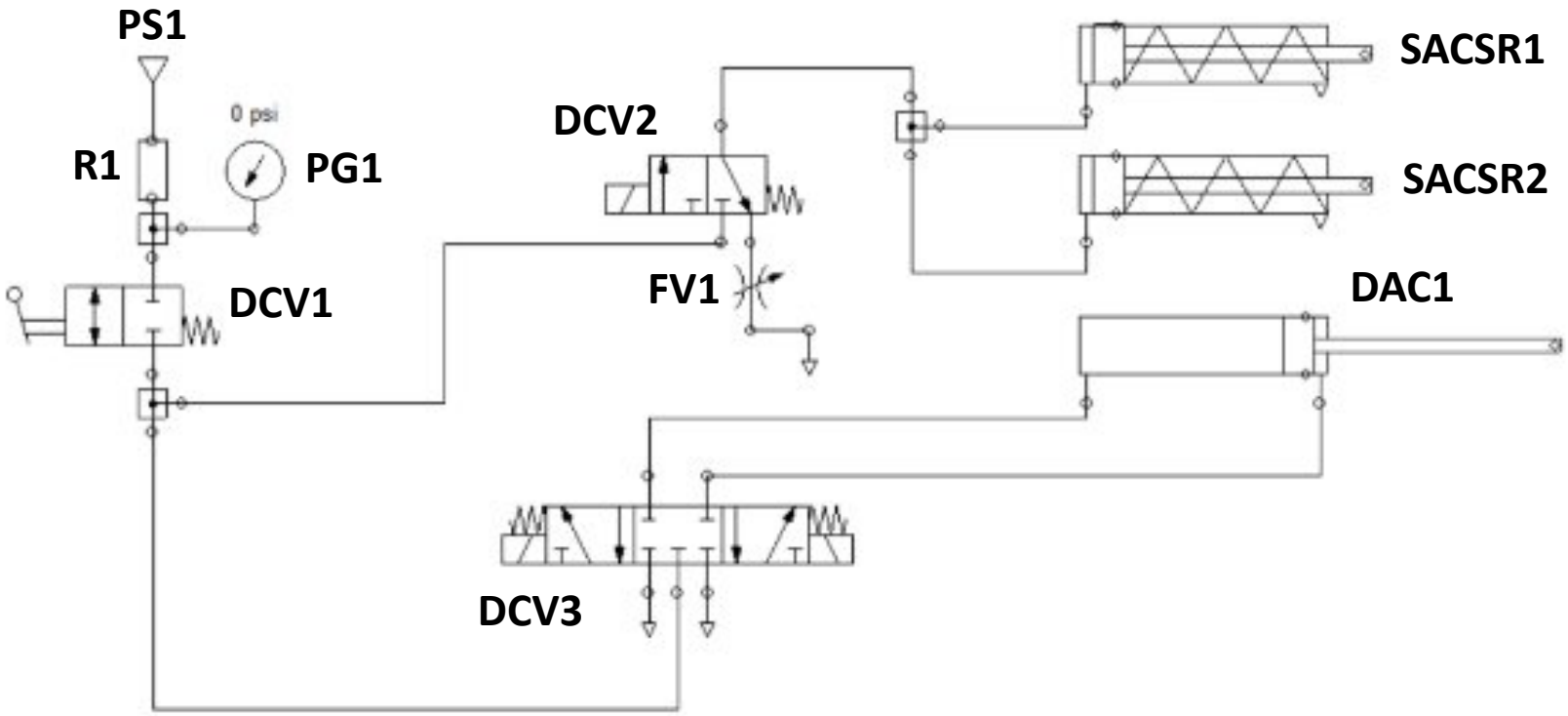






Previous Year's Pneumatic Design

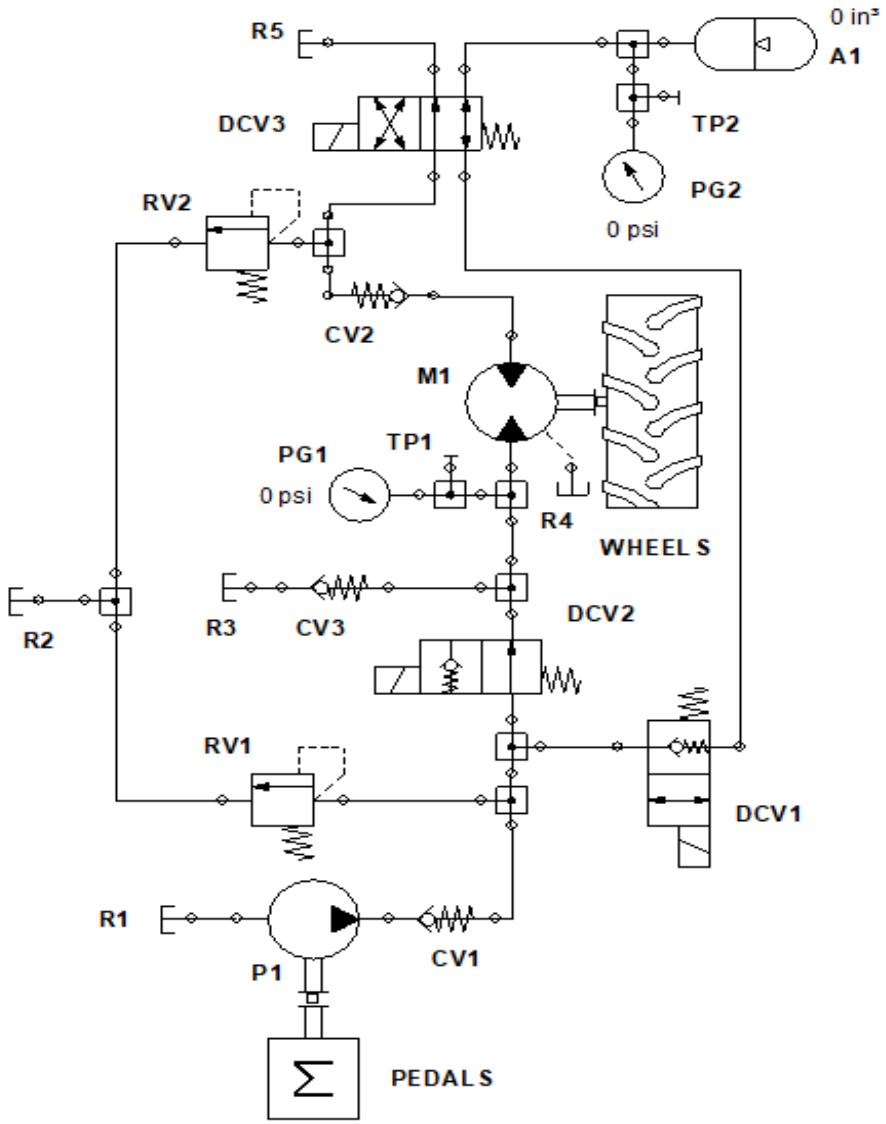
PS# - Pressure Source (Air Pump)
R# - Reservoir
PG# - Pressure Guage
DCV# - Directional Control Valve
FV# - Flow Control Valve
DAC# - Double Acting Cylinder
SACSR# - Single Acting Cylinder, Spring Retracting



Vehicle Design/Final Vehicle Hydraulics

Overall Circuit

- 3 DCV design
- Check and Relief valves positioned to protect motor and pump from reverse pressure
- CV3 used in regenerative braking line instead of a DCV
- DCV3 acts as focal point of the hydraulic circuit

