

10 YEARS

N F P A

Fluid Power

= **VEHICLE**

Challenge



NFPA
Education and
Technology
Foundation

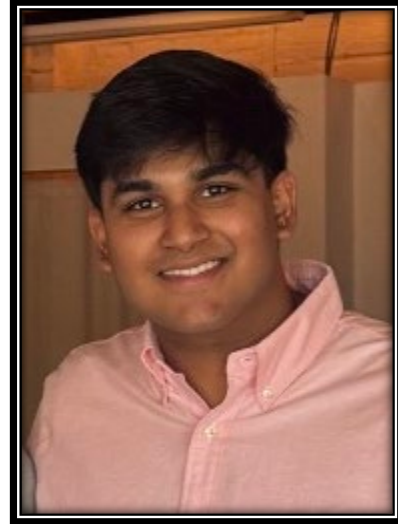
UAB SCHOOL OF
ENGINEERING
The University of Alabama at Birmingham

FINAL PRESENTATION & DESIGN REVIEW
University of Alabama at Birmingham
Mentor: David Littlefield
April 6, 2026

Meet the Team



Brandon Walker



Rohan Singh



Preet Patel



Christopher McKay



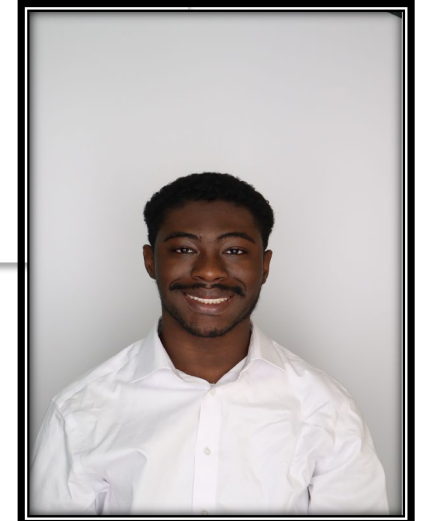
Nathan Smith



Vivian Garcia



Micah Owens



Cameron Dix

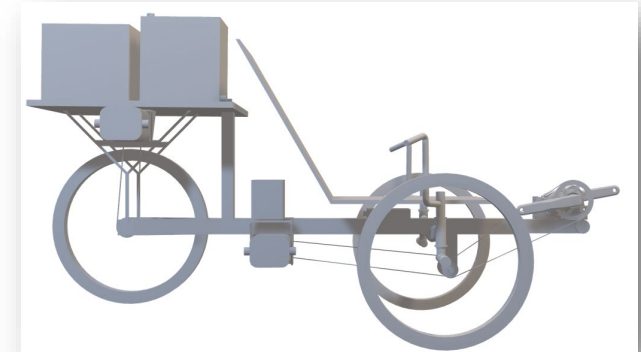
Midway Review Summary



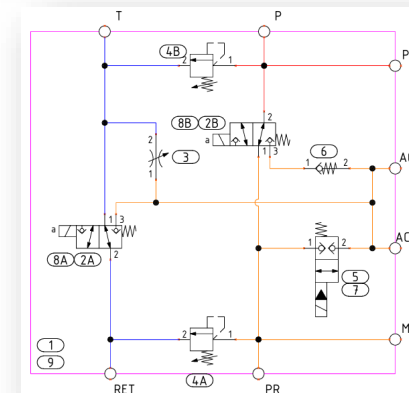
- Decided to reuse last years frame
- Components Added:
 - Front Gearbox
 - Rear CVT
 - Redesigned Manifold
 - Optimized mounting
- Feedback:
 - Endure test points are present
 - Ensure motor->wheel drive connection is strong enough.



