NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

Final Presentation
University of Akron
Scott Sawyer
5/1/2025

Agenda

- Team Introductions
- Frame Design
- Hydraulic Circuit
- Manufacturing
- Electronics
- Testing
- Results & Conclusions
- Questions

Team Introductions

Team Introductions

Five Mechanical Engineering Students graduating May 2025.

- Sierra Bockziewicz
  - Controls, Treasurer
- Ryan Hamrick
  - Controls, Reservoir
- Thomas Kesic
  - Assembly, CAD
- Jackson McMinn-Hyde
  - Assembly, CAD
- Steve Breimaier
  - Hydraulic Circuit, Welding, Assembly

2025 University of Akron Senior Design Day

Frame Design

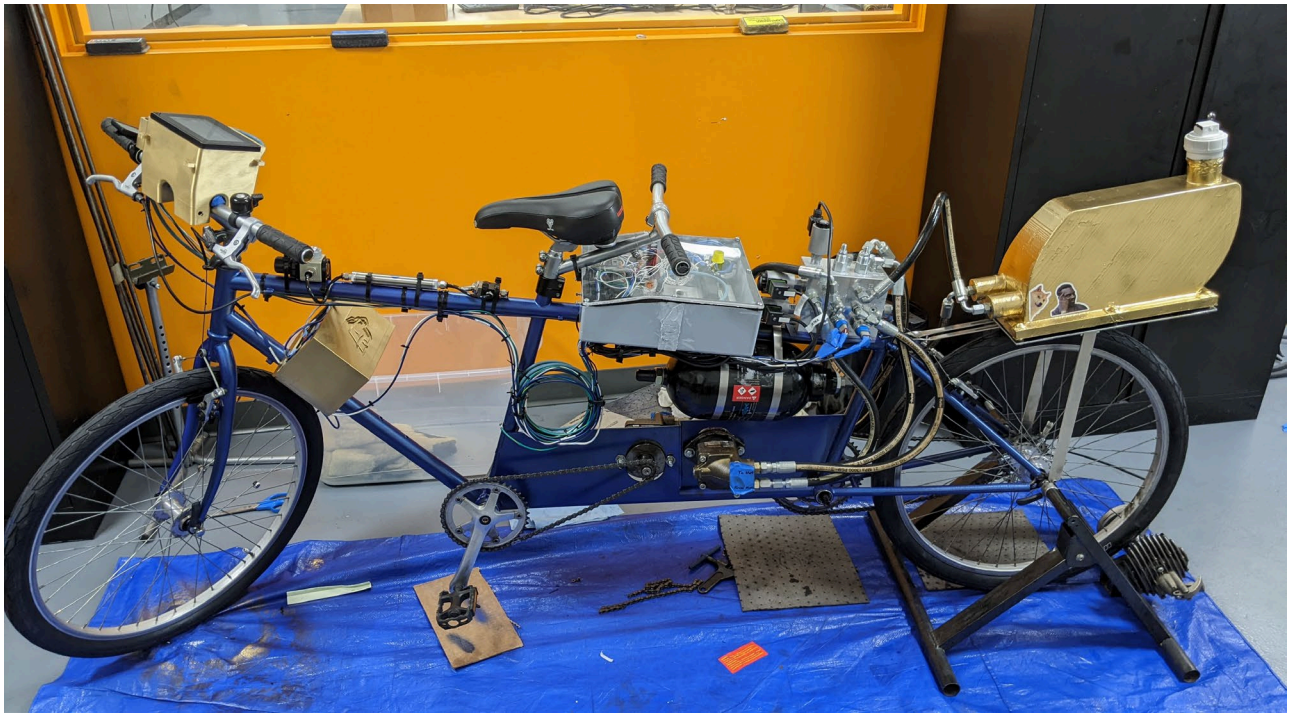
Previous Team's Design:

Vehicle Chosen:

- Touring Bicycle

Design Details:

- One-speed
- 3D printed Reservoir above tire
- Custom electronics



Our Team's Design:

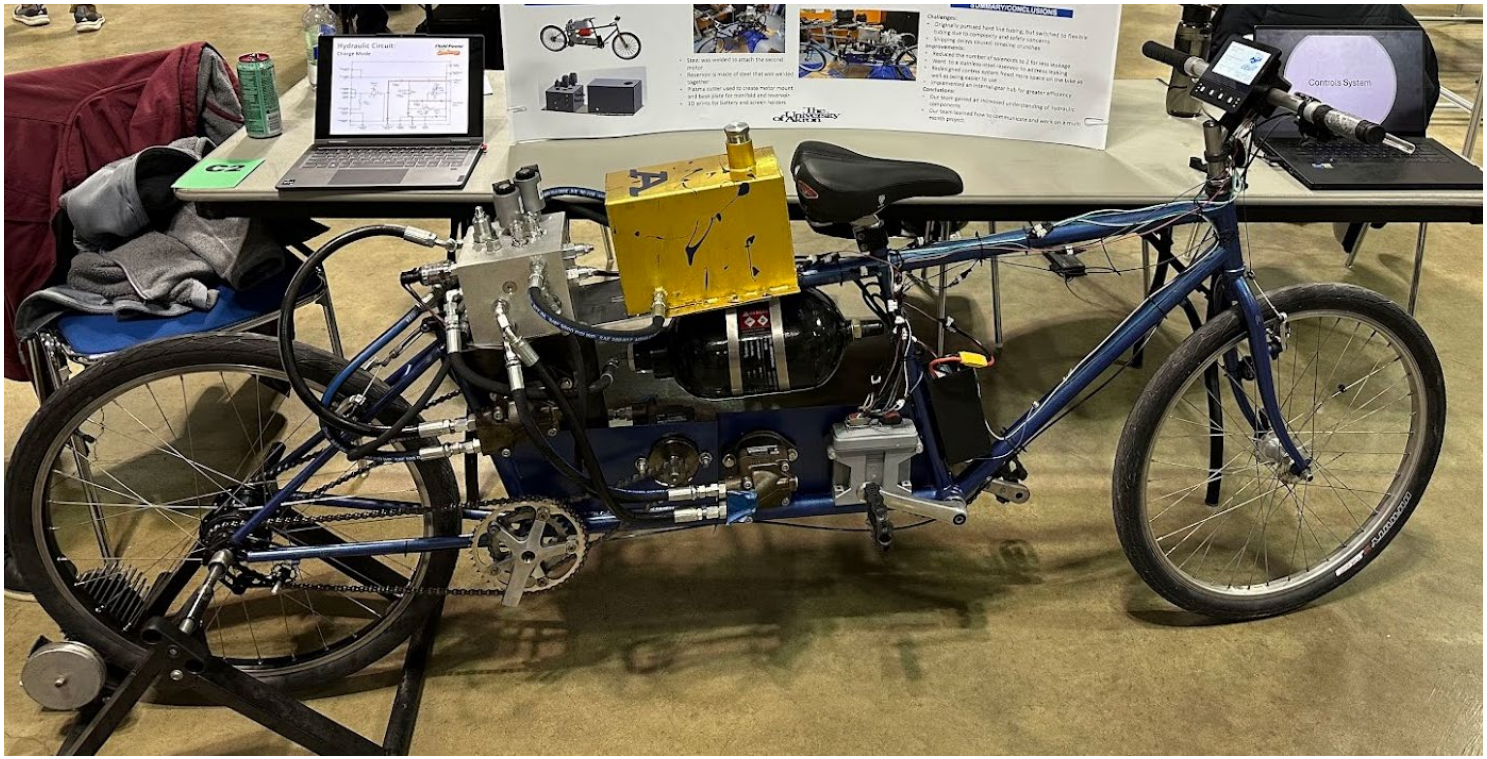
NFPA Fluid Power VEHICLE Challenge

Vehicle Chosen:

- Modified prior year frame

Design Details:

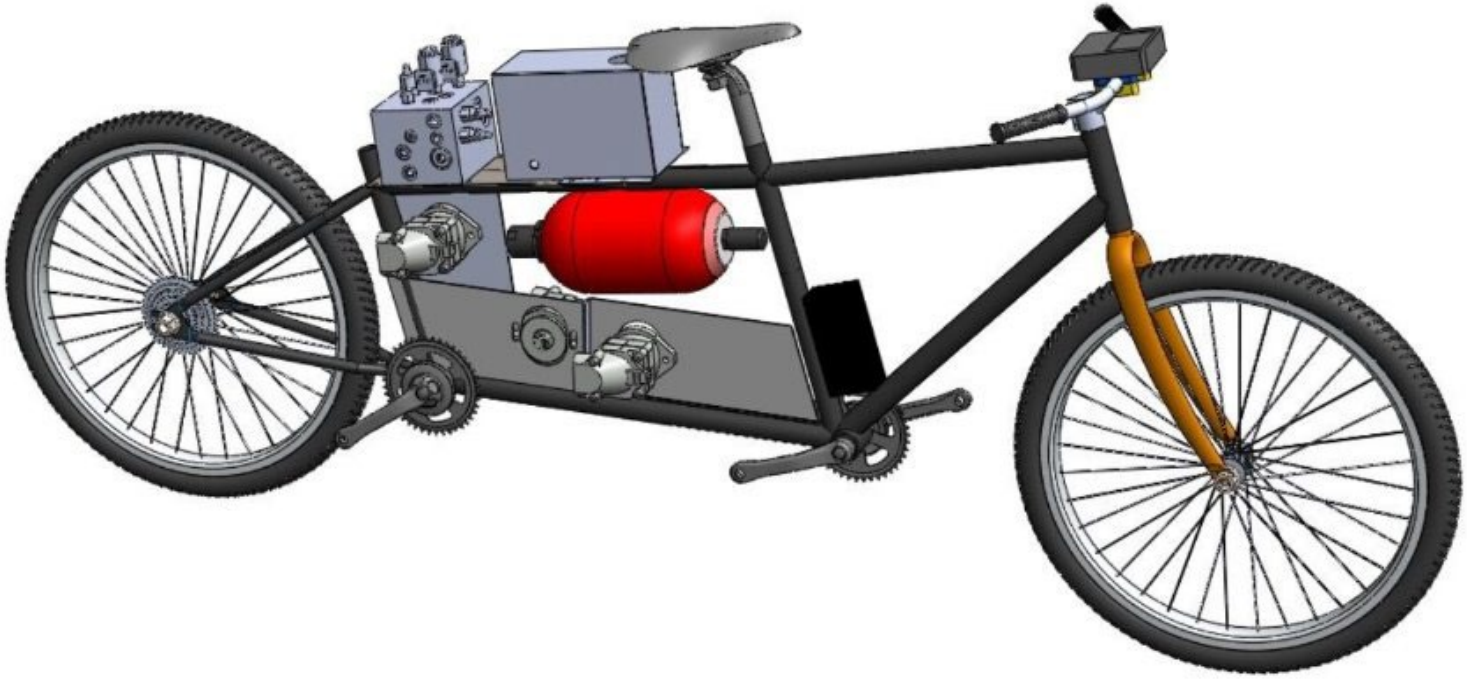
- 11-speed internal gear hub
  - Additional regen motor
- Welded reservoir
- Stable mounting
- Ideal tandem weight distribution



