



N F P A

Fluid Power

=VEHICLE

Challenge



NFPA
Education and
Technology
Foundation

**FINAL PRESENTATION & DESIGN
REVIEW**

**California Polytechnic State
University – San Luis Obispo**

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PROJECT OVERVIEW (CHANGES MADE)



Since this vehicle is a continuation of a previous model, key improvements include:

- Variable gearset replacing previous single ratio
- Regenerative gear design introducing regenerative drive capability
- Frame addition reducing deflection, improving alignment, and increasing mounting space
- Improved electronics integration, including optimized wiring, custom PCB implementation, real-time pressure readout on the Nextion display, and protective housing for electrical components

RESEARCH PROCESS



Review of previous report, competition material, and industry mentor meetings informed the team that:

- Successful vehicles utilized gearsets to maximize motor output for varying speeds
- Alignment issues due to frame deflection were prevalent failure modes during previous competitions
- Solid hydraulic lines would provide a significant performance increase due to reduced pipe losses

DESIGN PROCESS



Final Design Decisions

• Drivetrain Configuration

- 3-speed gearset mounted on an intermediate shaft between rear wheel and motor
- Components: ANSI 40 flexible chain, flat sprockets, $\frac{3}{4}$ " shaft, shaft collars
- Enables variable regenerative gear ratios while maintaining chain alignment and minimizing slack

• Frame Modification

- $\frac{3}{4}$ " steel tubing extension welded to existing chassis
- Reduces frame deflection and provides flat mounting surface for motor, pump, manifold, and gearing system

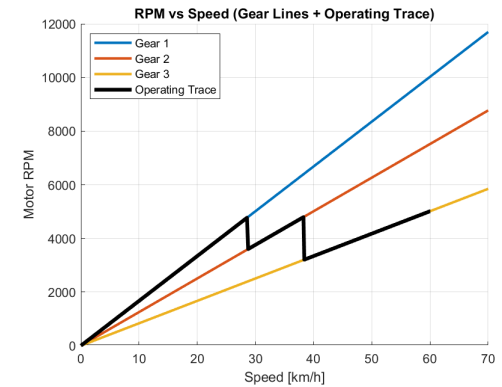
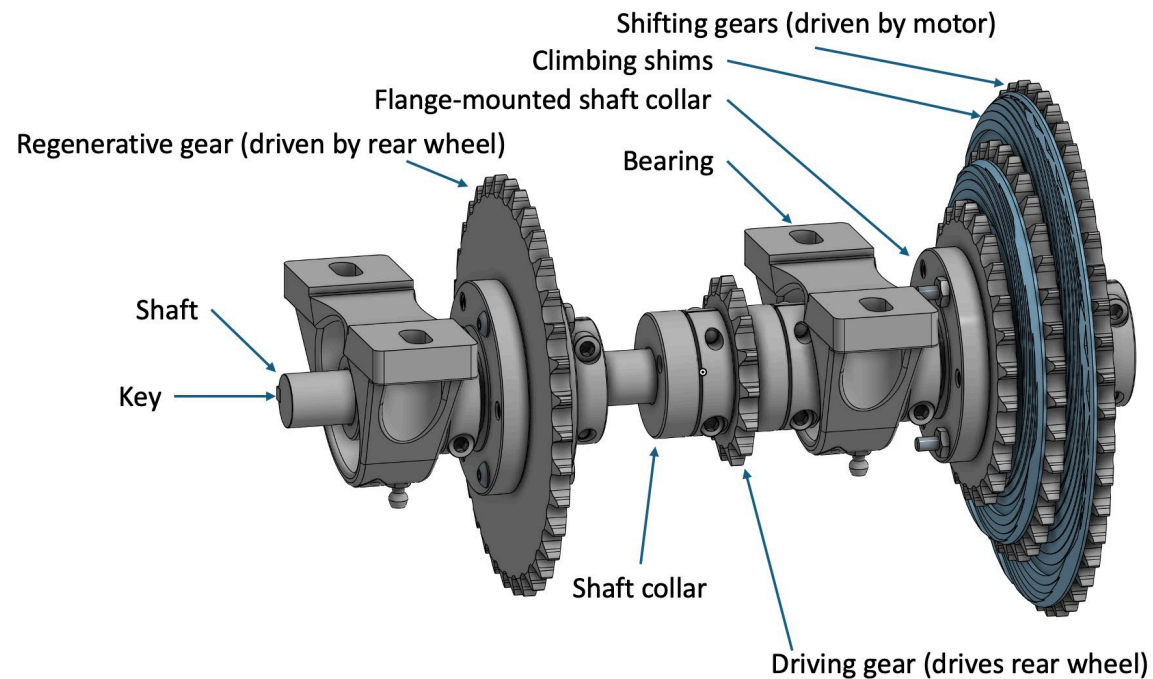
• Electronics Modification

- Cleaner and improved wiring organization with optimized routing for the custom PCB, plus a better protective housing for the PCB and portable charger.
- A new real-time motor pressure gauge on the Nextion display to analyze hydraulic fluid losses between hardlines and flexible hoses.

