

10 YEARS

N F P A

Fluid Power

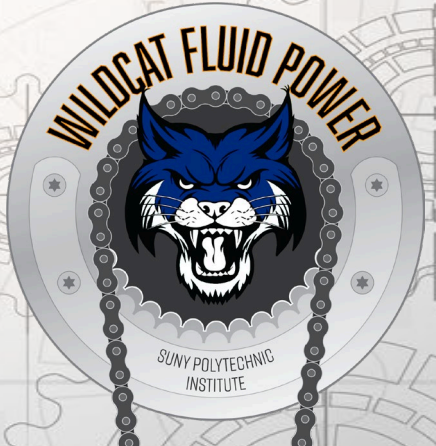
=VEHICLE

Challenge

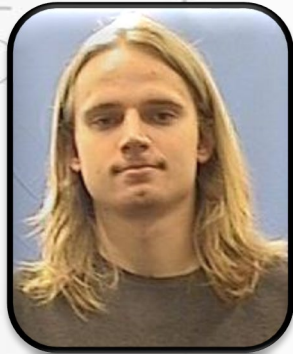


SUNY POLYTECHNIC INSTITUTE

Final Presentation
Wildcat Fluid Power
Ahmed Abdelaal
4/15/2026



The Team



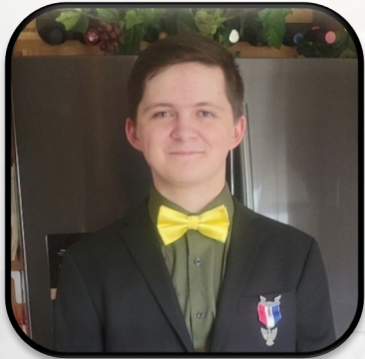
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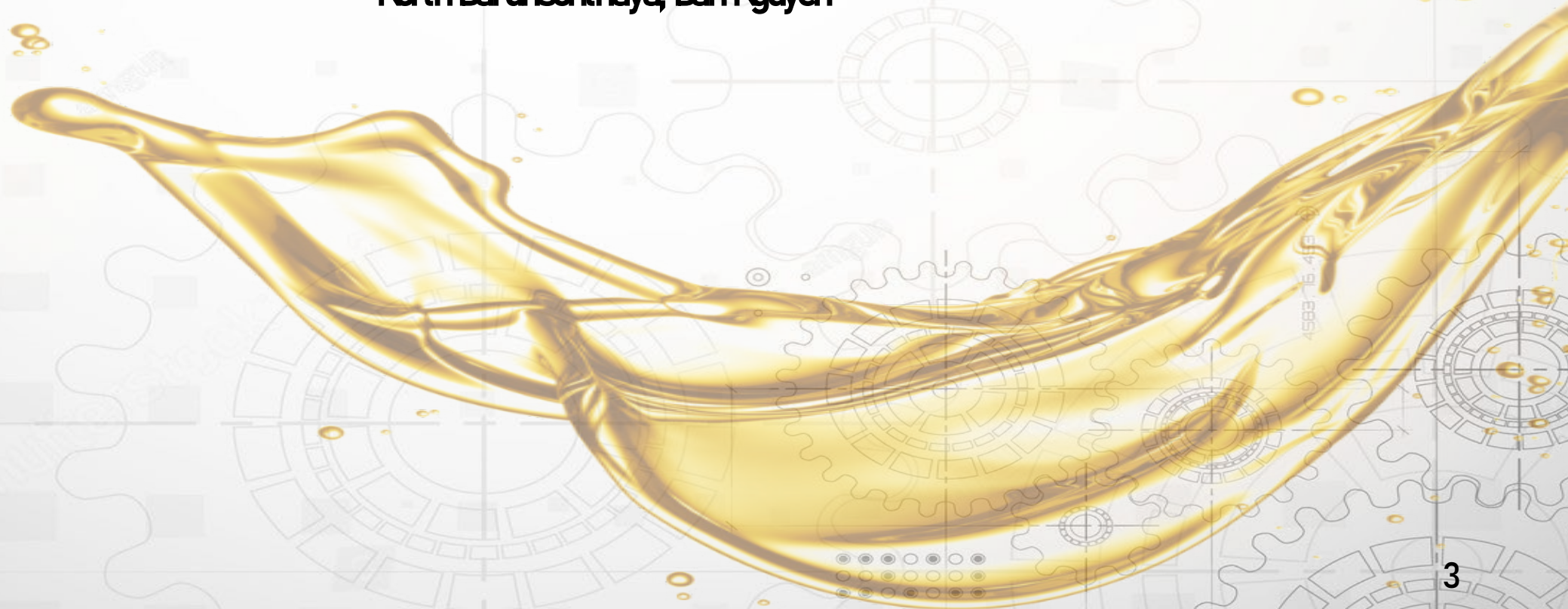
Dan Nguyen
WFP Member
Hydraulic Design