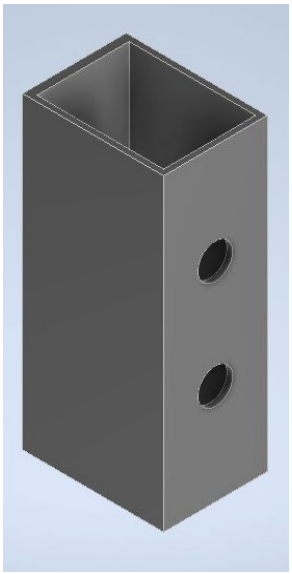
Our Team's Design:

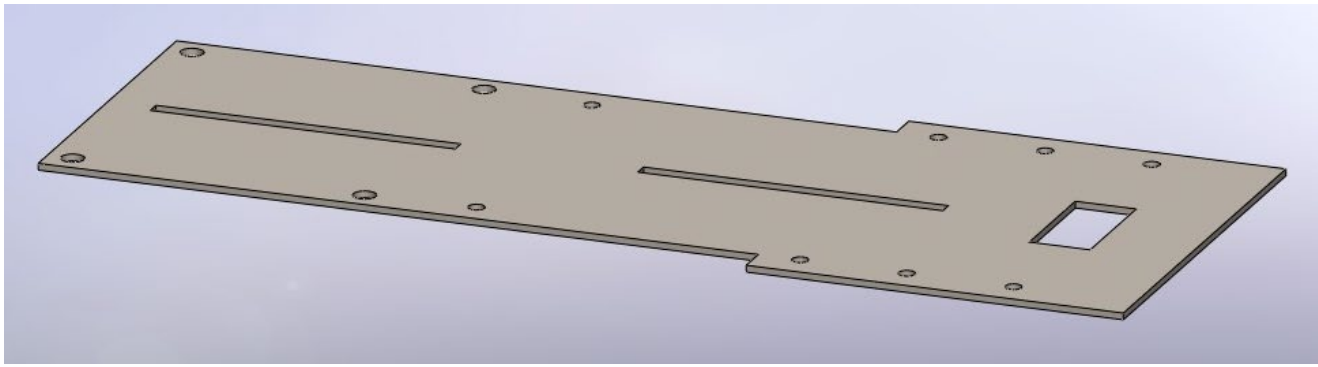
- **Equipment used:**
  - Pump & Motor
    - Parker Hannifin F-11-005 Bent Axis Piston Pumps
  - Accumulator
    - Parker Hannifin 3000 PSI Bladder Accumulator
  - Manifold
    - Custom made from IFP Motion Solutions INC.
  - Reservoir
    - 1/16" stainless steel sheet
  - Electronics & Programming
    - Danfoss DM430E Series Display (HMI)
    - Danfoss MCO24-110 Microcontroller

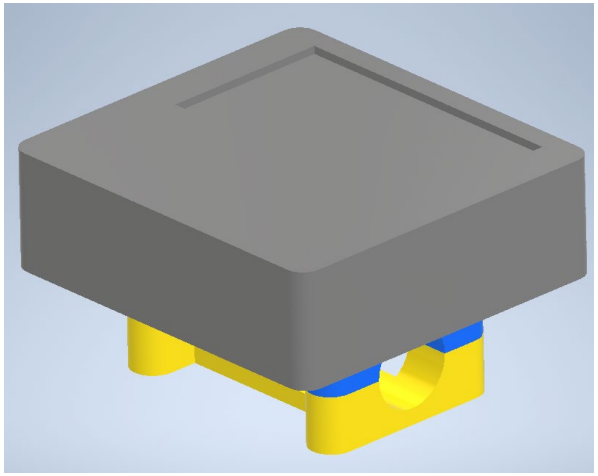
SolidWorks Model

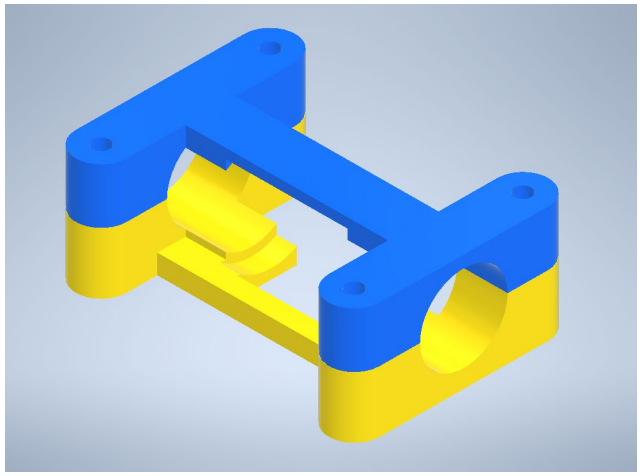


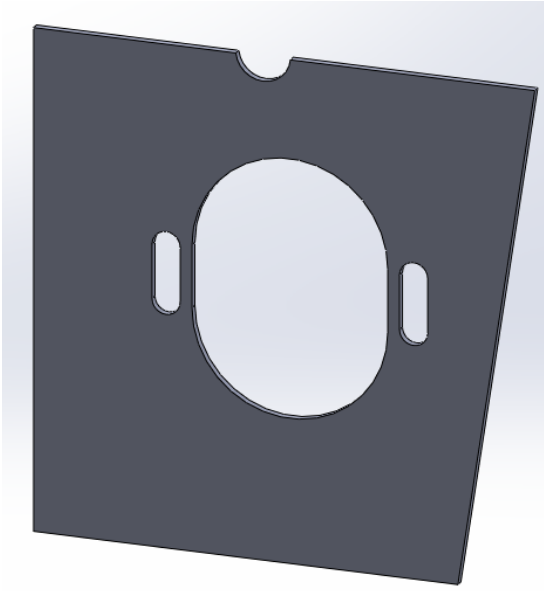
Chain Guard, Plates, Display Holder and Battery Box





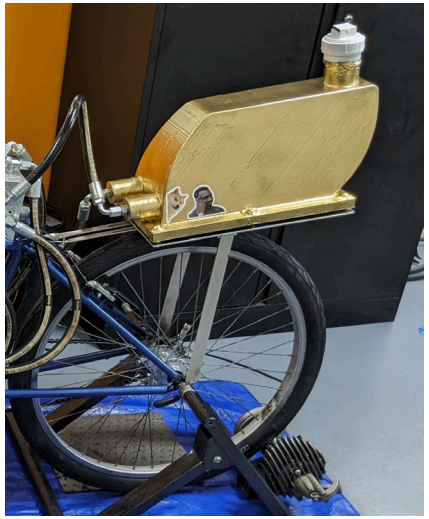






Reservoir

- **Issues with last years design:**
  - Printed out of PETG which lead to leakage issues
    - Used Flex Seal to address issues
    - Became stuck to the frame attachment
  - Was located on top of the back wheel
- **New Design**
  - 1/16" stainless steel sheet
    - Bent and welded
  - Attached to a base plate that was welded onto the frame
  - Located directly behind rider



Manufacturing

Manufacturing:

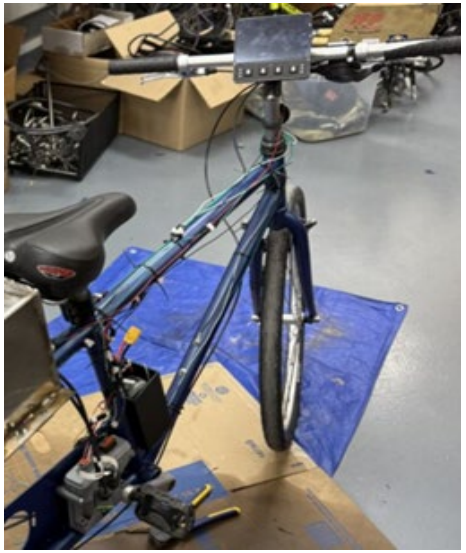
Main Bike Assembly

- Plasma cutting:
  - Base plate for reservoir and manifold mount
  - Plate for third motor
- Welding
  - 1/16" thick stainless steel plate for reservoir
  - 1/8" thick base plate
  - 1/8" thick motor plate

Manufacturing

Electronic Assembly

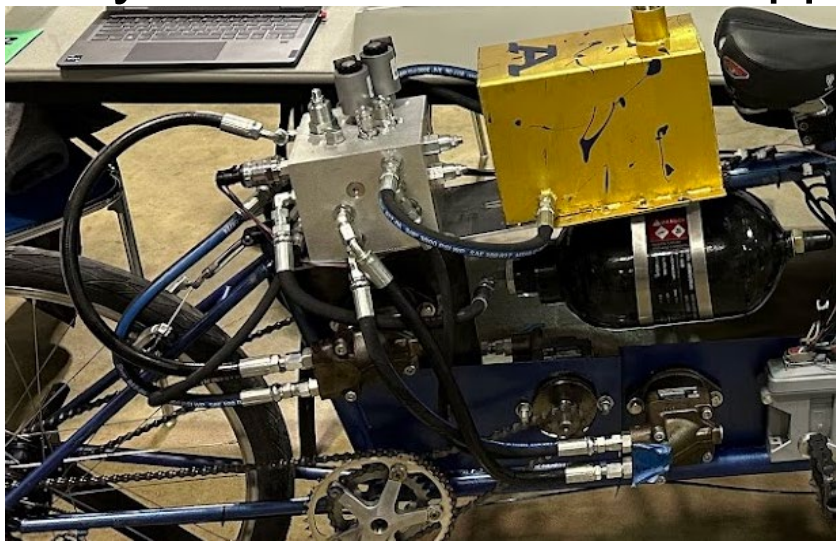
- Controller s crewed on to motor plate
- Display mounted on holder
- Wiring ziptied to bike frame



Manufacturing:

Hydraulic Assembly

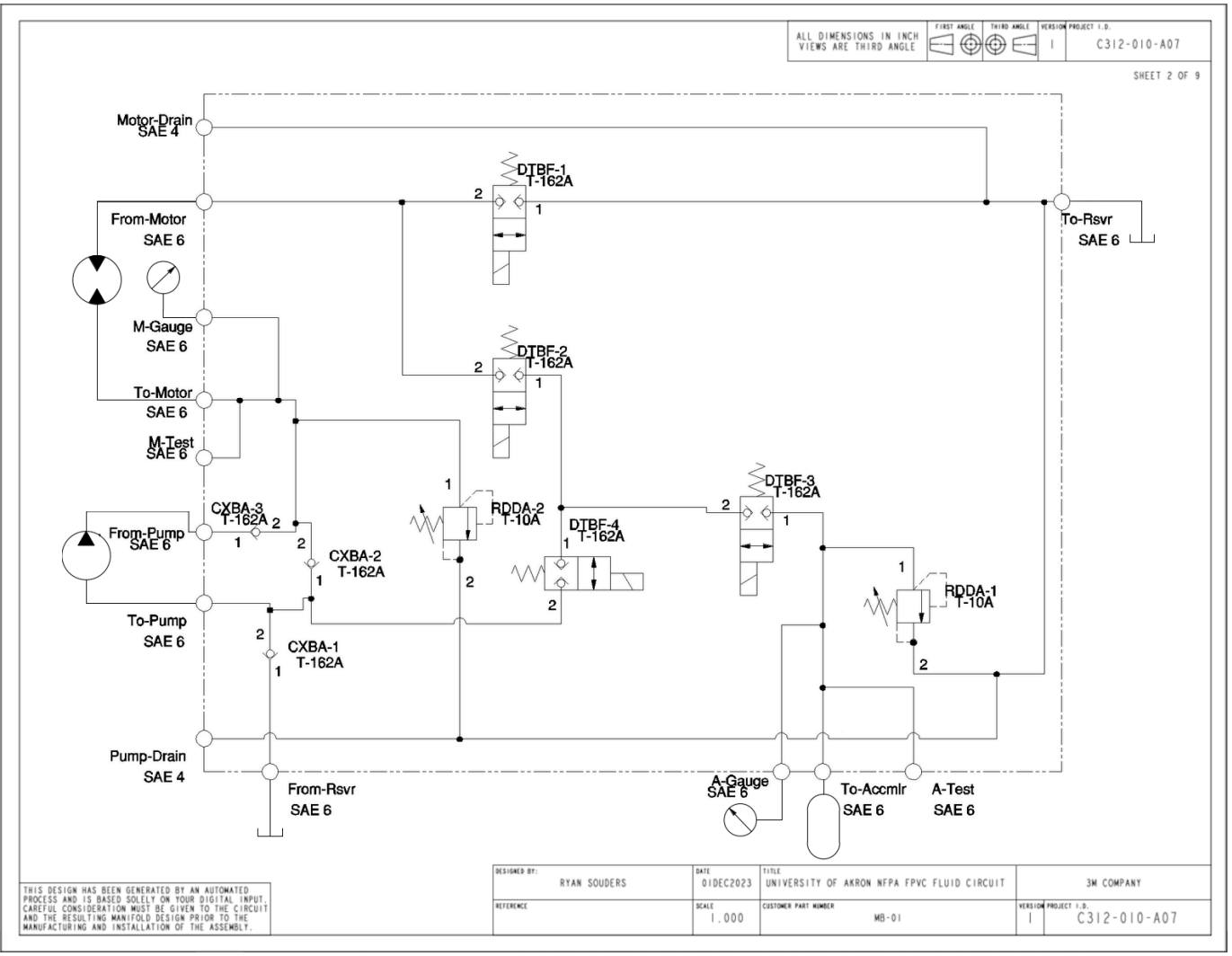
- Connections
  - Originally planned for hard-lining
    - Prevented by practicality
  - 3/8”rubber hose rated for 3000 psi utilized
    - Donated by Koehler Rubber & Supply



Hydraulic Circuit

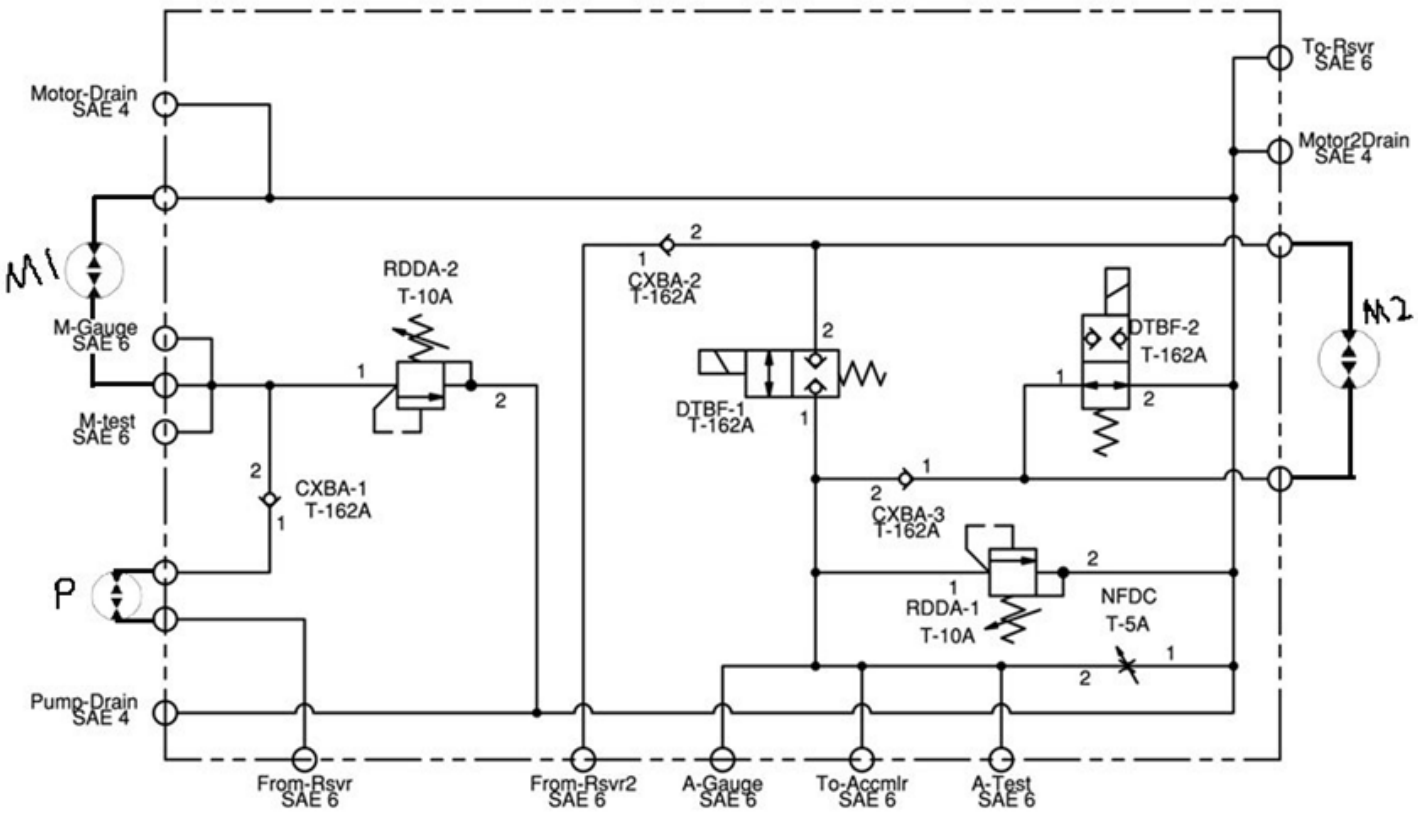
Hydraulic Circuit:

previous Team's Design



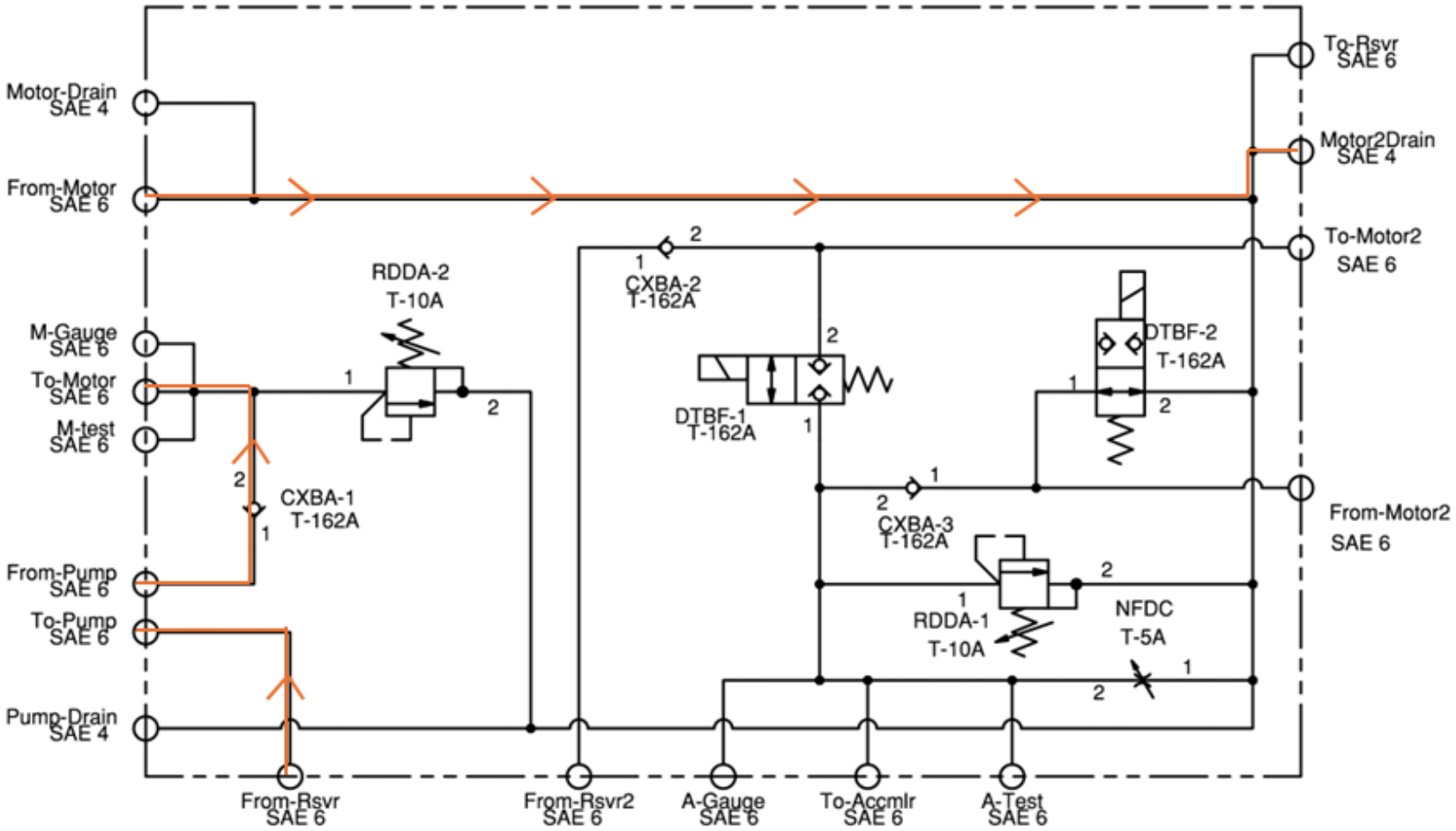
- **Components:**
  - 4 DTDF 2-Way Solenoid
  - 3 CXBA Check Valves
  - 2 RDDA Relief Valves, set at 3000 Psi

