NFPA Fluid Power Vehicle Challenge

NFPA
Education and
Technology
Foundation

FINAL PRESENTATION &
DESIGN REVIEW
UNIVERSITY OF CINCINNATI
MUTHAR AL-UBAIDI
04/09/2025

Team Introductions

- Morgan Taylor
- Hunter Marshall
- Omar Villegas
- Spencer Lloyd
- Christopher Axelson
- Logan Balla
- Zarria Gray

Team Introduction

- Morgan Taylor
  - B.S. Mechanical Engineering Technology, Minor in Robotics and Automation
  - Fifth Year
  - Dry Ridge, Kentucky
  - Co-Ops with:
    - Mazak
    - ThermoFisher Scientific
    - Greif
    - CertainTeed

Speaking Now: Morgan

Team Introduction

- Hunter Marshall
  - B.S. Mechanical Engineering Technology, University of Cincinnati
  - 5th Year
  - From Cleveland, Ohio
  - 1 co-op at EGC Enterprises
  - 3 co-ops at CertainTeed

Speaking Now: Hunter

Team Introduction

- Omar Villegas-Jimenez
  - Mechanical Engineering Technology
  - 5th Year
  - From Zacatepec, Morelos
  - First two Co-Ops: Gaylor Electric
  - Last Co-Ops: Bilstein & Thaman Rubber

Speaking Now: Omar

Team Introduction

- Spencer Lloyd
  - Mechanical Engineering Technology
  - 5th year
  - Westerville, Ohio
  - Par Excellence, Monti Inc
  - ATS Automation, GCI Consultants

Speaking Now: Spencer

Team Introduction

- Christopher Axelson
  - Mechanical Engineering Technology
  - 5th year
  - Loveland, Ohio
  - First 2 co-op's: Emerson Commercial & Residential Solution (Copeland)
  - Last 3 co-op's: GE Aerospace

Speaking Now: Chris

Team Introduction

- Logan Balla
  - Mechanical Engineering Technology
  - Fifth Year student
  - From Westerville, OH
  - First three co-ops with Thomas Tool & Mold Co.
  - Last two co-ops with HFI-INC.

Speaking Now: Logan

Team Introduction

- Zarria Gray
  - Mechanical Engineering Technology Minor in Robotics and Automation
  - 5th Year
  - From Cincinnati, Ohio
  - 2 Co-op rotations at Standard Aero
  - 3rd Co-op at CERN in Switzerland
  - 4th Co-op at CRANE Chem pharma

Speaking Now: Zarria

Team Introduction

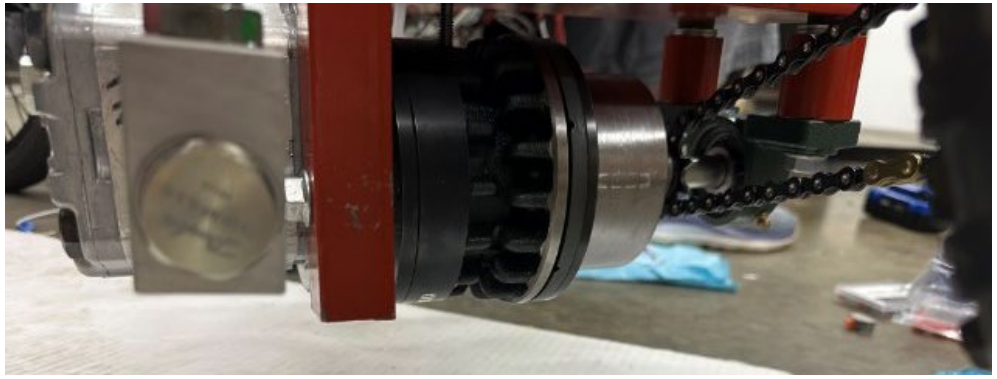
- Faculty Advisor Muthar Al-Ubaidi, PhD
- **Professor and Director Mechanical Engineering Technology Program Education**
  - B.S. Mechanical Engineering, University of Baghdad
  - Masters Nuclear Engineering, University of London
  - PhD Nuclear Engineering, University of Cincinnati
- **Hometown**
  - Baghdad, Iraq
  - Came to Cincinnati, USA in 1978

