

N F P A

Fluid Power

VEHICLE

Challenge



NFPA
Education and
Technology
Foundation

Final Presentation
TENNESSEE STATE UNIVERSITY
DR. MOHAMMAD HABIBI
April 7th, 2026



TENNESSEE
STATE UNIVERSITY

AGENDA

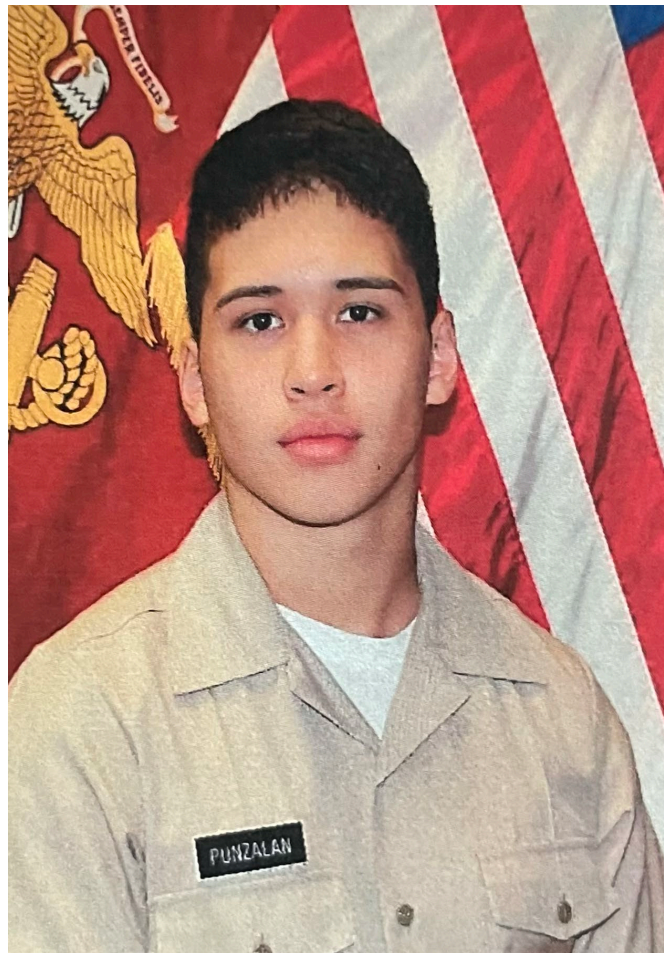
- Team Introductions
- Previous Year Design
- Improvements
- Design Choices
- This Year Hydraulic Design
- Vehicle Construction
- Vehicle Testing
- Final Vehicle Brought to Competition
- Regenerative Braking
- Lessons Learned
- Safety
- Questions?

MEET THE TEAM



Donovan Davis
Mechanical Engineering
Junior

MEET THE TEAM



Jesse Punzalan
Mechanical Engineering Junior

MEET THE TEAM

Freshman Team Members



Gregg Moore

Mechanical Engineering

Sa'Mya Quinney

Mechanical Engineering

Joe Tunstall

Mechanical Engineering

MEET THE TEAM

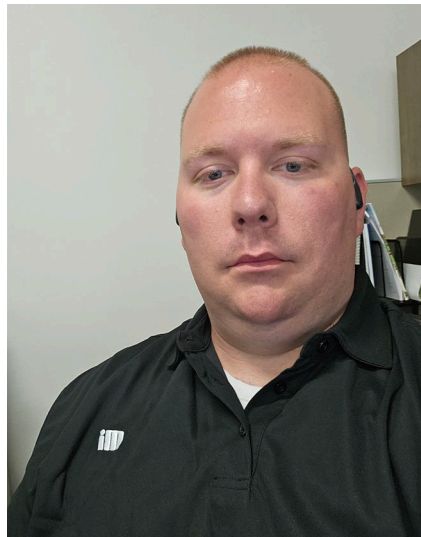


Dr. Mohammad Habibi
Faculty Advisor
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MENTORS & TECHNICAL LIAISON