Hydraulic Circuit:
Current Team's Design

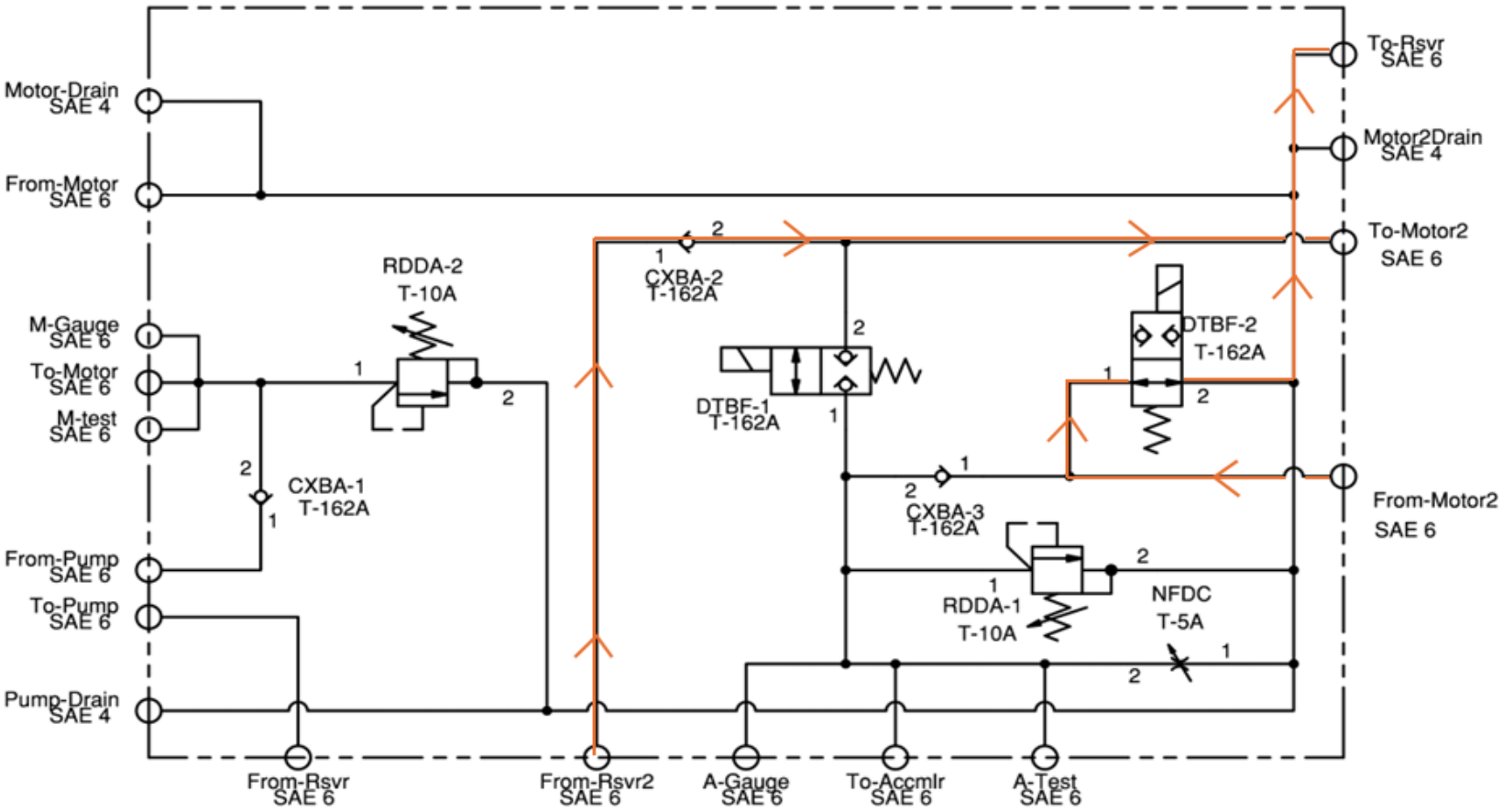


- **Components:**
  - 2 DTDF 2-Way Solenoid
  - 3 CXBA Check Valves
  - 2 RDDA Relief Valves, set at 3000 Psi
  - 1 NFDC Needle Valve
- **Benefits:**
  - 2 solenoids
  - Needle valve

