NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION
Purdue University - WL
Advisor: Jose Garcia-Bravo
4/26/2024

Team Introductions

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Pneumatic

John Murray
Electrical

Wayne Huang
Pneumatic

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Pneumatic/Electrical

Ethan Coy
Mechanical

Jarrod Robbins
Hydraulic/Mechanical

Austin Hahn
Mechanical

Outline

- Problem Statement
- Vehicle Construction
  - Mechanical
  - Hydraulic
  - Pneumatic
  - Electronic
- Vehicle Testing
- Final Vehicle
- Lessons Learned

Problem Statement

The Vehicle Challenge hosted by the NFPA tasks teams from colleges across the country to build human powered hydraulic bicycles. We will be developing the bicycle in four sub-teams: frame, hydraulics, pneumatics, and electronics. The frame team will focus on all mechanical aspects of the project with a focus on the frame design. Hydraulics will improve designs from the previous year's bike. Pneumatics will design a new regenerative brake system. Lastly, electronics will utilize a PLC and HMI display to monitor diagnostics as the bike runs.

Vehicle Construction

Mechanical System

Previous year's design

Pros:

- Vehicle was very lightweight ~120lbs
- Ergonomically comfortable

Cons:

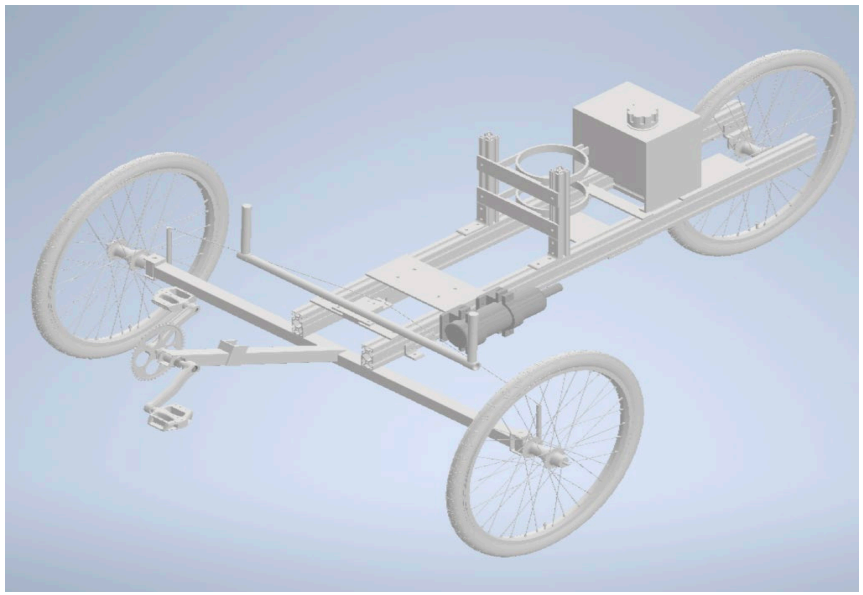
- Frame was not rigid → caused swaying
- Long lengths of chain → energy loss
- Component layout was very spread apart → energy loss
- Steering system had limitations and very difficult to manufacture

Vehicle Construction

Mechanical System

Objectives: Rigidity, Modularity, Compactness

- 80/20 extruded aluminum frame rails → Modularity
  - The ability to slide components along the T-slot framing allowed chain tensioning to be simplified.
  - Component layout could be tested in different configurations to optimize positioning.
- Aluminum mounting plates create a boxed frame → Rigidity