GEARSET DESIGN



- Initial Design:
 - 3 gear reductions: 1:3, 1:4, 1:5
- Design Modification:
 - Low gear (1:5) removed after initial operation
 - Reused existing gears to reduce manufacturing time
 - Final configuration: 2 gear reductions (9:35 and 3:7)
- Performance impact:
 - Reduced acceleration
 - Increased top speed
 - Lower vehicle efficiency
 - Increased vehicle ground clearance



GEARSET DESIGN



- **Initial Approach**

- Regenerative mode achieved by switching engaged gears
- Competition rules did not explicitly require dynamic switching between drive and regenerative modes

- **Design Constraint**

- Manufacturing limitations prevented implementation of a more complex switching mechanism

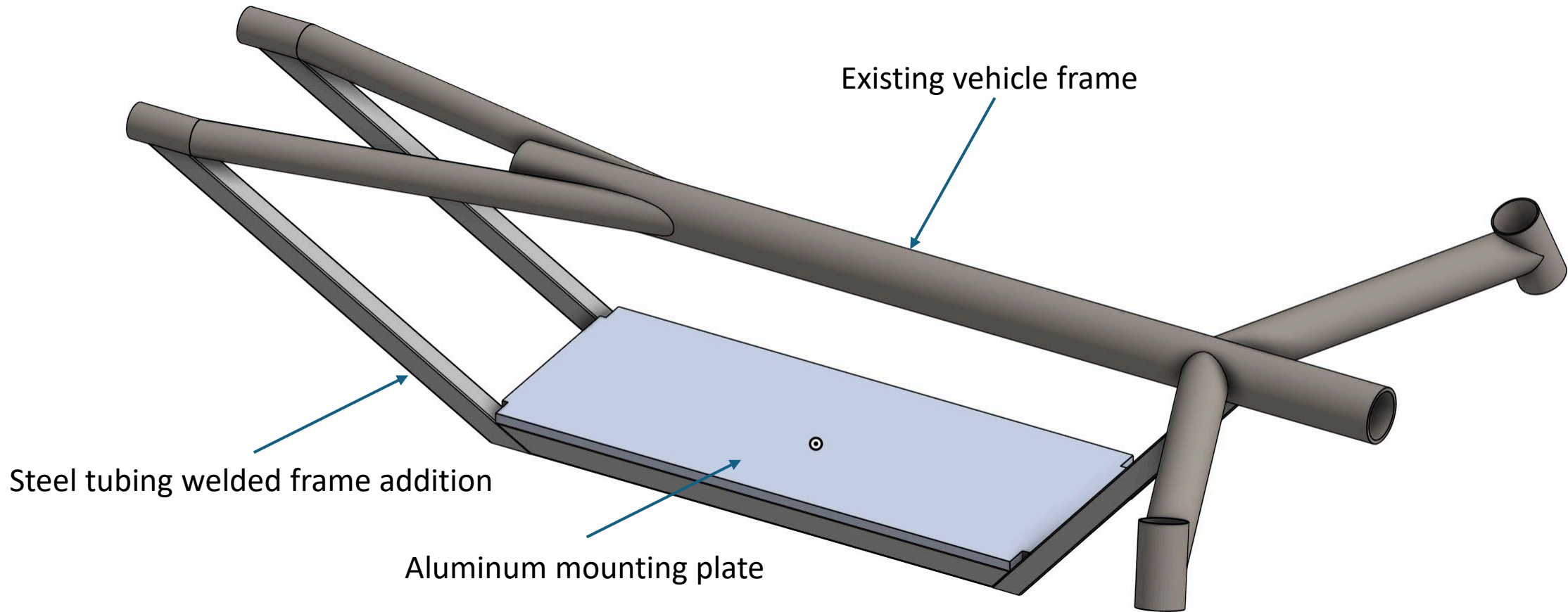
- **Implemented Solution**

- Regenerative mode achieved by physically reversing wheel orientation

- **Performance Impact**

- More time-intensive access to regenerative mode
- Fixed 1:1 regenerative gear ratio
- Non-optimized regenerative efficiency

