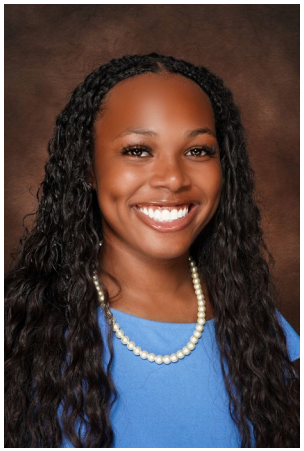
NFPA Fluid Power Vehicle Challenge

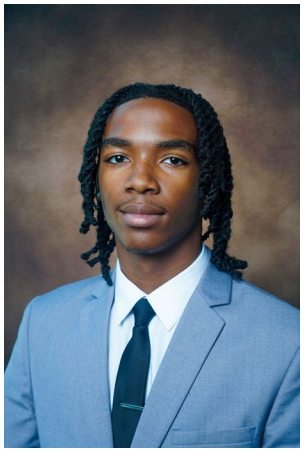
NFPA Education and Technology Foundation

Fluid Power Team
North Carolina A&T State University
Paul Akangah
April 26th, 2024

Team Introductions



Aminah Bland
Team Lead



Tylen McGee
Assistant Team Lead

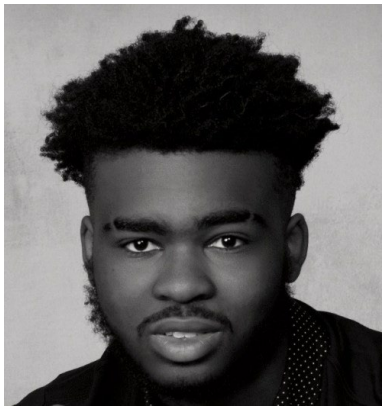
Ofori Baidoo
Pneumatics Lead

Logan Pugh
Hydraulics Lead

Jaylen Nipper
Manufacturing Lead

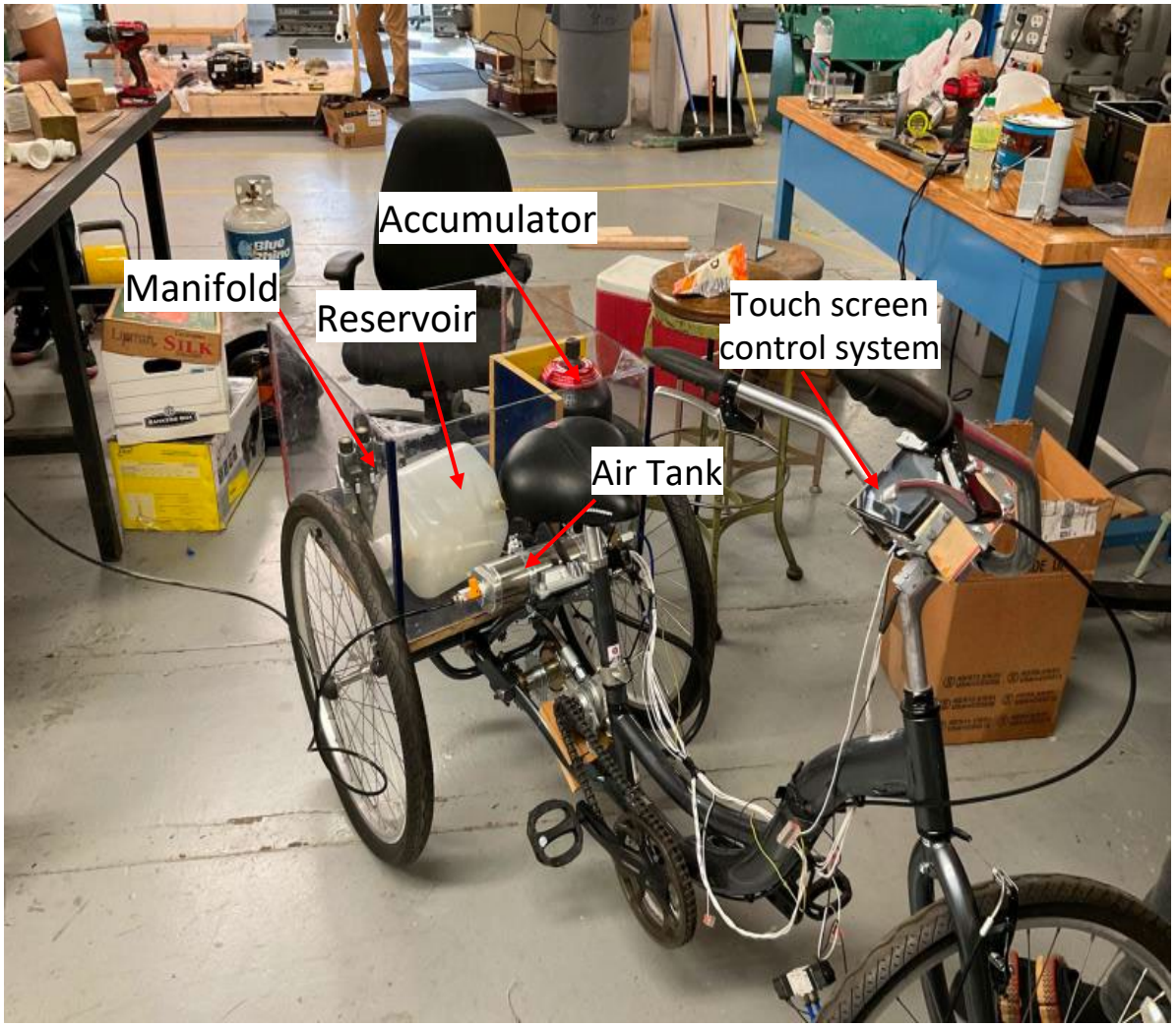
Destiny Shaw
Integration Lead

Michael Harris
Controls Lead



Anthony Harrison
Controls lead

Past Vehicle Design

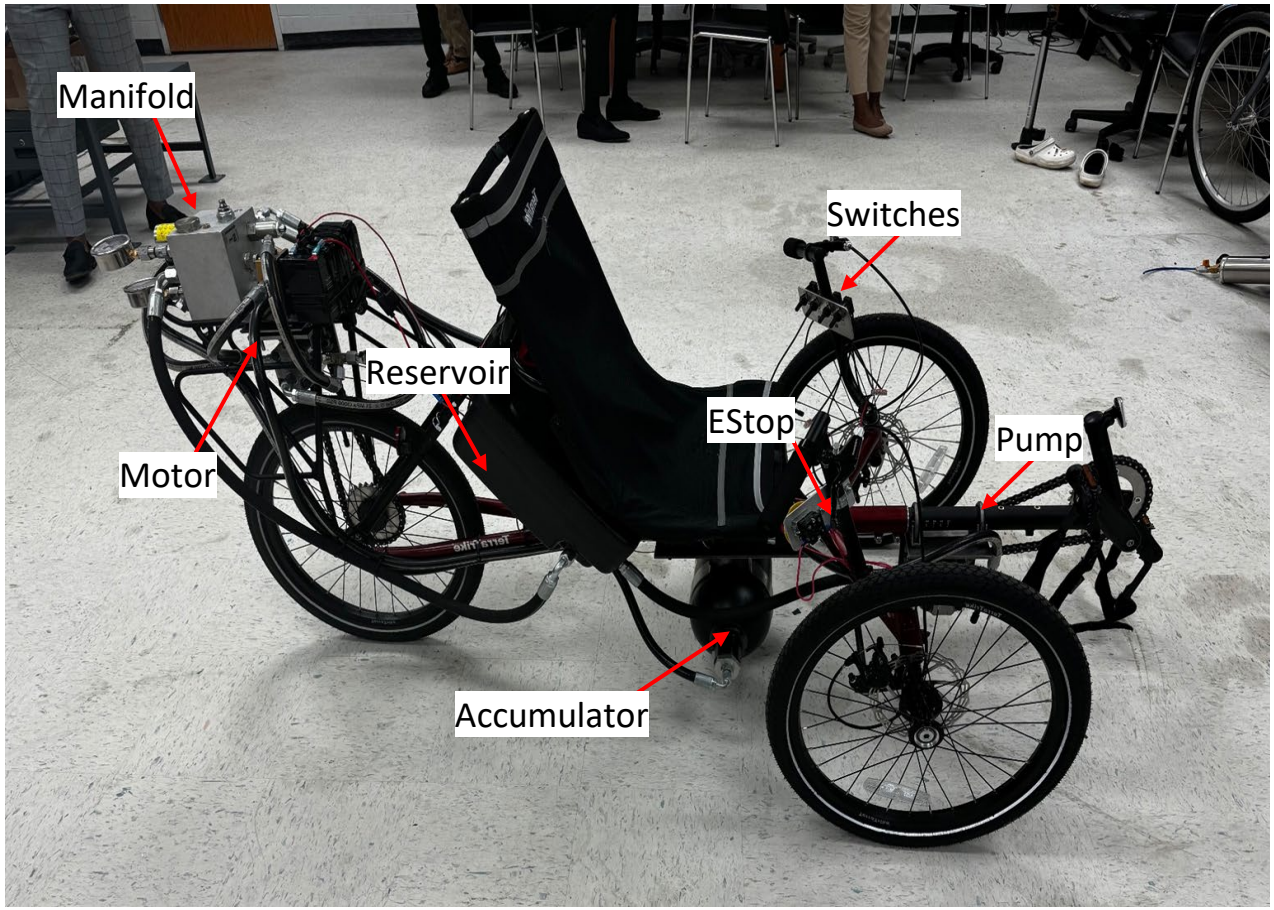


Lessons Learned:

- The pump and motor must be integrated correctly so that they work within the system