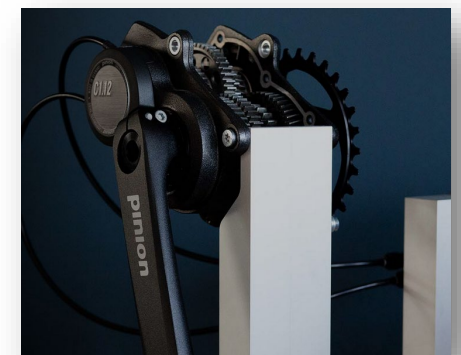
CVT



Bike 3D Mockup



Hydraulic Circuit

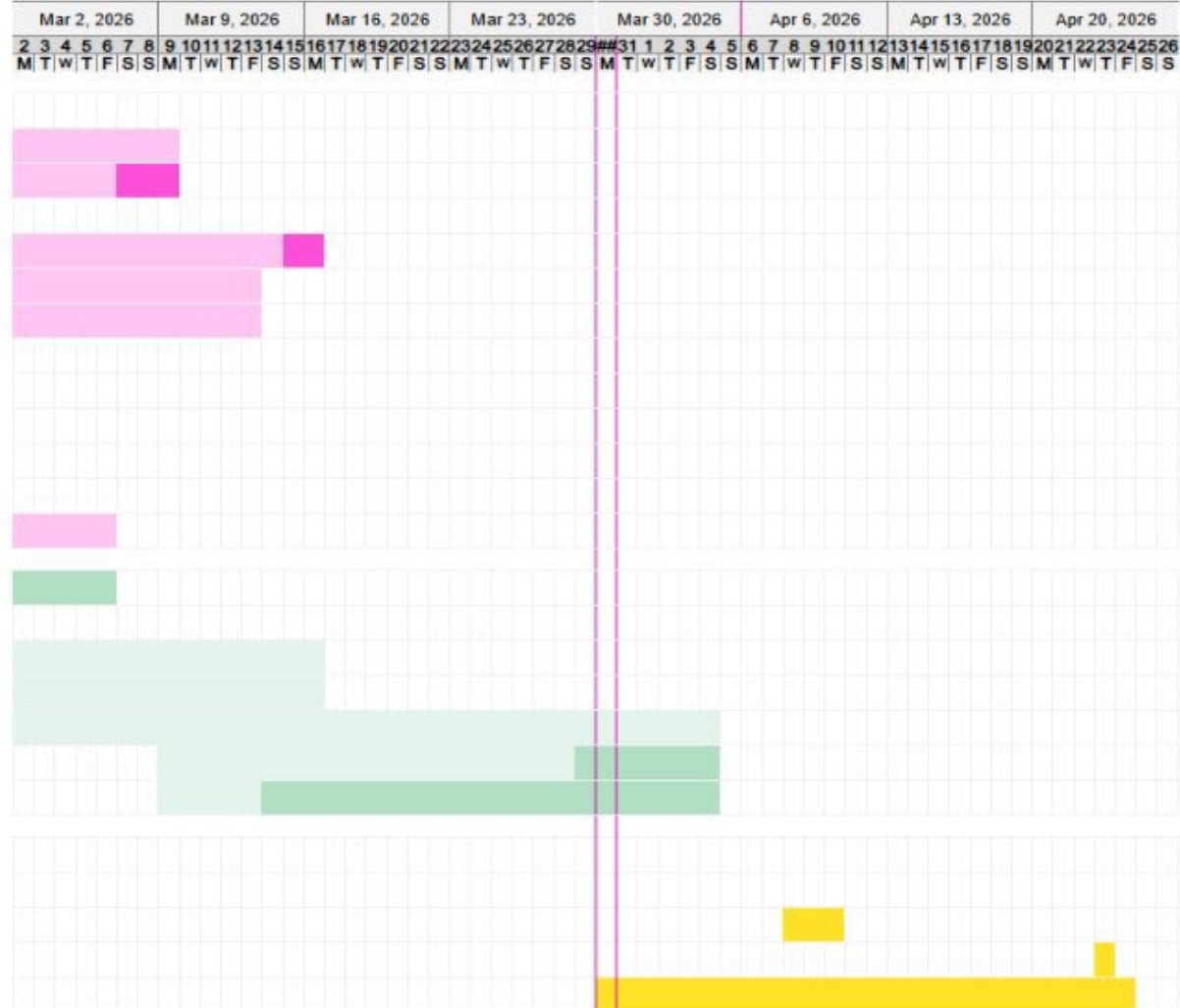


Gearbox

Gantt Chart



TASK	ASSIGNED TO	PROGRESS	START	END
Fabrication & Assembly				
Disassembling Previous Bike	Frame & Hydraulic Team	100%	12/5/25	1/24/26
Frame Assembly	Frame Team	100%	1/12/26	3/9/26
Wheels & Brakes	Frame Team	95%	1/26/26	3/9/26
Brackets & Clamps	Frame Team	95%	1/26/26	2/20/26
Electronics Implementation	Frame Team	95%	2/9/26	3/16/26
Gearbox Implementation	Frame Team	100%	2/2/26	3/13/26
CVT Implementation	Frame Team	100%	2/2/26	3/13/26
Rebuild Kit for Accumulator	Hydraulic Team	100%	1/12/26	2/20/26
Hosing, Gauges, & Valves	Hydraulic Team	95%	1/12/26	2/2/26
Reservoir Mounting	Hydraulic Team	100%	2/2/26	2/13/26
Accumulator Mounting	Hydraulic Team	100%	2/9/26	2/27/26
Manifold Mounting	Hydraulic Team	100%	2/2/26	2/27/26
Motors/Pumps Mounting	Hydraulic Team	100%	2/16/26	3/6/26
Testing & Analysis				
Weight Comparison	Hydraulic Team	75%	2/16/26	3/6/26
CID Comparison	Hydraulic Team	100%	1/12/26	1/30/26
Electronics Testing	Frame & Hydraulic Team	100%	2/27/26	3/16/26
Pressure Displays	Frame & Hydraulic Team	100%	2/27/26	3/16/26
Modes Testing	Frame & Hydraulic Team	100%	3/2/26	4/4/26
Speed Testing	Frame & Hydraulic Team	75%	3/9/26	4/4/26
Efficiency Analysis	Frame & Hydraulic Team	20%	3/9/26	4/4/26
Deliverables & Evaluation				
Midway Review	Frame & Hydraulic Team	100%	11/24/25	1/22/26
Team Registration Deadline	Frame & Hydraulic Team	100%	2/16/26	2/16/26
Attend Competition	Frame & Hydraulic Team	0%	4/8/26	4/10/26
Media Day	Frame & Hydraulic Team	0%	4/23/26	4/23/26
Senior Design Final Report	Frame & Hydraulic Team	0%	3/30/26	4/24/26



