NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION

Michigan Technological University
David Wanless

4/6/2021

Michigan Tech

Team Introductions

Members: John Kurburski, Jake Lehmann, Andrew Ward
Alexander Provoast
Faculty advisor: Dave Wanless
Mentors: Courtney Castelic & Cedrick Barber

Midway Summary 2/11/21

- Design Objectives: Schematics Finalized Shortly After Midway Review
- Vehicle Design: Placements of Motor and Pump
- Fluid Power Circuit Design: Schematic Was Not Finalized

Midway Summary 2/11/21

- Selection of Hardware: Mix of Parts on Hand, on Order, and Waiting to be Ordered
- Results and Incorporations: Feedback Taken from Both Review and Mentor Consultations, Changed and Improved Designs

Spring Objectives

- Build a Safe and Reliable Vehicle
- Finalize Hydraulic Design
- Finalize Pneumatic Circuit Design
- Fully Assemble Hydraulic and Pneumatic Circuits
- Successfully Test All Functions of the Bike

Bike Assembly

1. Air Tank
2. Air Piston
3. Accumulator
4. Manifold
5. Hydraulic Tank
6. Hydraulic Motor

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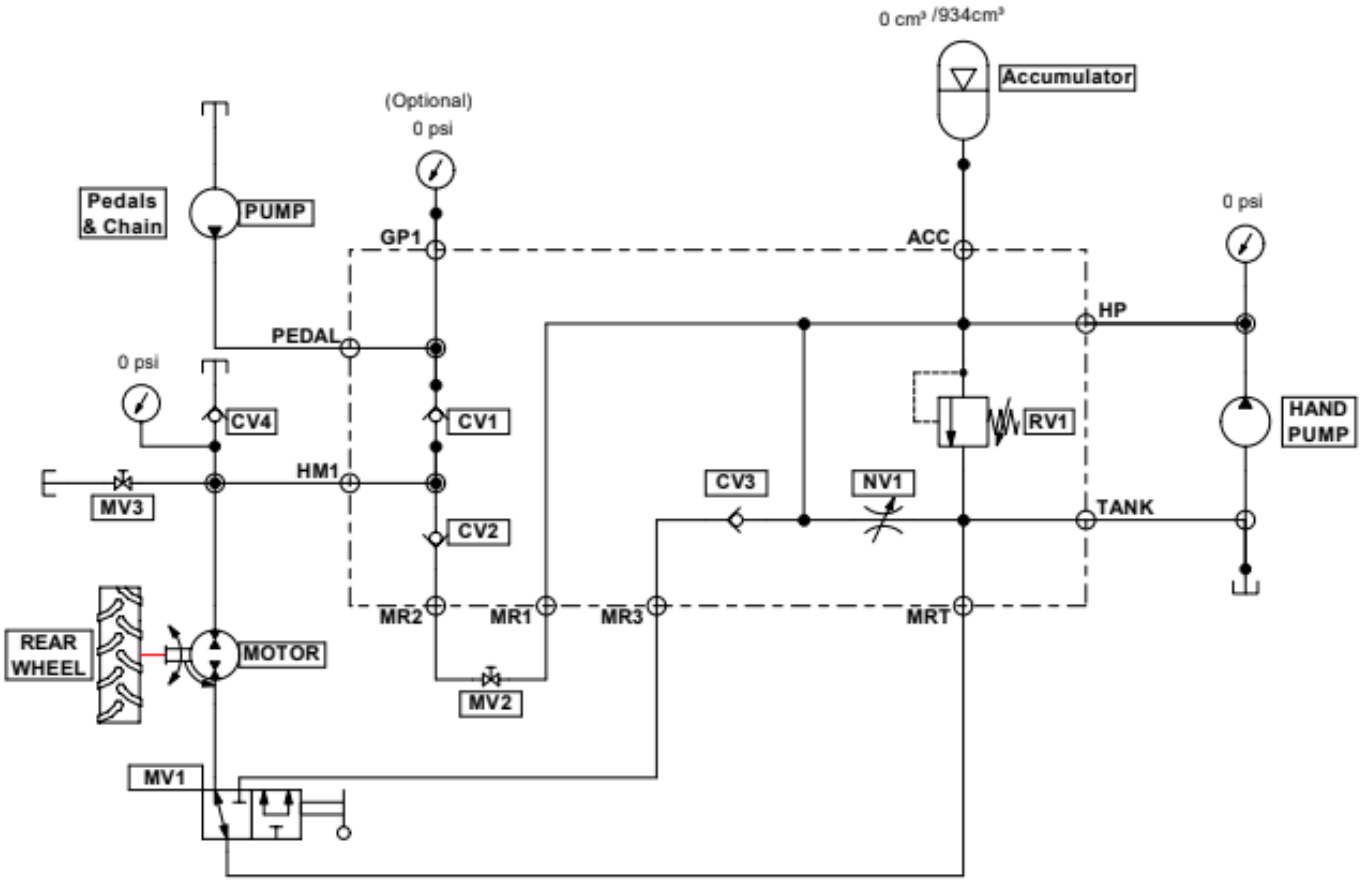
Bike Assembly