- All components must be mounted to withstand torque produced
- It is important to ensure the alignment of the shaft and chain to prevent slippage
- Hydraulics and Controls must work seamlessly together for the functionality of the bike
- A touch screen control system is more difficult to use

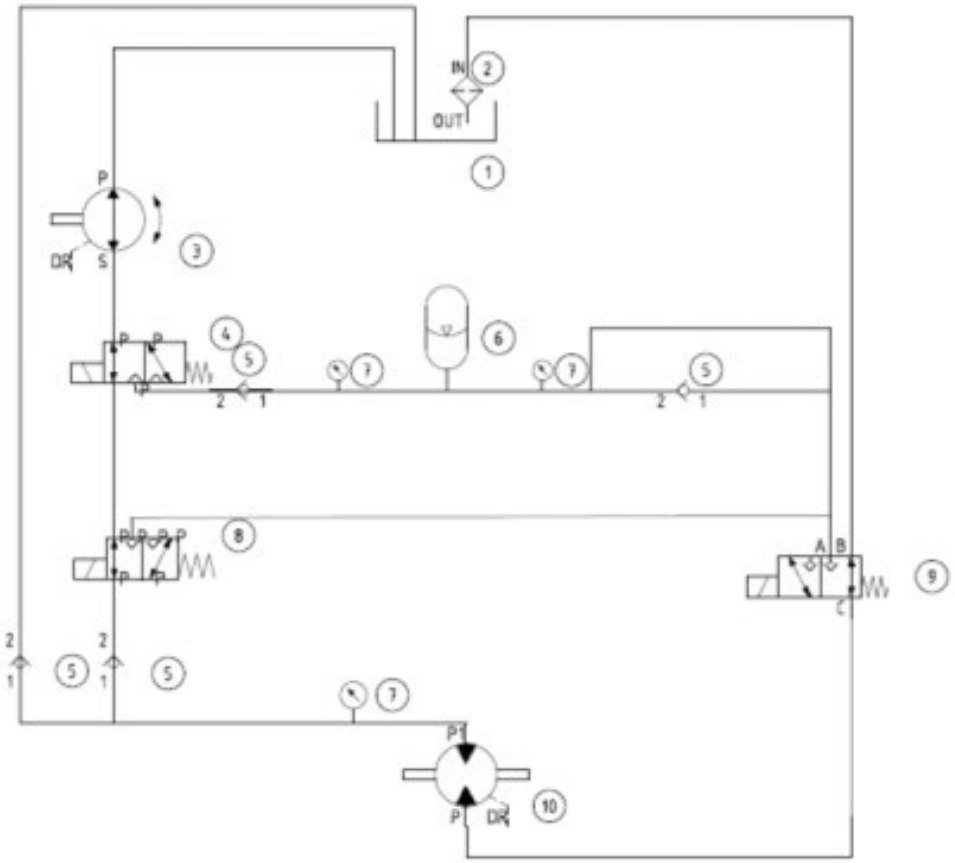
Current Vehicle Design

This year's vehicle design incorporated a recumbent style design



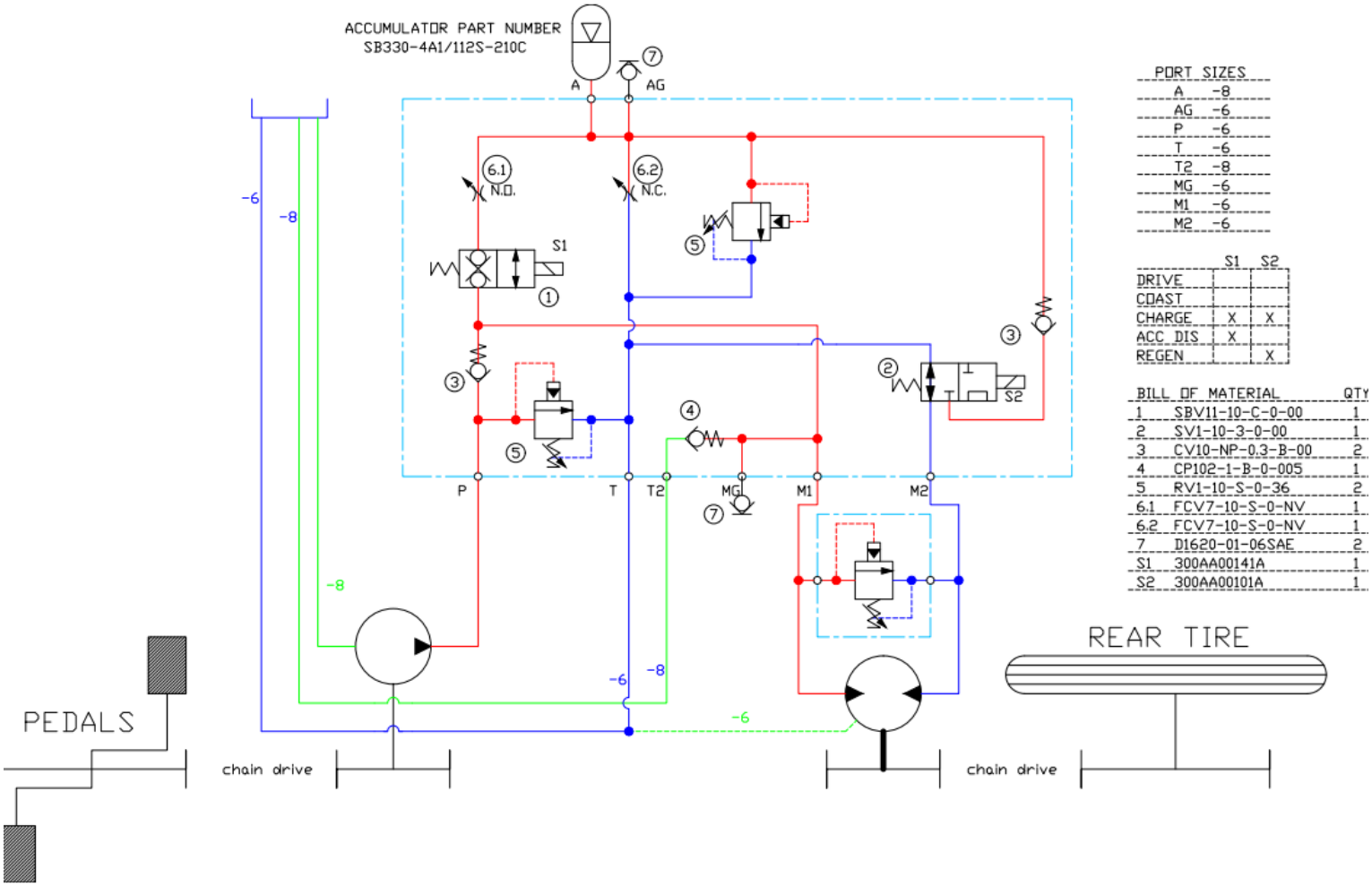
- Frame style offers enhanced stability and comfort
- Lower profile reduces wind resistance, allowing riders to achieve higher speeds
- Better placement of subsystems so that components, hosing, and wiring do not interfere
- Correct alignment of shafts and sprockets prevents chain slippage