Hydraulic Circuit

Key

R – Reservoir

P – Pump

RV – Relief Valve

PG – Pump Gauge

NV – Needle Valve

DPV3 – Directional Poppet Valve

CV – Check Valve

ACC – Accumulator

DPV1 – Directional Poppet Valve 1

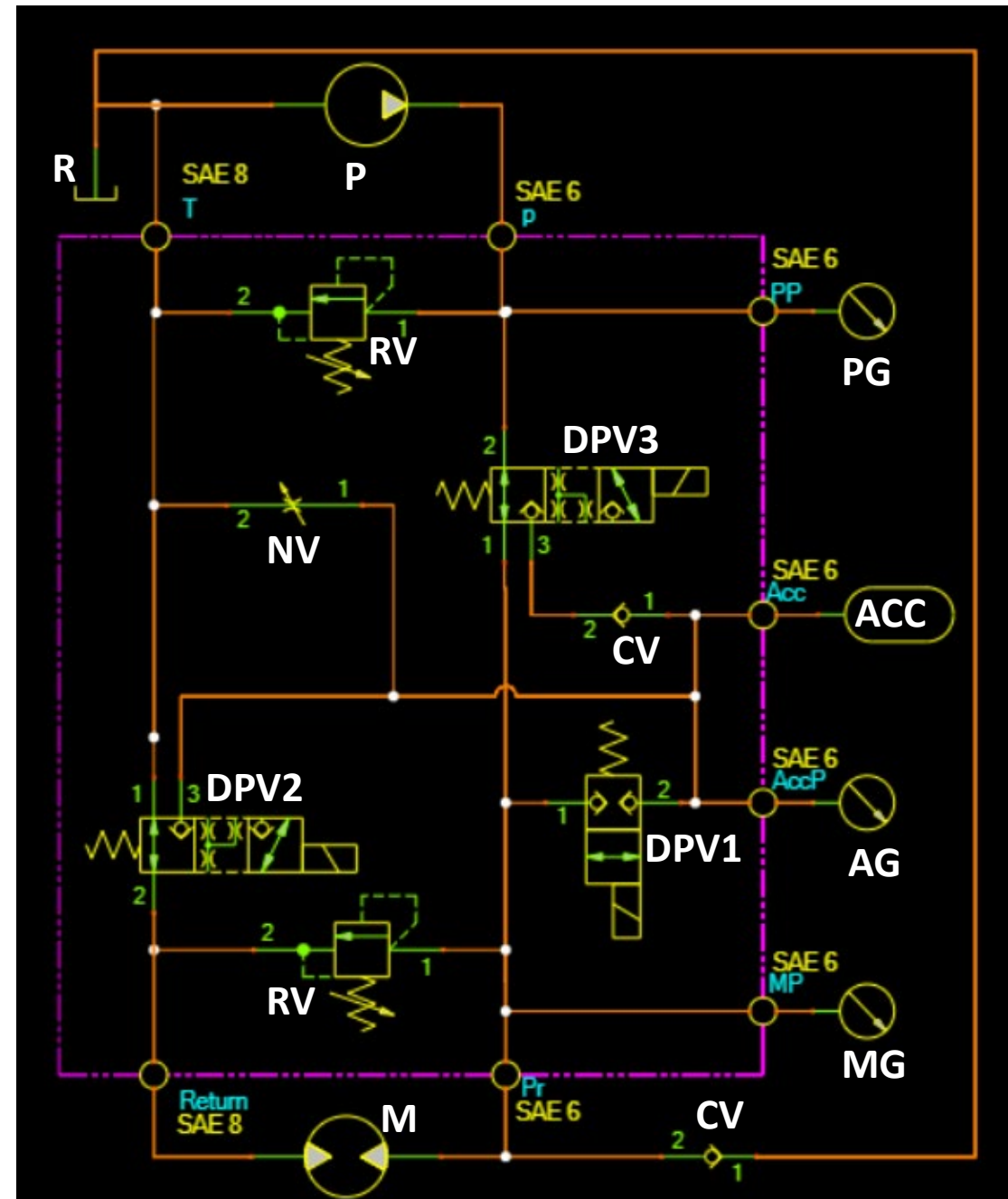
DPV2 – Directional Poppet Valve 2

AG – Accumulator Gauge

MG – Motor Gauge

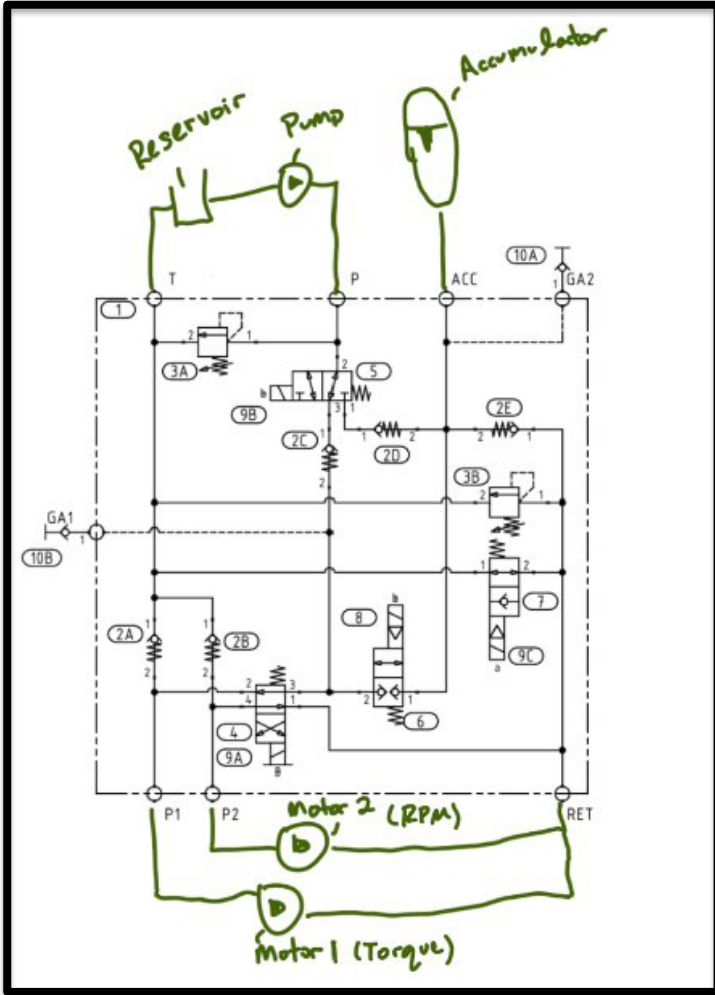
M - Motor

Total Components: 15



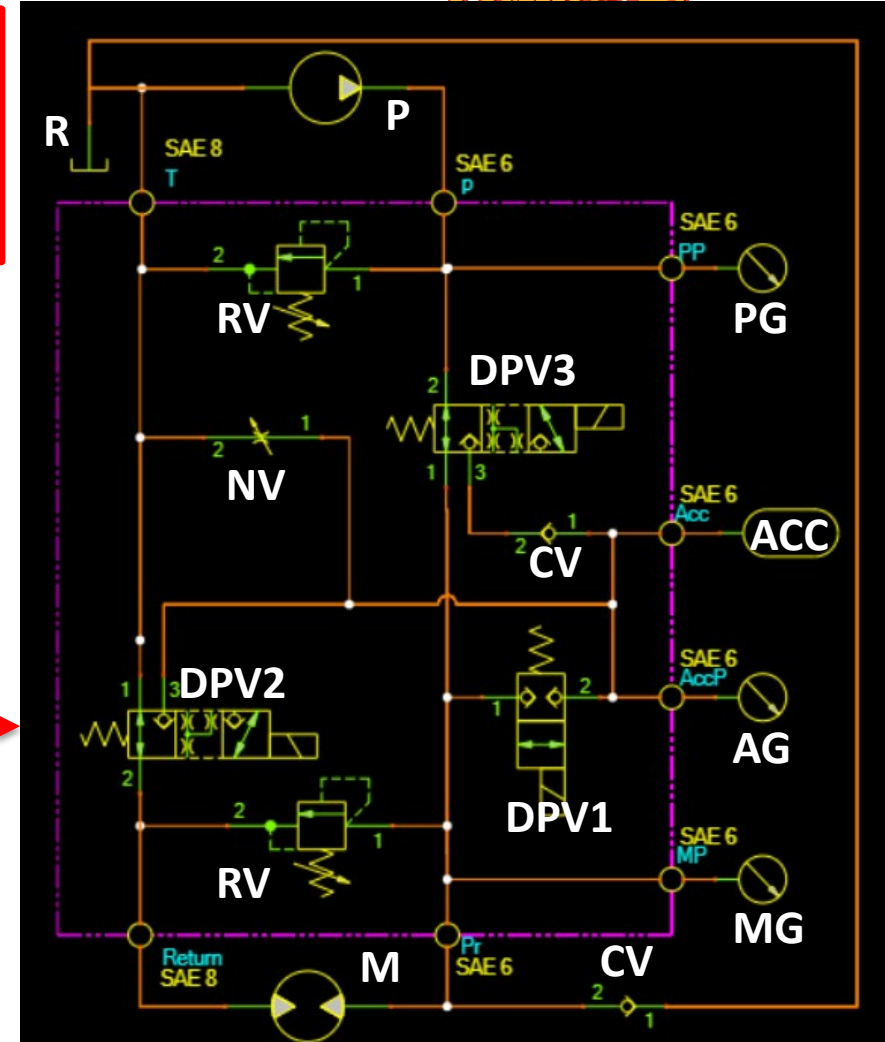
Hydraulic Circuit Design

Circuit Comparison



- Dual Motor System
- 5 Modes (High & Low Drive)
- 4 Solenoids

- Single Motor System
- 4 Modes
- 3 Solenoids
- Minimized pressure loss (poppet valves & fewer CV)