Vehicle Construction

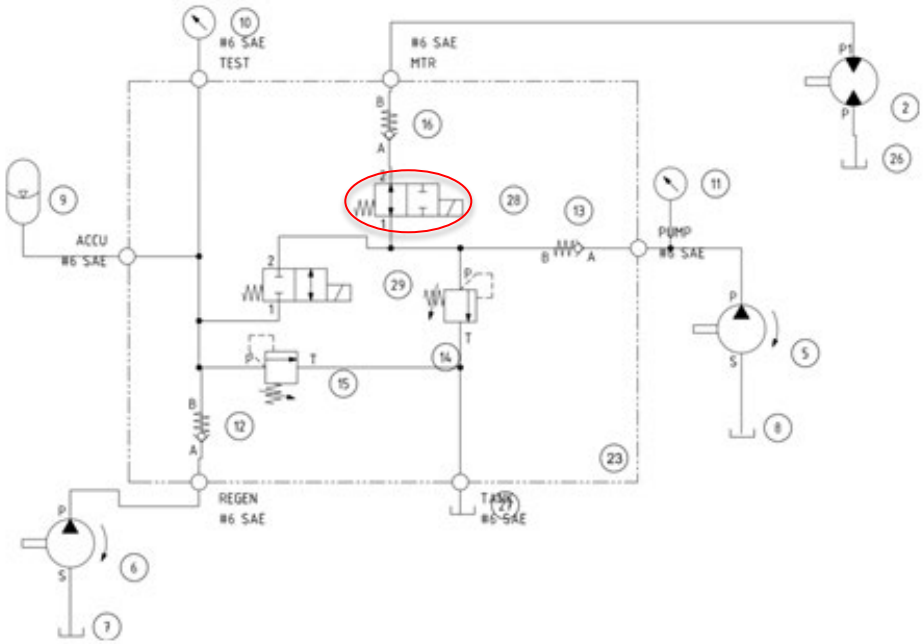
Mechanical System

Steering Design: “Go Kart” configuration

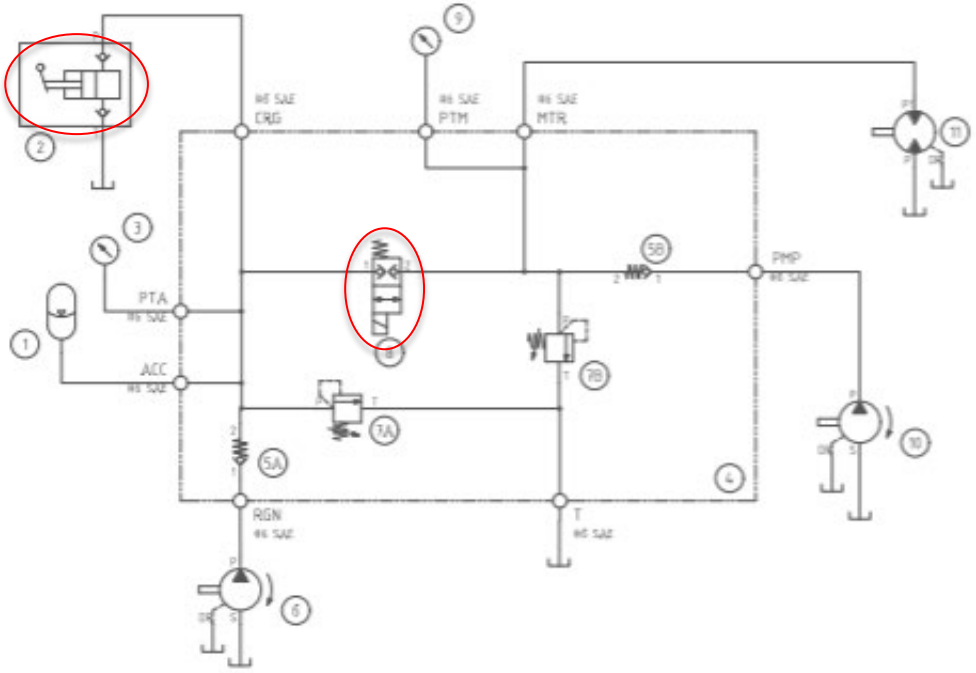
- Ease of manufacturing
- Independent steering adds increased adjustability
- Handlebars are ergonomically comfortable
- All components are easily replaceable