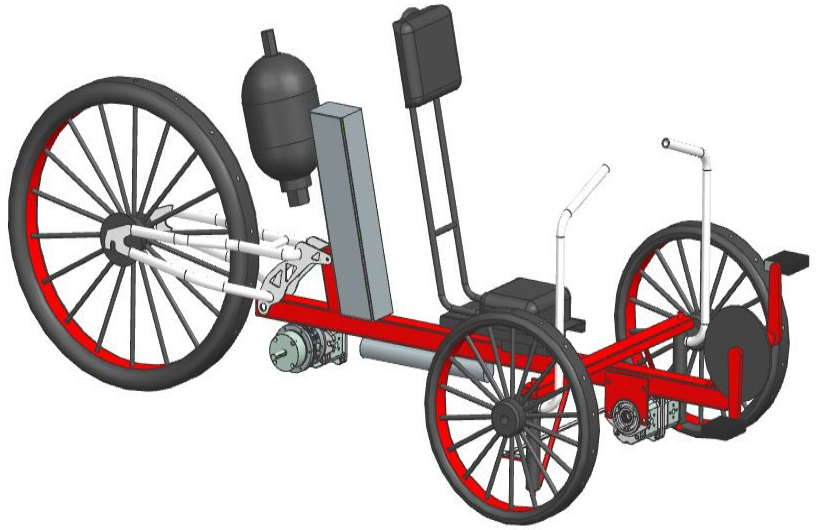
- Industry Mentor Dan Turner
  - President of GPM Controls

Speaking Now: Zarria

Frame Design, Calculations, and Construction Materials

- **Front pump pedal assembly:** Upgraded to the 2nd iteration of gears
- **Front chain guard:** Reverted to the 1st iteration due to lead time issues
- **Manifold block mounts:** Added ¼-20 bolts for secure mounting
- **Motor mount:** Refined design for lining up the rear gear and motor output gear
- **Reservoir:** Improved the clear reservoir with a second build and a better sealant
- **Accumulator mount:** Simplified with 2 hose clamps for easy installation
- **Carbon fiber cover:** Protects the rider from hydraulic, electrical, and moving components during operation