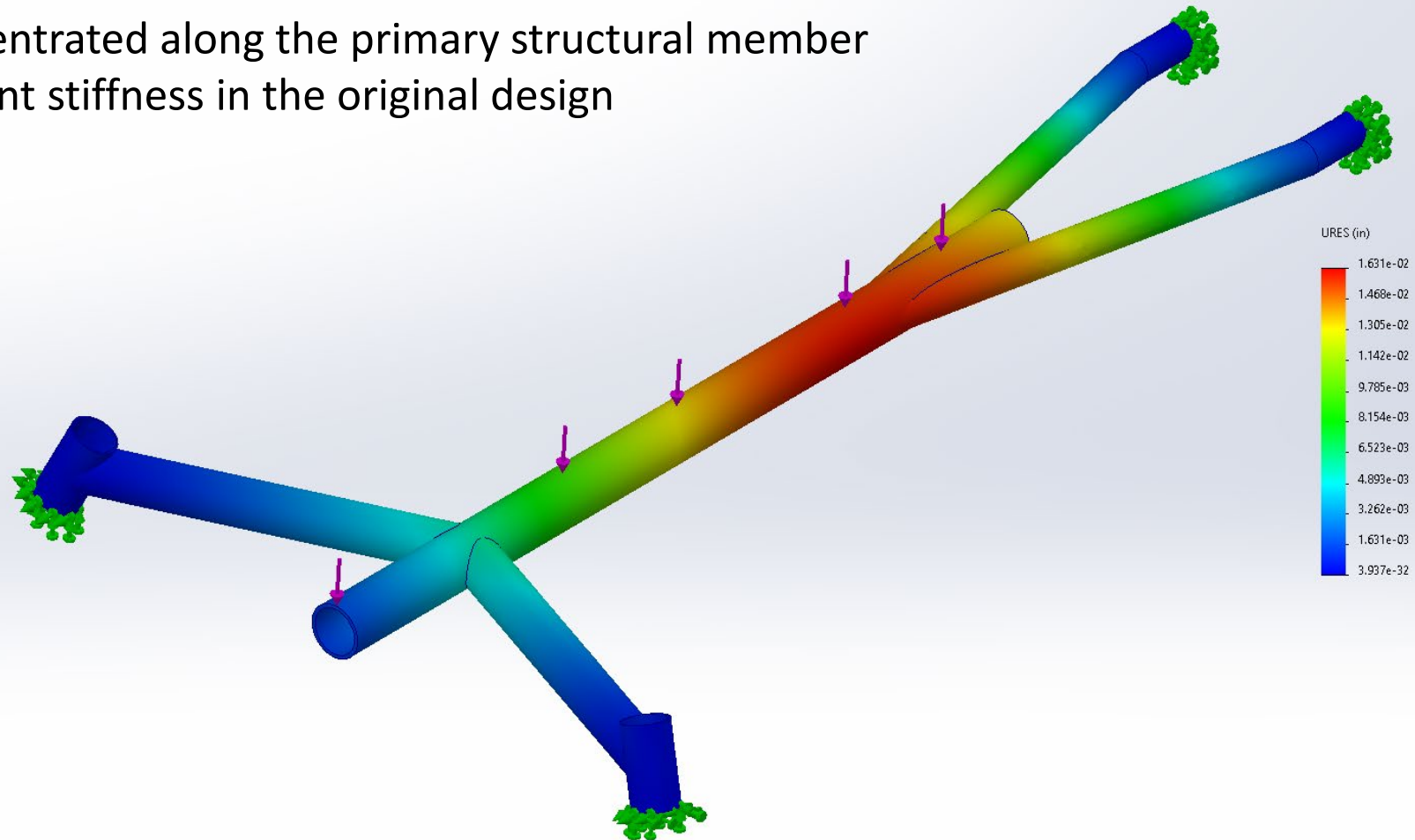
FRAME ADDITION DESIGN



FRAME ADDITION DESIGN



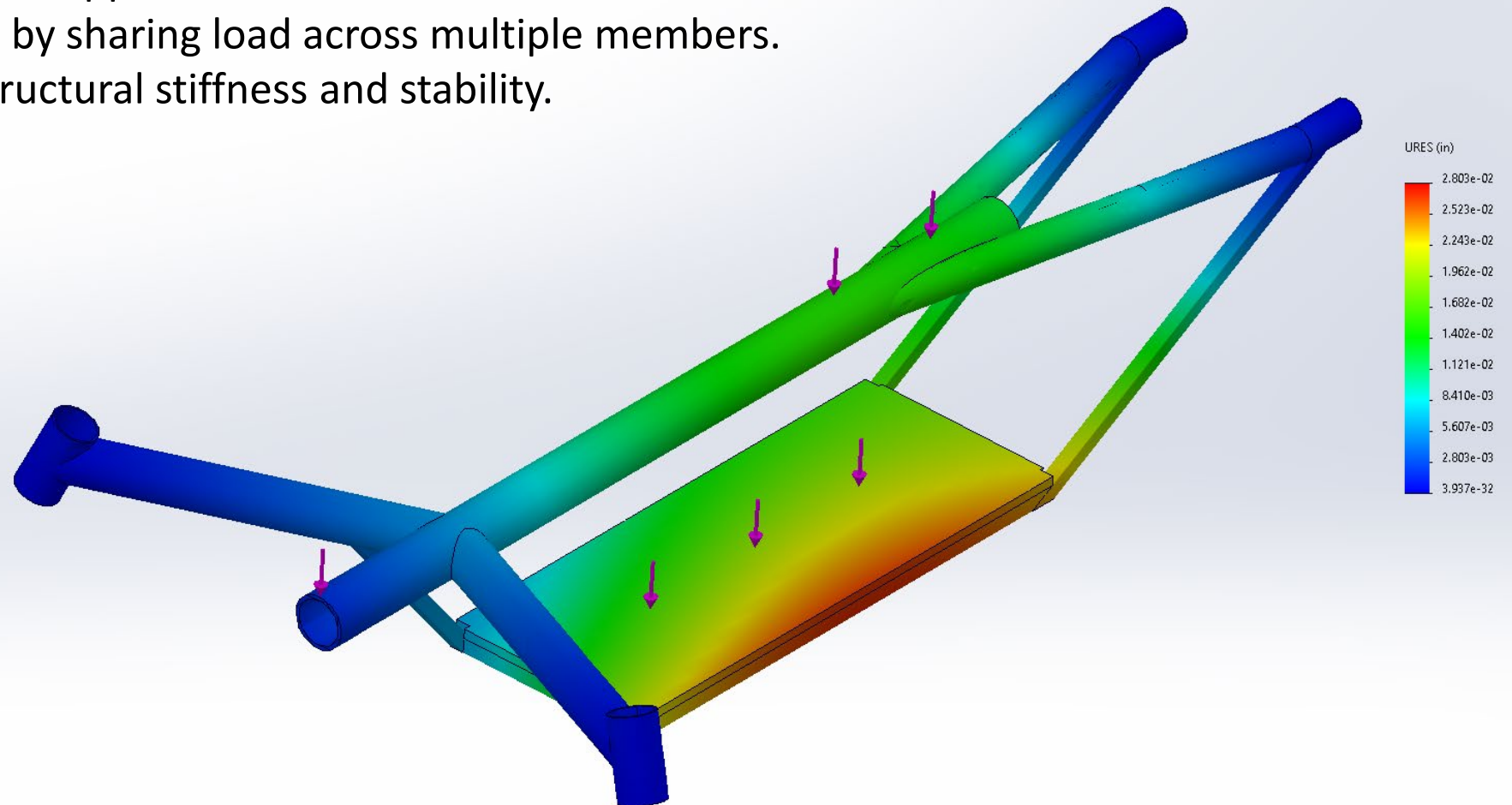
- Excessive deflection in the main frame under load
- Deformation concentrated along the primary structural member
- Indicates insufficient stiffness in the original design