Hydraulic Design

North Darunsonthaya, Dan Nguyen



Drive Pump

| | |
|--------------|---------------------------|
| Brand | Marzocchi |
| Type | External gear |
| Model # | ALPIA-D-7 |
| Material | Aluminum |
| Rotation | Clockwise |
| Displacement | 5.2 cm ³ /rev. |
| Provider | Iowa Fluid Power |



Fig. 1: Marzocchi Gear Pump



Accumulator

| | |
|----------------|---------------------|
| Brand | Hydac |
| Model # | SB330-4A1/112S-210C |
| Material | Carbon Steel Shell |
| Capacity | 1 gallon |
| Pressure Range | 0-3000 psi |



Fig. 2: Hydac Bladder Accumulator

Motors



| | |
|--------------|----------------------------|
| Brand | Dynamic FC |
| Type | External Gear |
| Model # | GM-F10-41-P-B |
| Material | Aluminum |
| Rotation | Bi-directional |
| Displacement | 4.1 cm ³ / rev. |
| Provider | Iowa Fluid Power |

| | |
|--------------|----------------------------|
| Brand | Dynamic FC |
| Type | External Gear |
| Model # | GM-F10-52-P-B |
| Material | Aluminum |
| Rotation | Bi-directional |
| Displacement | 5.2 cm ³ / rev. |
| Provider | Iowa Fluid Power |

| | |
|--------------|----------------------------|
| Brand | Dynamic FC |
| Type | External Gear |
| Model # | GM-F10-41-P-B |
| Material | Aluminum |
| Rotation | Bi-directional |
| Displacement | 4.1 cm ³ / rev. |
| Provider | Iowa Fluid Power |



Fig. 3:
Dynamic FC 4.1cc Motor



Fig. 4:
Dynamic FC 5.2cc Motor

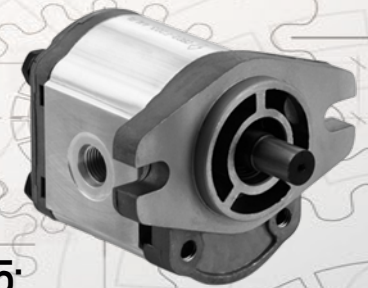
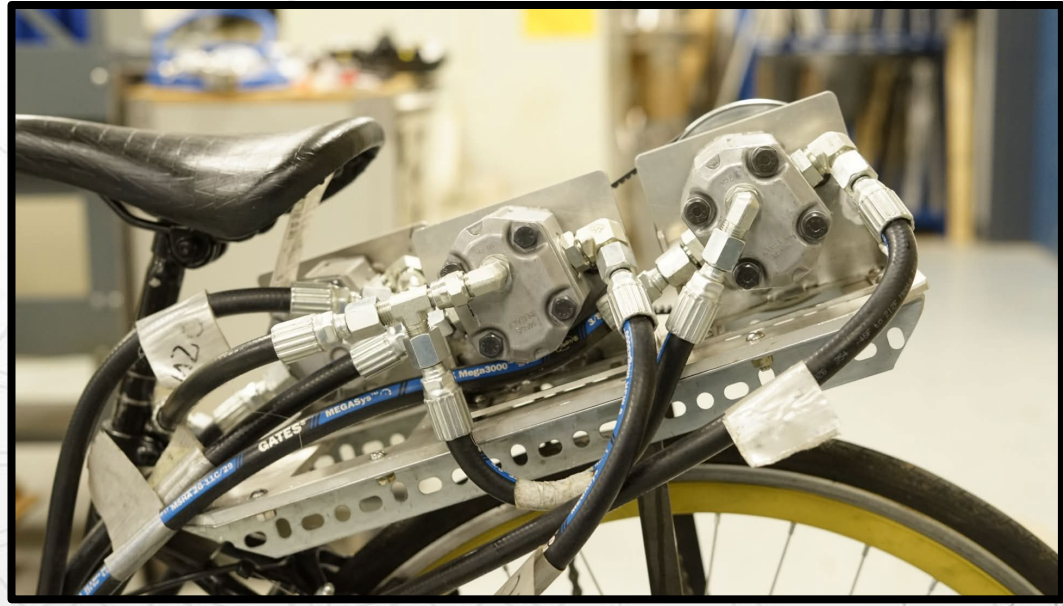