1. Air Tank
2. Hand Pump
3. Hydraulic Pump
4. Air Piston

Hydraulic Upgrades

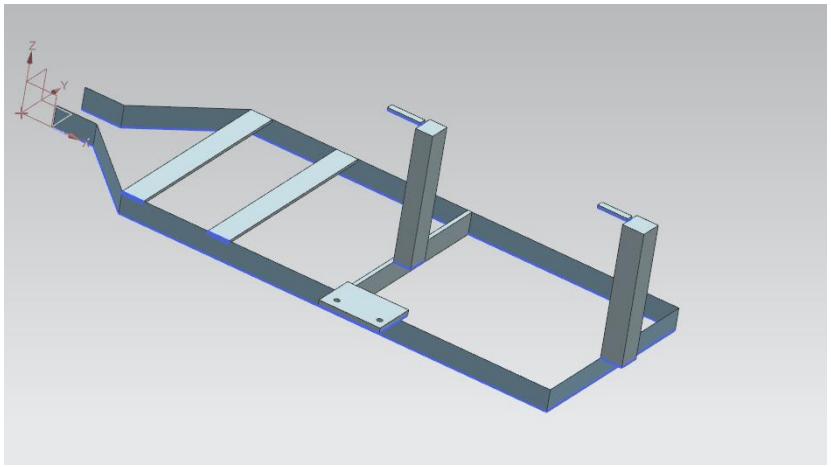
- Smaller & Lighter Accumulator
- Simplified Hydraulic System
- User friendly Valve Actuation Via Pneumatics
- Added Relief and Check Valves

Hydraulic Schematic



Custom Back Rack Design

- Easily Removable
- Strong and Lightweight - Skeleton Design
- Provides Many Mounting Options
- Base of Whole Hydraulic Structure
- Could Be Transferred to Another Bicycle