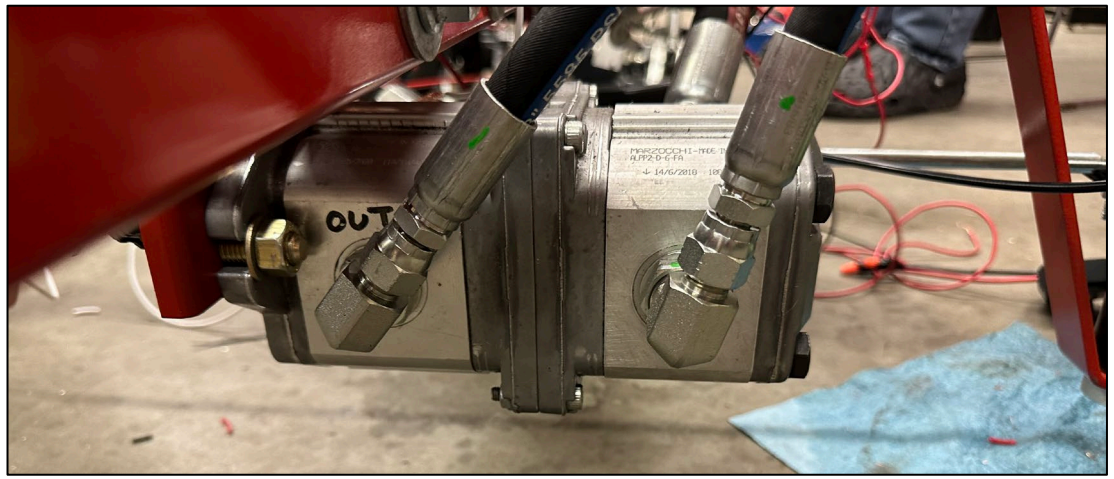
Speaking Now: Chris and Logan

Mechanical Components

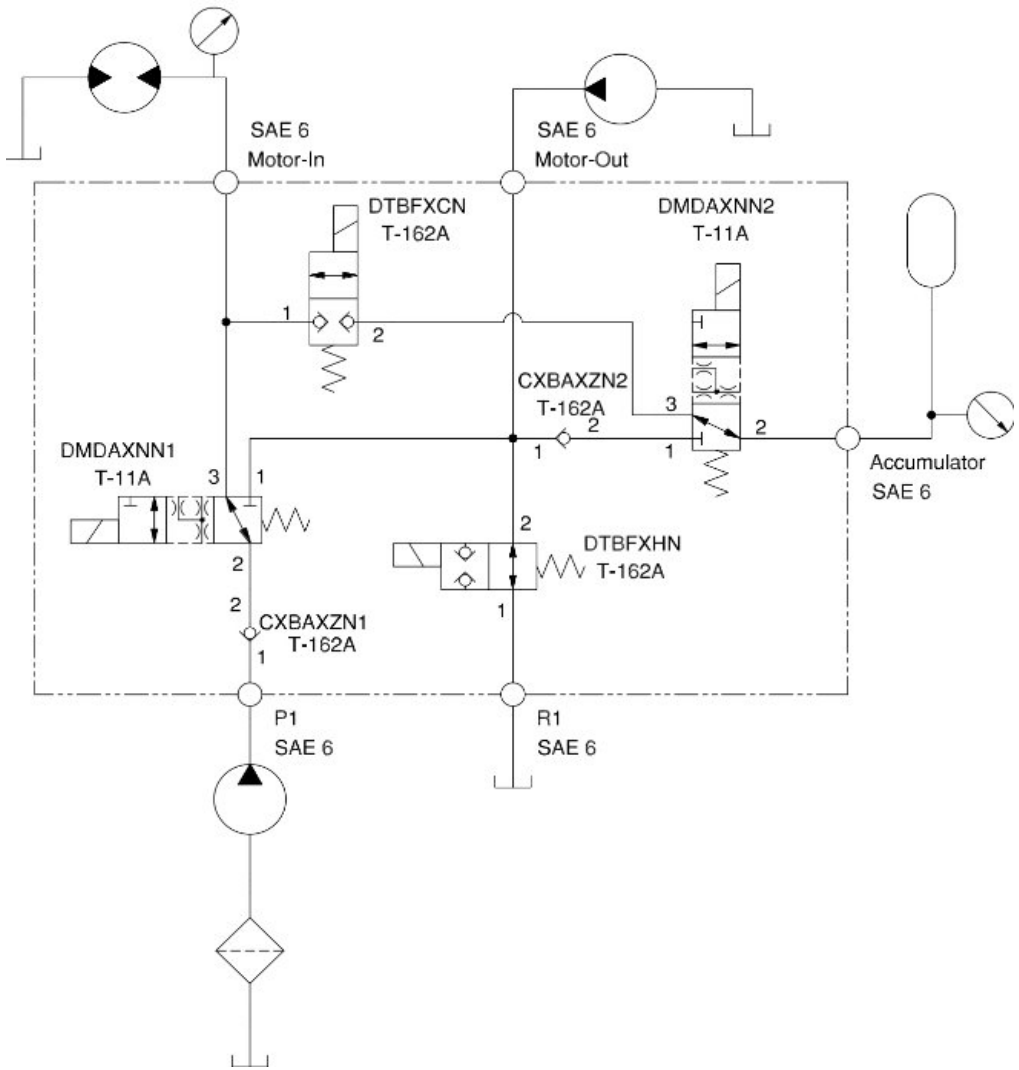
Clutch Assembly

Front Gearing

Reservoir connections



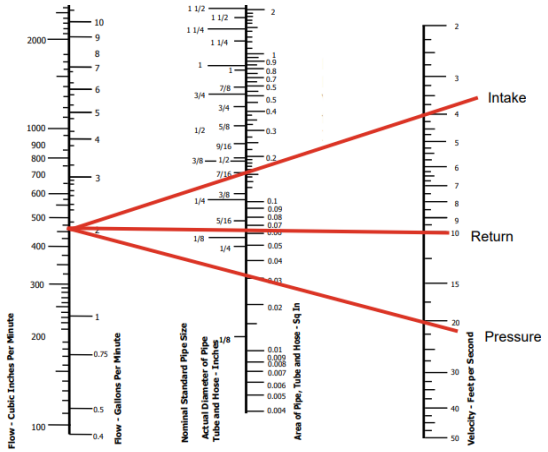
Previous Year's Hydraulic Circuit