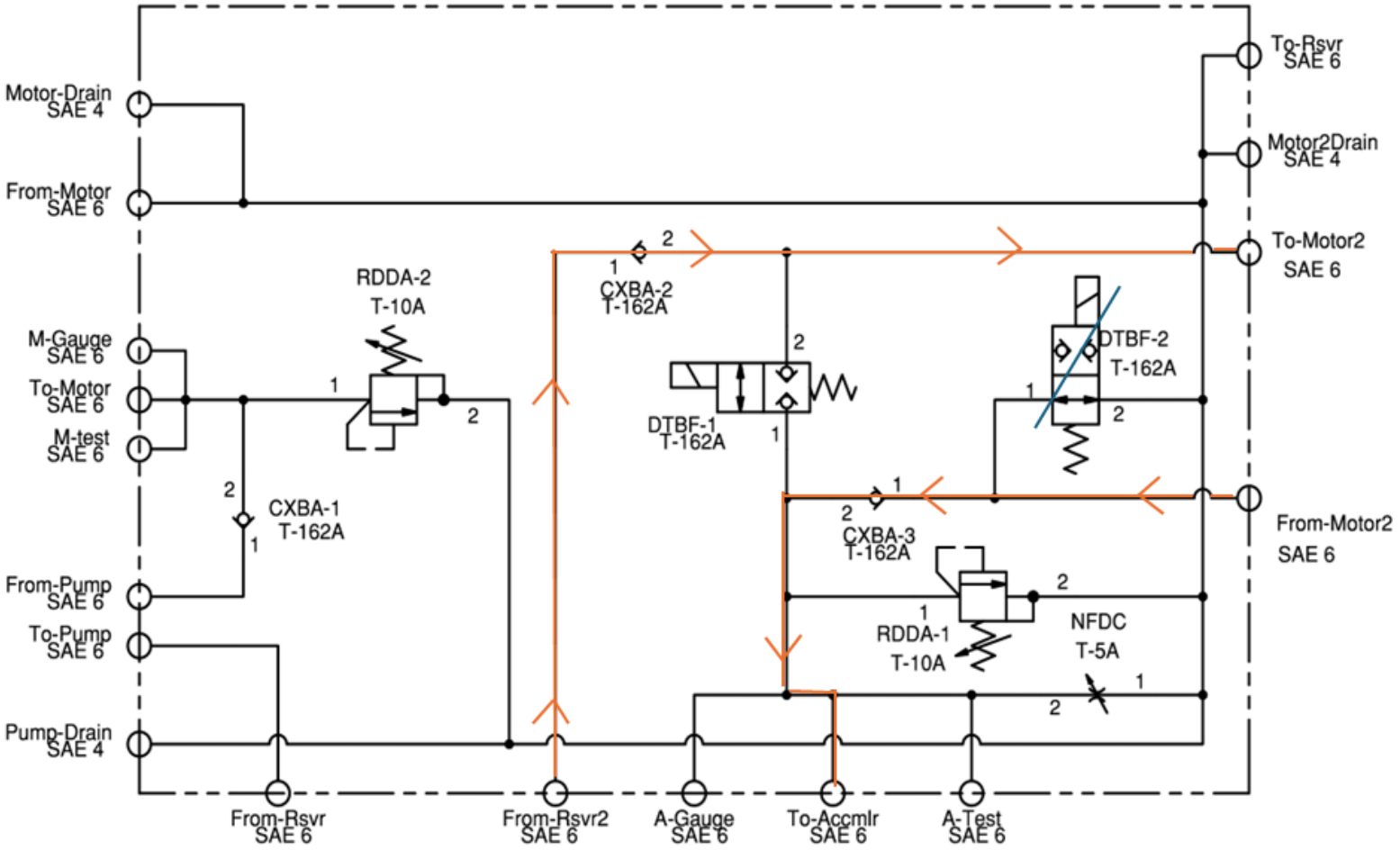
Hydraulic Circuit: Direct Pedal Mode



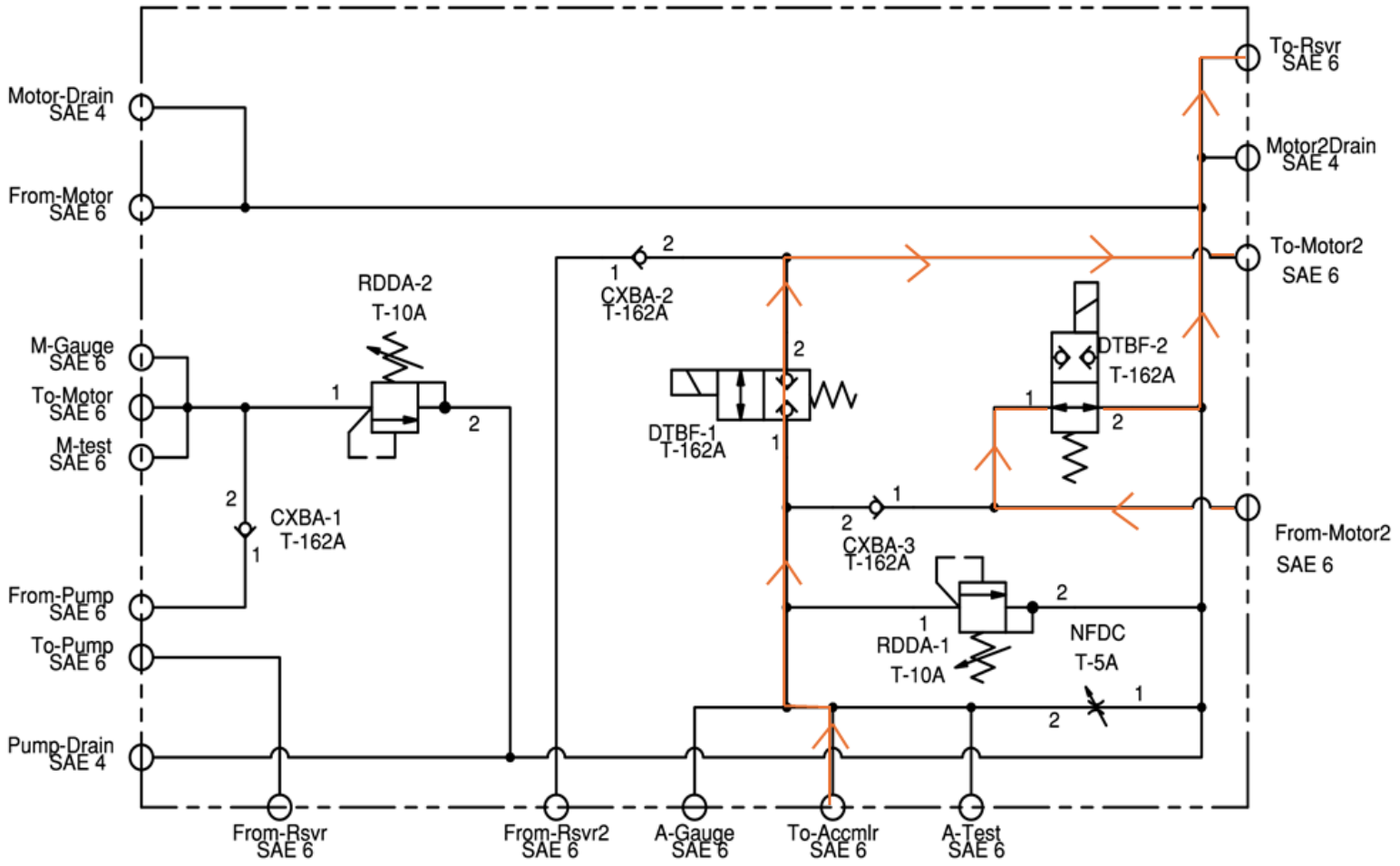
Hydraulic Circuit: Passive



Hydraulic Circuit: Charge Mode



Hydraulic Circuit: Discharge Mode



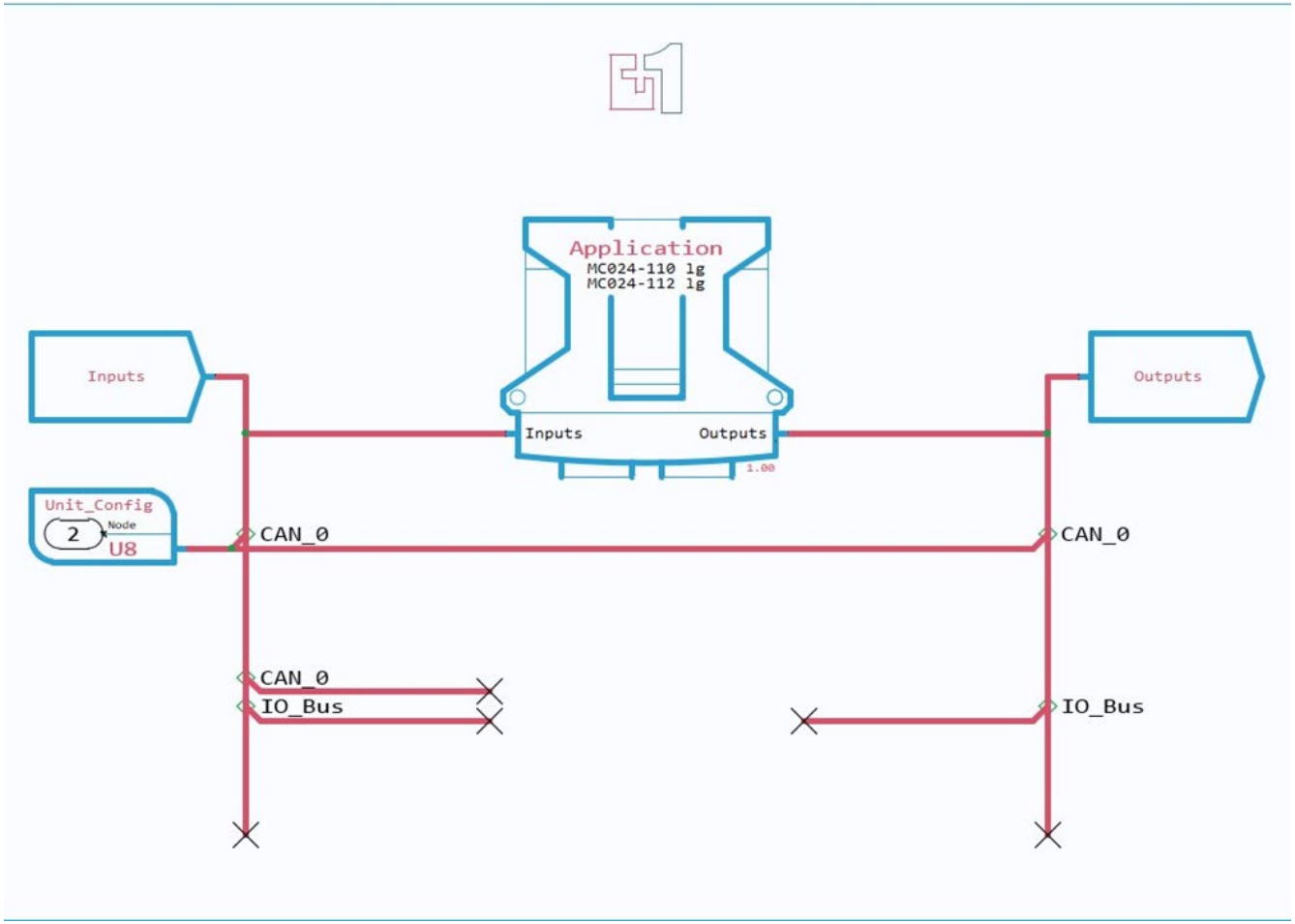
Electronics

Electronics: Overview

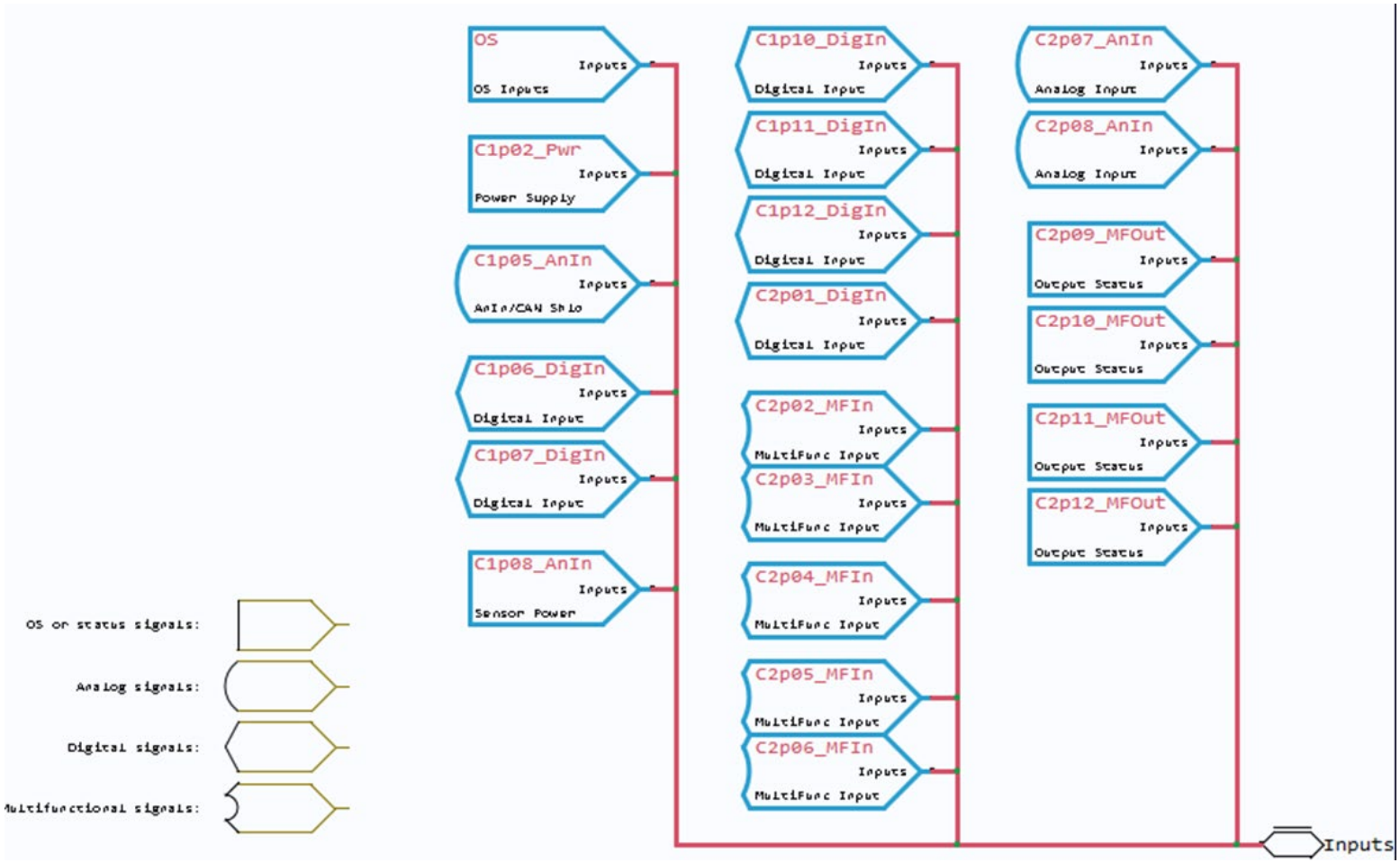
Components:

- 16-20 AWG Pin Bag Assembly
- DM430E Series Display (HMI)
- MC024-110 Microcontroller
- CG150-2 CAN USB Interface/Gateway
- 6S 5000 mAh Lipo Battery XT90 50C-100C 22.2V
- XT90h XT90 WireXT 90 Plug Male and Female Connector 150 mm 10 AWG Silicone Wire
- Lipo Charger H B6 RC Charger Lipo Battery
- Pressure Transducer Type MBS 3250