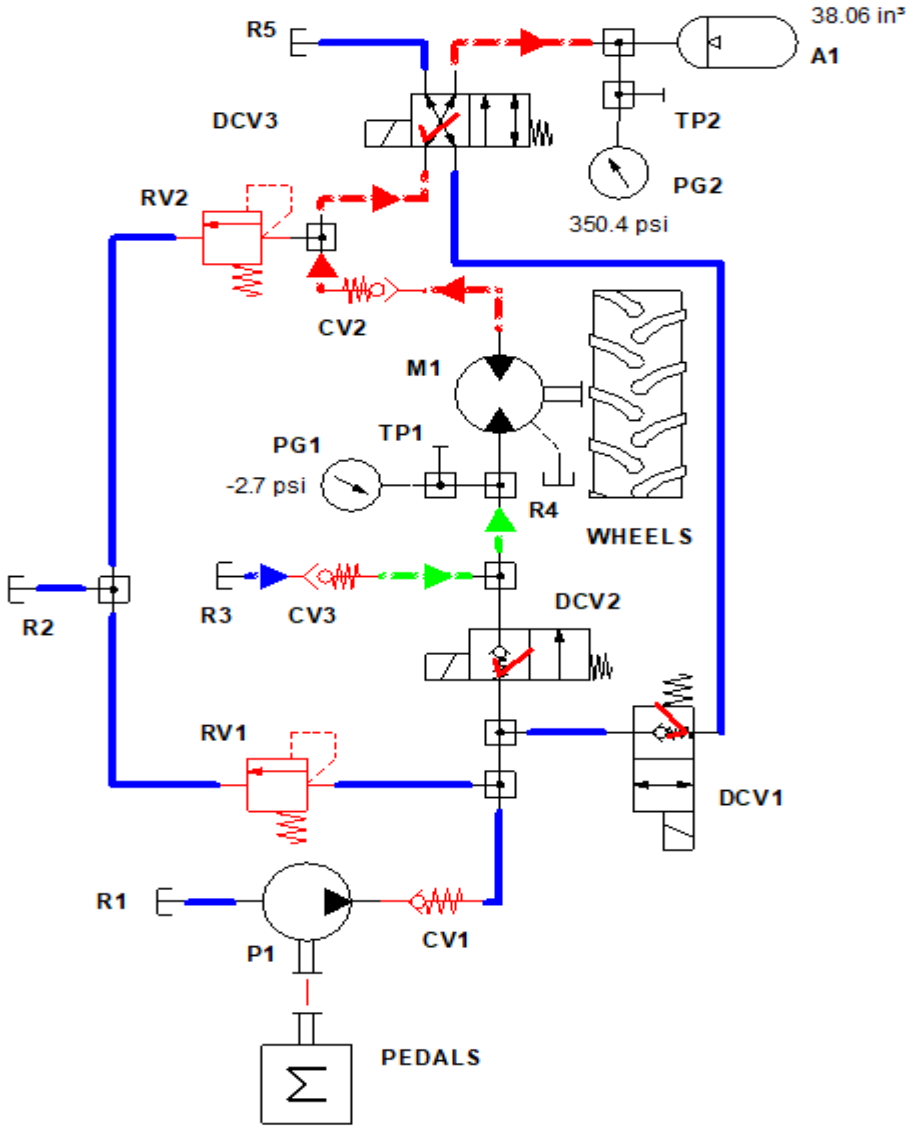


A# - Gas Pressurized Accumulator
P# - Unidirectional Pump
M# - Bidirectional Motor
R# - Reservoir
DCV# - Directional Control Valve
RV# - Pressure Relief Valve
CV# - Check Valve
PG# - Pressure Gauge
TP# - Test Point

Vehicle Design/Final Vehicle Hydraulics

Regen Mode

- CV3 replaced an original DCV for lower pressure drop and overall complexity
- DCV2 is closed to prevent and unwanted flow from the pump. This also increases the pressure from the motor to the reservoir by sealing off the rest of the circuit
- DCV3 is activated only for this mode