Fig. 5:
Dynamic FC 4.1cc Motor



Hydraulic Calculations



Table 1: Effects of Pedal Gearbox on Fluid Circuit

| Pump Data based on Pedal Gearbox | | | | | | | | |
|----------------------------------|-----------------------------|-------------|-----------------------|------------|------------|----------------------|-------------------|------------|
| 300W Sustained Pedaling | | | | | | | | |
| Gear | Pump [in ³ /rev] | Pedal [rpm] | Pedal Torque [in*lbf] | Gear Ratio | Pump [rpm] | Pump Torque [in*lbf] | Pump [gallon/min] | Pump [psi] |
| 1 | 0.3172 | 55 | 360 | 5.25 | 288.75 | 68.57 | 0.40 | 1358.28 |
| 2 | 0.3172 | 50 | 360 | 6.60 | 330.00 | 54.55 | 0.45 | 1080.45 |
| 3 | 0.3172 | 50 | 360 | 8.05 | 402.50 | 44.72 | 0.55 | 885.84 |
| 4 | 0.3172 | 45 | 360 | 10.20 | 459.00 | 35.29 | 0.63 | 699.12 |
| 5 | 0.3172 | 40 | 360 | 12.50 | 500.00 | 28.80 | 0.69 | 570.48 |
| 6 | 0.3172 | 40 | 360 | 15.65 | 626.00 | 23.00 | 0.86 | 455.65 |

Table 2: Motor Torque based on Accumulator Parameters

| Motor & Wheel Data based on Accumulator Parameters | | | | | | | | | |
|--|------------------------------------|-----------------|---------------------|---------------------------|----------------------------|----------------------------|----------------------------|----------------------------|---------------------------------|
| Motor Displacement [in ³ /rev] | Max. Pressure of Accumulator [psi] | Precharge [psi] | Wheel Diameter [in] | Avg. Motor Pressure [psi] | Avg. Motor Torque [in*lbf] | Max. Motor Torque [in*lbf] | Avg. Wheel Torque [in*lbf] | Max. Wheel Torque [in*lbf] | Accumulator Usable Volume [psi] |
| 0.250 | 3000 | 750 | 26.5 | 1409.25 | 15.6 | 37.9 | 72.6 | 176.7 | 172.4 |
| 0.500 | 3000 | 750 | 26.5 | 1409.25 | 59.4 | 144.7 | 277.3 | 675.0 | 172.4 |
| 0.568 | 3000 | 750 | 26.5 | 1409.25 | 123.8 | 301.4 | 577.9 | 1406.6 | 172.4 |
| 0.818 | 3000 | 750 | 26.5 | 1409.25 | 167.7 | 408.2 | 782.6 | 1905.0 | 172.4 |



Mechanical Design

Alex Sortor, Aiden Kostlecki

Changes From Last Year

- Clubs first 3-wheeled design
- Variable displacement motor
 - 3 separate motors with different displacements
 - Allows 3 distinct displacements
- Better rider ergonomics
 - Accumulator location
 - Reservoir location
 - Lower center of gravity