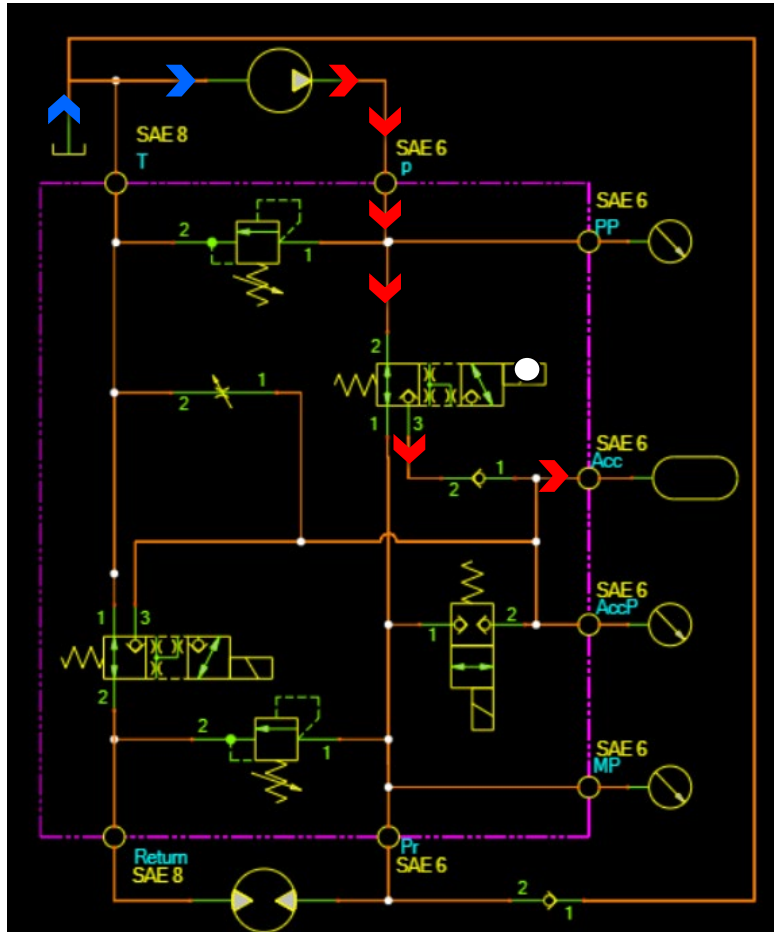


24-25 Circuit Design

25-26 Circuit Design

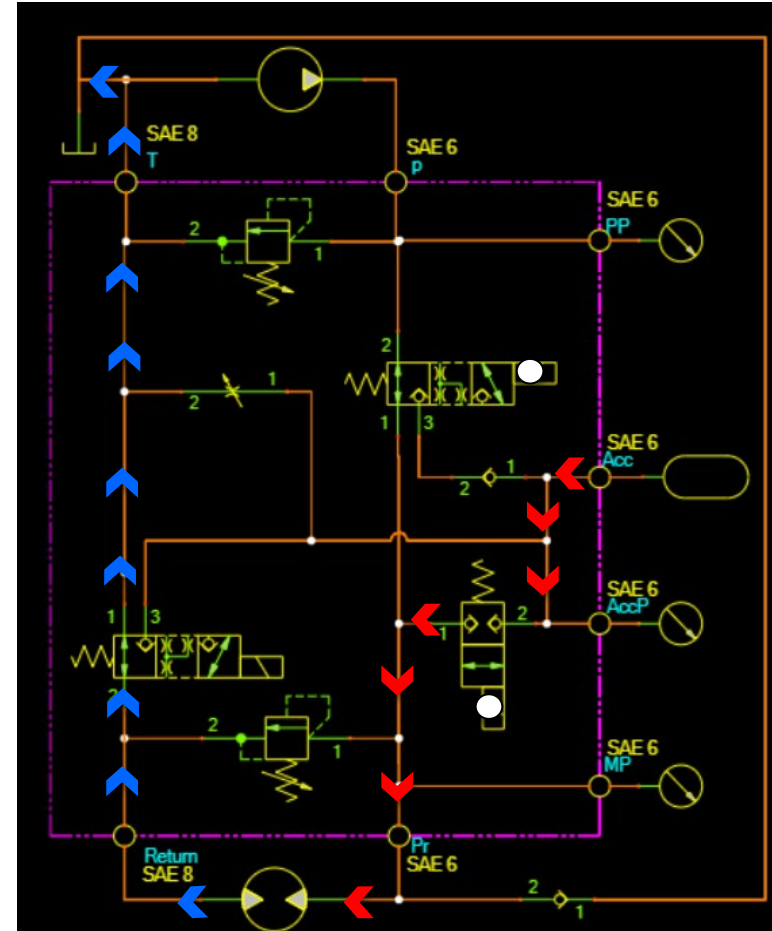
Hydraulic Circuit Overview

Overall Hydraulic Circuit