Steve Gluck, CFPHS
Technical Liaison



Joshua Rodman
Industry Mentor
Motion Industries



Jonathan Johnson
Industry Mentor
Motion Industries

IMPROVEMENTS FROM PRIOR DESIGN

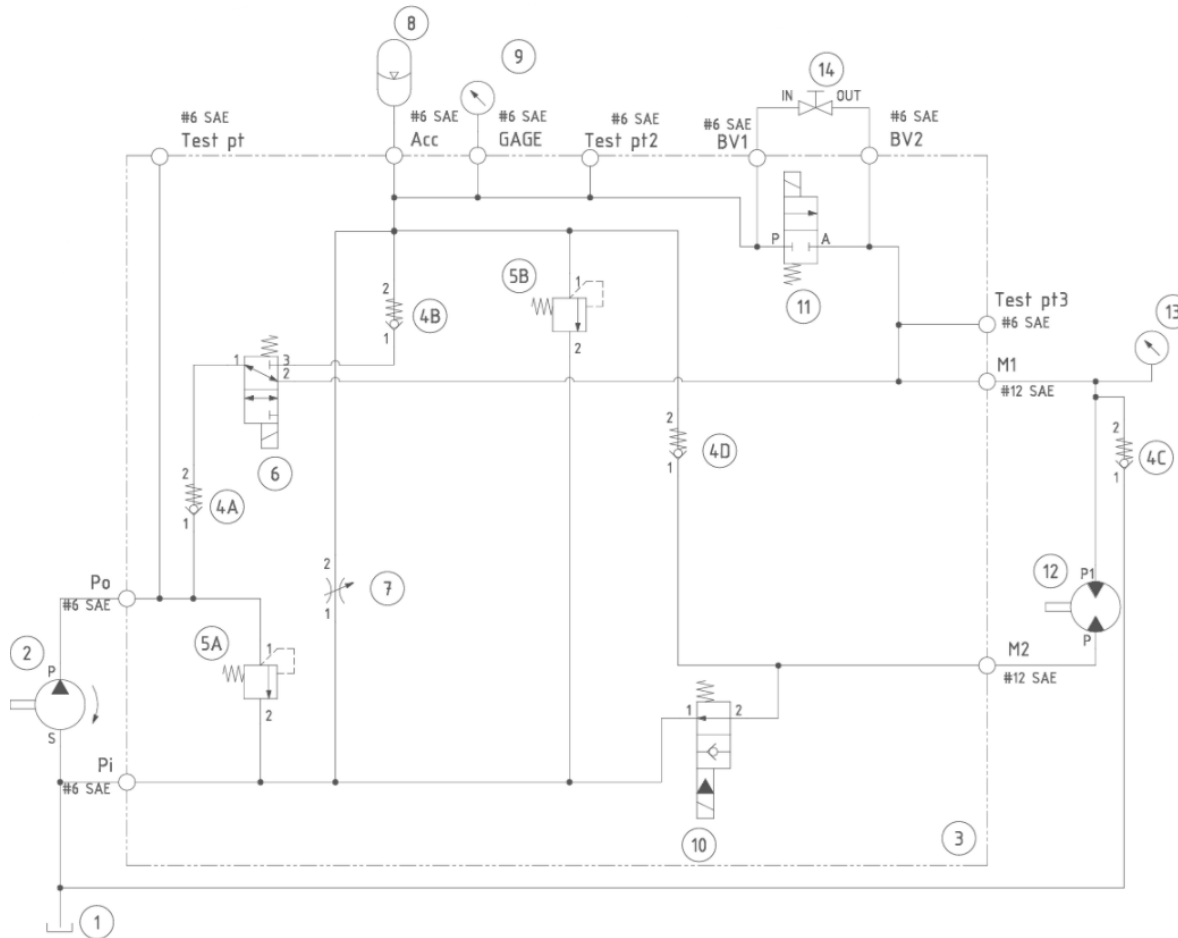


- Replaced manually switched solenoid valves with HMI-controlled solenoid valves for improved operator control
- Designed new, lighter mounting platform with significantly more space for all hydraulic and electrical components
- Optimized pump and motor displacements (CID) for better system efficiency and flow matching
- Corrected gear ratios between motor-to-wheel and pump-to-pedal sprockets
- Optimized hose diameters for reduced pressure drop and improved fluid flow

Design Choices

- Selected a recumbent bicycle frame for easier access to the rear wheel sprocket, allowing simple conversion from freewheel to fixed sprocket
- Improved overall weight distribution using a strategic combination of steel and aluminum components for strength and reduced weight
- Motor-to-wheel sprocket ratio set at 1.375:1 to increase torque while maintaining good wheel speed
- Pedal-to-pump sprocket ratio set at 0.3:1 to maximize hydraulic flow (gallons per minute) during accumulator charging
- Arm-mounted HMI for convenient and quick operator access during riding and testing

HYDRAULIC CIRCUIT DESIGN



HMI Code



HMI Screen:



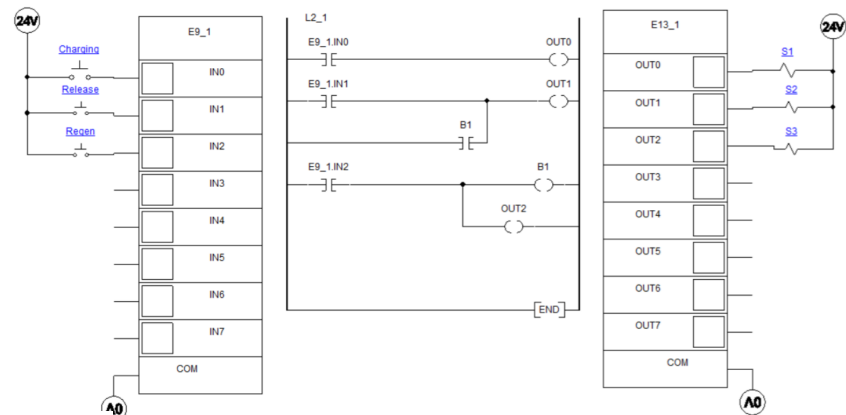
Codesys Code for PLC Controller:

```

1 PROGRAM Project_Main_Program
2 VAR
3
4 charging: BOOL:=FALSE;
5 release: BOOL:=FALSE;
6 regen: BOOL:=FALSE;
7
8 END_VAR
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
1 charging:=switch1;
2 release:=switch2;
3 regen:=switch3;
4
5
6 IF charging = TRUE THEN
7     s1 := TRUE;
8     ELSIF charging = FALSE THEN
9         s1 :=FALSE;
10 END_IF
11
12 IF release = TRUE THEN
13     s2:=TRUE;
14     ELSIF release = FALSE THEN
15         s2:=FALSE;
16         s3:=FALSE;
17
18 END_IF
19
20 IF regen = TRUE THEN
21     s2 := TRUE;
22     s3 := TRUE;
23     ELSIF regen=FALSE THEN
24         s3:=FALSE;
25
26 END_IF
27