Pneumatic System Updates

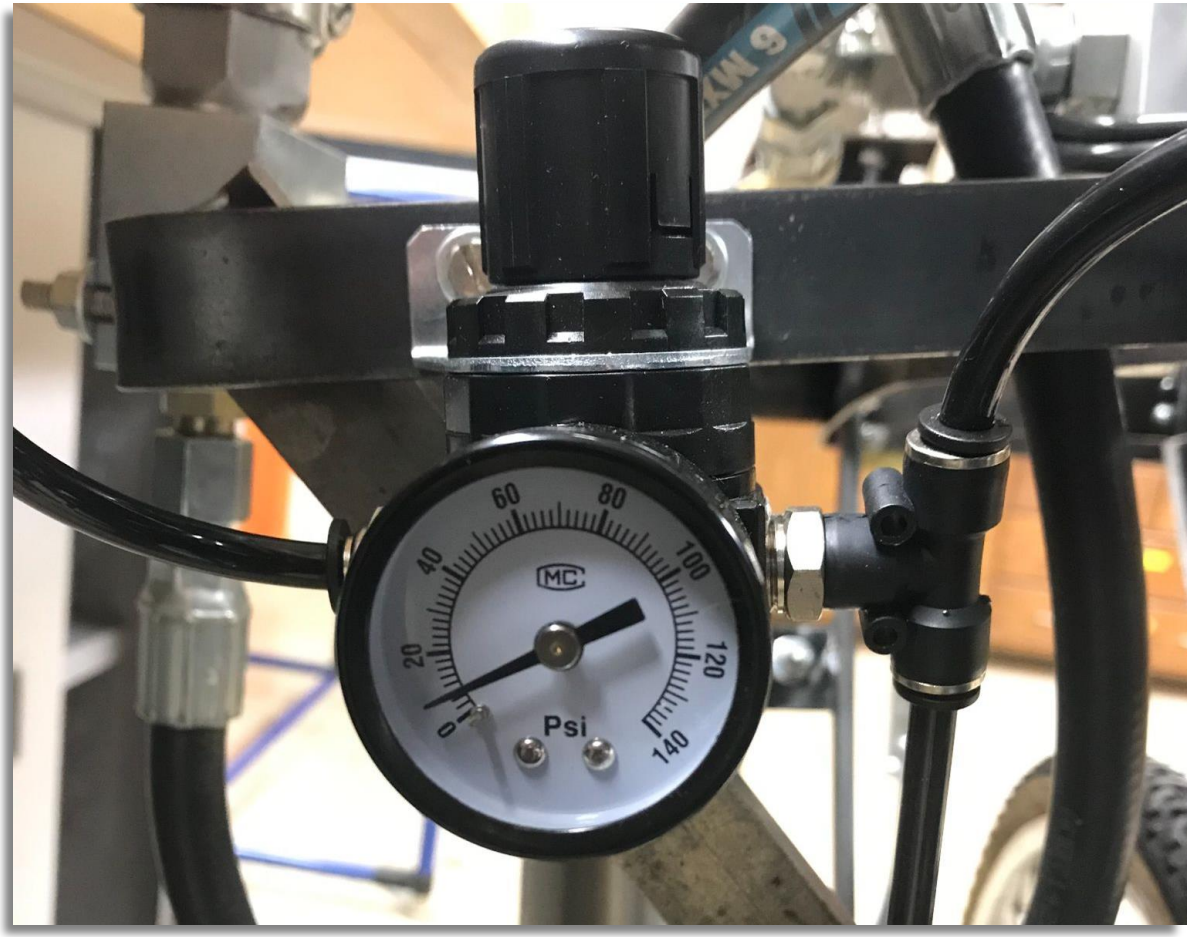
- Finalized Pneumatic Layout
- Spec'd Pneumatic Cylinders
- Ordered and Installed Parts
- Performed System Test

Valve Actuation

- Use of air cylinders to open and close hydraulic valves
- Switches Near Handlebar for Easy Actuation
- Allows Hydraulics and Pneumatics to Work Together