Fig. 6: 2024 -2025 Vehicle

Bike Design

- Tilting Cargo Trike Design
- Built by club members, using school facilities

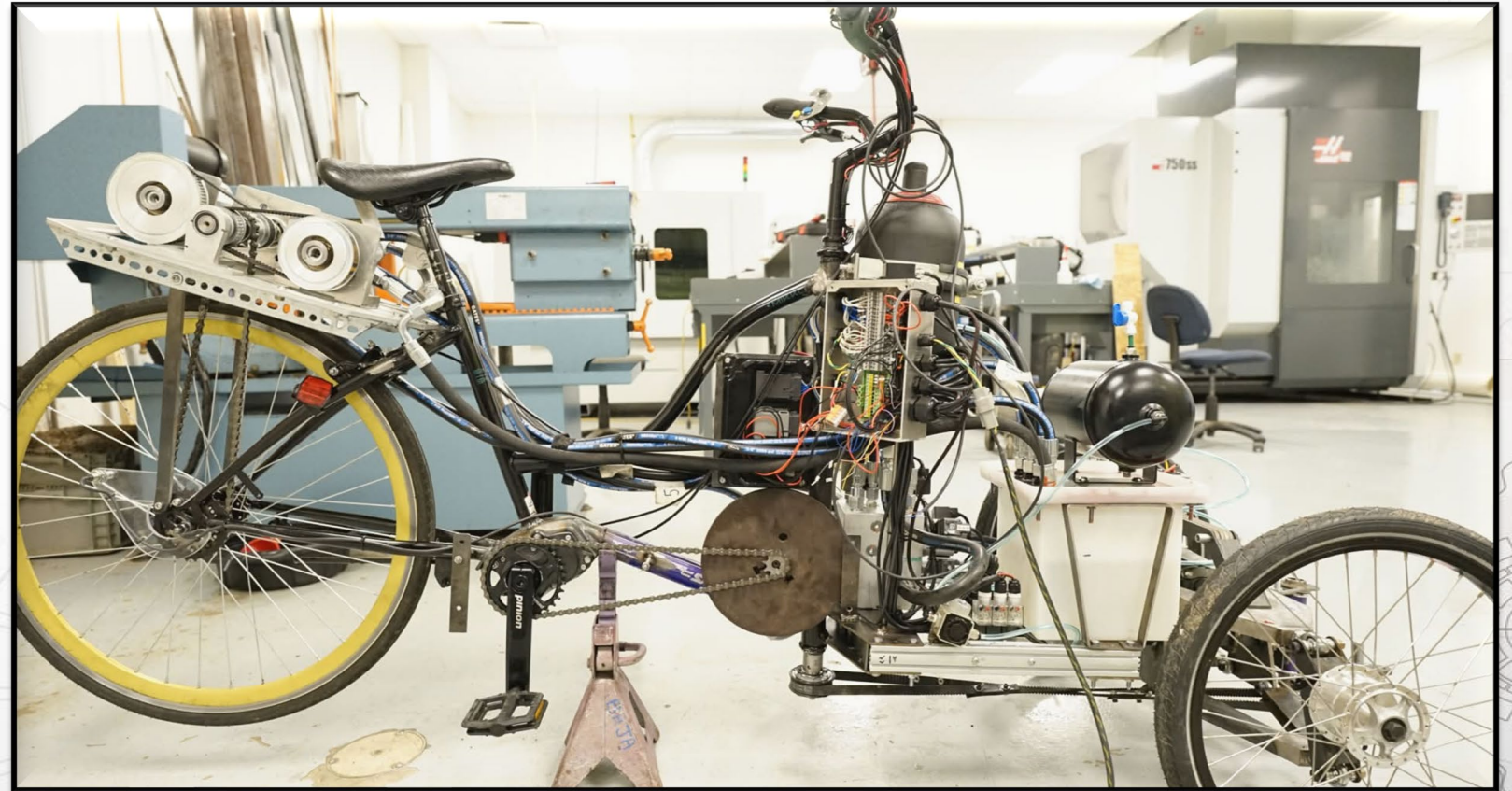


Fig. 7: 2025 – 2026 Vehicle

Pinion Crankset Gearbox

- 6-speed German engineered gearbox
 - Input from crankset, output to drive pump
 - 295% gear range
 - Total pump gear ratio from 3:1 to 10:1

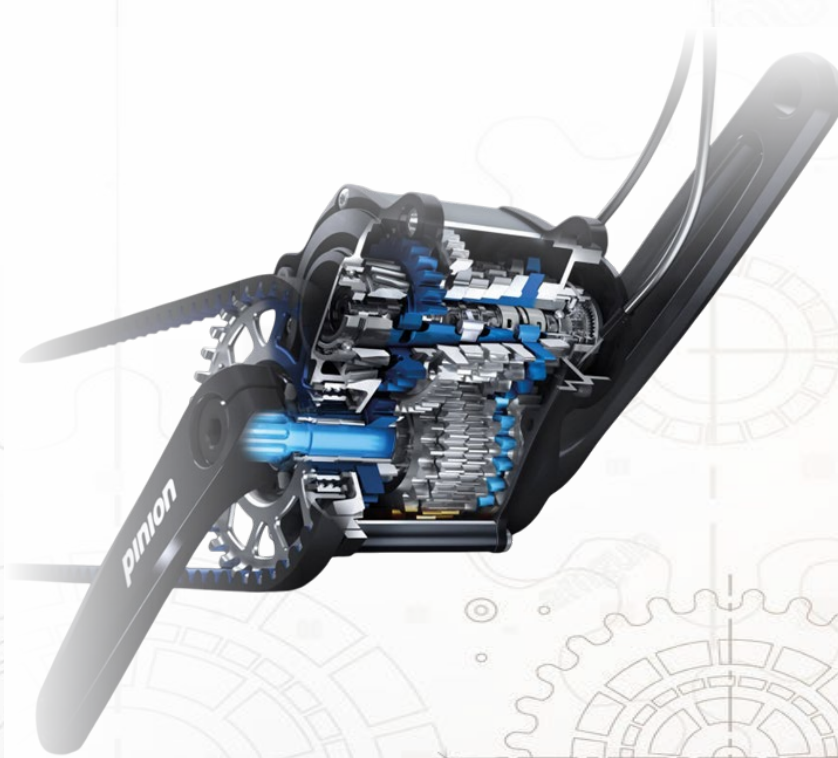


Fig. 8:
Pinion 6-Speed
Gearbox Cutaway



Fig. 9:
Pinion Gearbox



Rear wheel motor arrangement

- Variable displacement motor
 - 3 Motors to achieve 3 effective gear ratios by varying total displacement
 - Motor 1 (4.1 cc)
 - Motors 1 and 2 (8.2 cc)
 - Motors 1, 2, and 3 (13.4 cc)