Hydraulic Circuit Calculations, Components, and Construction

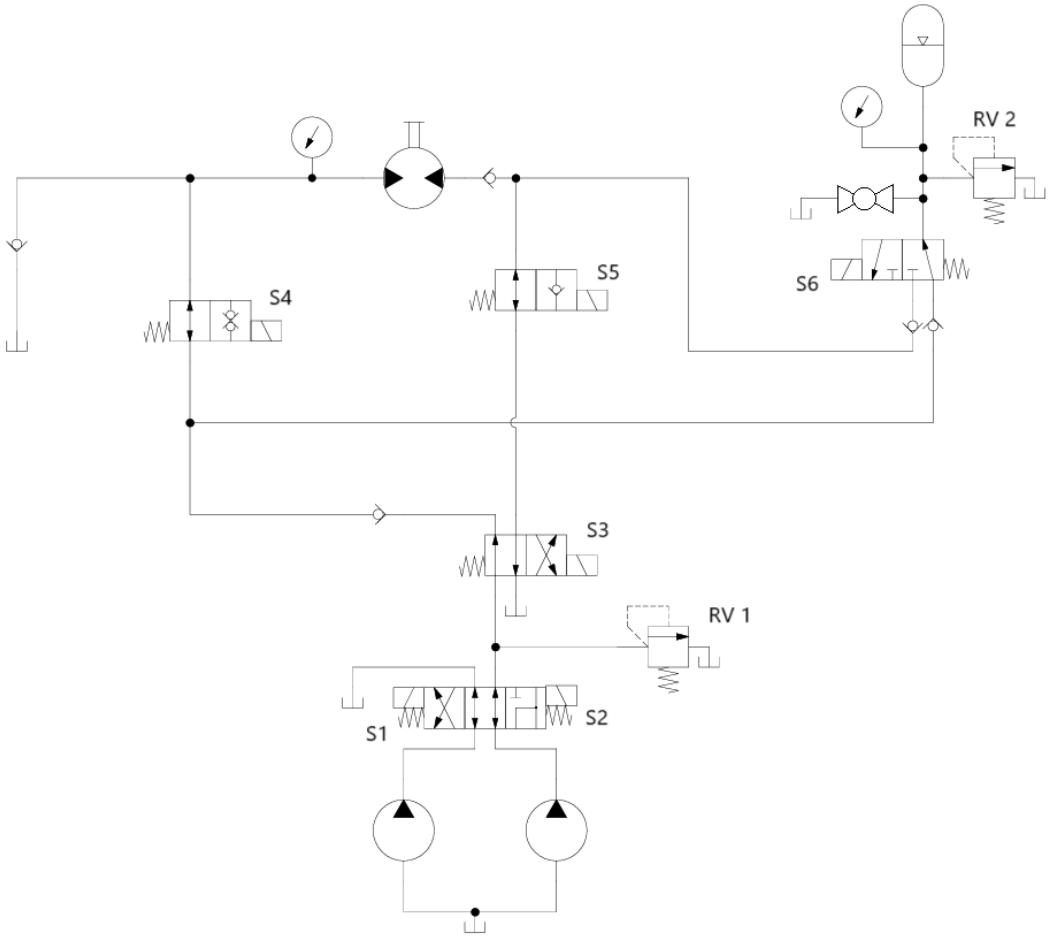
Calculations

- Pump Displacements
  - Low – 4.5 CC/Rev
  - Medium – 11.5 CC/Rev
  - High – 16 CC/Rev
- Motor Displacement – 8.4 CC/Rev
- Resulting Gear Ratios
  - Low - .54:1
  - Medium – 1.4:1
  - High – 1.9:1
- Hose Sizing