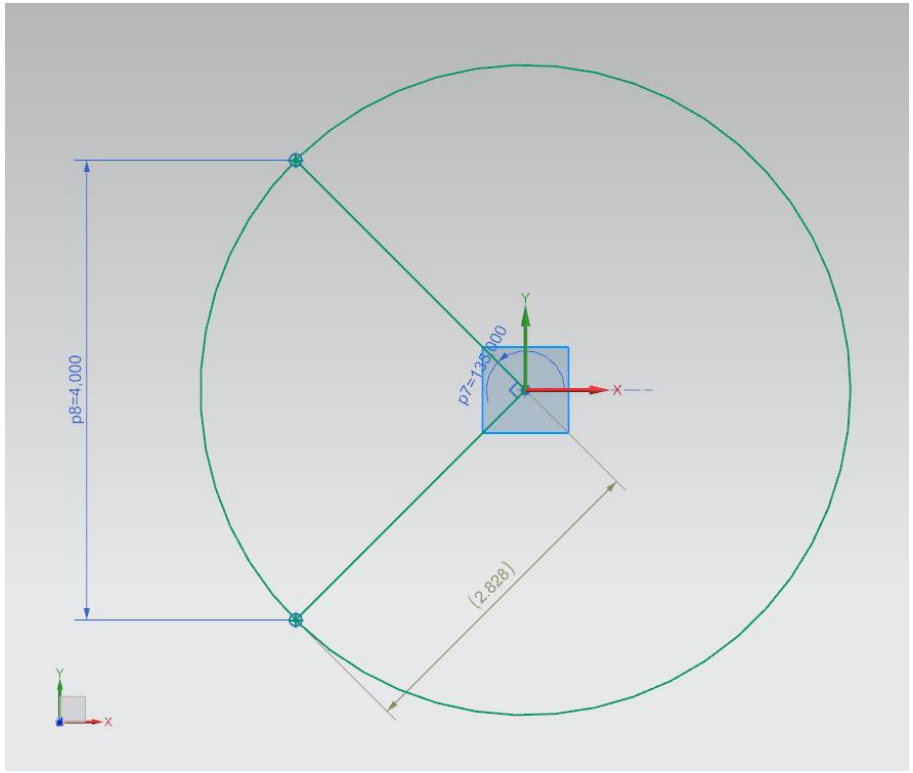
Pneumatic Switches

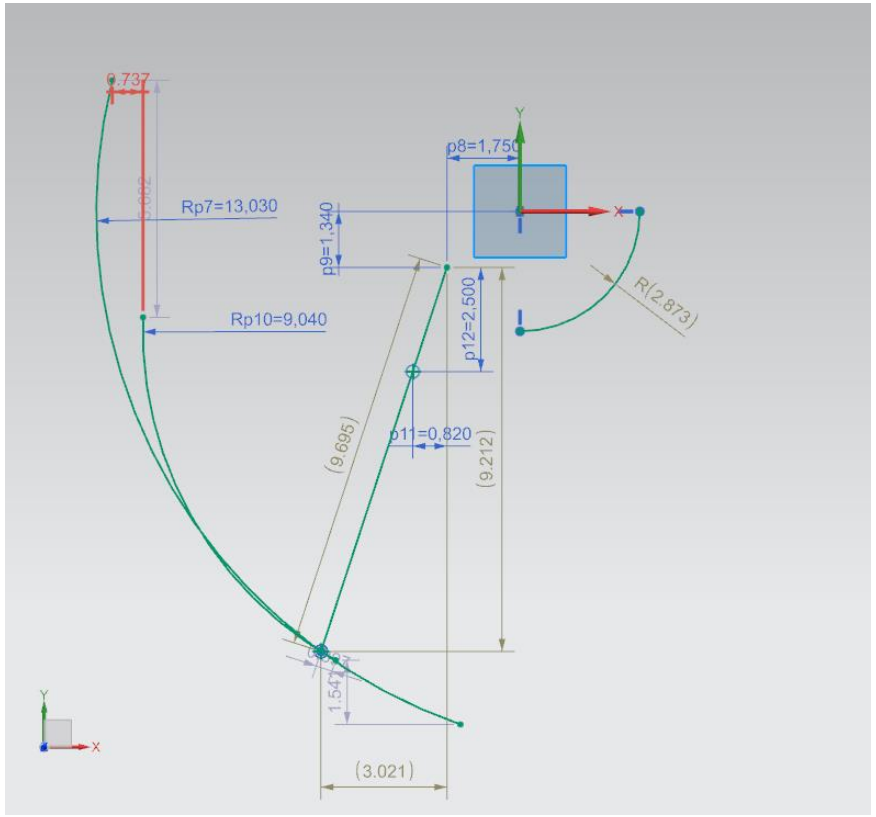
Pressure Regulator