Vehicle Construction

Hydraulic Circuit



Old Design

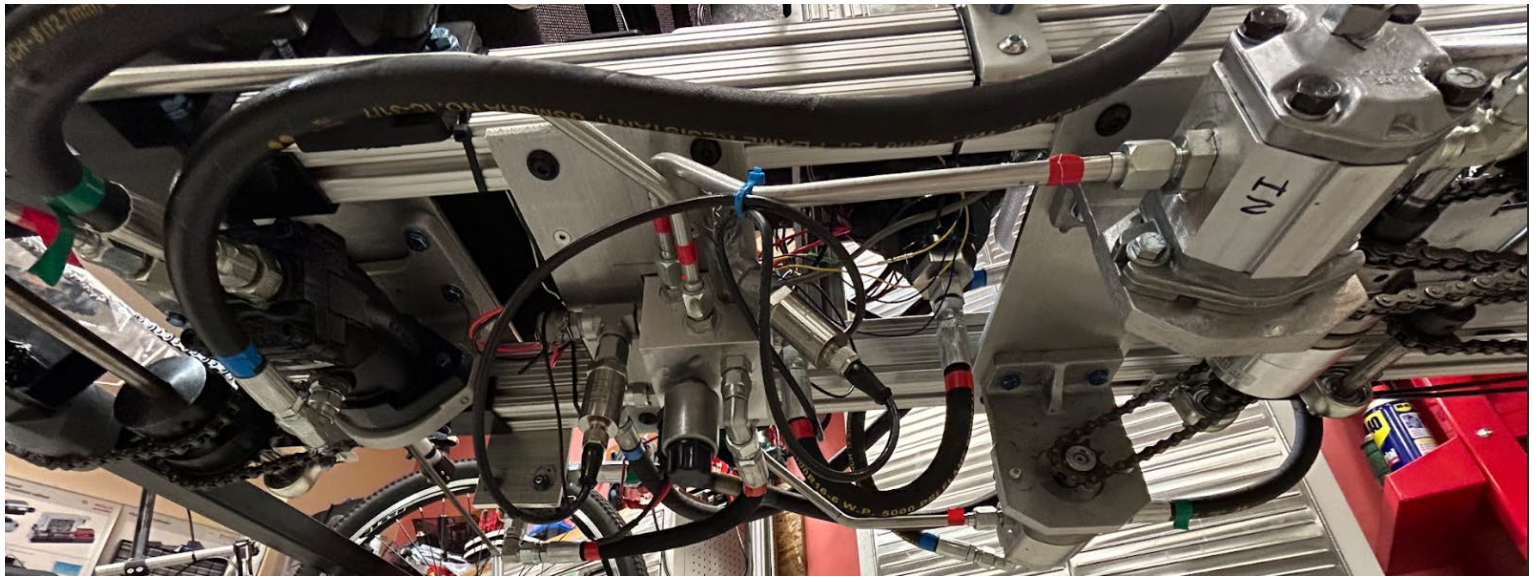


New Design

Vehicle Construction

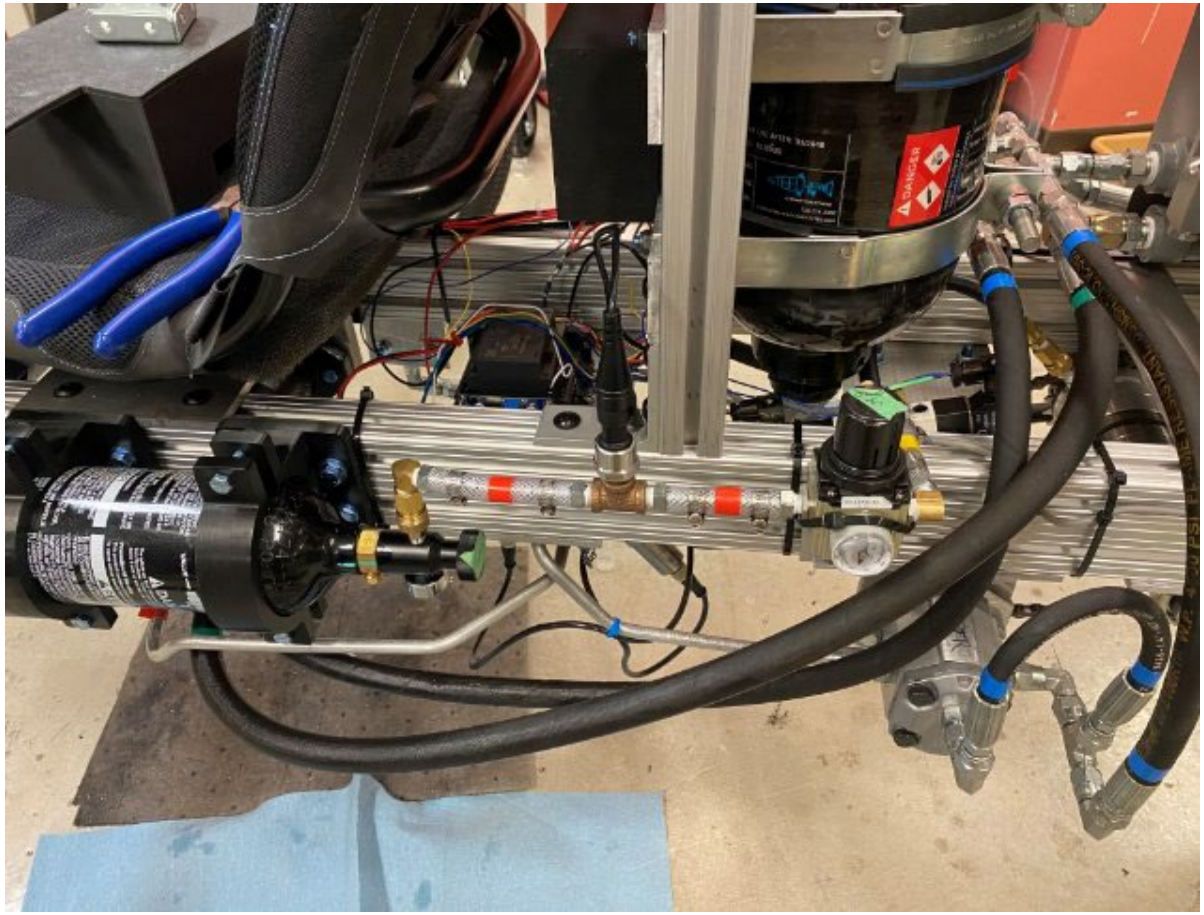
Hydraulic System

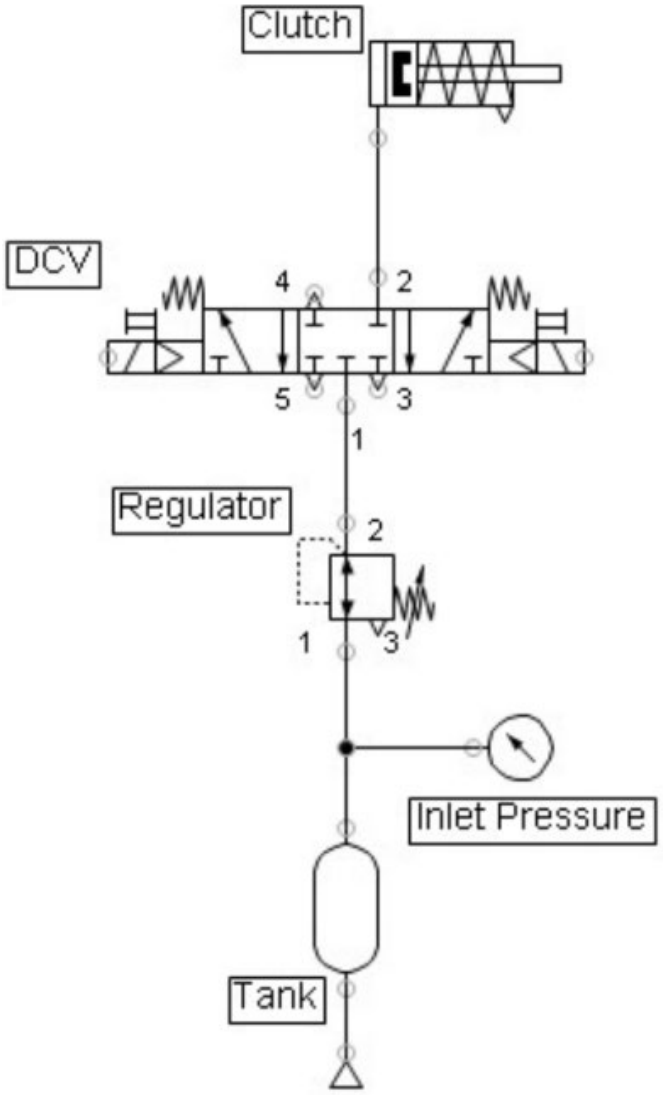