BOM

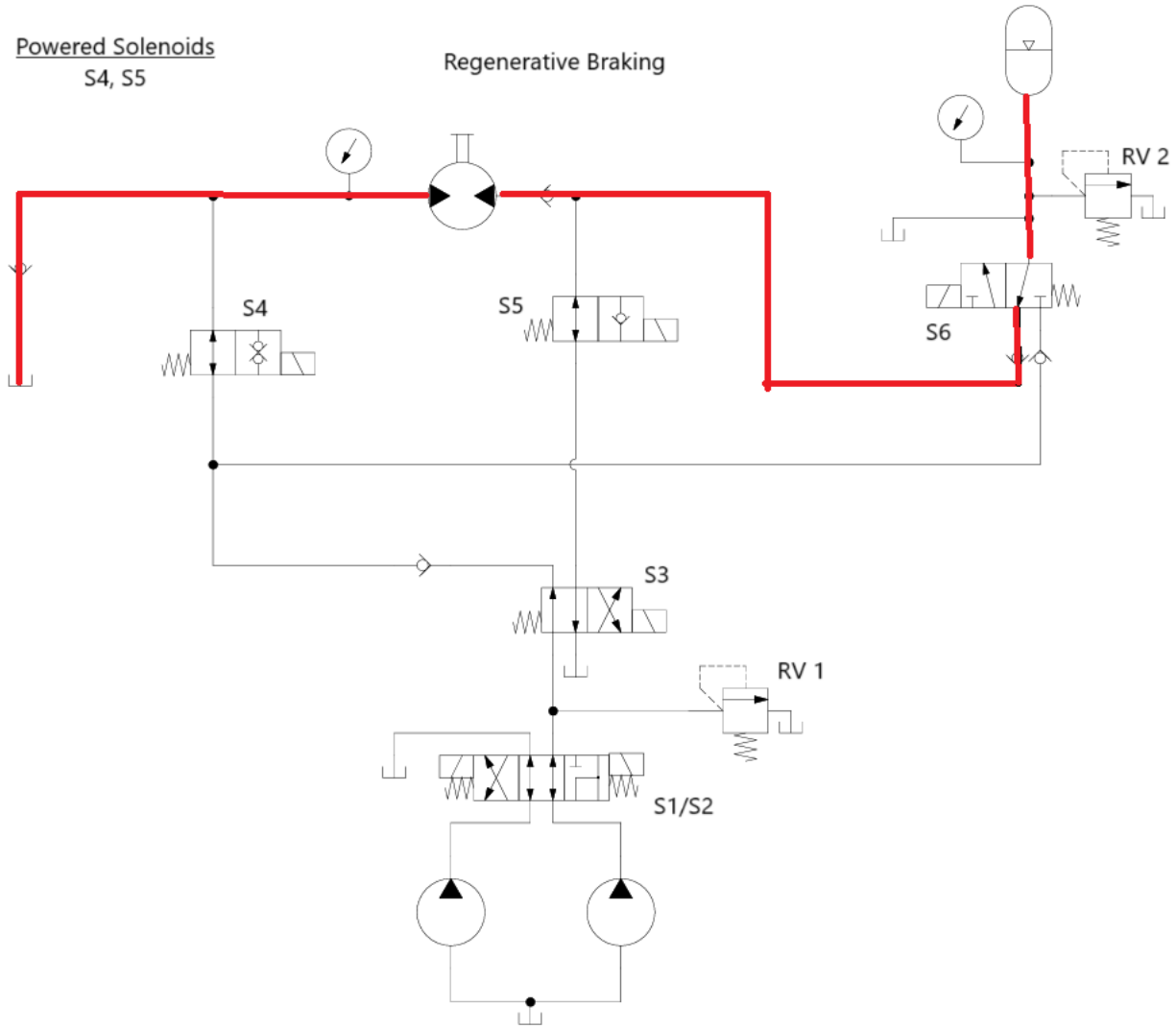
- Motor
- Pump
- Valves
  - DCV - 5
  - Check Valves – 5
  - Relief Valves - 2
- Accumulator – 1 Gal
- Reservoir – 1.5 Gal
- Hoses
  - Pressure – 3/8"
  - Intake – 3/4"
  - Return – 3/8"



Speaking Now: Hunter

Regenerative Braking Circuitry and Concepts

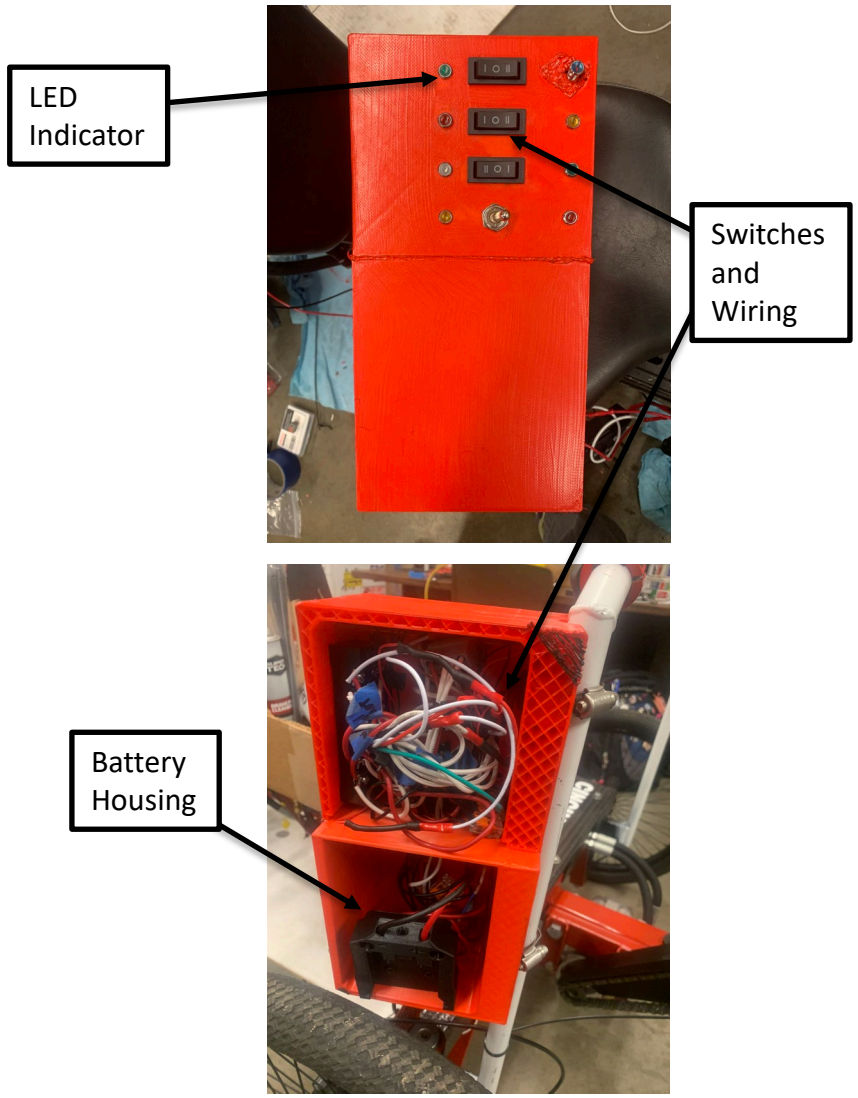
- Accumulator pre-charged to 950 PSI
- Determined experimentally
  - Set slightly over minimum pressure required to move
  - ~50% of maximum system pressure