FRAME ADDITION DESIGN



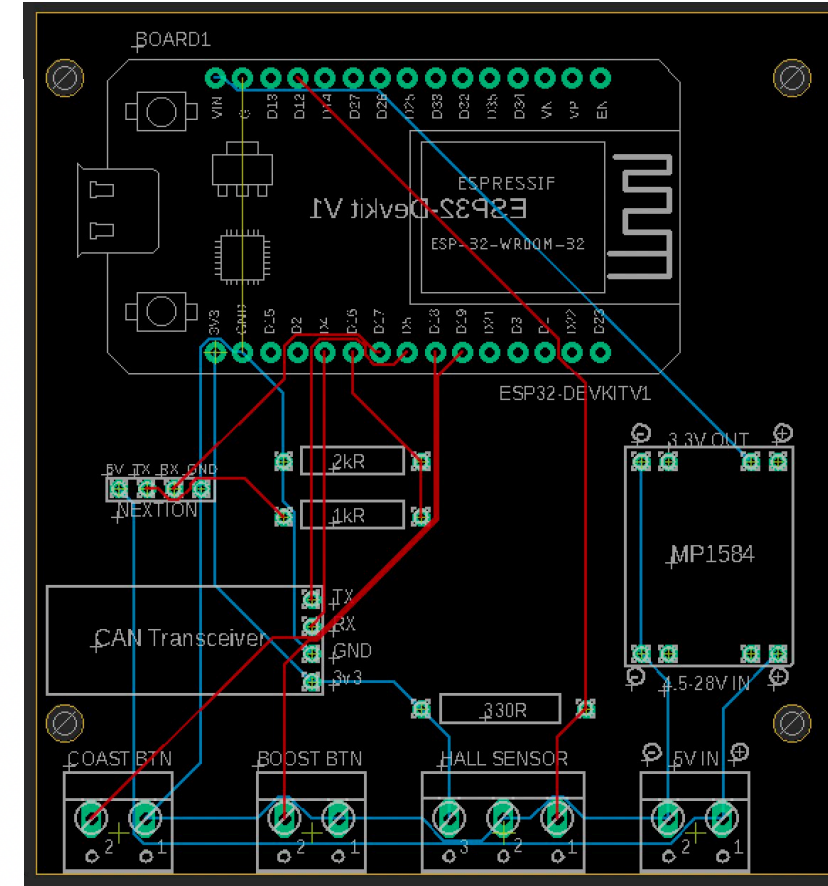
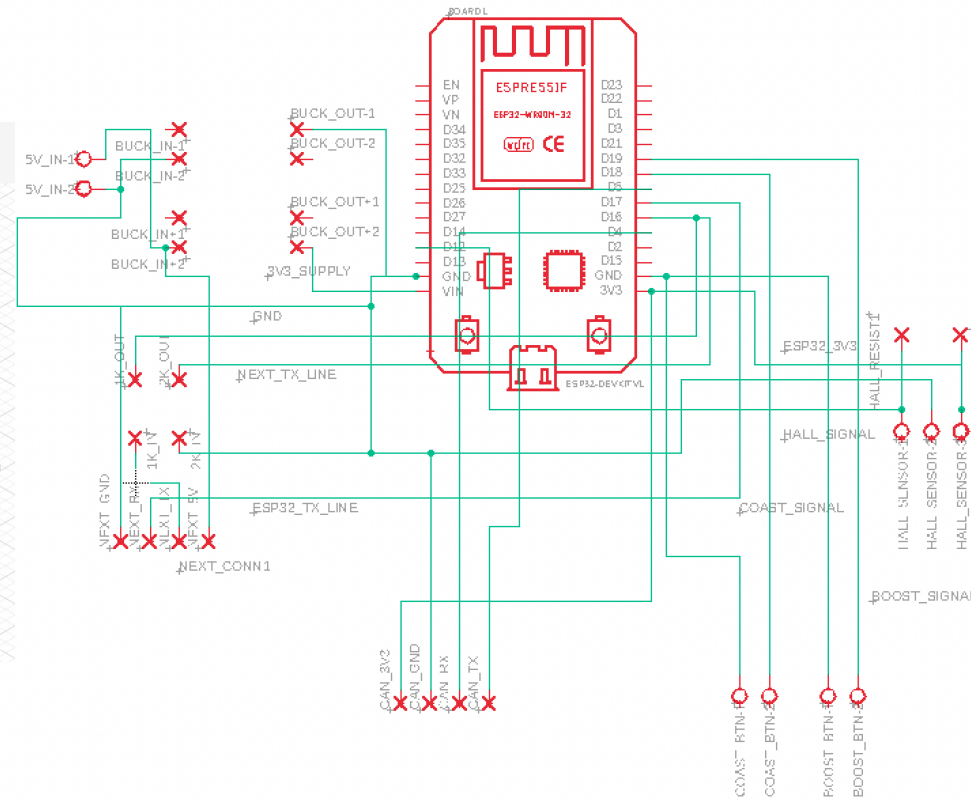
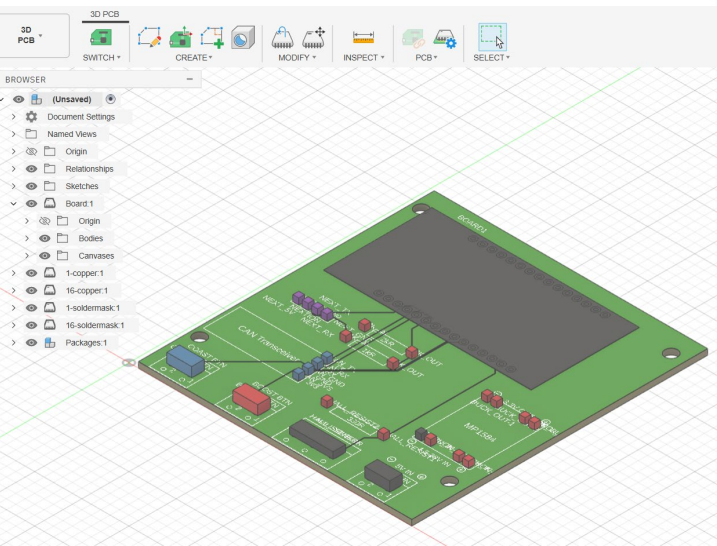
- Added a subframe to support and redistribute loads
- Reduced deflection by sharing load across multiple members.
- Improved overall structural stiffness and stability.