- Hardlines selected based on ID
- All hydraulic lines are color coded
- Reduced Accumulator Pressure
- Gear ratios adjusted for proper power input and output



Vehicle Construction

Pneumatic System

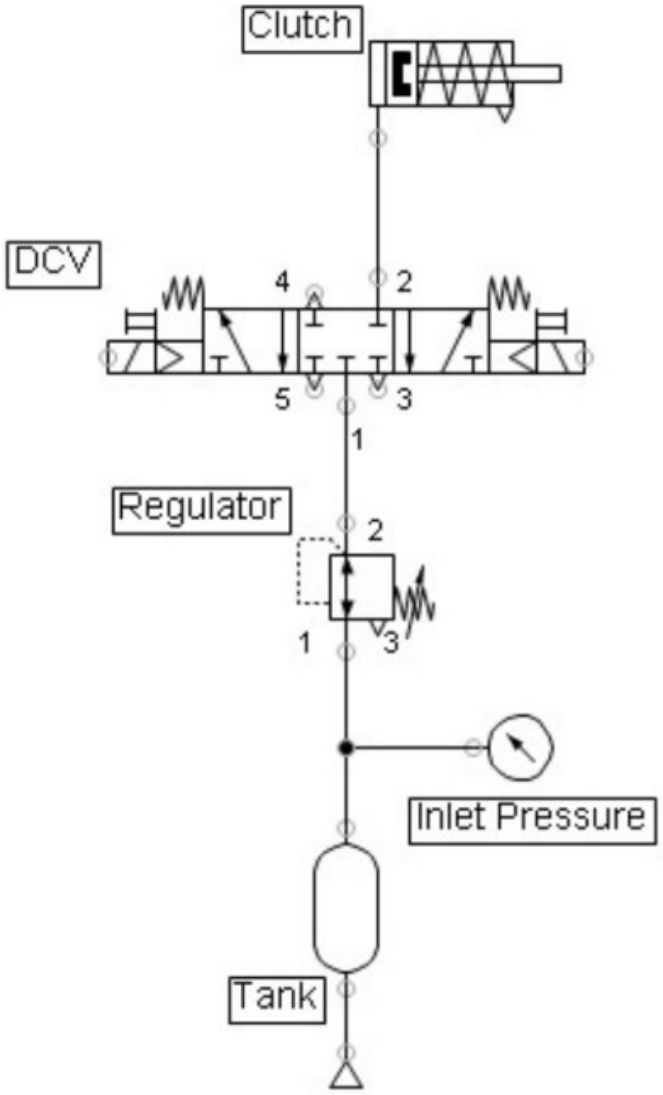




Vehicle Construction

Pneumatic System

- Pneumatic Friction Clutch to engage Hydraulic Regen Pump
  - Nexen "Air Champ" Model 802870
- Operating Pressure: 80 psi