Hydraulics: Old Circuit



1. Reservoir
2. Filter
3. Pump
4. 3x2 solenoid spring directional control valve
5. Check Valve
6. Accumulator
7. Pressure Indicator
8. 3x2 solenoid spring directional control valve
9. 3x2 solenoid spring directional control valve
10. Motor

Hydraulics: New Circuit

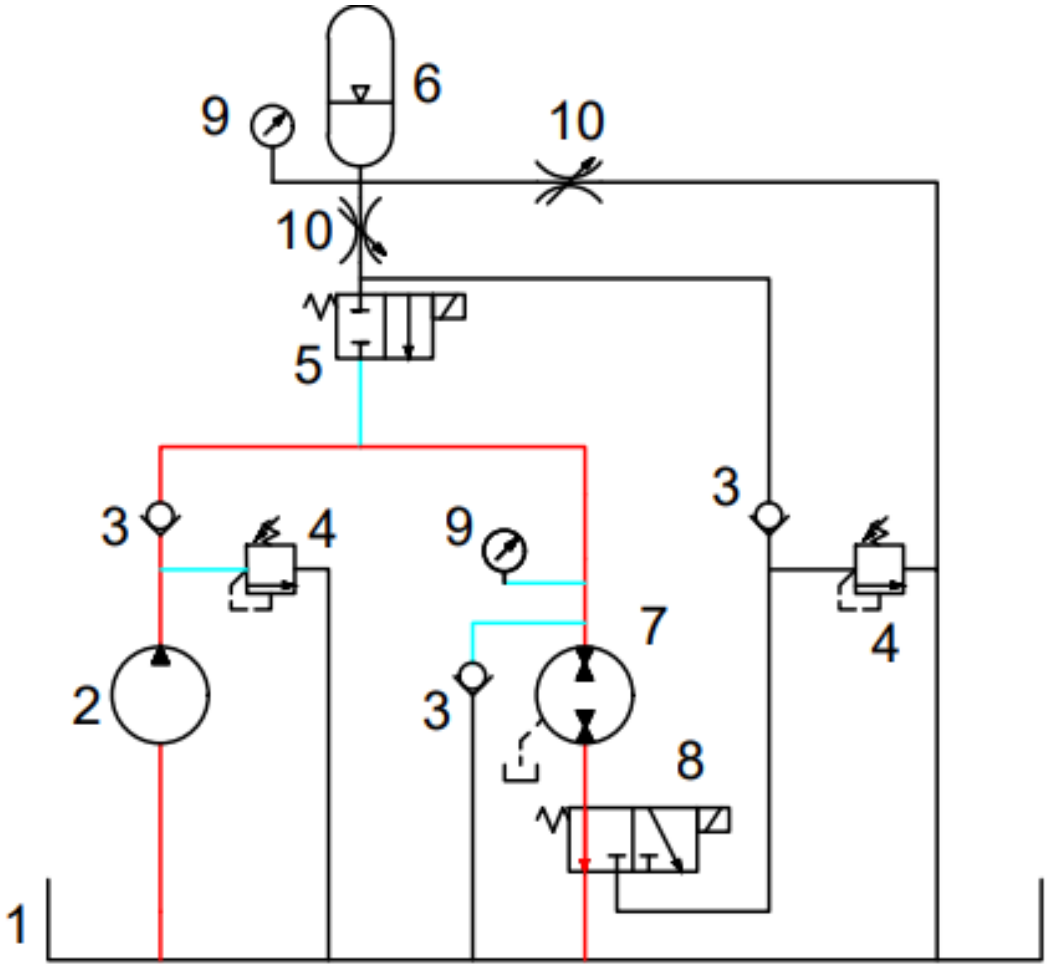


PORT SIZES	
A	-8
AG	-6
P	-6
T	-6
T2	-8
MG	-6
M1	-6
M2	-6

	S1	S2
DRIVE		
COAST		
CHARGE	X	X
ACC DIS	X	
REGEN		X

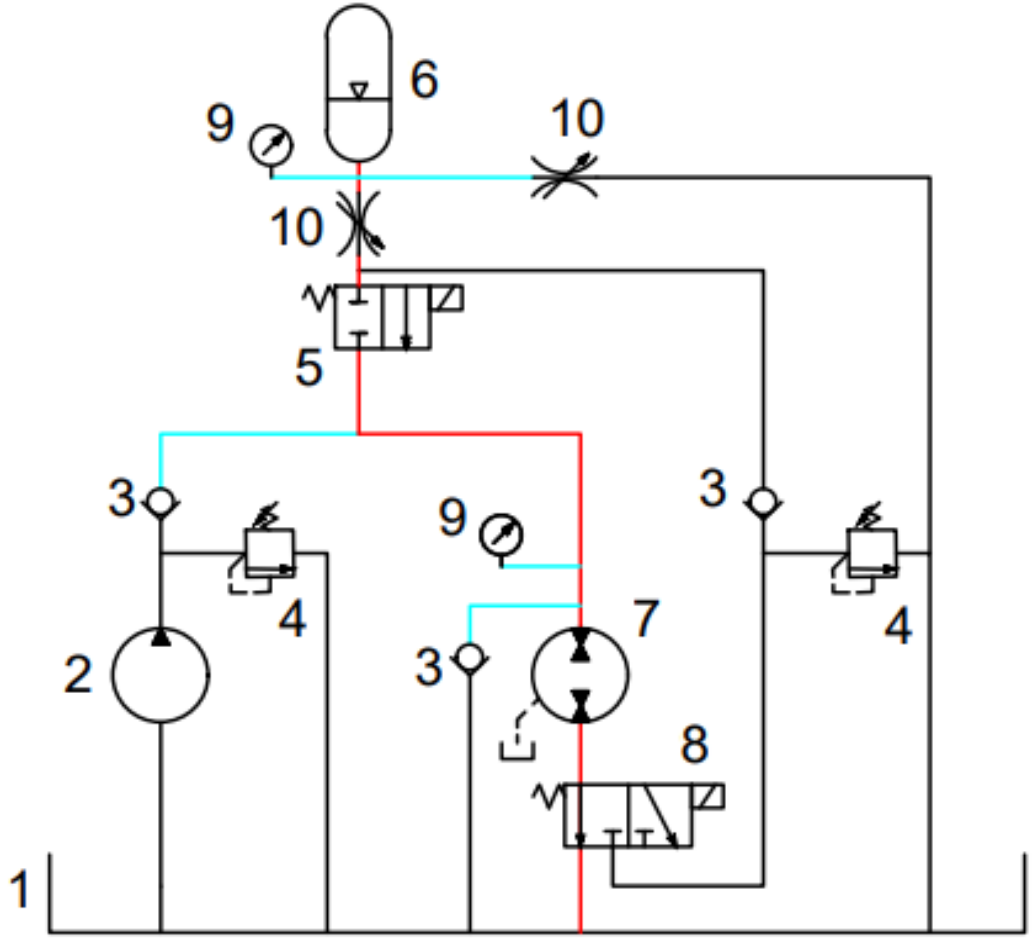
BILL OF MATERIAL		QTY
1	SBV11-10-C-0-00	1
2	SV1-10-3-0-00	1
3	CV10-NP-0.3-B-00	2
4	CP102-1-B-0-005	1
5	RV1-10-S-0-36	2
6.1	FCV7-10-S-0-NV	1
6.2	FCV7-10-S-0-NV	1
7	D1620-01-06SAE	2
S1	300AA00141A	1
S2	300AA00101A	1

Hydraulics: Pedal Mode



1. Reservoir
2. Hydraulic Pump
3. Check Valve
4. Pressure Relief Valve
5. 2x2 solenoid spring directional control valve
6. Accumulator
7. Hydraulic Motor with case drain
8. 3x2 solenoid spring directional control valve
9. Pressure Gauge
10. Adjustable needle valve