Electronics Design



- **Custom PCB Design:** Full schematic and layout featuring the ESP32 module. Created using Autodesk Fusion 360's integrated electronics workspace.



Electronics Design

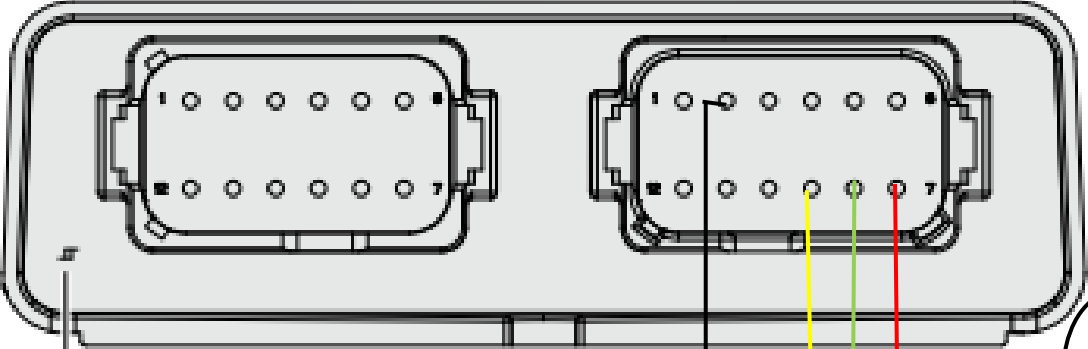
Nextion
HMI



Valve Driver

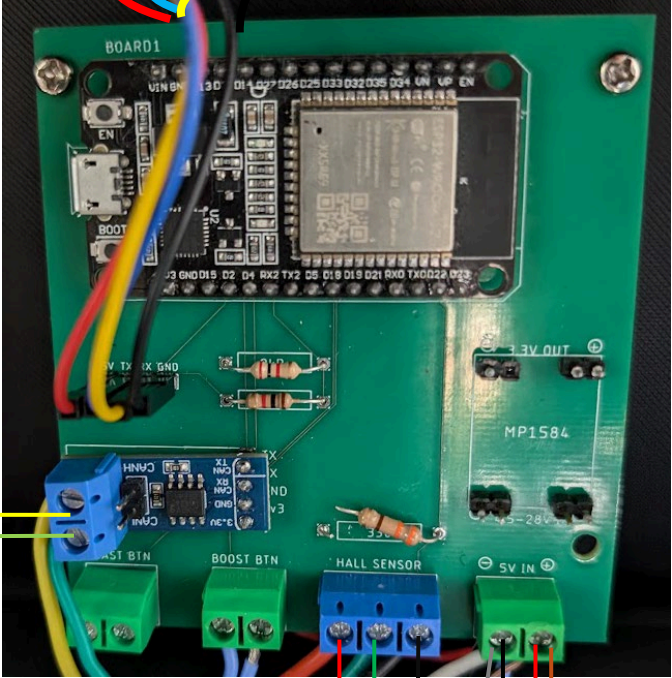
X2 (black)

X1 (gray)