```

Automation Studio PLC Simulation :



Vehicle Construction



Vehicle construction began in February 2026. The team worked nearly every day for six weeks to complete the build. Manufacturing processes included:

- Welding
- Drilling
- Cutting
- Sanding and deburring

All work was performed by the students with valuable guidance from TSU Mechanical Engineering Technician **Mr. Lee Isenberg**.

Vehicle Testing

Initial testing revealed several performance issues:

- Charging modes not functioning correctly
- Incorrect accumulator installed (later replaced with the proper unit)
- Chain skipping on the pump sprocket

Key fixes implemented:

- Re-routed and properly assembled hydraulic hoses
- Increased pump sprocket size to eliminate chain slip
- Verified and corrected accumulator specifications

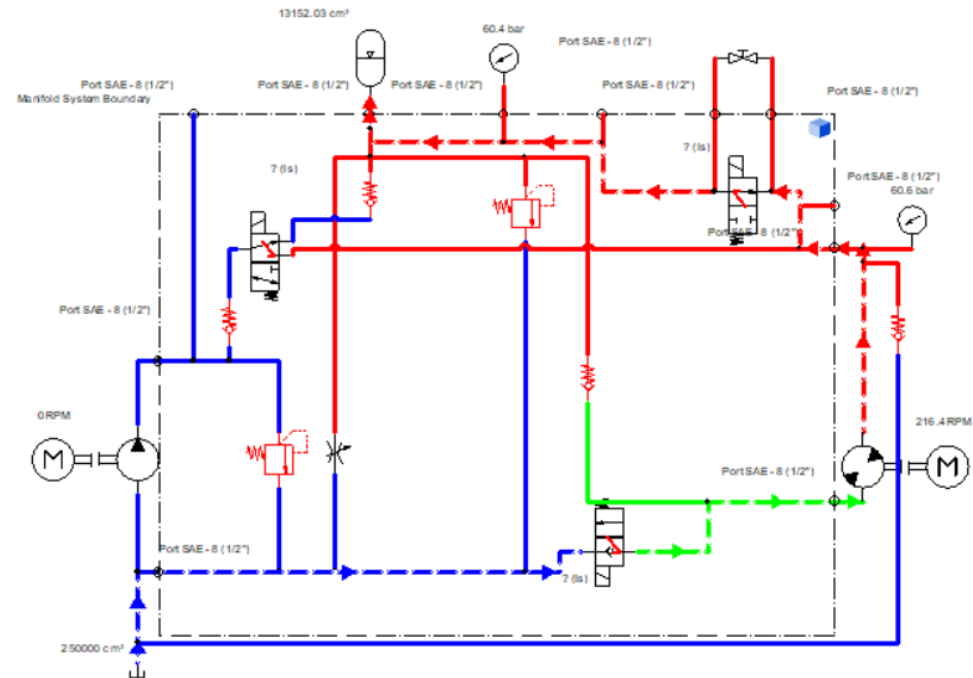
Testing continued after each correction to validate improvements.

Regenerative Braking

Regenerative braking captures the vehicle's kinetic energy during deceleration and converts it into hydraulic energy to charge the accumulator.

Benefits:

- Slows the vehicle without wasting energy as heat
- Stores energy for later use in propulsion
- Improves overall system efficiency



Lessons Learned

- Deepened understanding of hydraulic circuits and the critical role of valves in flow and pressure control
- Gained hands-on experience with electrical circuit design and solenoid operation
- Developed skills in Codesys programming for both PLC and HMI interfaces
- Improved ability to properly size hydraulic components and calculate optimal gear ratios
- Learned proper selection and mating of hydraulic fittings for complex manifolds
- Enhanced chain and sprocket sizing techniques
- Strengthened adaptability when facing unexpected design and assembly challenges

Safety



To protect the rider, the vehicle was built with:

- Radiused corners and fully deburred edges to prevent cuts and scrapes
- Chain guard fully enclosing the pedal-to-pump chain to avoid injury and chain damage
- Required safety gear for the rider: helmet, steel-toed shoes, and optional shin guards

These measures minimize risks from falls, pedal slip, or moving components.



THANK YOU



Questions?