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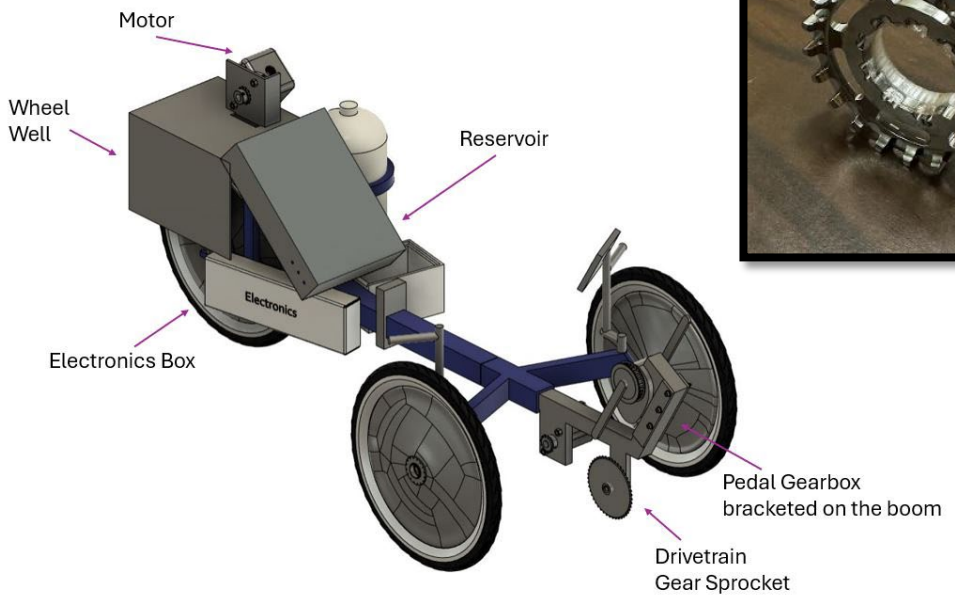
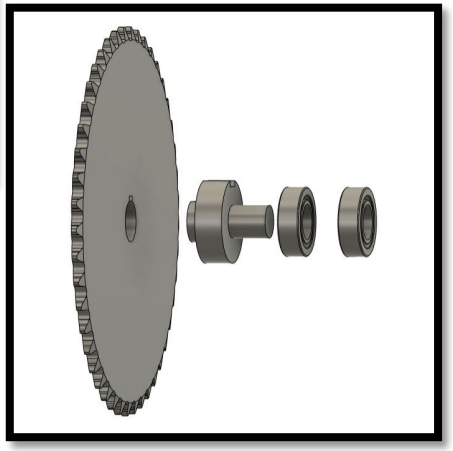
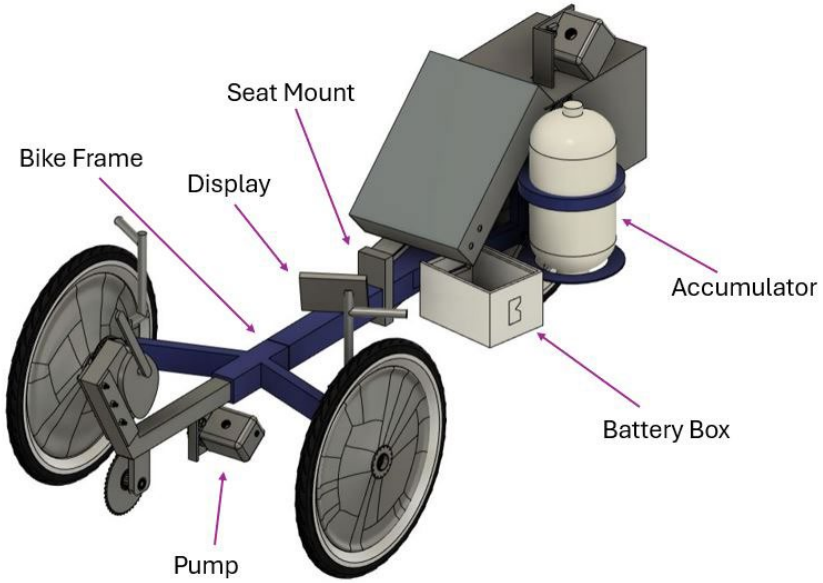
Vehicle Design/Final Vehicle Mechanical

Description	Specification
Overall Frame Length – Pedals to Rear Axle	78 Inches
Wheelbase Length – Distance from Front Axle to Rear Axle	48 Inches
Front Axle Width	33 Inches
Frame Height (Clearance)	15 Inches
Bike Weight	~150 lbs