Charge

Reservoir → Pump → Accumulator



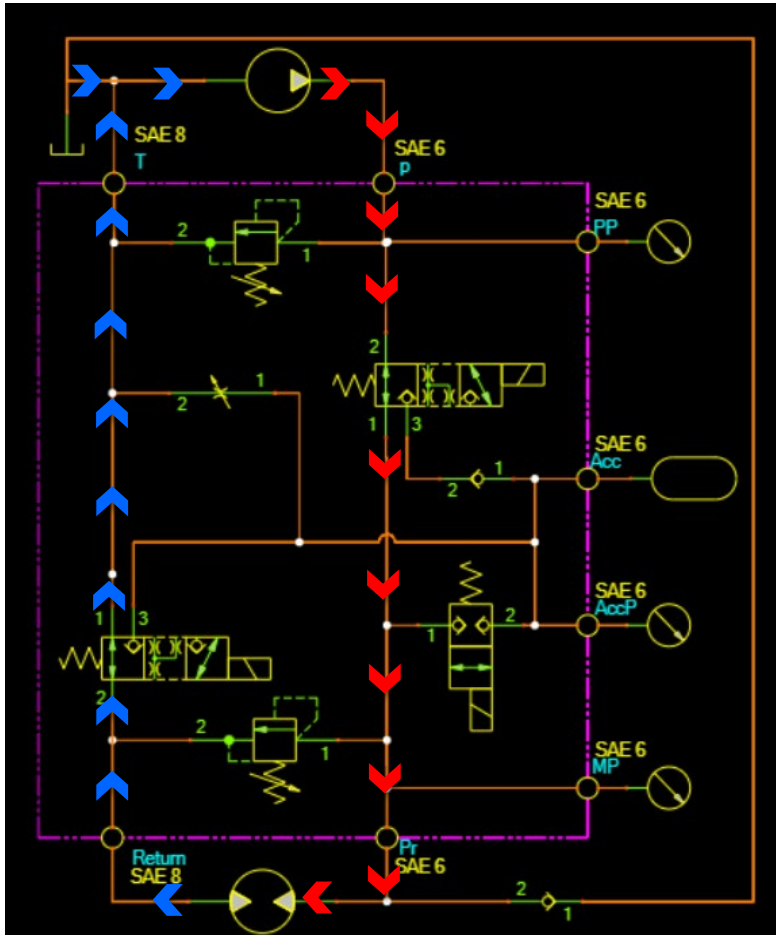
Launch

Accumulator → Motor → Reservoir

Hydraulic Circuit Overview

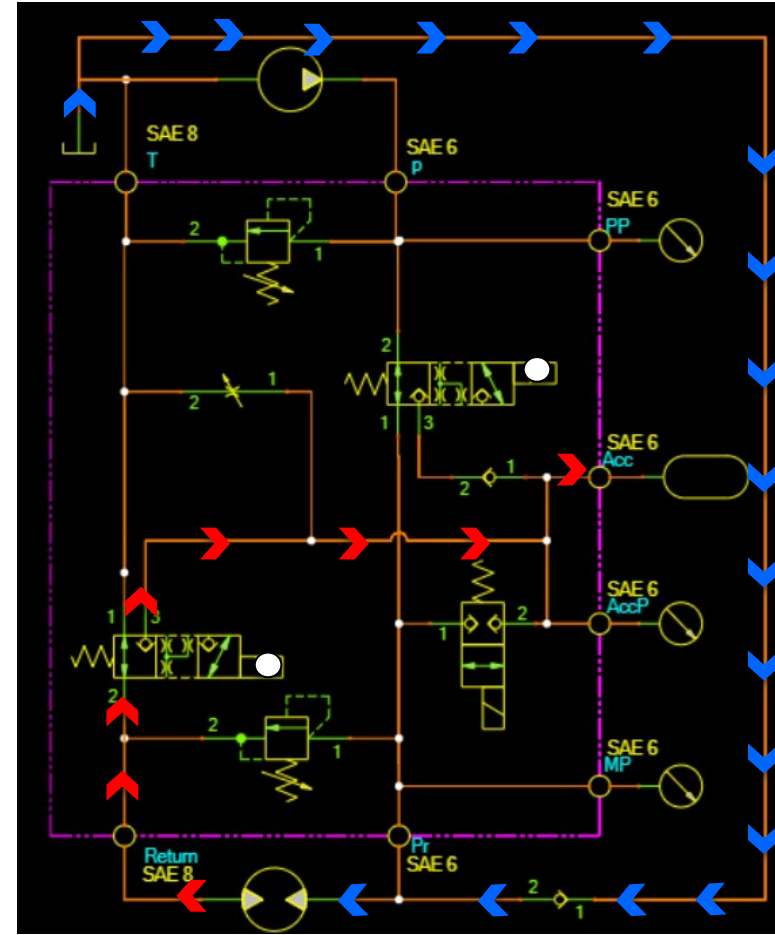