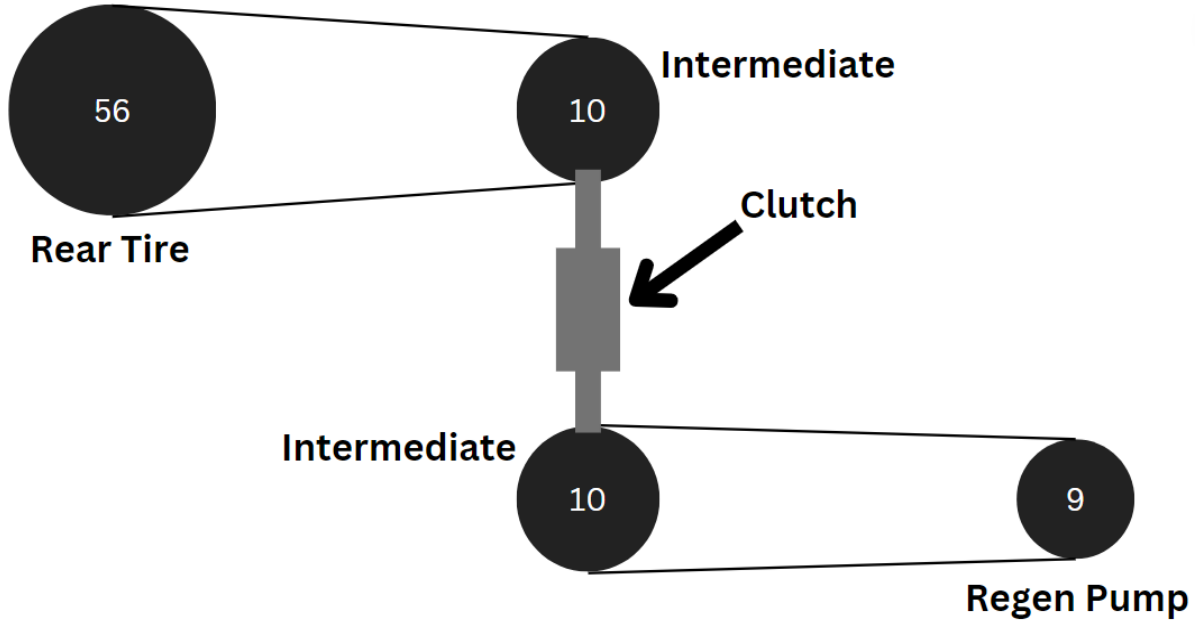


Vehicle Construction

Pneumatic System

Chain Drive

- Speed ratio of 1:5
- At 5 MPH the regen pump spins at 322 RPM

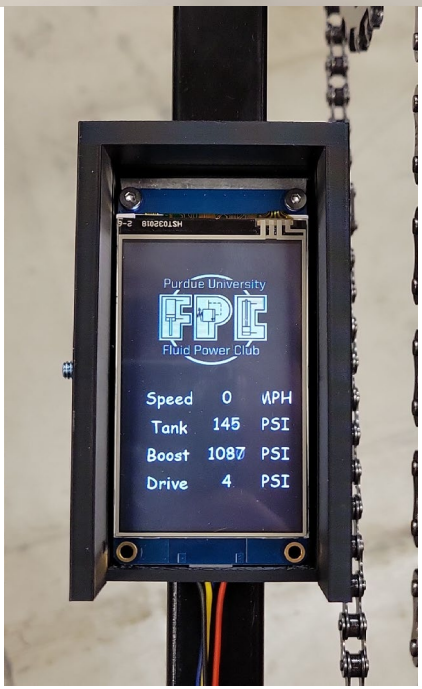


Vehicle Construction

Electronic System

- Arduino Opta PLC
  - Industry grade controller
  - Capable of both digital and PLC level controls
  - Serial communication to the HMI DRO