LED Indicator

Micro
USB



Custom
PCB

Hall Effect
Sensor



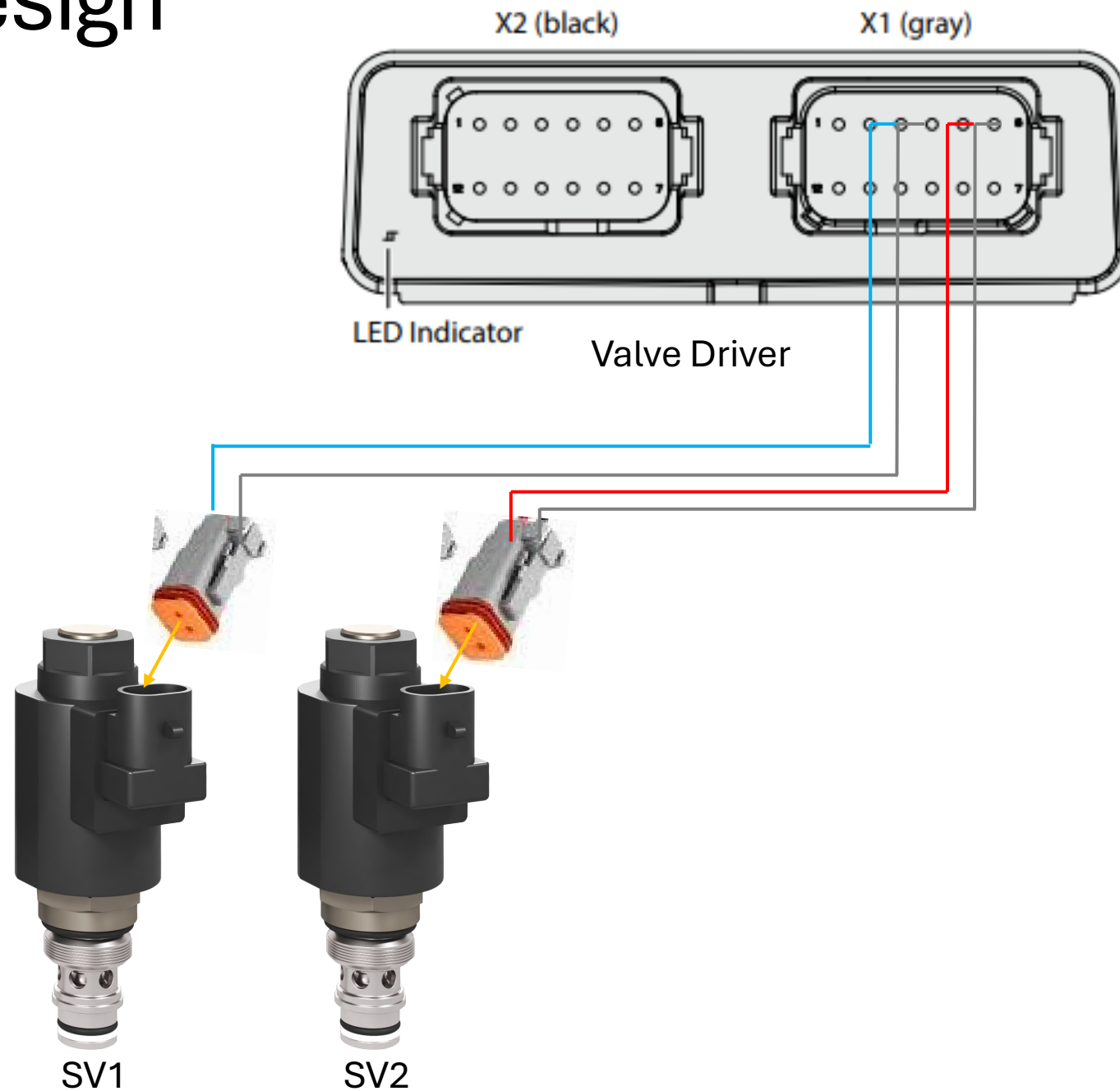
USB2.0

Portable Charger

USB2.0



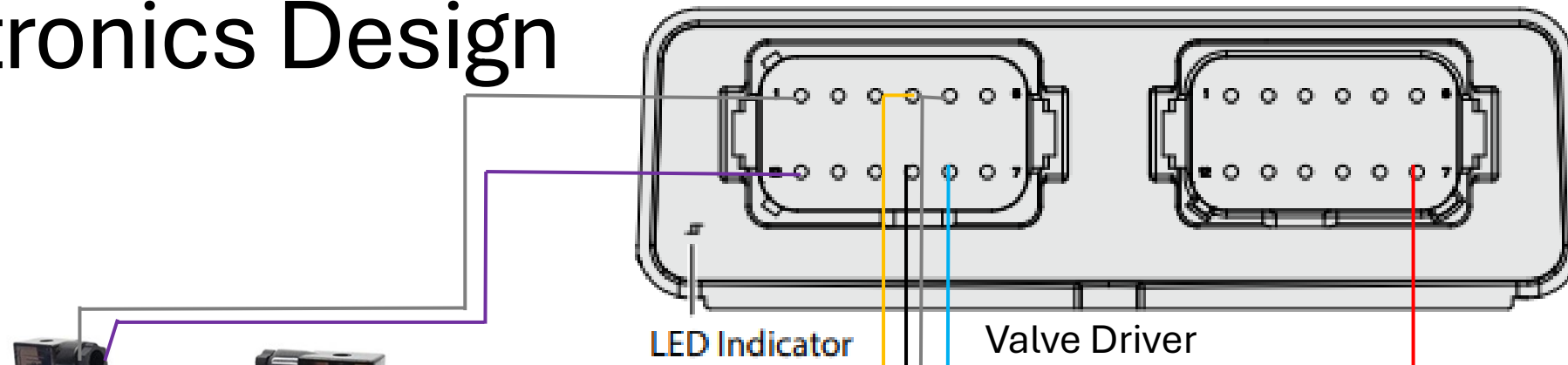