Air Cylinder & Valve

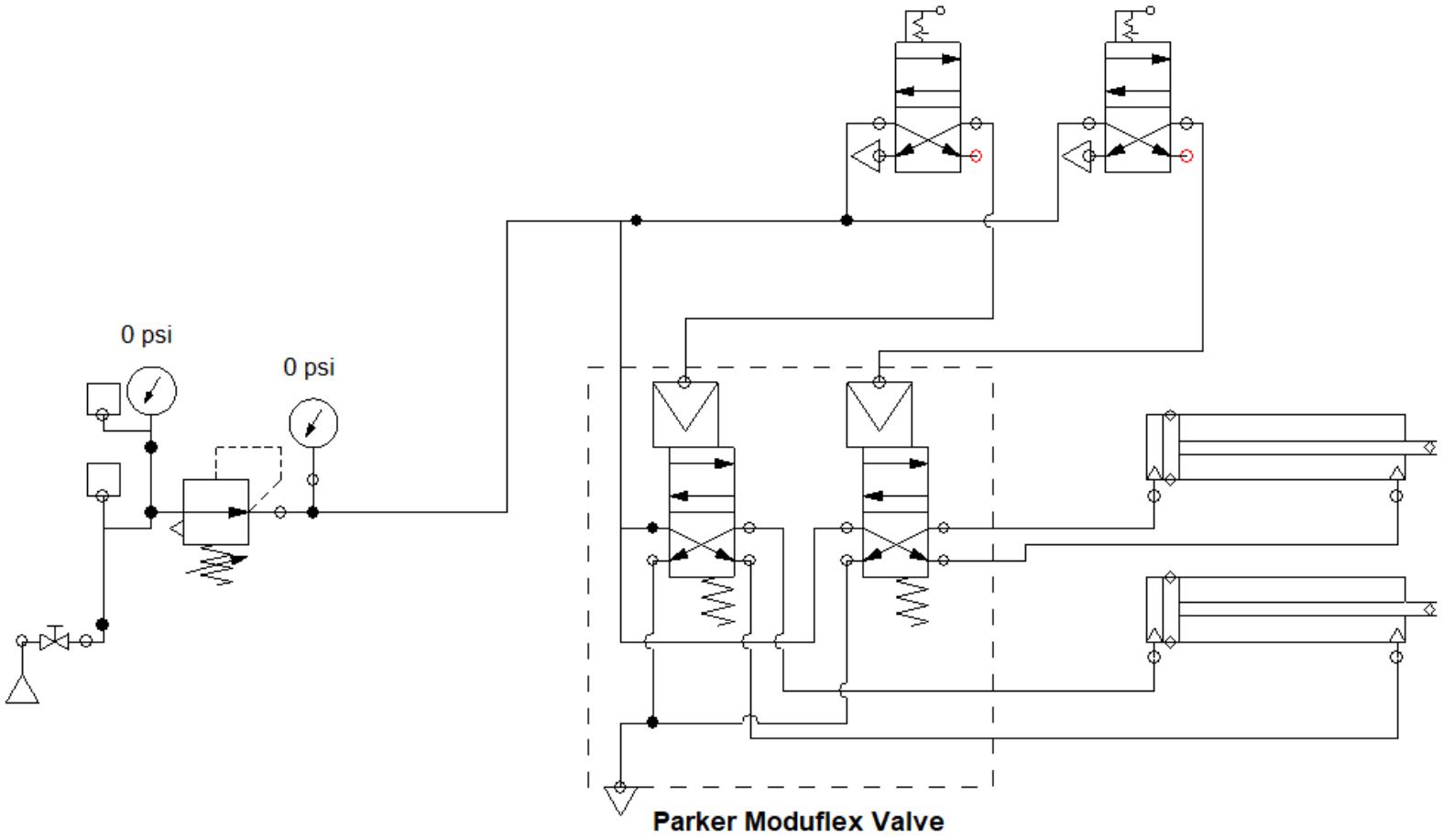
Pneumatic Cylinder Placement Calculations