- HMI DRO
  - Speed – In MPH from back tire proximity sensor
  - Tank – Air tank pressure in PSI
  - Boost – Accumulator pressure in PSI
  - Drive – Main hydraulic line pressure in PSI



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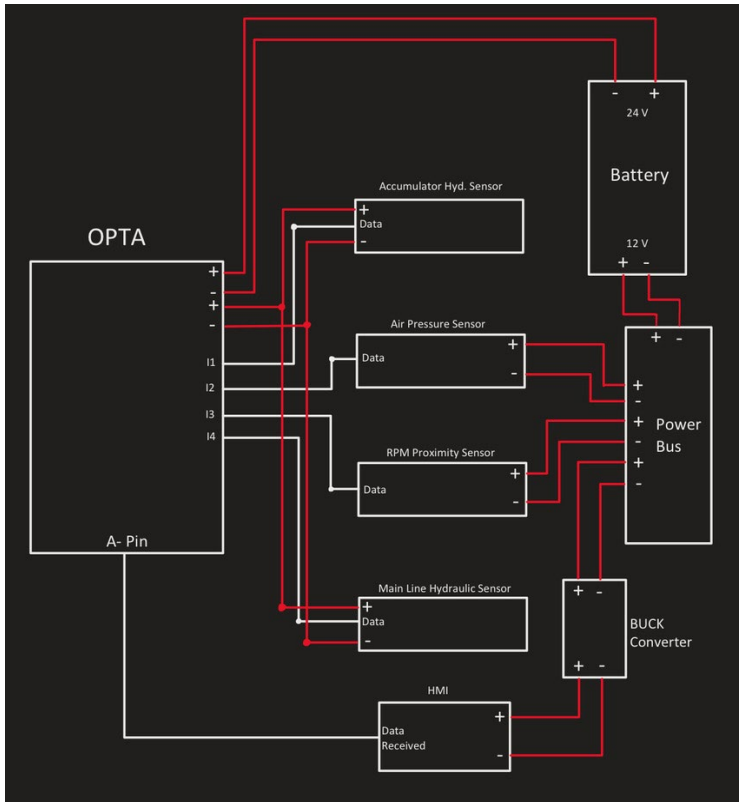

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Vehicle Testing

Efficiency

- Accumulator precharge of 900 PSI
- Test Efficiency at different pressures
- Used Efficiency formula from previous years

Accumulator Pressure (PSI)	Charge Pressure (PSI)	Total weight (lbs)	Distance Traveled (ft)	Efficiency (%)
900	1230	385	185	6.91
900	1450	385	360	8.92
900	1740	385	490	8.82

Vehicle Testing

Regen & Pneumatics

- Regen Pump Charging Test
  - 6 ft depression over 20 ft in length
  - ~1150 psi

- The regenerative brake system is more of a pneumatic brake than a hydraulic regen
- At 5 MPH the regen pump spins at 322 RPM
  - Limits the maximum pressure we regenerate
  - Traded slower RPM for a slower brake to allow more time for fluid to fill into the accumulator

Final Vehicle

- Modular design with 80/20 rail system
- Simplified hydraulic manifold
  - Bent-axis pump addition
- Pneumatic clutch
- Arduino OPTA and HMI for diagnostics

Lessons Learned

- Commit to design decisions as early as possible
- The shorter the pneumatic circuit the better
- Have spare sprockets for more gear ratio options
- Hardlines are not necessary for Suction and return lines
- Stay on schedule

Thank You!

NFPA Fluid Power Vehicle Challenge

NFPA **Danfoss** **HYDAC**

IFP **Trelleborg** **Dr. Jose Garcia**