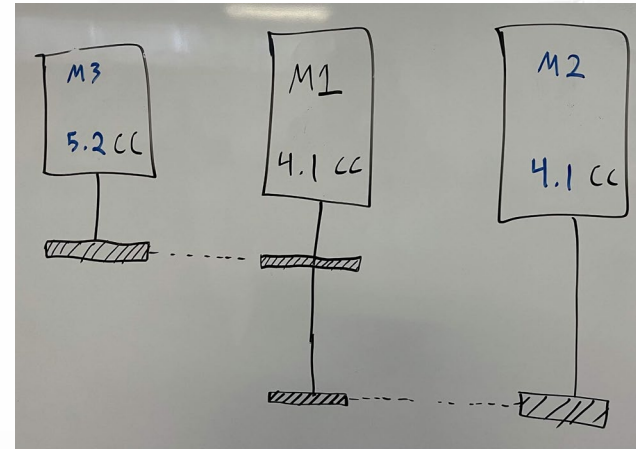


Fig. 10:
Variable
Displacement
Motor
Configuration



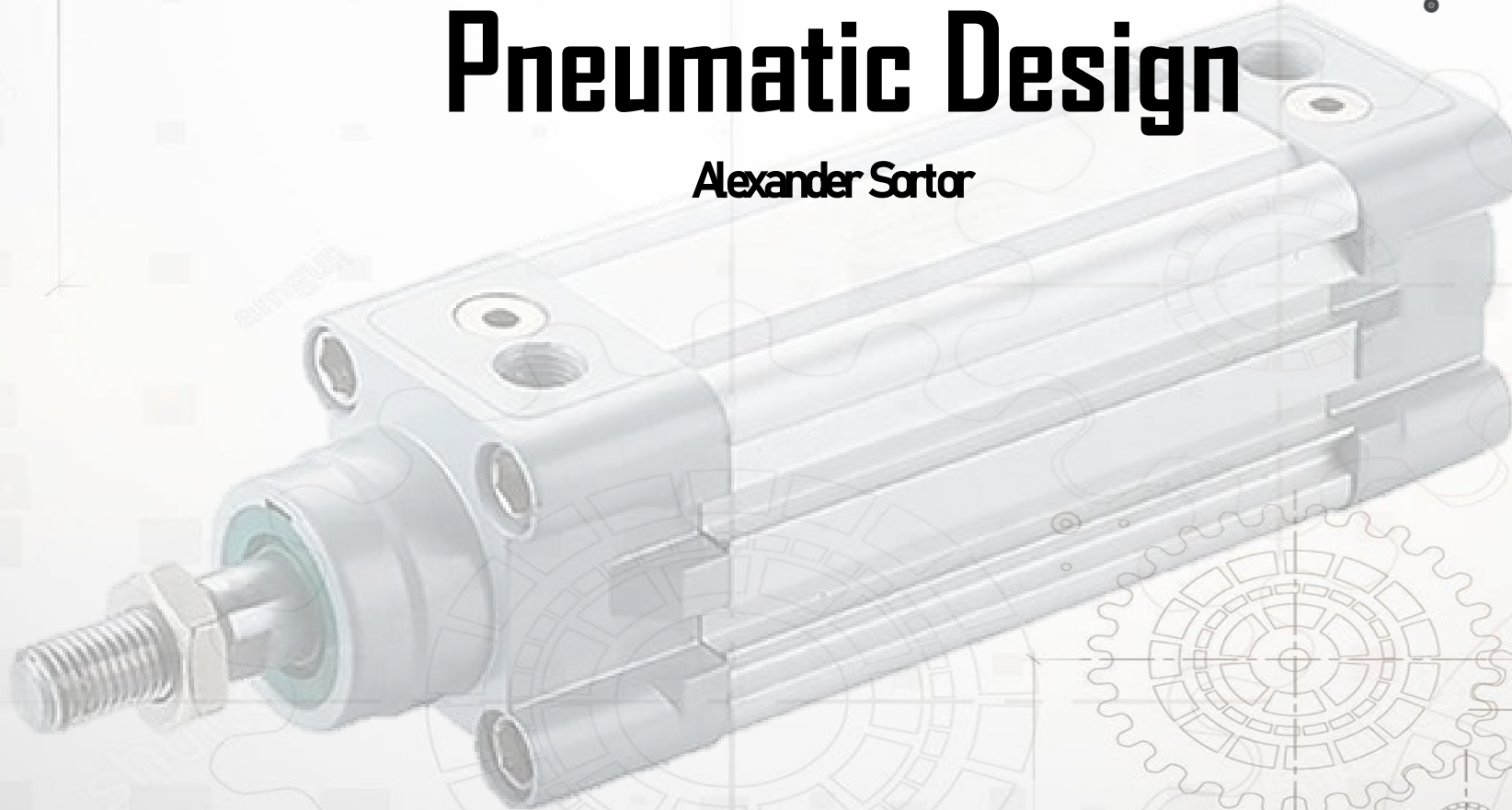
Fig. 11:
Motor
configuration on
bicycle





Pneumatic Design

Alexander Sortor



Diagram

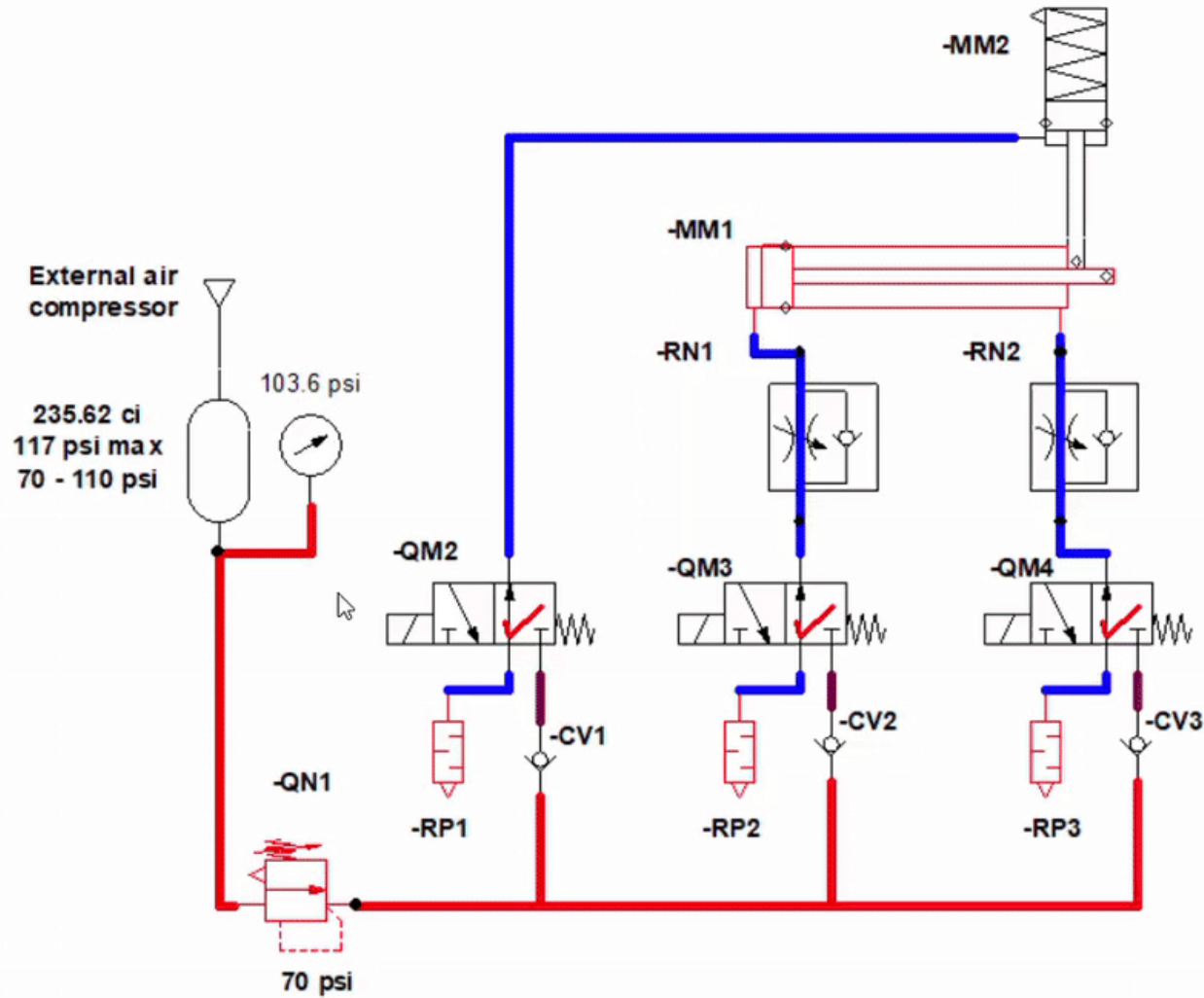


Fig. 12: 2025 - 2026 Pneumatic Diagram Operation

Pneumatic Usage

- Prevent the bike from leaning and center it based on speed
- Uses a pneumatic cylinder placed within the front suspension



Fig. 13:
Pneumatic Cylinder
In Suspension



Electrical Design

Robert Bohl, Braeton Henzel



Components



Components

Controller

IFP Control Kit

- uControl MC3-21-10




Fig. 14: uControl MC3-21-10 PLC

Components



Fig. 16: Momentary Buttons



Fig. 17: Installed Buttons

Components

Battery of Choice

- Talentcell Lithium Ion Battery
- 12V-24V
- 35,000 mAh
- Includes its own on/off switch



Fig. 15: Talentcell Lithium Battery



Components

Angular Position Sensor

- Used to determine the tilt of the bike
- 0-5V output
- Will be used to up-write for pneumatic controls



Fig. 20: Voltage Output Inclinometer



Components

Cadence & Speed Sensors

- Inductive Sensors 24VDC NPN
- Monitor pedals & rear wheel rotation speed

Sensor Pulses




Fig. 18: Expected Output (Square Wave)