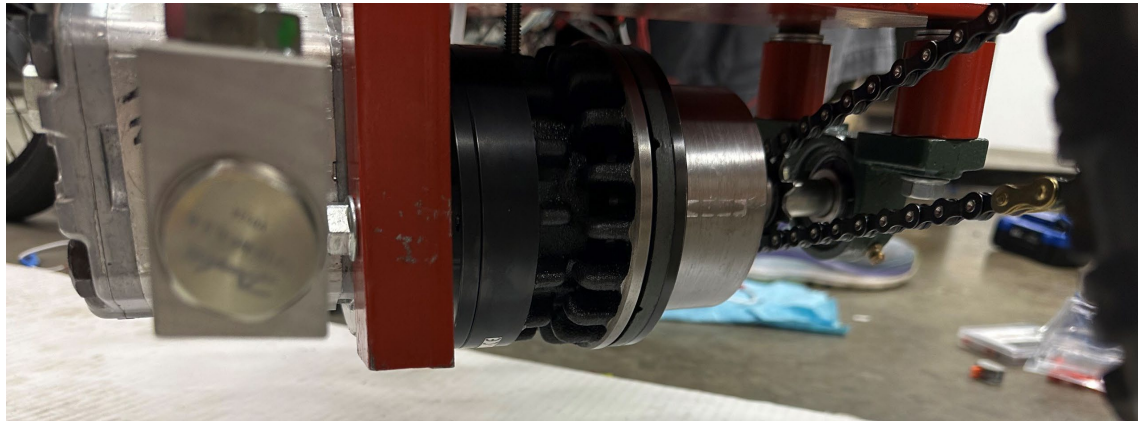
Speaking Now: Hunter

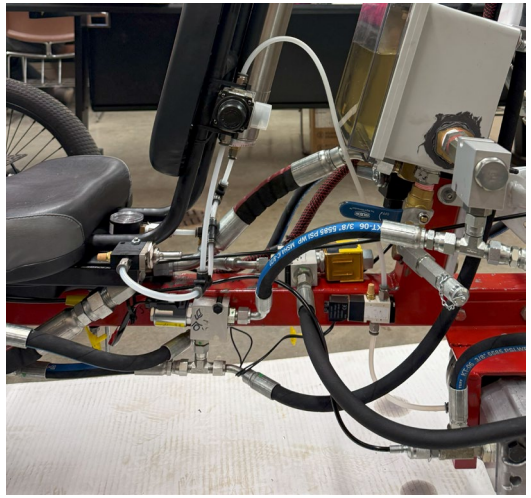
Solenoid Controls Calculations, Components, and Construction