Overall Hydraulic Circuit



Direct Drive

Res → Pump → Motor → Res



Regen

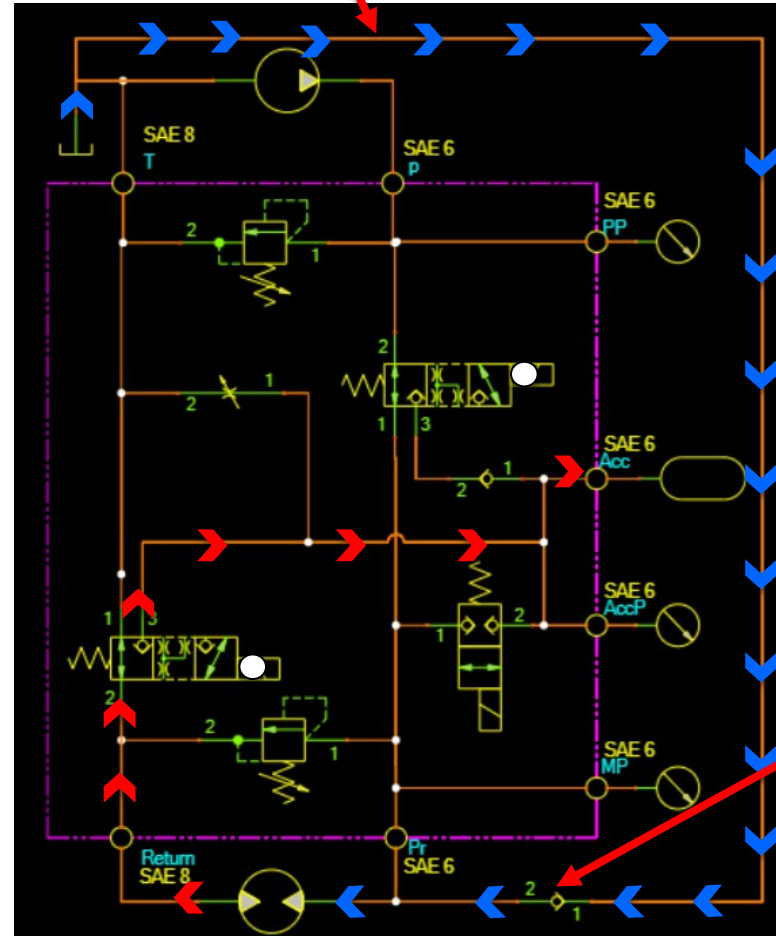
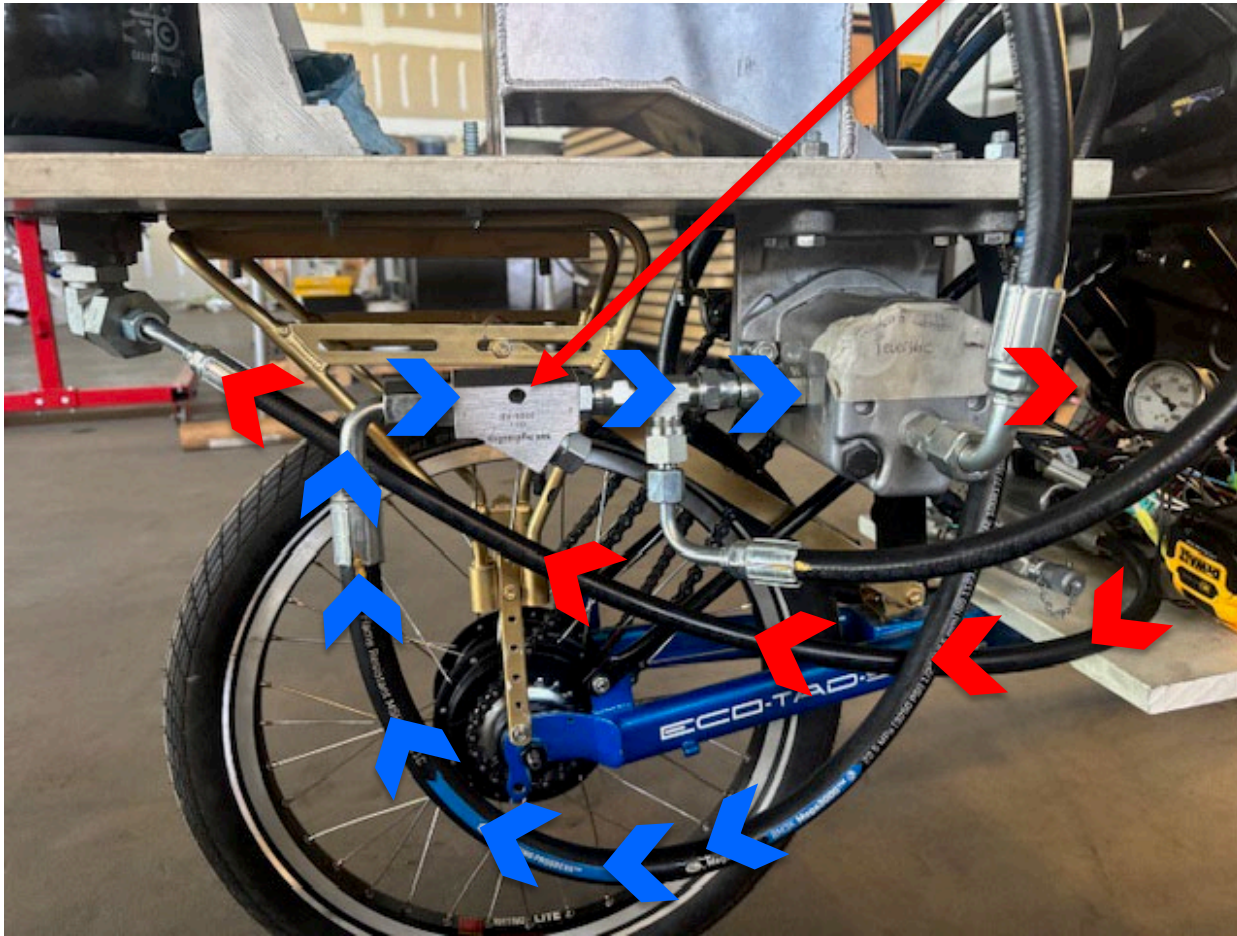
Res → Motor → Accumulator