Fig. 19: NPN Proximity Sensor Configuration



Components

Controller

IFP Control Kit

- uControl MC3-21-10

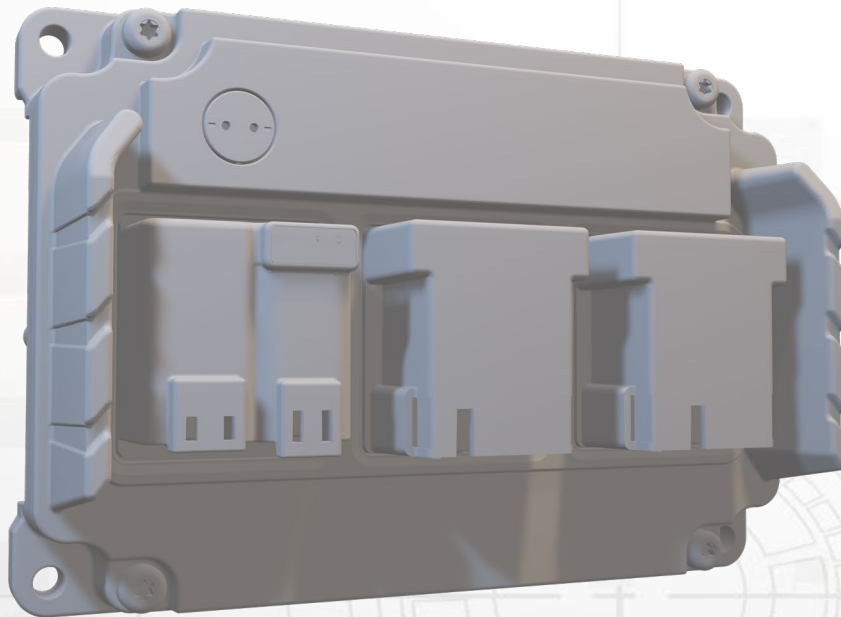


Fig. 14: uControl MC3-21-10 PLC

Components

Battery of Choice

- Talentcell Lithium Ion Battery
- 12V-24V
- 35,000 mAH
- Includes its own on/off switch



Fig. 15:
Tallentcell Lithium Battery



Components



Fig. 16: Momentary Buttons



Fig. 17: Installed Buttons

Components

Cadence & Speed Sensors

- Inductive Sensors 24VDC NPN
- Monitor pedals & rear wheel rotation speed

Sensor Pulses

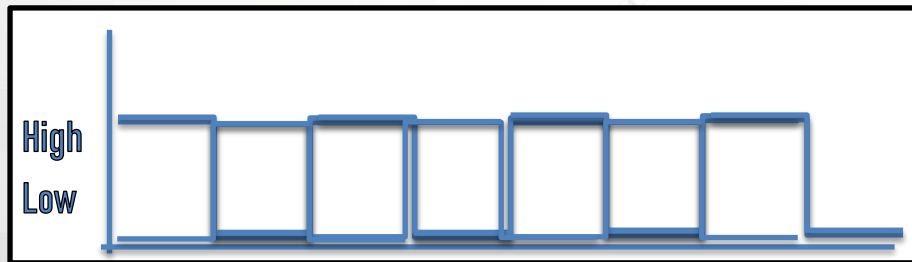


Fig. 18: Expected Output
(Square Wave)

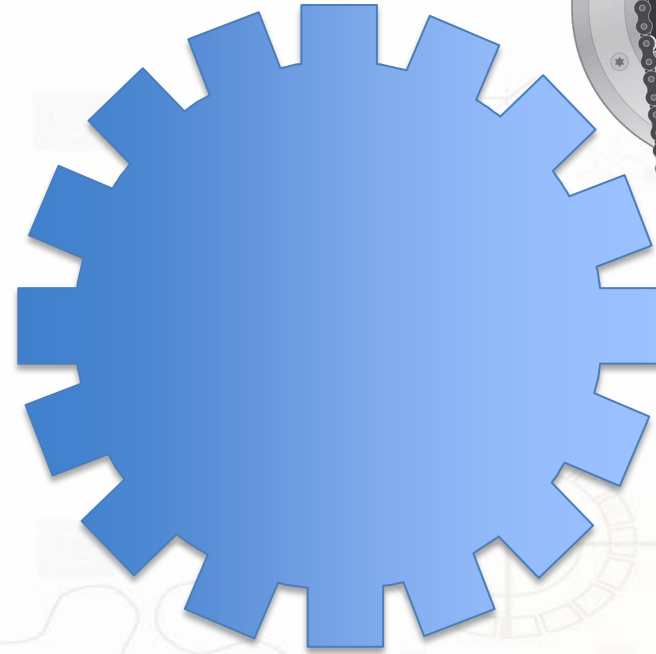


Fig. 19: NPN
Proximity Sensor
Configuration

Components

Angular Position Sensor

- Used to determine the tilt of the bike
- 0-5V output
- Will be used to up-write for pneumatic controls