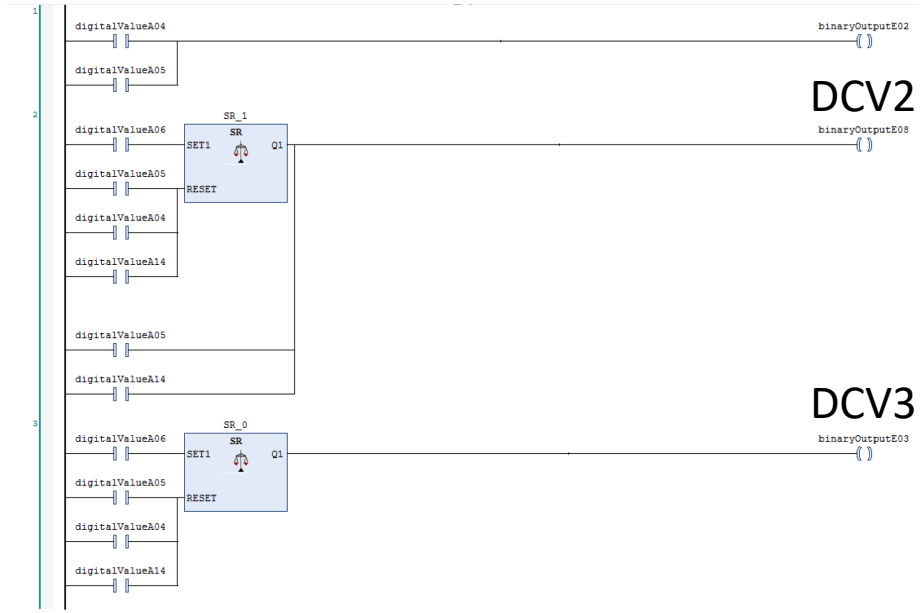


Gear Box Gear Ratio	
1st	1.82
2nd	1.47
3rd	1.19
4th	0.95
5th	0.76
6th	0.62
7th	0.49
8th	0.4
9th	0.32