Hydraulics: Accumulator Discharge



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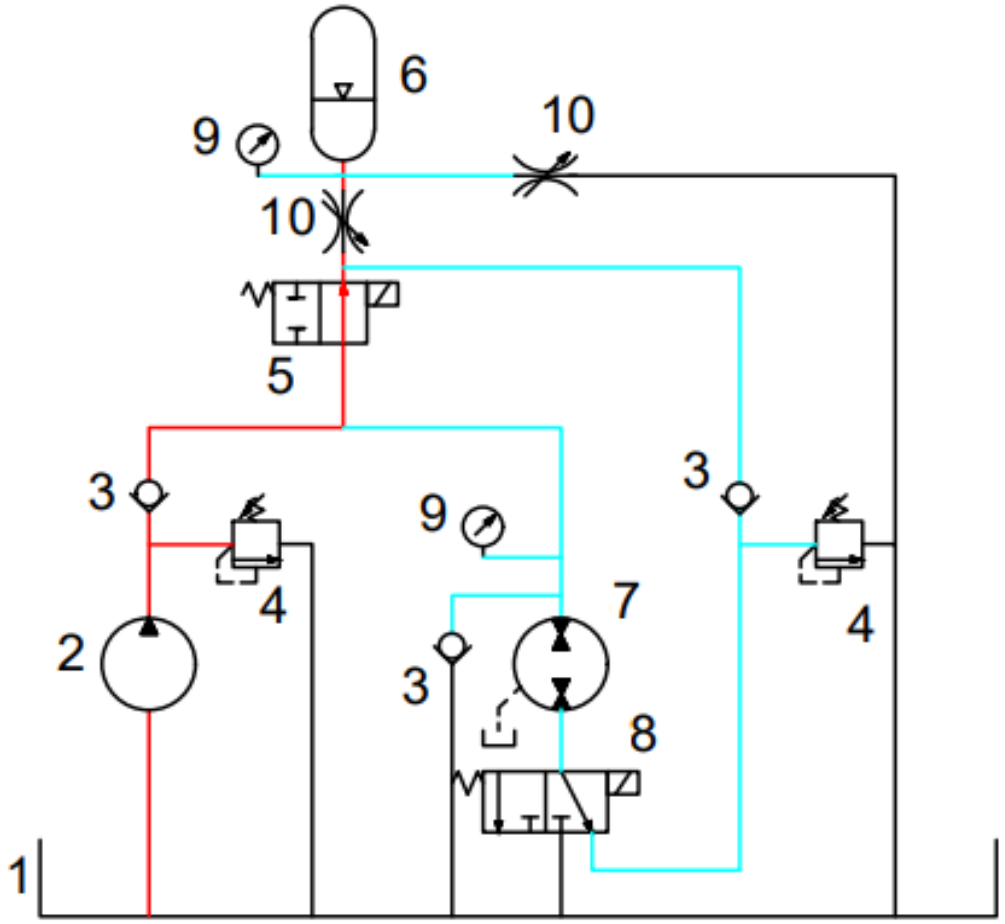
Hydraulics: Accumulator Charge



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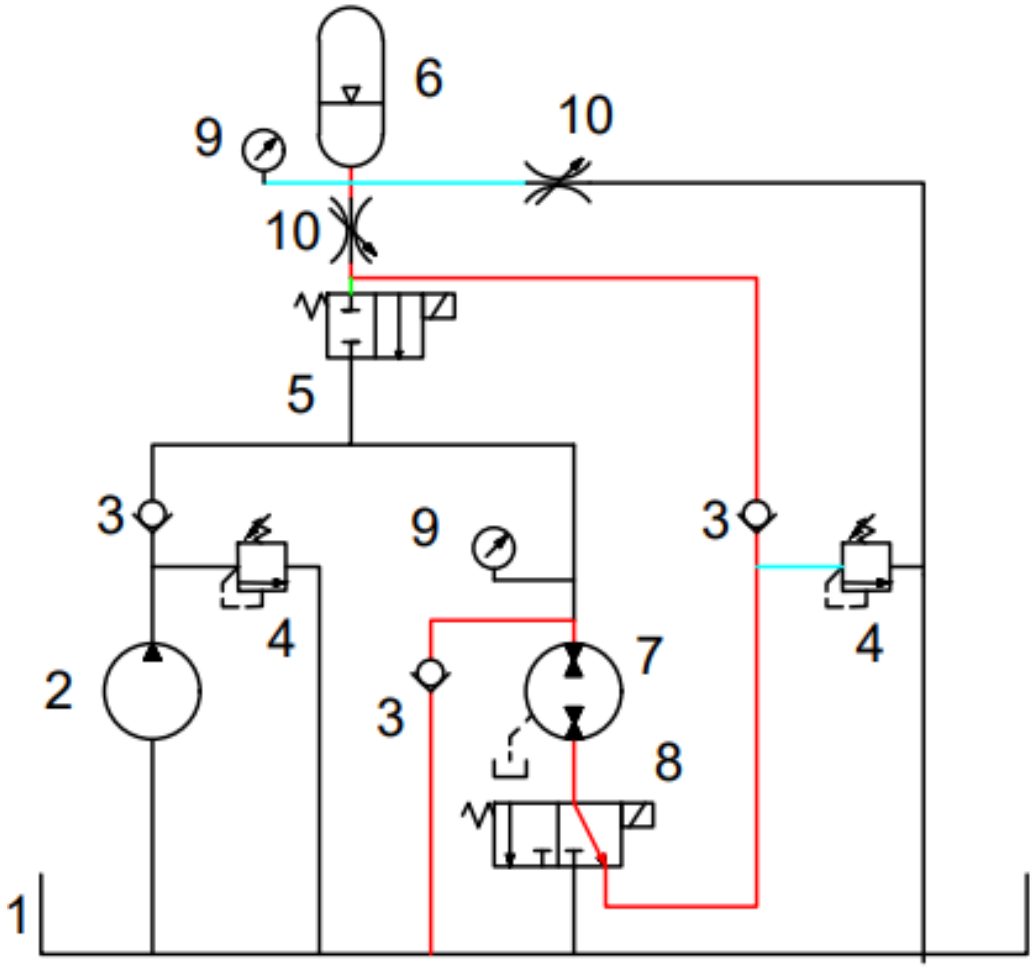
Hydraulics: Regen Mode



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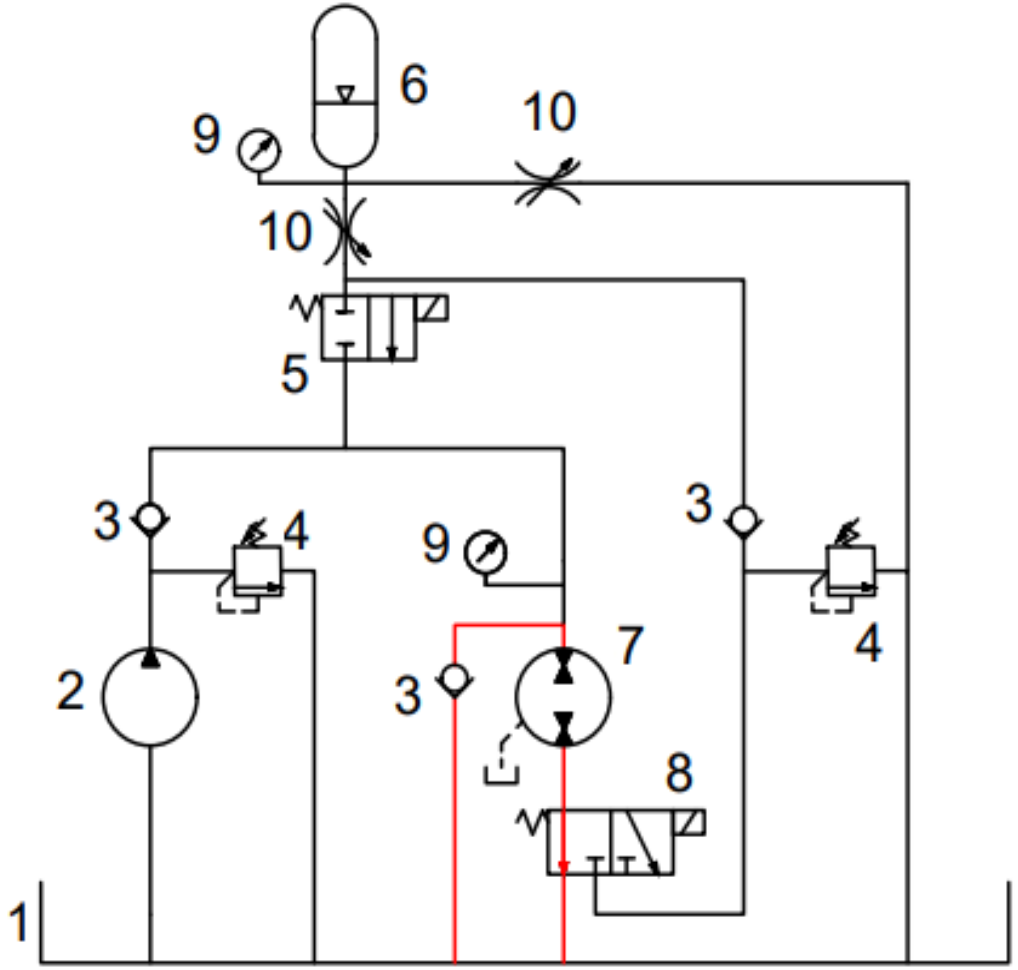
Hydraulics: Coast Mode