Regenerative Breaking



Check Valve

External Line for Regen

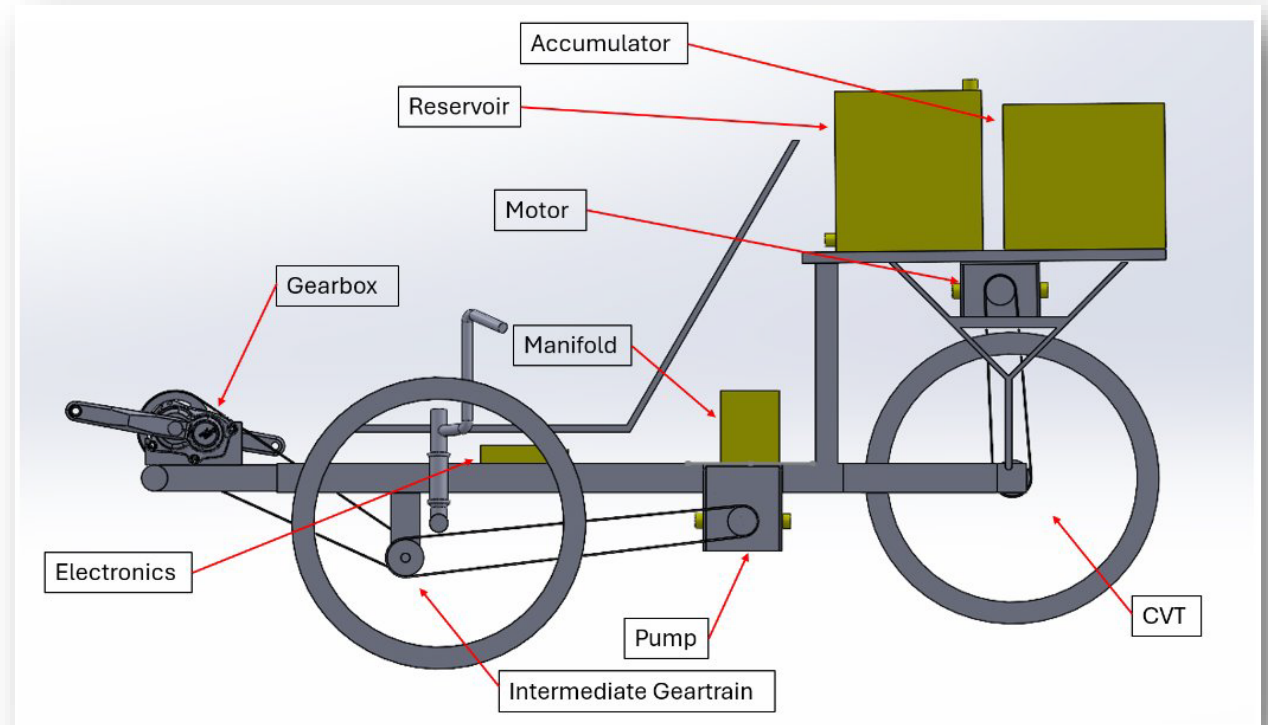


Cracking pressure = 1 PSI
(Suction side pressure differential.)

Design Choices

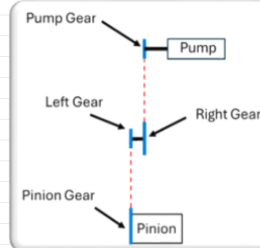


- Adding variable gear ratio to input and output of hydraulic circuit
 - This required a dual chain system on the rear to maintain regen capability (found after construction began)
- Buttons for electronics instead of touch screen on HMI as a more ergonomic solution
- Additional gear ratio for the pump from the intermediate geartrain, this also helped mount the pump at a more optimal location for hose routing.
- Changing the design philosophy for selectable gearing. Previous year used dual motors. This year our rear CVT gives variable ratio without added hydraulic circuit complexity.