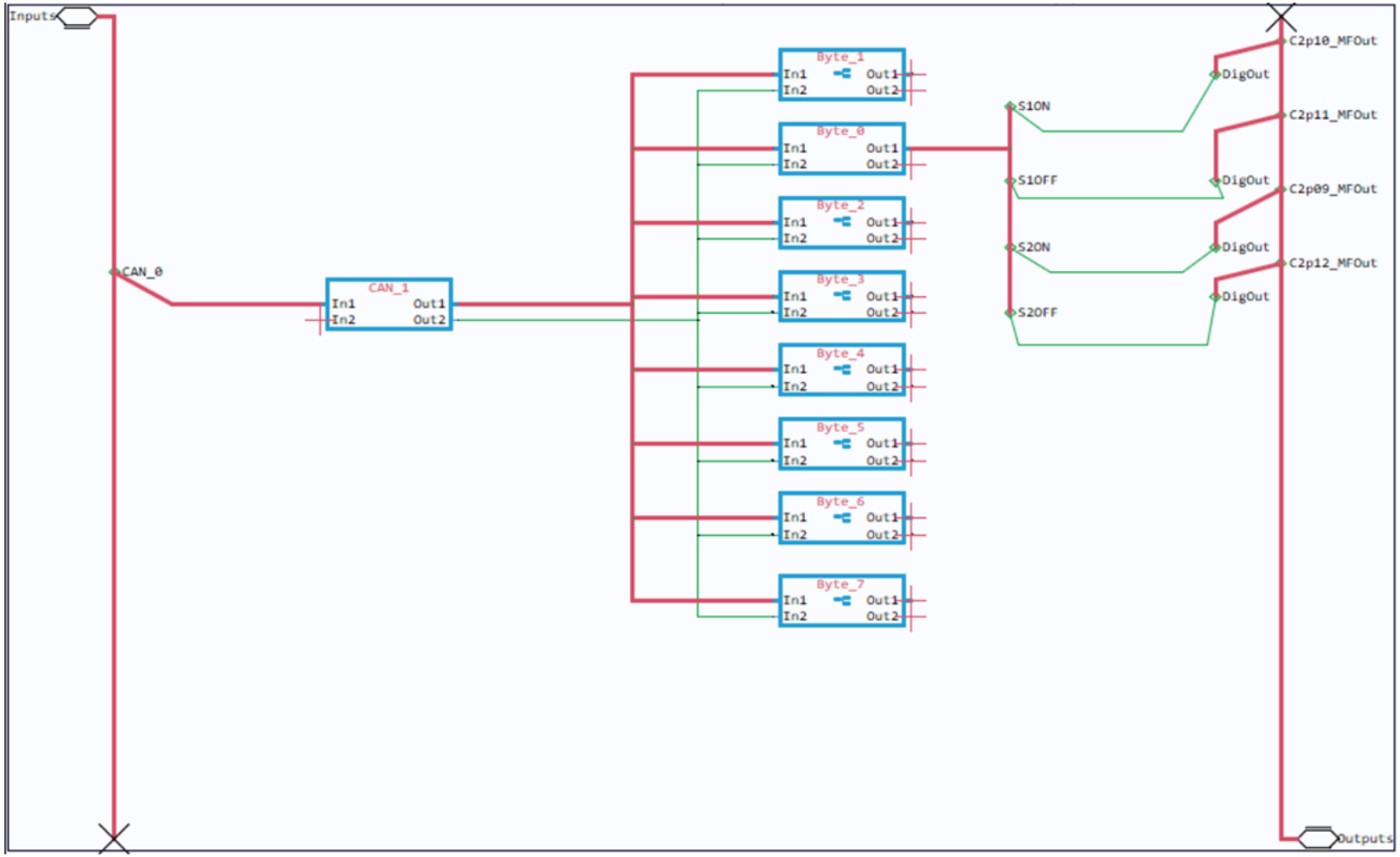
Controller Design



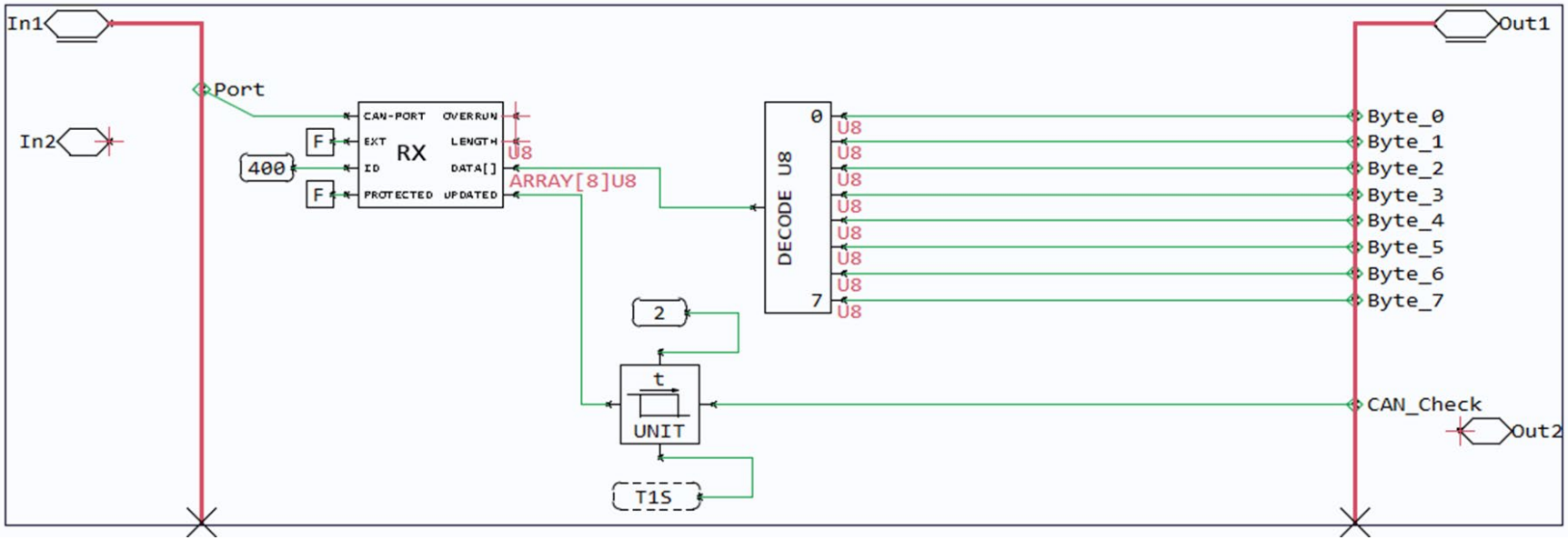
Inputs


OS
Inputs
OS Inputs
C1p02_Pwr
Inputs
Power Supply
C1p05_AnIn
Inputs
AnIn/CAN Shld
C1p06_DigIn
Inputs
Digital Input
C1p07_DigIn
Inputs
Digital Input
C1p08_AnIn
Inputs
Sensor Power
C1p10_DigIn
Inputs
Digital Input
C1p11_DigIn
Inputs
Digital Input
C1p12_DigIn
Inputs
Digital Input
C2p01_DigIn
Inputs
Digital Input
C2p02_MFIn
Inputs
MultiFunc Input
C2p03_MFIn
Inputs
MultiFunc Input
C2p04_MFIn
Inputs
MultiFunc Input
C2p05_MFIn
Inputs
MultiFunc Input
C2p06_MFIn
Inputs
MultiFunc Input
C2p07_AnIn
Inputs
Analog Input
C2p08_AnIn
Inputs
Analog Input
C2p09_MFOut
Inputs
Output Status
C2p10_MFOut
Inputs
Output Status
C2p11_MFOut
Inputs
Output Status
C2p12_MFOut
Inputs
Output Status
Inputs
OS or status signals:
Analog signals:
Digital signals:
Multifunctional signals:

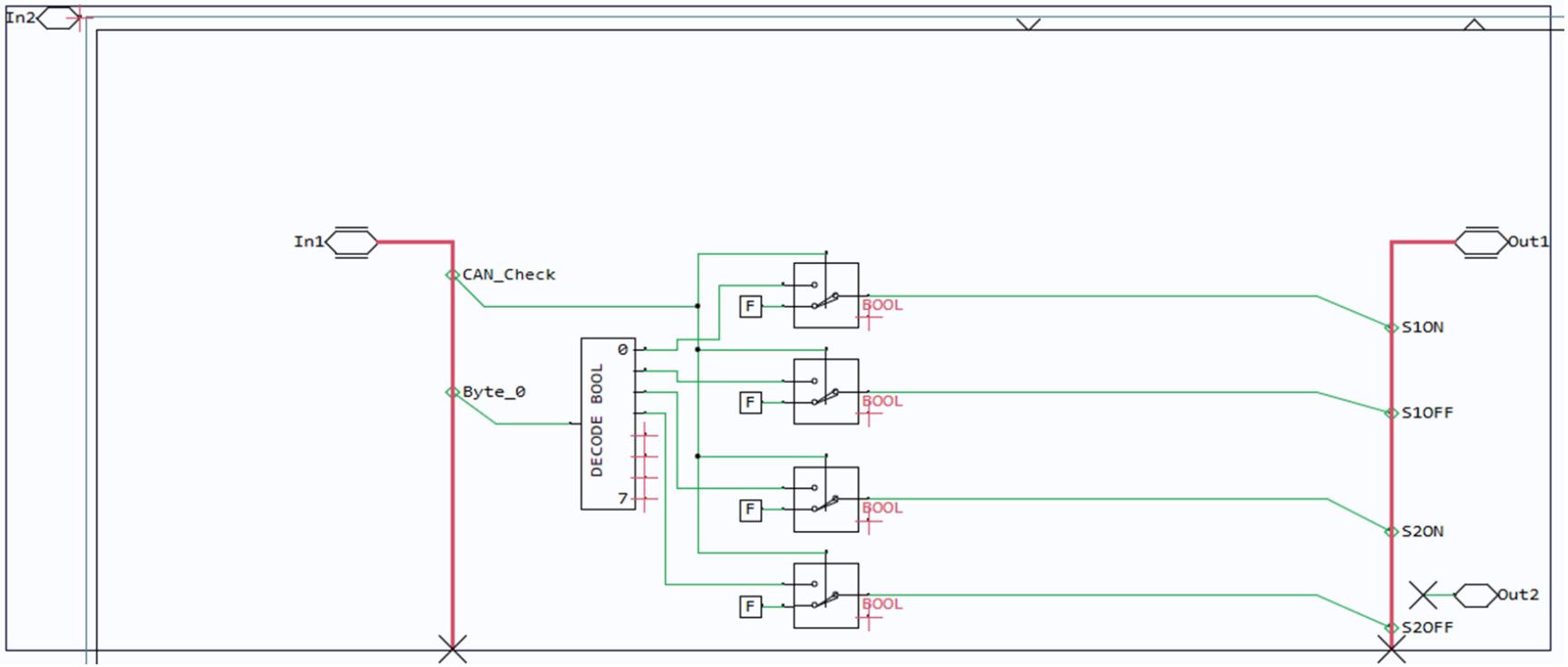
Interface


Inputs
CAN_0
CAN_1
In1
In2
Out1
Out2
Byte_1
Byte_0
Byte_2
Byte_3
Byte_4
Byte_5
Byte_6
Byte_7
S1ON
S1OFF
S2ON
S2OFF
DigOut
C2p10_MFOut
C2p11_MFOut
C2p09_MFOut
C2p12_MFOut
Outputs