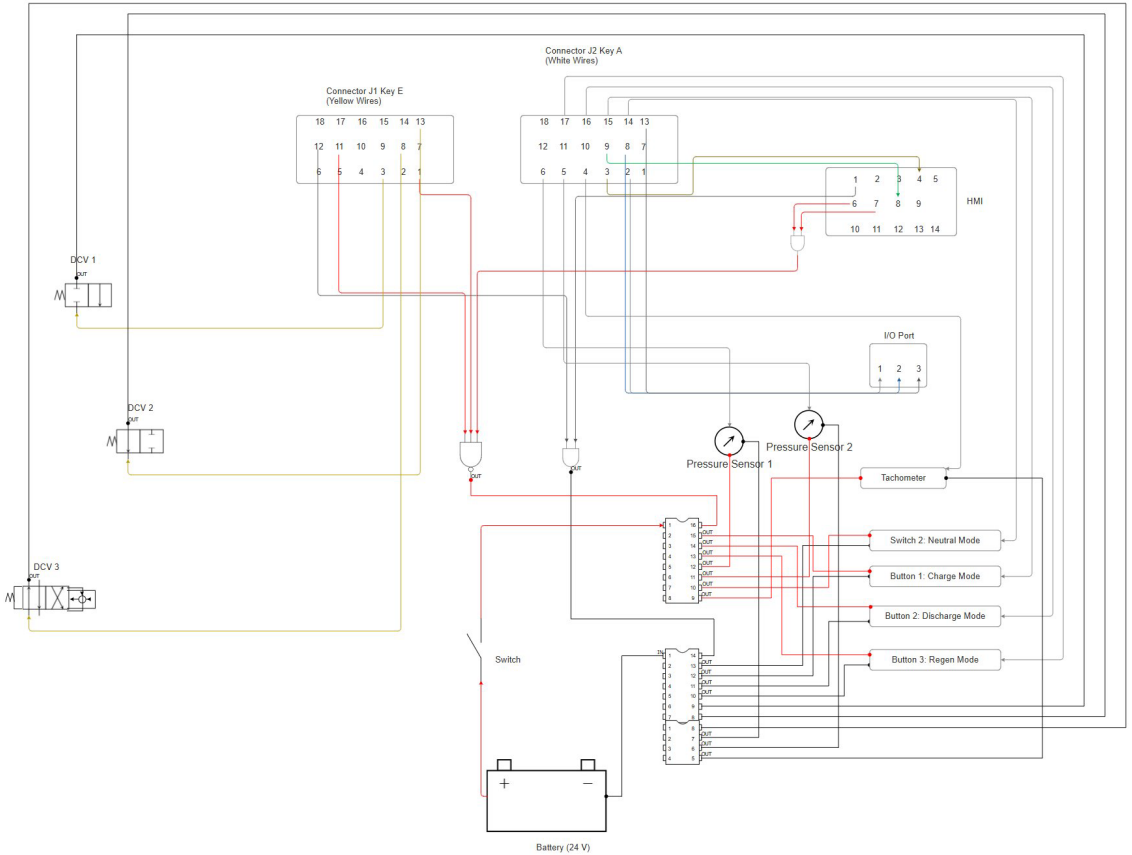


Vehicle Design/Final Vehicle Electronics

CODESYS PLC Ladder Logic

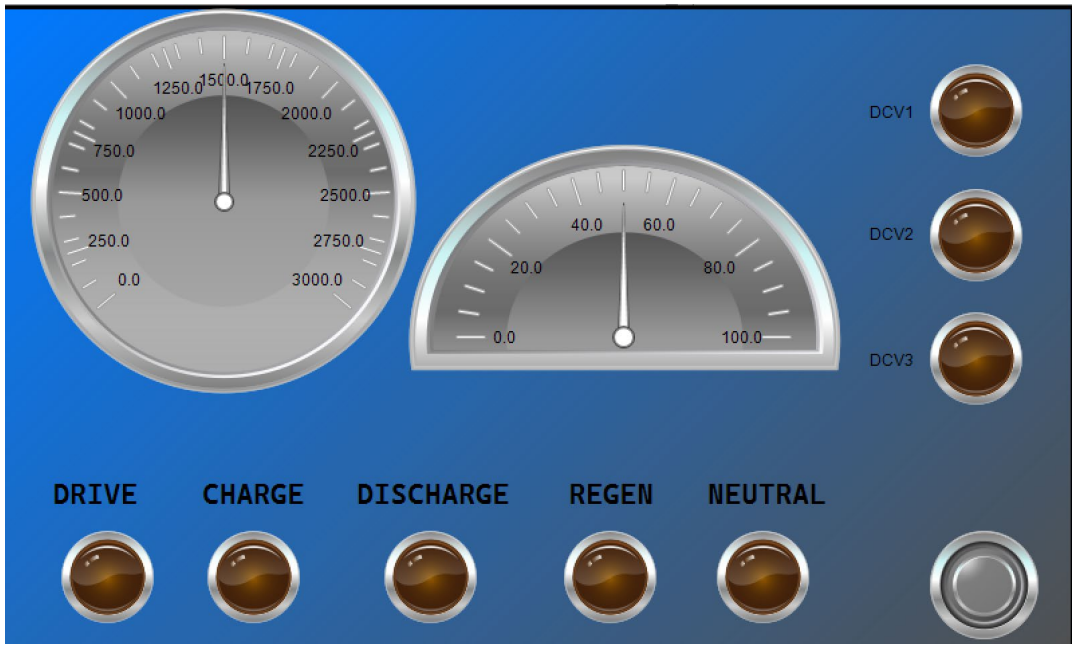


Drawn Logic Circuit

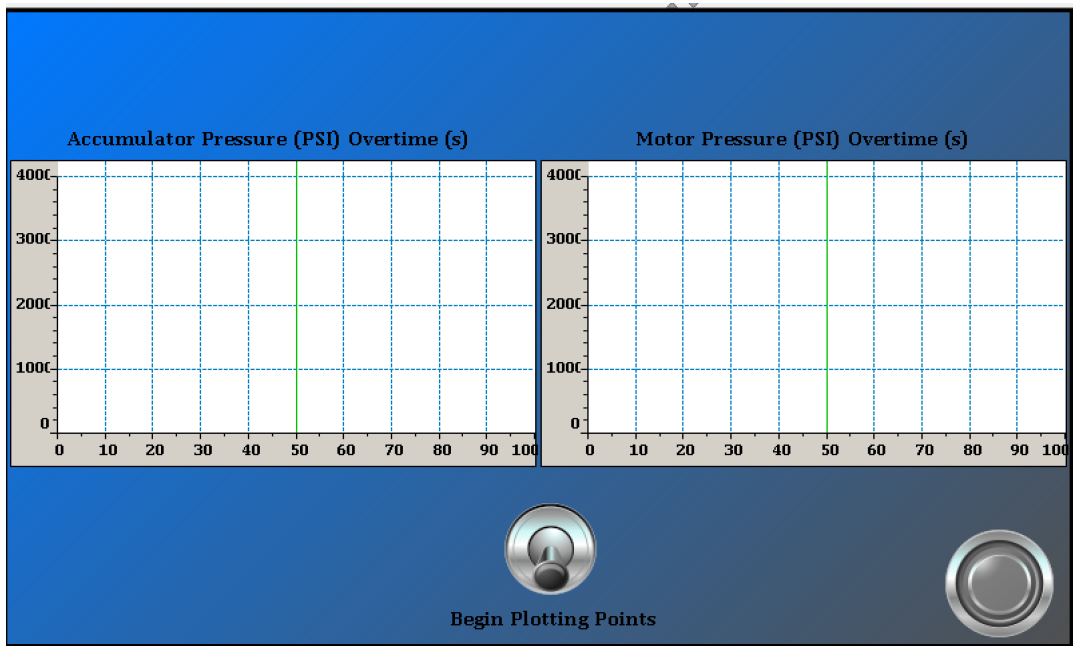


Vehicle Design/Final Vehicle Electronics

HMI Start Screen w/ Indicators and Pressure meter



HMI Test Screen w/ Pressure Tables



Vehicle Design/Final Vehicle Electronics

PLC Structured Text Code

```
PROGRAM POU_1
VAR
    data: DINT;
    speed: REAL; //meter per second
    distance: REAL;
    circumference: REAL;
    meter: REAL;
    pulse: REAL;
    //22 diameter in.
    //8 pulses per rev
    MaxScaled:          REAL:= 3000.0;
    MinScaled:          REAL:= 0.0;
    SensorMin:          REAL:= 0.0;
    SensorMax:          REAL:= 10000.0;
```

```
_DINT_MC2_1:= data;
_REAL_MC2_1:= speed;

_BOOL_MC2_1 := binaryOutputE02; //DCV1
_BOOL_MC2_2 := binaryOutputE08; //DCV2
_BOOL_MC2_3 := binaryOutputE03; //DCV3


(*
data := (((REAL_TO_DINT(analogValueA15)-0)*(3000-0))/(36000-0))+0;
*)

data:= REAL_TO_DINT(((MaxScaled-MinScaled)/(SensorMax-SensorMin)*analogValueA15)+(MinScaled-(SensorMin*(MaxScaled-MinScaled)/(SensorMax-SensorMin))));

pulse := 8;
circumference := 22*3.14;
meter := circumference * 0.0254;
speed := (frequencyA07*meter)/pulse;

IF binaryOutputE02 = FALSE AND binaryOutputE08 = FALSE AND binaryOutputE03 = FALSE THEN
    _BOOL_MC2_4 := TRUE; //DRIVE