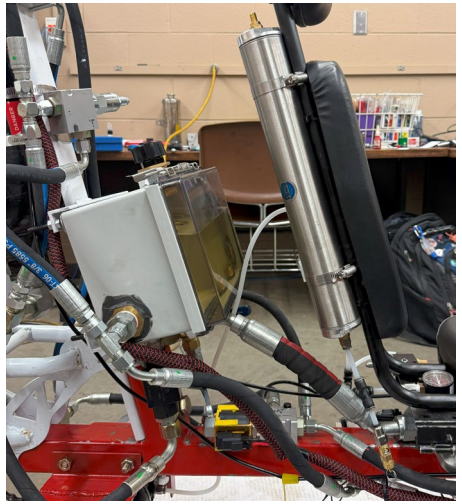
- Resistor for LED indicators, $P = I^2R$
  - Watts = Volts * Amps
  - Watts = 24 * 5 = 120 Watts
  - 120 = (5)^2 * R
  - R = 4.8 Ohms
- Equivalent Deutsch plug-in connectors with pigtails used to power 24V hydraulic solenoids
- Spring loaded terminal blocks connect wiring across the switches to the power source and switches to the negative
- Control panel 3D printed with PLA to house all components apart from the physical solenoids.

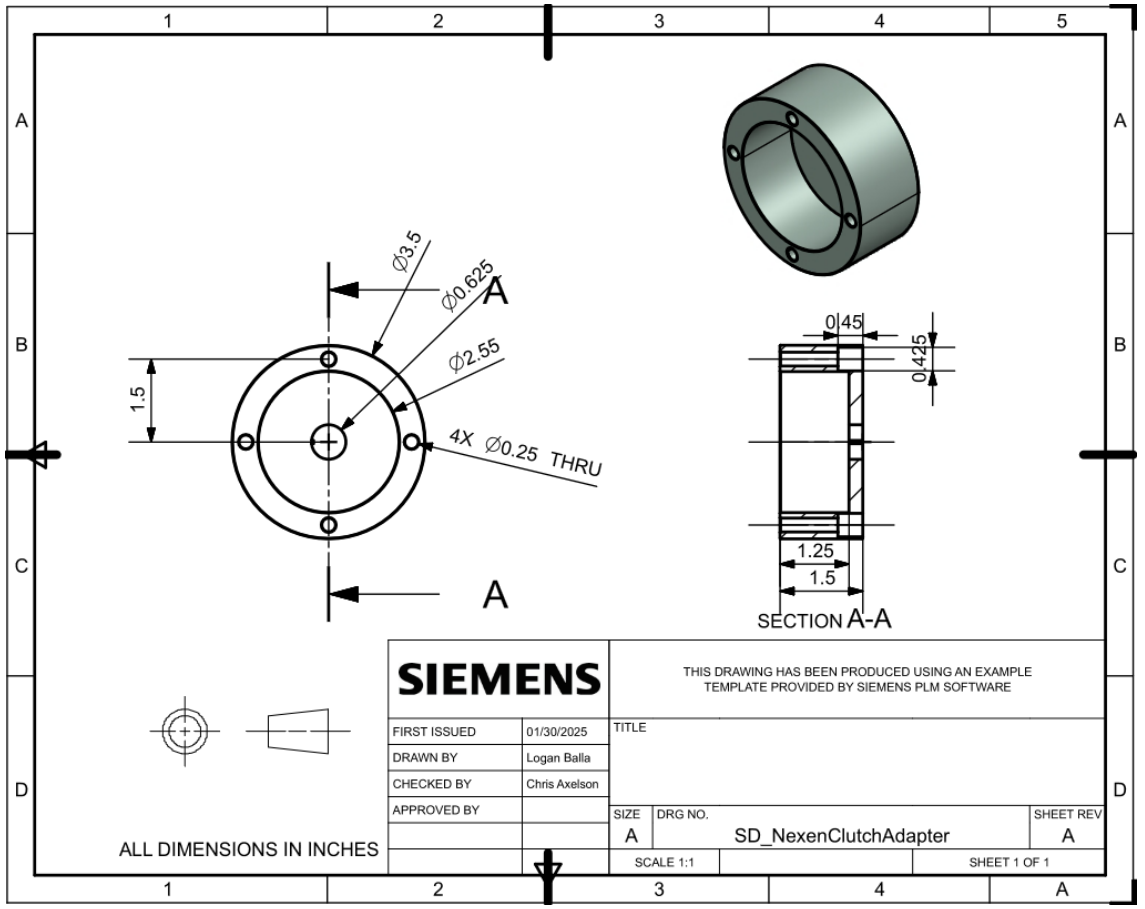


Pneumatic Circuit, Components, and Construction





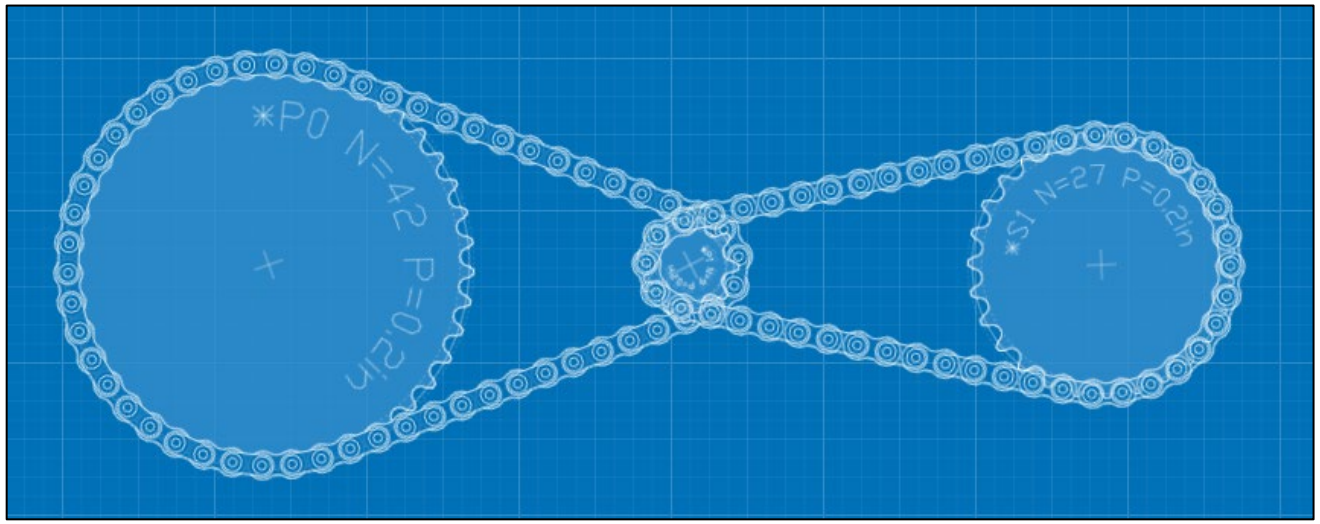




Speaking Now: Omar

Power Train Calculations, Components, and Construction

Motor	5.2 cc		16 cc		Dual 4.9-16cc							
	5.2	5.2	16	16	4.9	20.9	8.4	8.4	10.8	10.8	16.8	16.8
	T (in*lb)	RPM	T (in*lb)	RPM	T (in*lb)	RPM	T (in*lb)	RPM	T (in*lb)	RPM	T (in*lb)	RPM
Low	95.92	494.23	153.13	246.96	385.51	98.09	129.65	291.67	166.69	226.85	259.30	145.83
High	29.35	1288.46	418.75	90.30	27.66	1367.35	30.40	1244.05	39.08	967.59	60.79	622.02



Vehicle Testing Results and Improvements

- The reservoir was re-sealed after initial testing to prevent leaks
- All switches are housed in a single control panel for easier access by the rider, rather than being separated by pneumatic and hydraulic circuits
- After demonstrating a significant distance from boost charging in initial tests, pre-charging methods were improved by adjusting the gear ratio
- Additional covers were added for rider comfort and enhanced safety following initial testing

Speaking Now: Morgan

What We Changed

- No Manifold
- No Digital Display – The correct electronic combination for coding could not be determined based on the wiring harness pin layout to input the sensors and modes of the bike.
- Carbon fiber covers covering the front beam of the bike
- 3D Print chain cover instead of carbon fiber
- No Arduino board in controls circuit, solenoids are straight wired

Speaking Now: Spencer, Zarria

Final Vehicle

Lessons Learned

- Finalize circuits and order manifolds at least 2 months before the midway review to avoid delays during the holiday season.
- Account for lead times in planning to create more accurate deadlines and minimize downtime.
- Hydraulic oil leakage can compromise both the paint job and clutch performance.
- Team bonding and fun are just as critical to success as technical and conceptual expertise.
- While innovation fuels motivation, it can also complicate the project beyond initial expectations.

Improvements for Next Year

- Identify individual strengths prior to sub-team development
- Finalize circuits earlier
- Develop a plan to overcome the bike's potential energy more easily
- Create a more innovative controls approach for solenoids
- Implement more pneumatic applications
- Keep the frame design simple but keep in mind what the other sub-team's needs will be

Speaking Now: Chris

Thank You

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Questions?

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