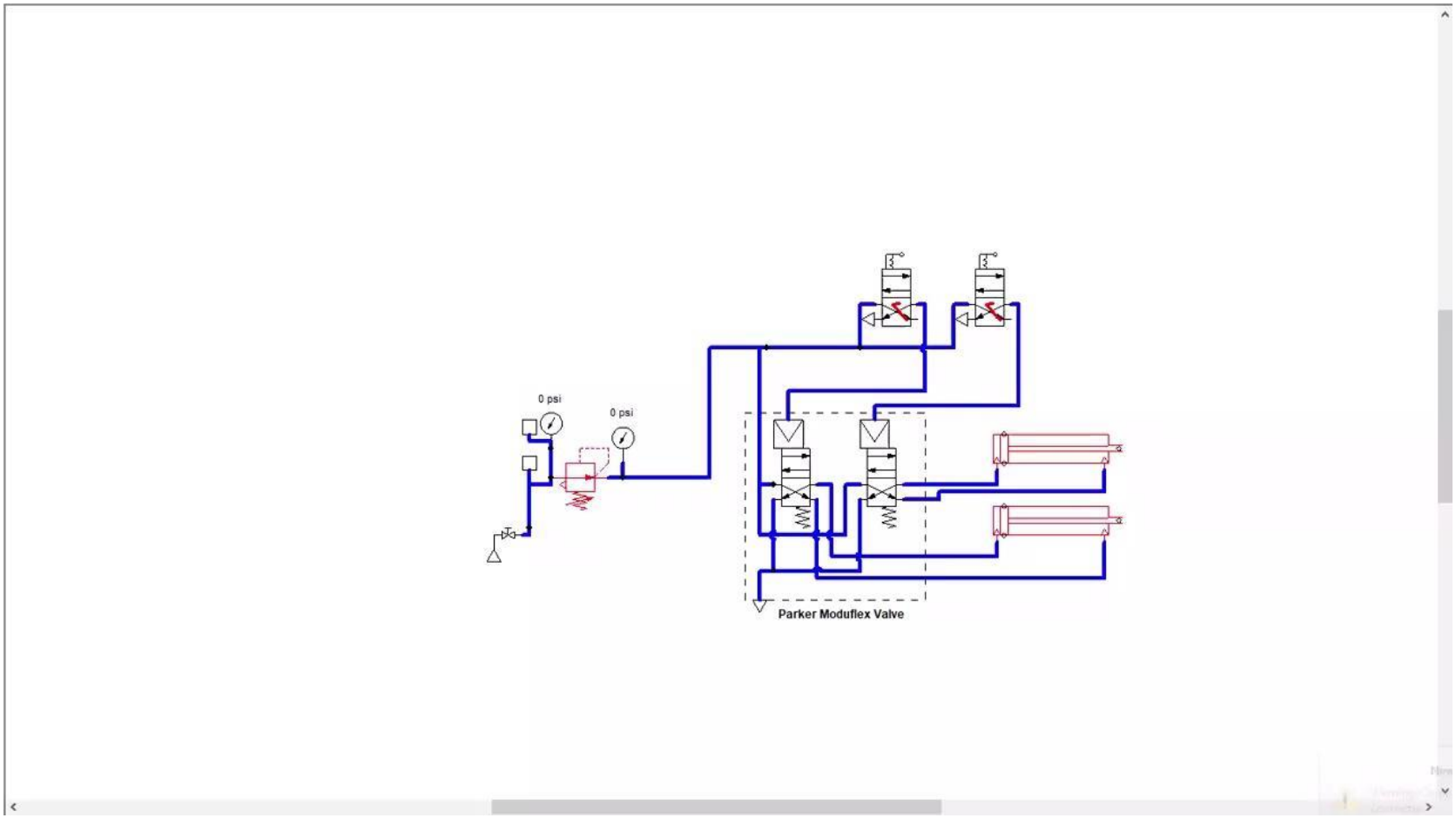


Air Cylinder & Valve

Pneumatic Logic Design



Pneumatic Simulation



Gear Ratio

Original Gearing				
Pedal rpm	Pedal Gear	Pump Gear	Ratio	Pump rpm
80	52	20	2.6	**208**
Motor rpm	Motor Gear	Hub Gear	Ratio	Wheel rpm
208	20	20	1	**208**

New Gearing				
Pedal rpm	Pedal Gear	Pump Gear	Ratio	Pump rpm
80	52	20	2.6	**208**
Motor rpm	Motor Gear	Hub Gear	Ratio	Wheel rpm
208	10	20	0.5	**104**

Original Ratio: 2.6
New Ratio: 1.3

- Motor and Pump work more efficiently at higher rpms.
- Gear ratio between motor and rear wheel restricted motor rpm to wheel rpm.
- 1:1 ratio gear drive between motor and rear wheel was changed to 0.5 to allow for higher motor rpms at lower speeds and higher torque.

Gear Ratio

Original
Meshed gears
40 teeth
Motor/Hub Ratio: 1

New
Sprocket & Chain
10 to 20 teeth
Motor/Hub Ratio: 0.5

Testing

All Tests Performed With 2 Trials

- 180 psi Nitrogen pre charged accumulator
- 1500 PSI charged accumulator

- 500ft Sprint: 29 Seconds
- 1 Mile Endurance: 7Min10Sec
- 100+ ft Efficiency: 25%

Challenges Faced

- Part Orders Delayed or Backordered
- Time Crunch
- Learning Curve of Hydraulics and Pneumatics
- Correct Size and Length Hoses
- Covid Restrictions
- Pulsations While Pedaling

Lessons Learned

- Deeper Understanding of Both Pneumatics and Hydraulics
- Machining and Fabricating Skills
- Communicating with Industry Contacts
- Dealing with Setbacks

Thank You for Your Time

Are There Any Questions?