Electronics Design



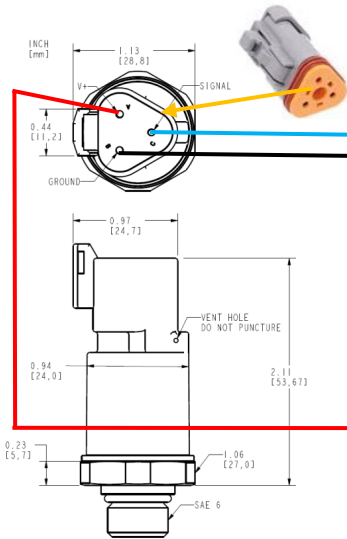
Electronics Design

X2 (black)

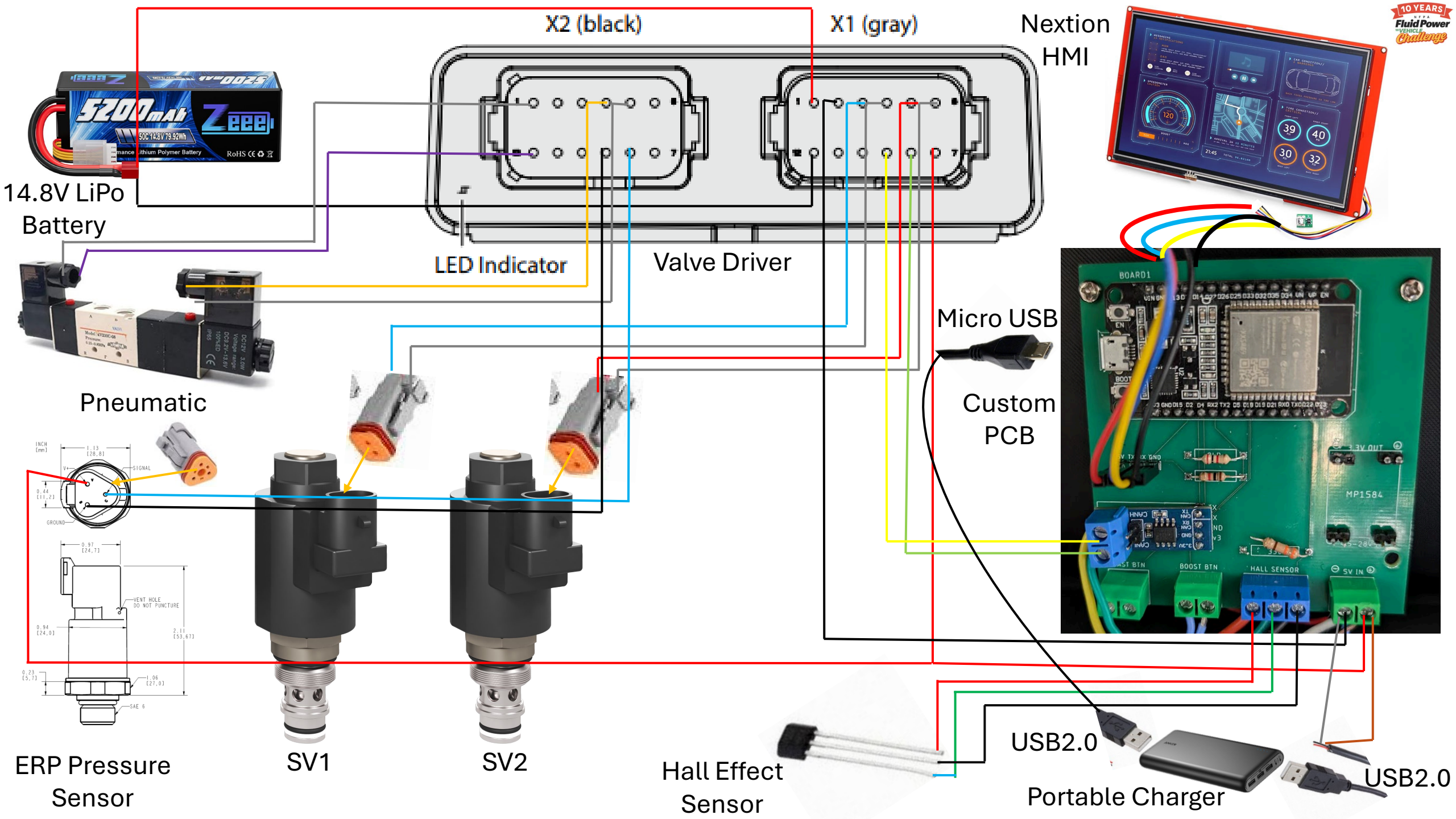
X1 (gray)