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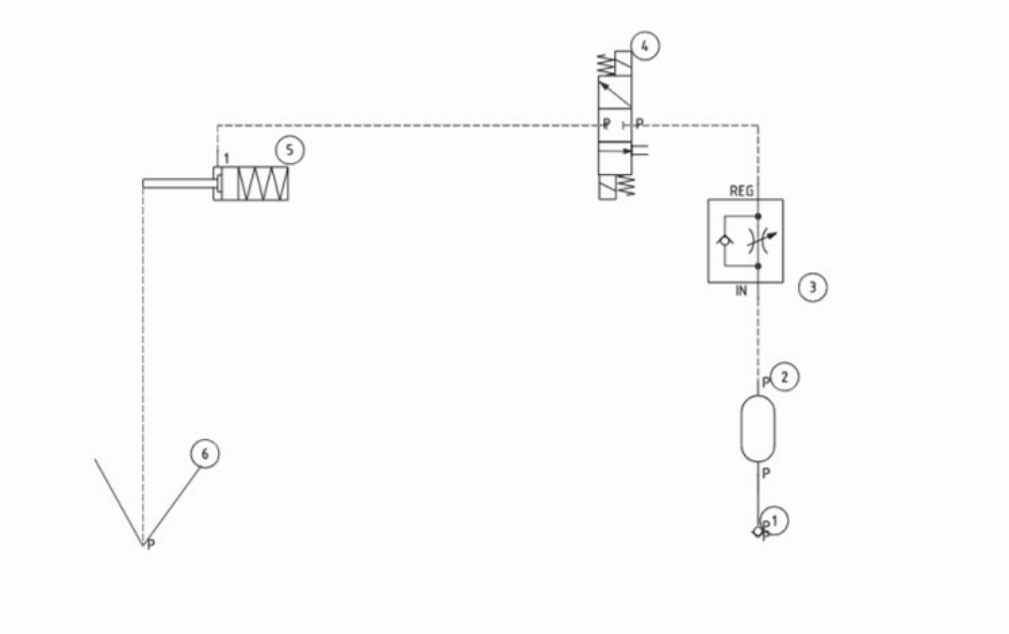
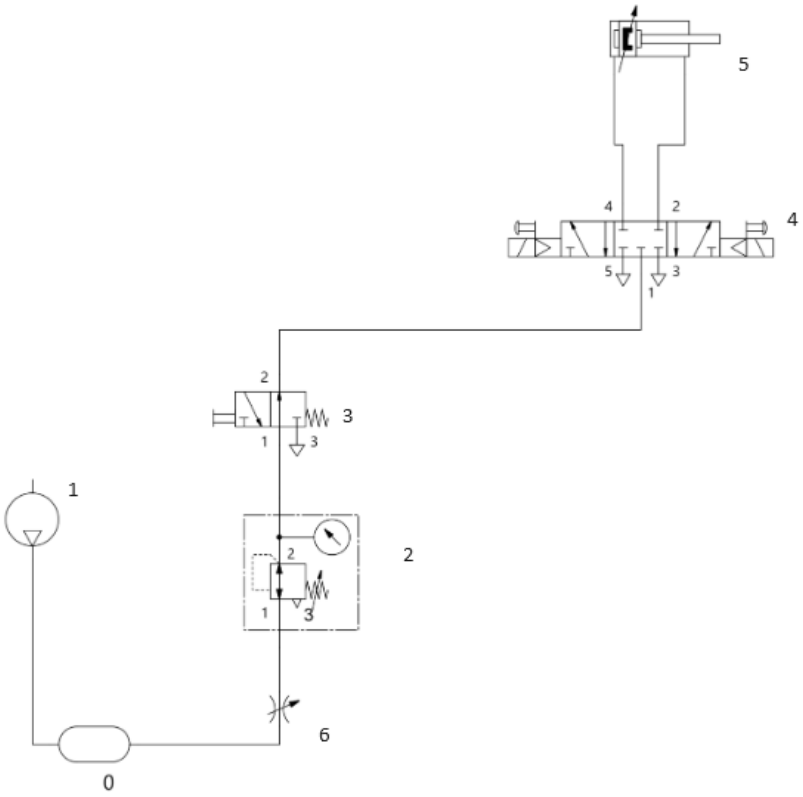
Past Pneumatic Design



1. Standard direction control valve
2. Reservoir tank
3. Adjustable flow control valve
4. 2x3 solenoid/spring valve
5. Single acting spring extend cylinder
6. Cable connected braking system

Purpose: Serves as a parking brake & ensures safety

Current Pneumatic Design



0 - **Air Tank/ Reservoir**.