Fig. 20: Voltage Output Inclinometer



Pneumatics Program

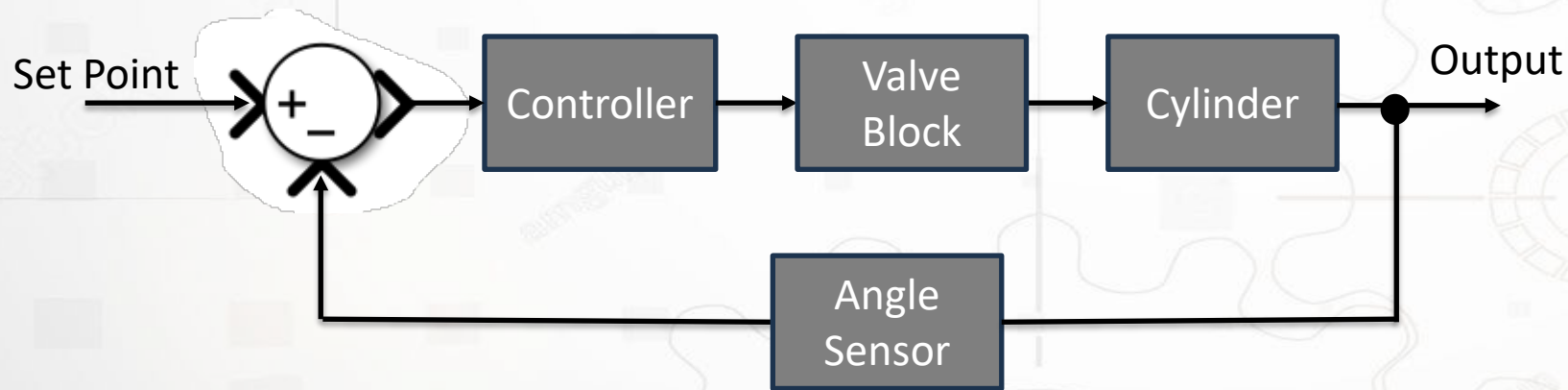


Fig. 21: Pneumatics Control Logic Loop

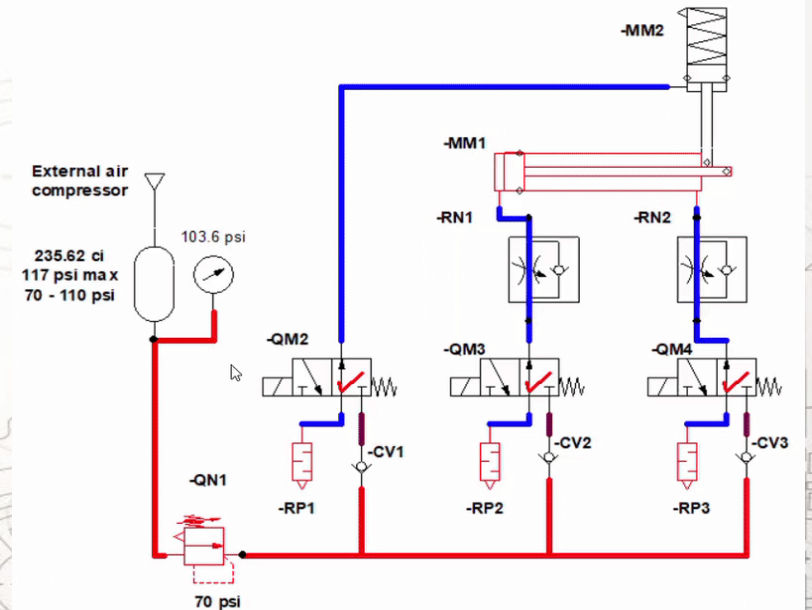


Fig. 22: Pneumatic Diagram Operation

**This program will only run when the bike is stationary

PLC Program

PLC Software

- Uses Codesys software



CODESYS

Fig. 23: Codesys



```
IF (PB1=TRUE) THEN // Mode 1 Drive
    CASE_Var:= 100;
END_IF

IF (PB2=TRUE) THEN // Mode 2 Coast
    CASE_Var:= 200;
END_IF

IF (PB3=TRUE) THEN // Mode 3 Charge
    CASE_Var:= 300;
END_IF

IF (PB4=TRUE) THEN // Mode 4 Discharge
    CASE_Var:= 400;
END_IF

IF (PB5=TRUE) THEN // Mode 5 Regen
    CASE_Var:= 500;
END_IF
```

Fig. 24: Code Sample - Buttons



Lessons Learned

Difficulties and Lessons Learned

- Lost & incorrect shipments, prolonged delays
- Motor failures & replacement
- Overambitious design
- Need time to test and acquire experimental data



Acknowledgements

Huge thanks to our sponsors,
organizers, and advisor

- NFPA: FPVC Organizer and Sponsor
- Danfoss mentor : Nate Fulbright
- Iowa Fluid Power: Component Supplier
and Manifold Manufacturer
- Applied Fluid Power : Component
Supplier
- IM : Component Supplier



NFPA
Education and
Technology
Foundation



Dr. Ahmed Abdelaal
PHD club advisor, and biggest fan

Questions ?