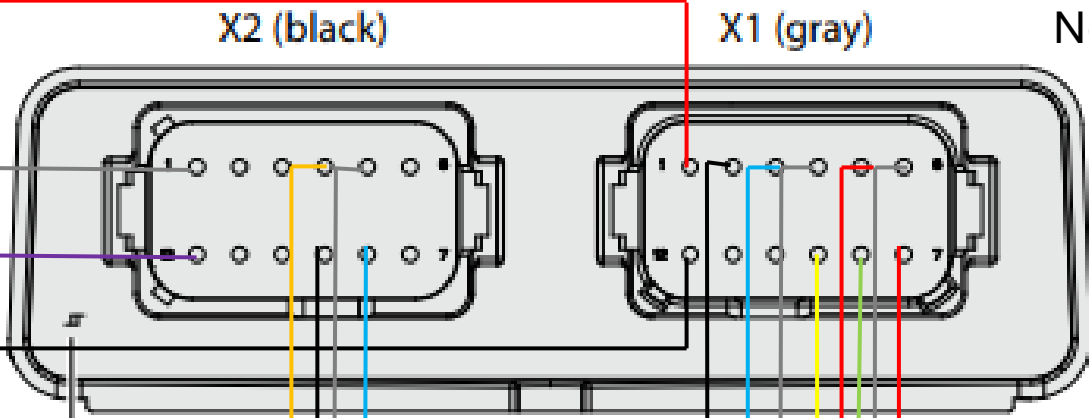
Pneumatic



ERP Pressure Sensor



14.8V LiPo Battery



LED Indicator

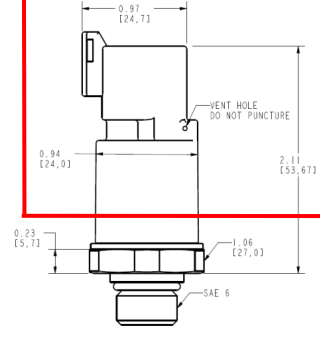
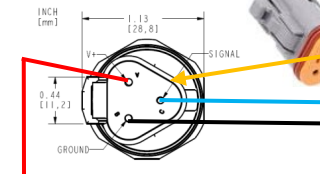
Valve Driver



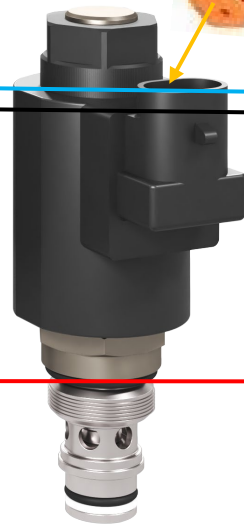
Nextion HMI



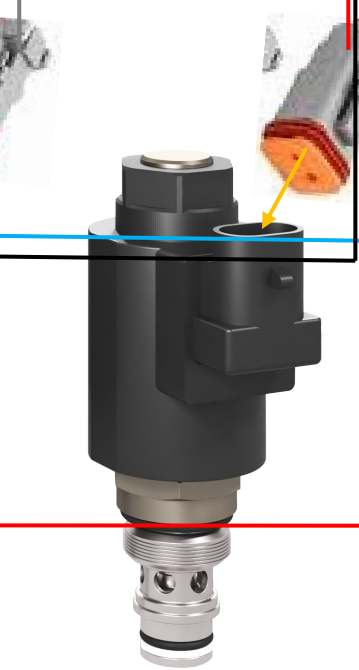
Pneumatic



ERP Pressure Sensor



SV1



SV2

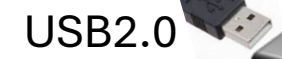
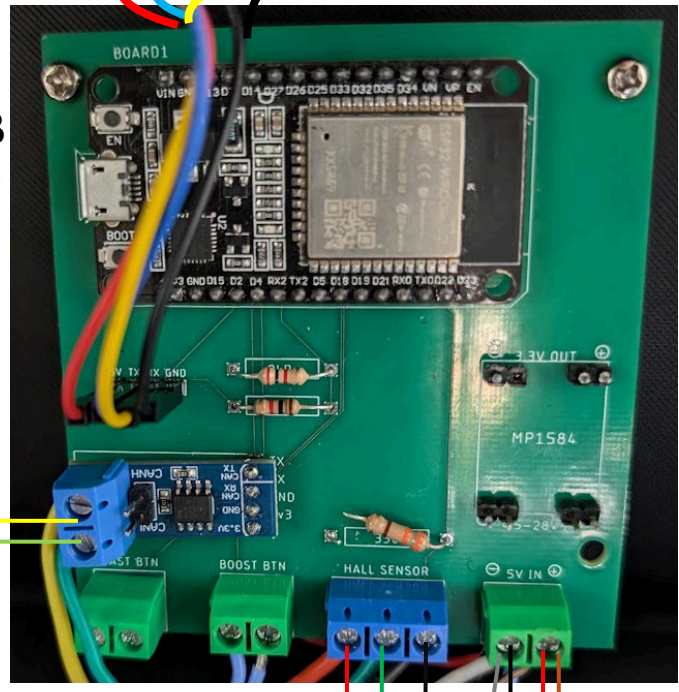


Hall Effect Sensor



Micro USB

Custom PCB



USB2.0



Portable Charger



USB2.0

LESSONS LEARNED



Throughout the research, design, manufacturing, and integration process, several key engineering insights were reinforced:

- Early design decisions strongly constrain downstream manufacturing and system integration
- Iterative refinement is necessary to resolve discrepancies between design intent and physical implementation
- Time constraints require prioritizing robust, manufacturable solutions over idealized designs
- Leveraging team collaboration and external input improves both design quality and problem-solving efficiency
- Real-world factors such as manufacturing limitations and team coordination significantly impact project timelines and outcomes