1 - **Air Compressor.**

2 - **Air Pressure Regulator.**

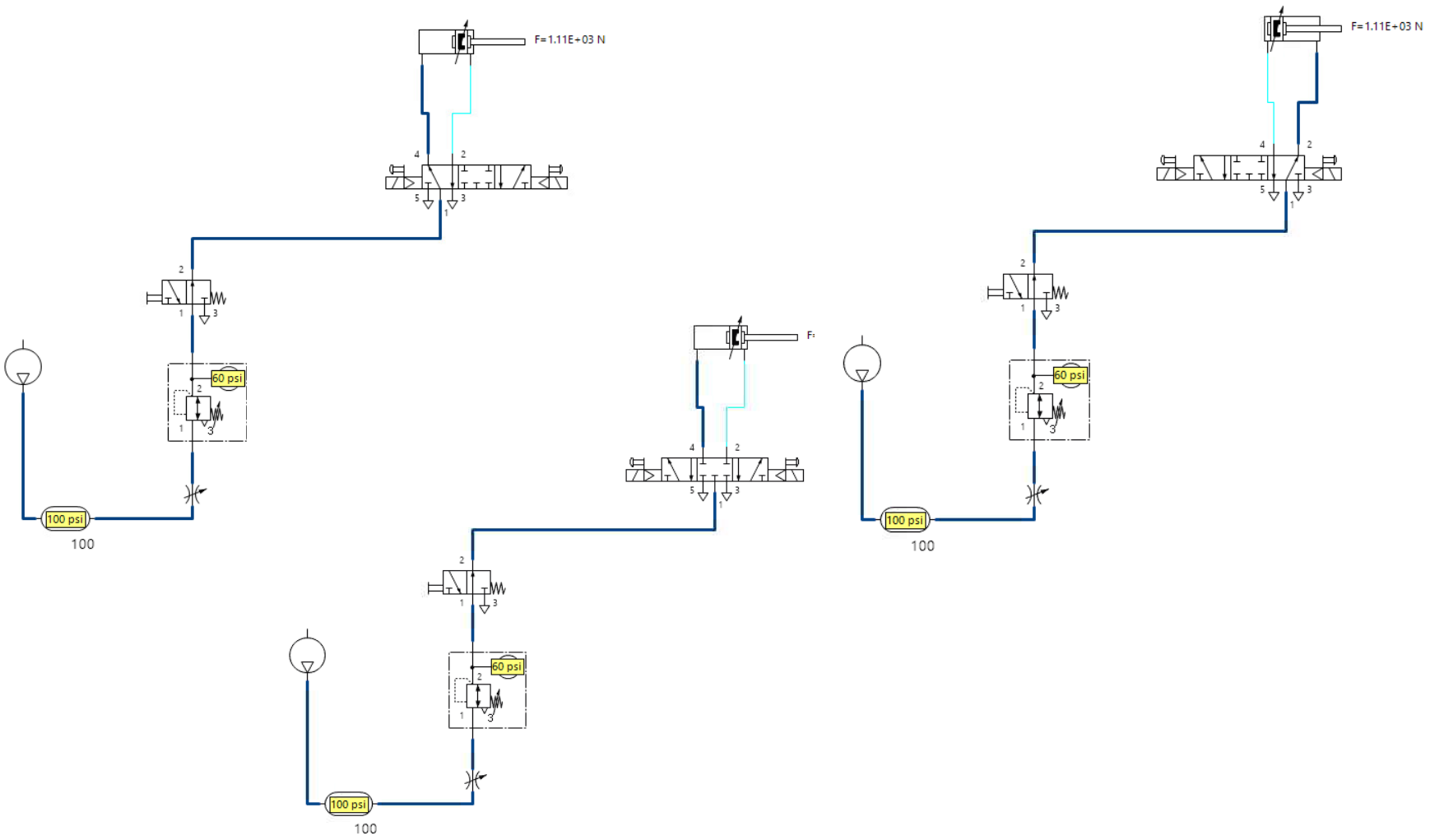
3 - **Drain Valve.**

4 - **5-Way/3-Position Solenoid Valve.**

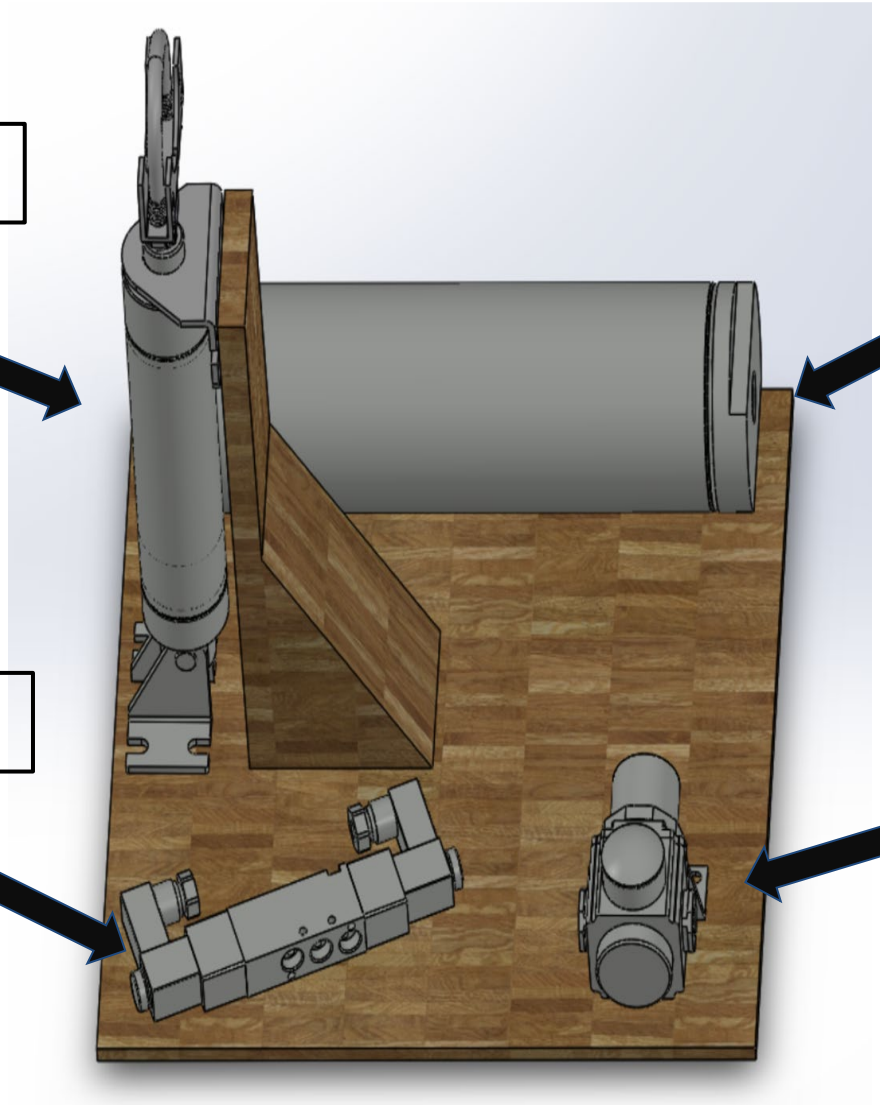
5 - **Double Acting Cylinder.**

6 - **Check Valve.**

Pneumatics Simulation



Pneumatic 3D Model



Control Systems

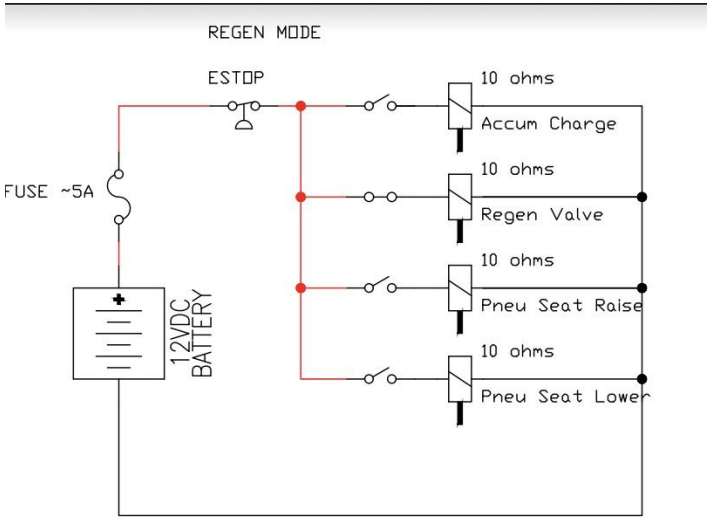
The vehicle control system controls:

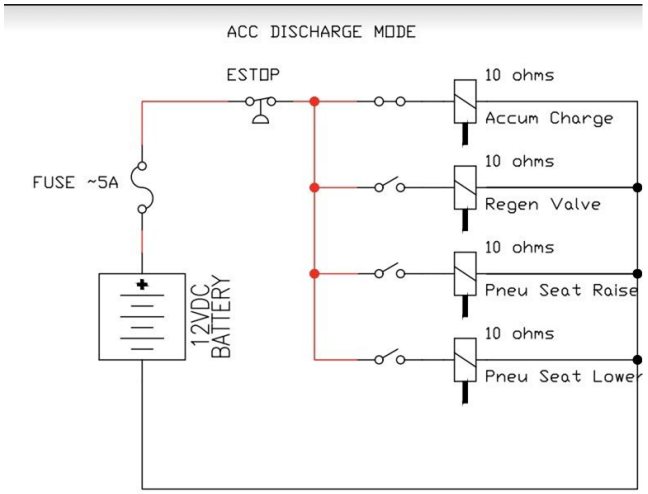
- Hydraulic solenoid valves
- Pneumatic solenoid valve

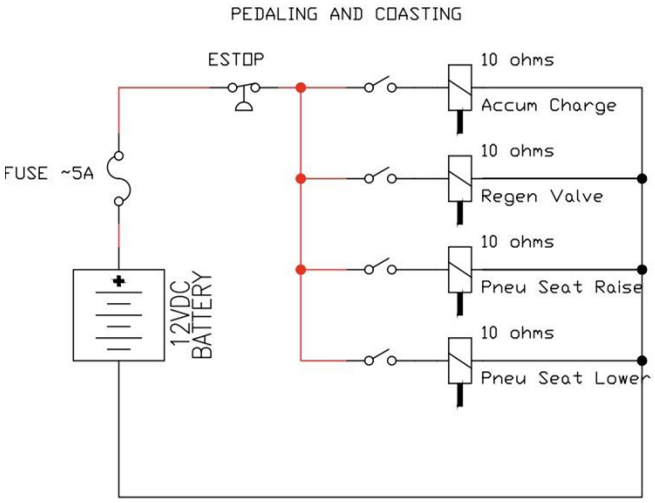
The control system consists of:

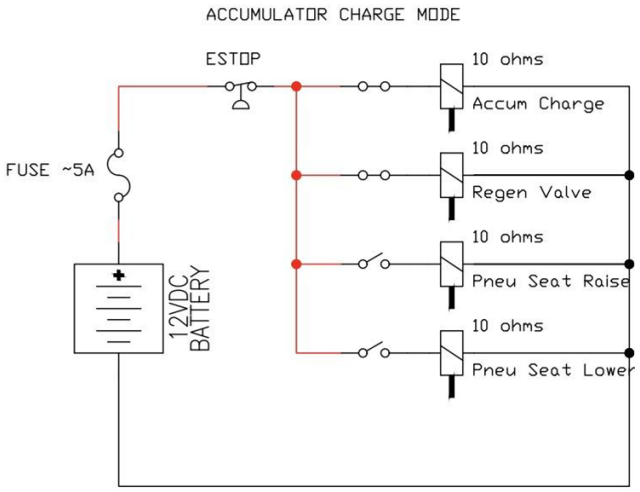
- Four two pin toggle switches
- A twelve volt dc battery
- An Emergency Stop (EStop) switch

Control Circuit Diagram







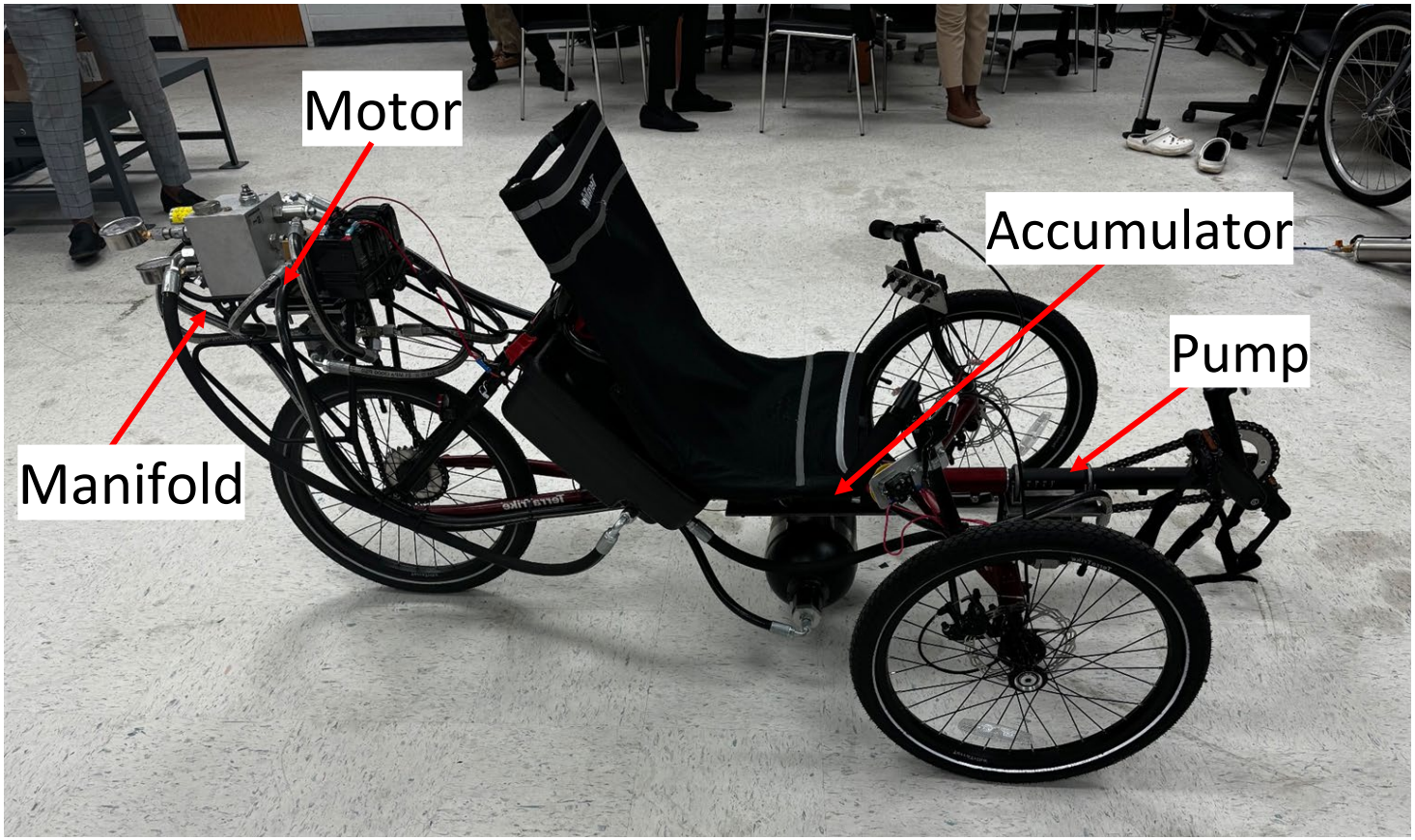


Vehicle Integration

- Outsourced bike from Terratrike
  - **Material:** Hi-Ten Steel
  - **Weight:** 39 lbs

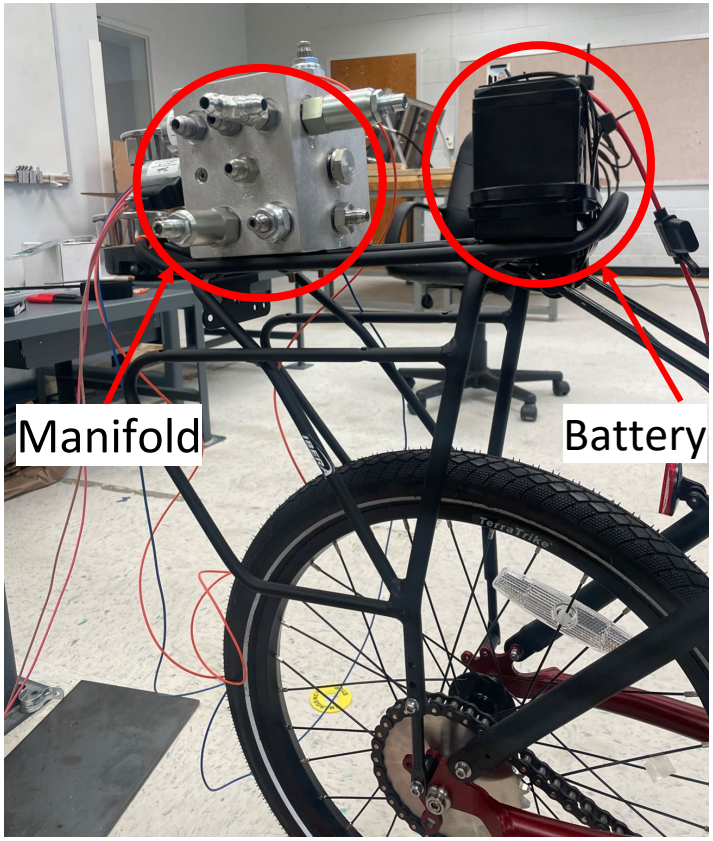
Vehicle Integration

- Placement of major hydraulic components



Vehicle Mounting- Manifold and Battery

- Our manifold and battery were mounted onto the back of the bike using a rack.



Vehicle Mounting-Pump and Motor

- Our pump was mounted in the front of the main frame, while the motor was mounted on the rear rack in the back.