Initial SolidWorks mockup

pedal rpm	60		
Gearing	tooth	Gear	total gear ratio
pinion sprocket	30	1	2.967032967
Left gear	10	2	3.673469388
Right gear	18	3	4.537815126
pump gear	10	4	5.684210526
		5	7.105263158
		6	8.709677419
		7	11.02040816
		8	13.5
		9	16.875
			final rpm
			178.021978
			220.4081633
			272.2689076
			341.0526316
			426.3157895
			522.5806452
			661.2244898
			810
			1012.5



Pump Gear Ratio Calculations

Vehicle Construction



Frame Disassembly



Gearbox Bracket
Manufactured and Gearbox
Mounted



CVT mounted to wheel

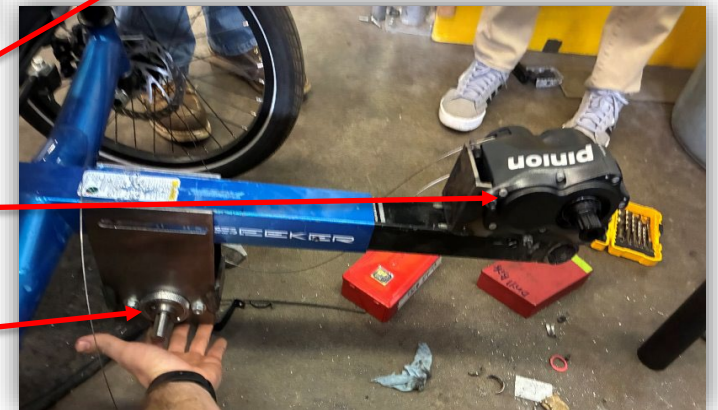


While our initial design involved a different component mounting system, issues with access to machining equipment led to us repurposing existing material for the components.

CVT

Gearbox

Intermediate
Geartrain



Vehicle Construction



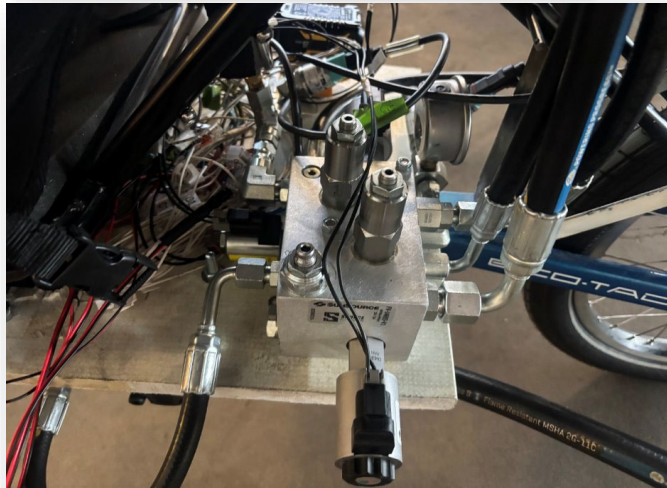
Manifold, Hoses, and Pump Mounted



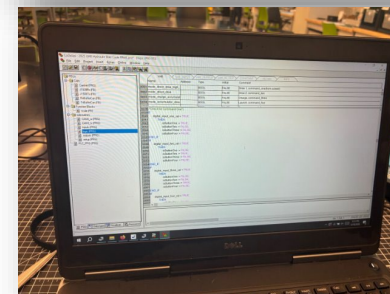
Chain Guard Mounted



Motor and Electronics Mounted and programmed



This is the dual chain system required to maintain regen. This is because of the free spin inherent to the CVT design.



Vehicle Testing



- Initial testing began on 3/20 where several laps were completed in direct drive mode showcasing a working vehicle. Several runs were completed on two different sized motors where the superior motor was selected with improvements to the peddling. The test was successful but also revealed some potential improvements to be made on the hydraulics
- After testing direct drive other modes where tested, it was discovered that one of the solenoids was wired with the wrong polarity and was not engaging.
- Another issue found required a timer to be added to the valve controlling launch mode. The accumulator had time to pressurize the pump before that circuit closed, thus moving the peddles and it risked blowing the seals on the pump as it was not reversible.
 - The timers completely corrected this issue.
- After some discussion and testing under max pressure, a ball valve was considered to reduce the impact on the drivetrain when launching
 - After discussing with our mentors, it was decided a ball valve was unnecessary.



Final Vehicle



Acknowledgements:

- Dr. David Littlefield
- Dr. Selvum Pillay
- N.F.P.A
- SunSource & IFP
- Danfoss
- Motion Industries
 - Drew, Ethan, Joshua



Lessons Learned



Hydraulics Systems

- Understanding how to design and build a fully functional hydraulic circuit by taking flow, pressure, and efficiency under consideration, while maintaining industry safety standards and professional tubing requirements to ensure reliability and safety of our system.

CAD/ 3D Printing

- This phase focused mostly on how well the printed parts fitted together properly by keeping precise clearances and tolerances, all of this was done by considering material properties and orientation to avoid weak points, and most importantly easy accessibility during maintenance.

Design Engineering

- This area helped us improve our ability to perform calculations necessary for a safe and reliable machine. This phase mainly focused on mechanical loading components such as sprockets, chains under tension, and other mechanisms that could handle forces and stress without failing.

Electronics

- We were introduced to the hardware and software components, showing how hydraulic operations are managed on HMI, we decided to go with the mechanical buttons to swap between modes as they can be easily accessible without moving hands off the handle, and are more reliable as compared to the touchscreen panels directly on the HMI.

Communication with Professionals:

- Professionals from organizations like Motion Industries and NFPA helped us lead in the correct direction by providing meaningful feedback. We learned to refine our design, developed respect for the schedule and time of the mentors.

Prototyping and Testing:

- Our main focus was to try and improve individual parts while keeping a stable system. We learned to coordinate design changes by preemptively ensuring each individual component does not negatively impact the overall testing and final assembly.

Finance Management:

- Our knowledge of economic management was tested as we had to ensure from the beginning that each key component would be within budget while leaving room in the budget for and contingencies.

Machine Shop:

- Working in the shop provided us with hands on experience, and helped in our understanding of real-world limitations, knowing what a machine can and cannot do directly influenced on how components are designed.



Thank you!
Questions?