ELSIF binaryOutputE02 = TRUE AND binaryOutputE08 = TRUE AND binaryOutputE03 = FALSE THEN
    _BOOL_MC2_5 := TRUE; //CHARGE
ELSIF binaryOutputE02 = TRUE AND binaryOutputE08 = FALSE AND binaryOutputE03 = FALSE THEN
    _BOOL_MC2_6 := TRUE; //DISCHARGE
ELSIF binaryOutputE02 = FALSE AND binaryOutputE08 = TRUE AND binaryOutputE03 = TRUE THEN
    _BOOL_MC2_7 := TRUE; //REGEN
ELSIF binaryOutputE02 = FALSE AND binaryOutputE08 = TRUE AND binaryOutputE03 = FALSE THEN
    _BOOL_MC2_8 := TRUE; //NEUTRAL
END_IF
```

Vehicle Design/Final Vehicle

Lessons Learned

- Technical Lessons:
  - Initial Design ≠ Final Design
  - 3D design is very hard to replicate in real life. Accounting for human and machine error is hard to do so prepare for some redesign/fixes.
  - Have better spacing between hydraulic components to fully optimize line placement and efficiency.
  - Small mistakes can lead to big mistakes if not handled properly and fixed completely.

- Personal Lessons:
  - Communication between team members and people outside the team is crucial for project success.
  - Finishing a project from start to finish takes an immense amount of time, dedication, and responsibility.
  - Finding a work-school-life balance is difficult.
  - Procrastination is a major problem in a project.

Thank You!

To all the people and companies who have helped us throughout this project, and Danfoss for hosting the competition.