Motor

Pump

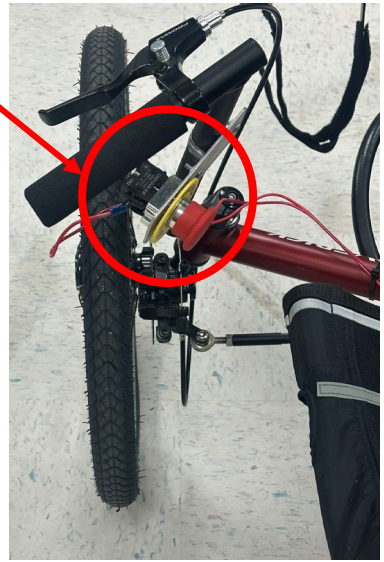
Vehicle Mounting-Reservoir

- Our hydraulic reservoir was mounted behind the vehicle's seat.

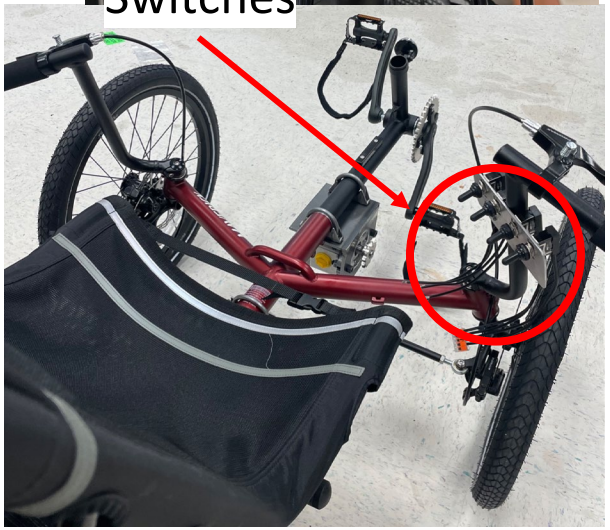
Vehicle Mounting- Switches and ESTOP

- Our switches and ESTOP were mounted to the handles of the bike.

ESTOP

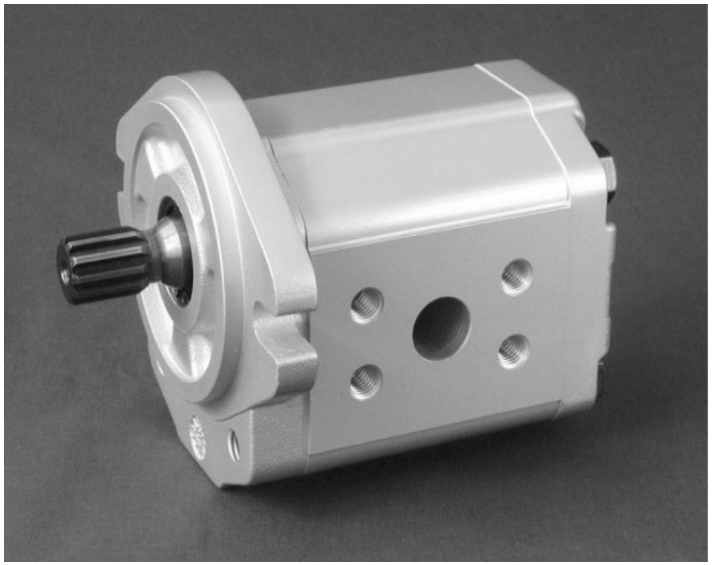


Switches

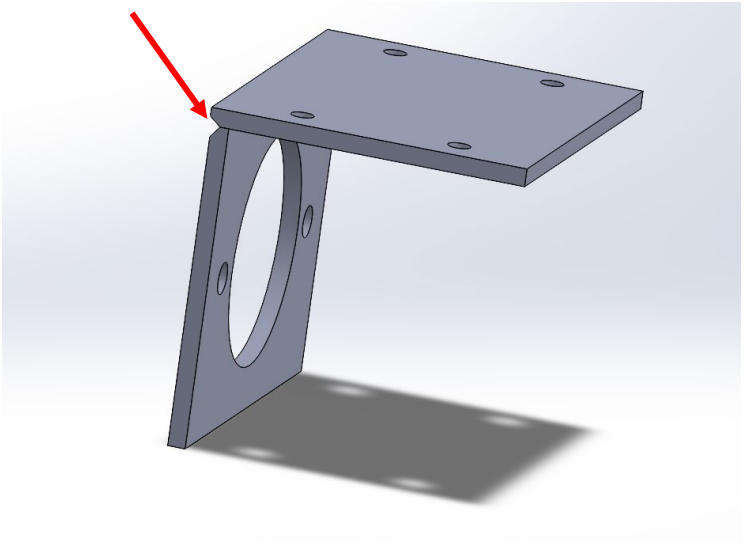


Hydraulic System: Pump

- For this year's competition, we selected a Danfoss 0.513 CID hydraulic gear pump with a 0.625 keyed shaft rotating clockwise to convert energy into fluid pressure for our hydraulic motor and accumulator.



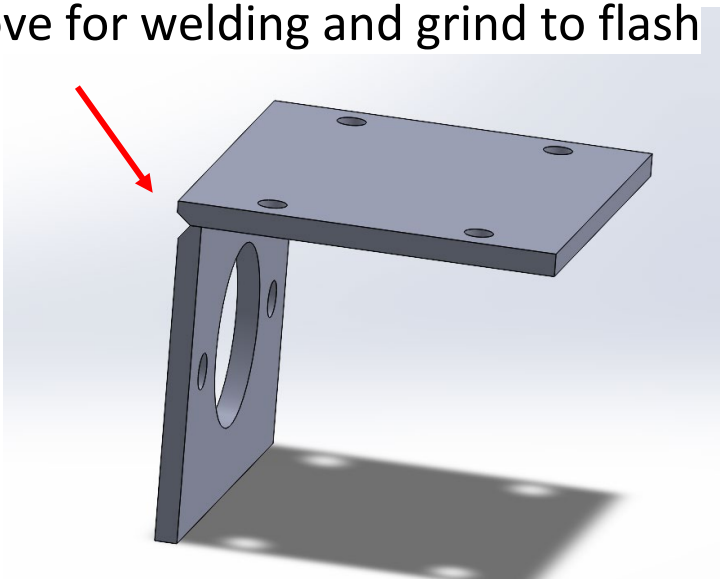
V-groove for welding and grind to flash



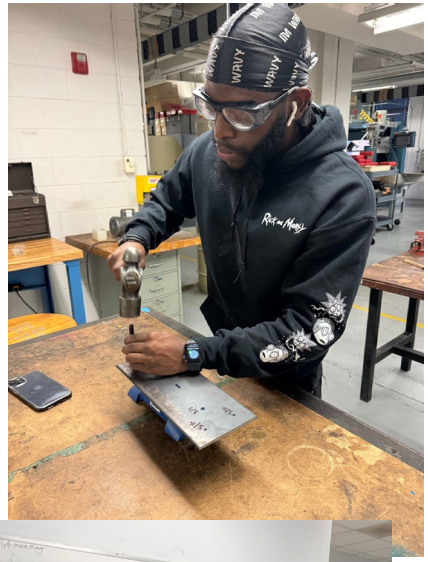
Hydraulic System: Motor

- This year, we selected an IFP 0.25 CID Hydraulic Gear Motor with a ½'' shaft and ⅛'' Key to help convert our hydraulic energy into mechanical energy to propel the vehicle.

V-groove for welding and grind to flash



In-House Work



Vehicle Testing

- We began testing very shortly after having the hoses and electronics installed onto the bike.
- We conducted tests to ensure that all 4 modes of the bike worked properly.
- For racing concerns we then conducted testing for the Speed and Regen Race.

Lessons Learned

- Charging the accumulator to high pressures does not always ensure faster speeds
- It is important to meter out the oil (using flow control valve) so that we can cover longer distances in races where that is required
- Placement of subsystems can be improved upon
- Using an existing frame causes difficulty when mounting subsystems

Acknowledgments

- We want to express our heartfelt appreciation for the following companies and individuals for their invaluable support and guidance throughout this project:
  - Cross Company, SunSource, IFP, Danfoss Power Solutions, Custom Hydraulic & Design, NFPA, Lions Hose and Tube Works, Norgren, Collins Aerospace, and Shell
  - Jeff Starkey (Cross Company), our mentor Eric Jacobs (Danfoss), Ernie Parker, Thaddeus Wolicki (NCAT Machine Shop), Professor Essau (NCAT Mechanical Engineering Department), and Josh Scarbrough (IFP)

Questions?