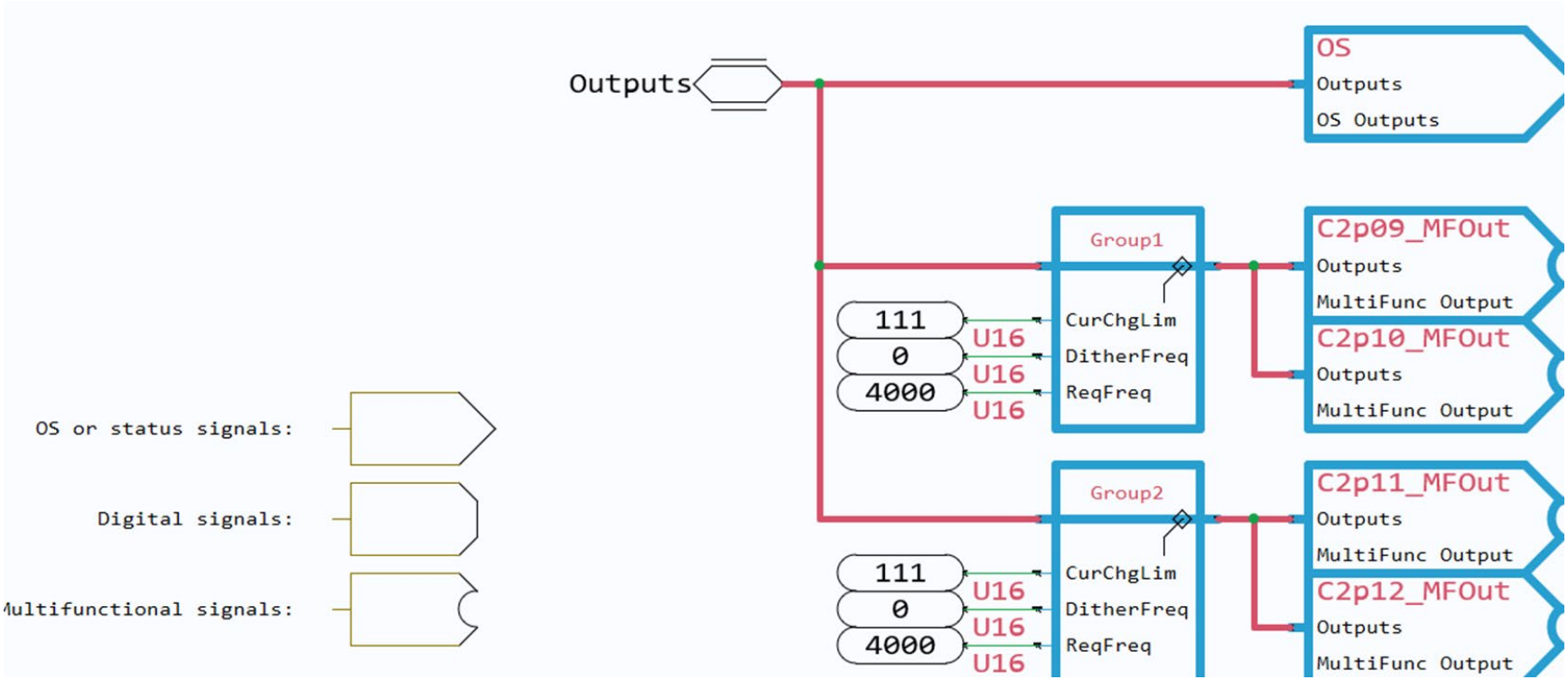
CAN Decoder


In1
In2
Port
400
F
F
CAN-PORT
EXT
ID
PROTECTED
RX
OVERRUN
LENGTH
DATA[]
UPDATED
U8
ARRAY[8]U8
DECODE U8
0
7
U8
2
t
UNIT
T1S
Out1
Byte_0
Byte_1
Byte_2
Byte_3
Byte_4
Byte_5
Byte_6
Byte_7
CAN_Check
Out2

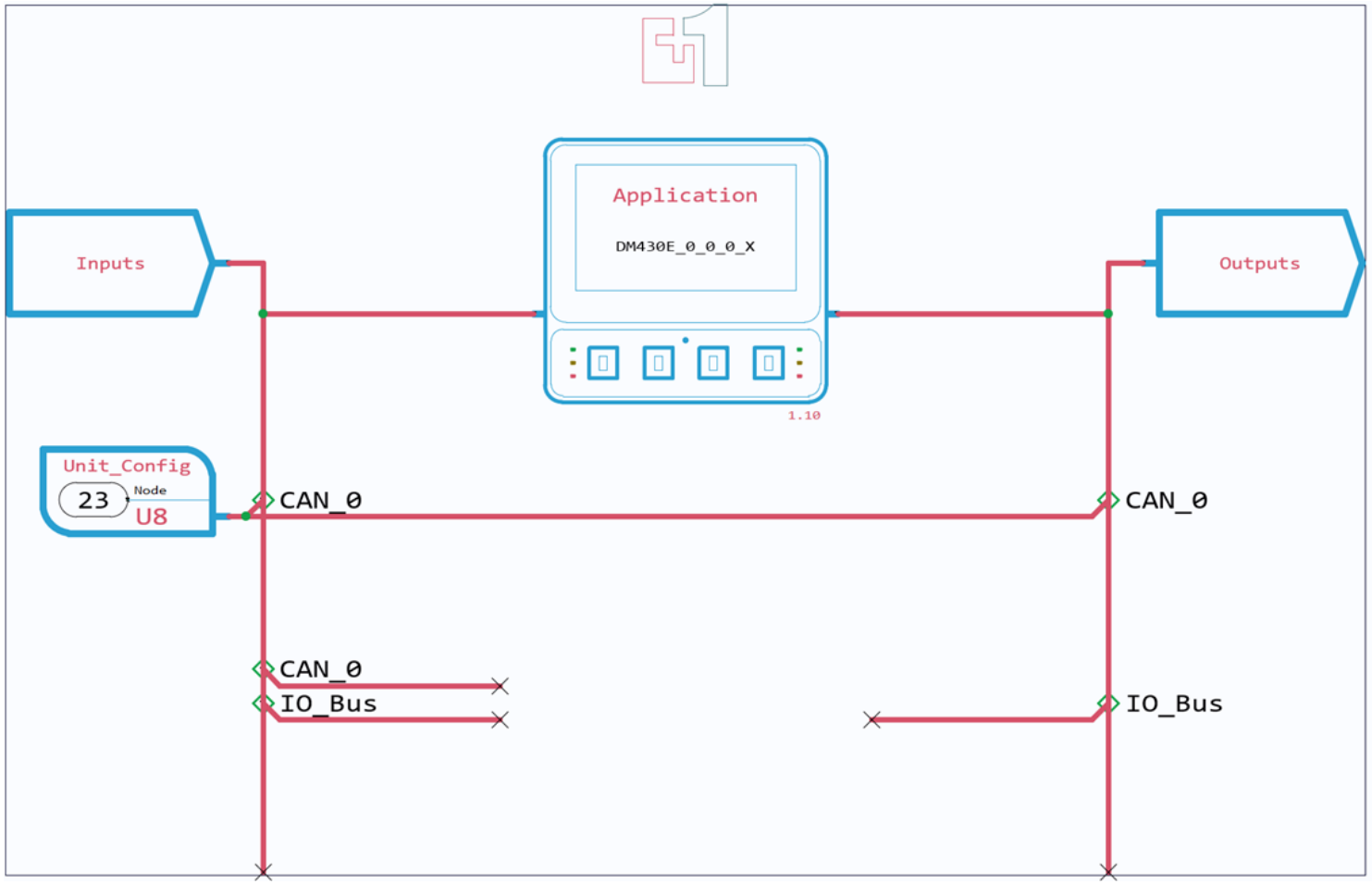
Byte_0


In2
In1
CAN_Check
Byte_0
DECODE BOOL
0
7
F
BOOL
F
BOOL
F
BOOL
F
BOOL
Out1
S1ON
S1OFF
S2ON
Out2
S2OFF

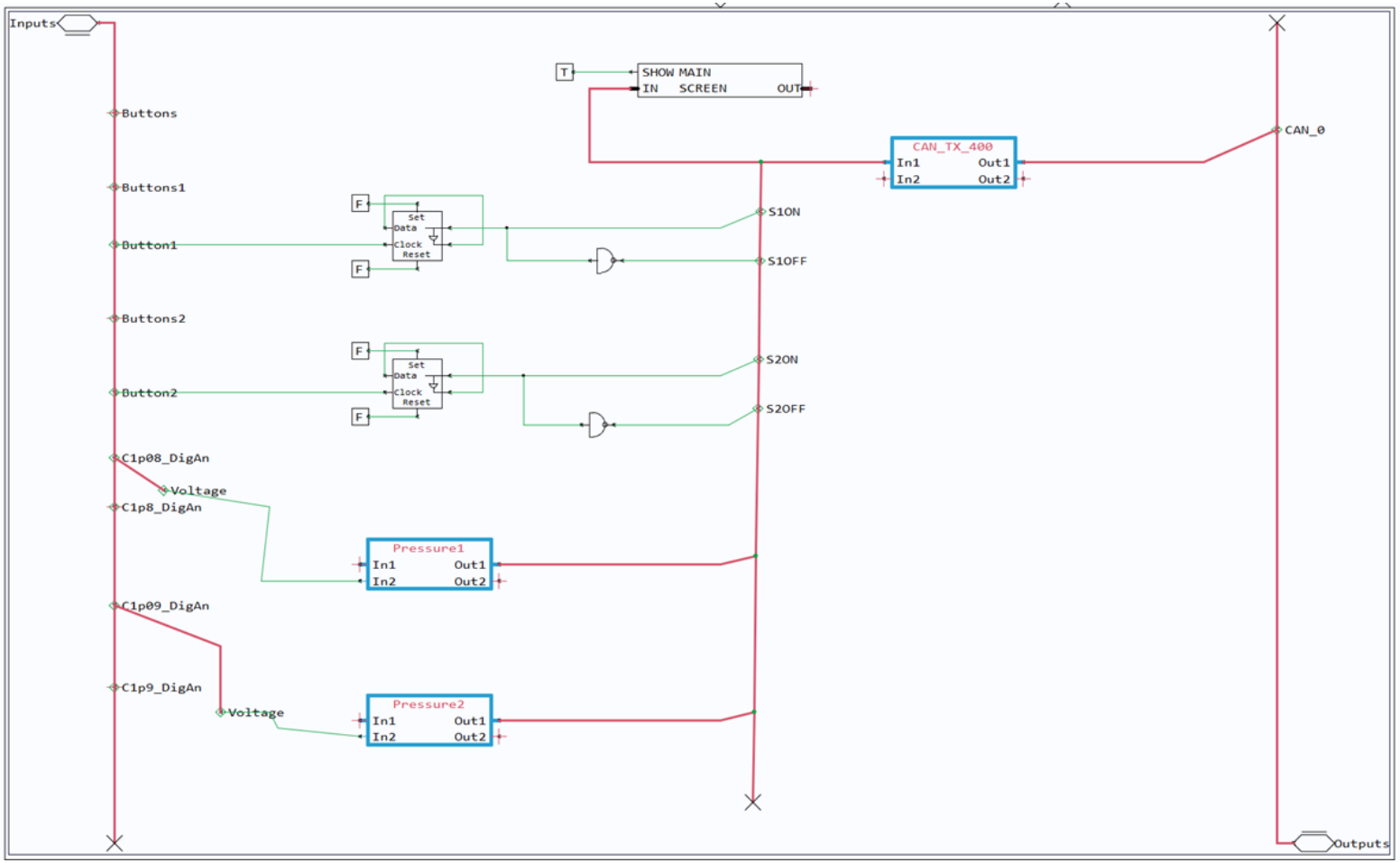
Outputs


Outputs
OS
Outputs
OS Outputs
Group1
111
U16
CurChgLim
0
U16
DitherFreq
4000
U16
ReqFreq
C2p09_MFOut
Outputs
MultiFunc Output
C2p10_MFOut
Outputs
MultiFunc Output
Group2
111
U16
CurChgLim
0
U16
DitherFreq
4000
U16
ReqFreq
C2p11_MFOut
Outputs
MultiFunc Output
C2p12_MFOut
Outputs
MultiFunc Output
OS or status signals:
Digital signals:
Multifunctional signals:

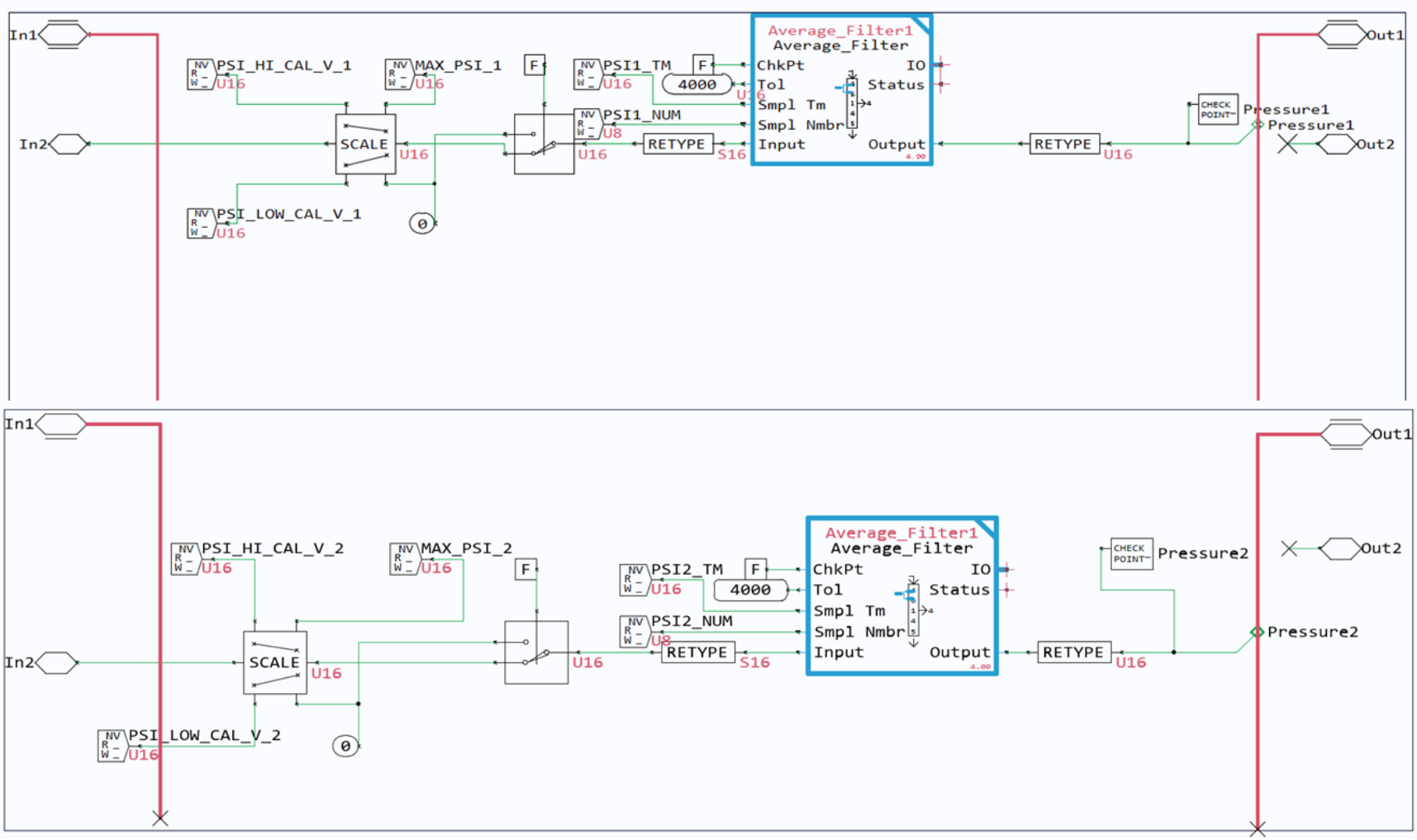
Display Screen Design



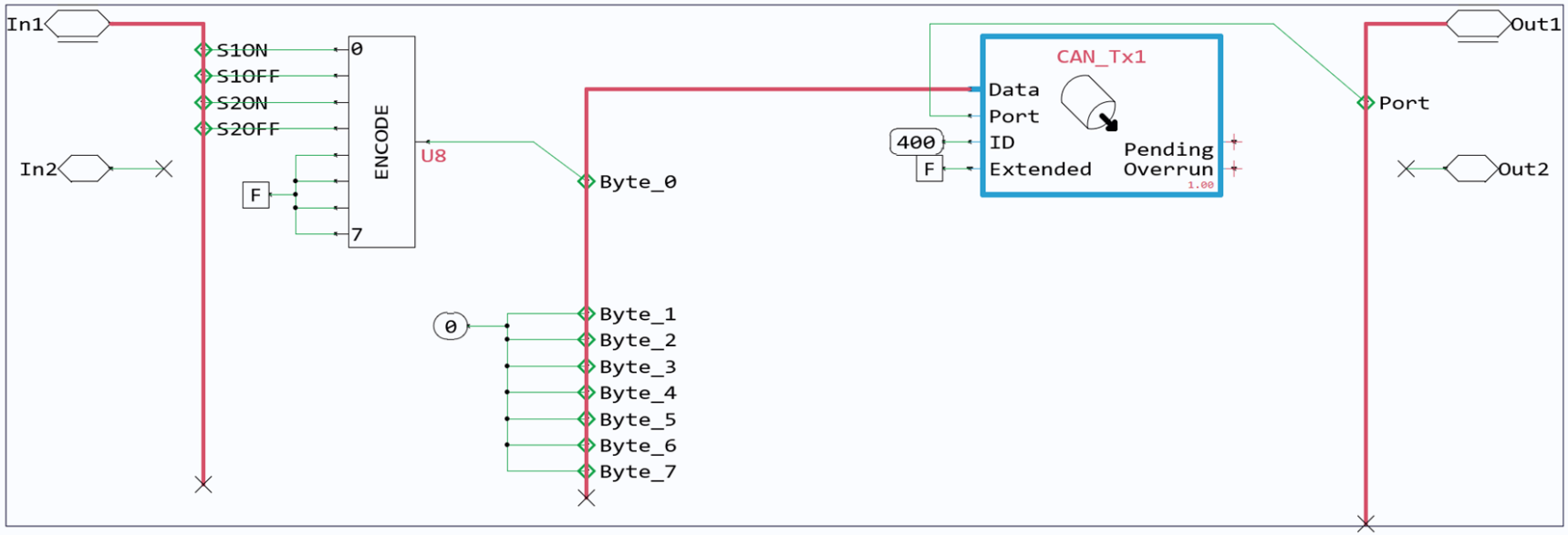
Transducer & Button Connection Set-Up



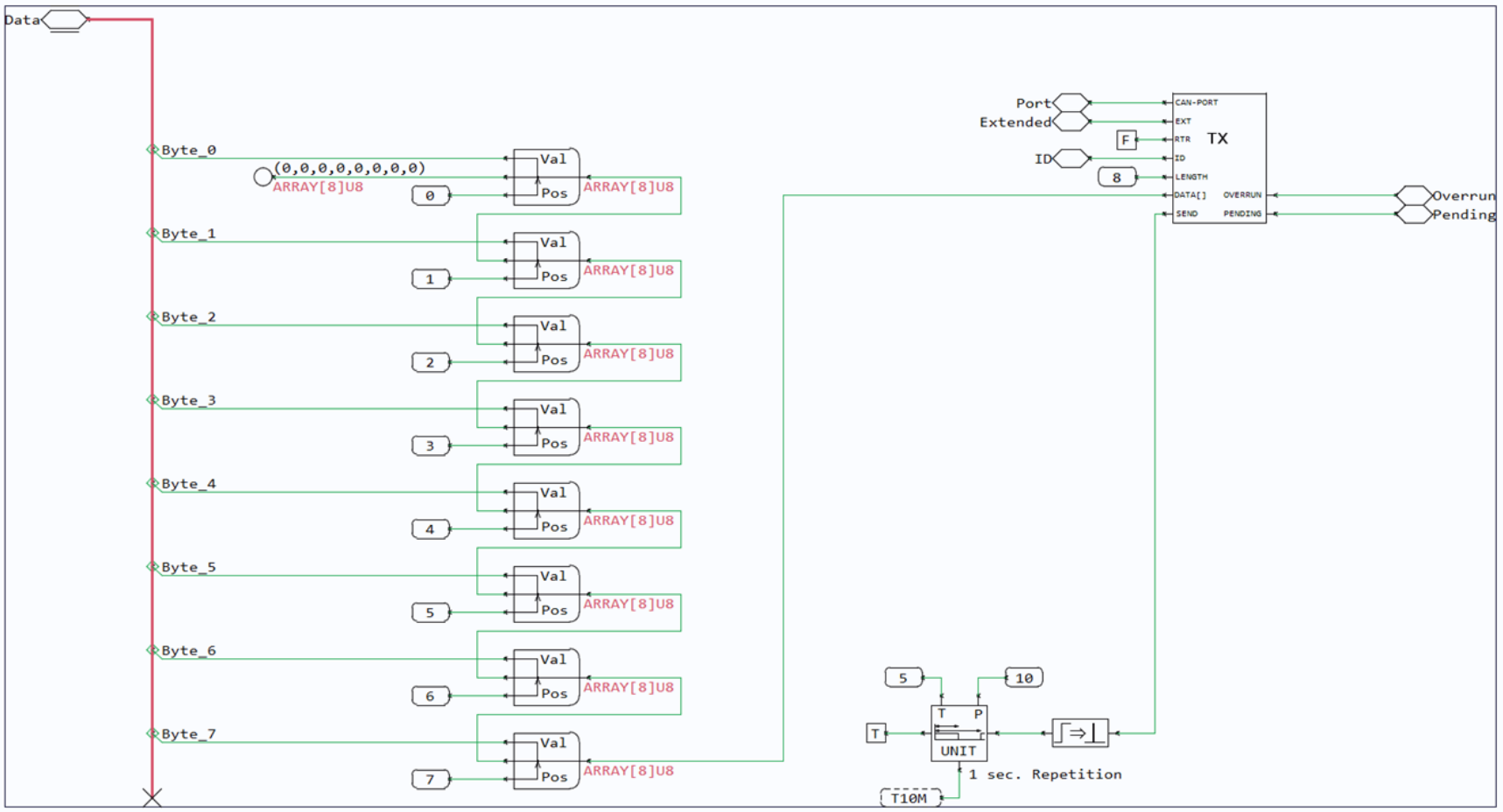
Pressure Transducer Scaling



CAN Encoding



Byte Conversion to a Readable CAN Message



Display Design

Motor Pressure

0 PSI

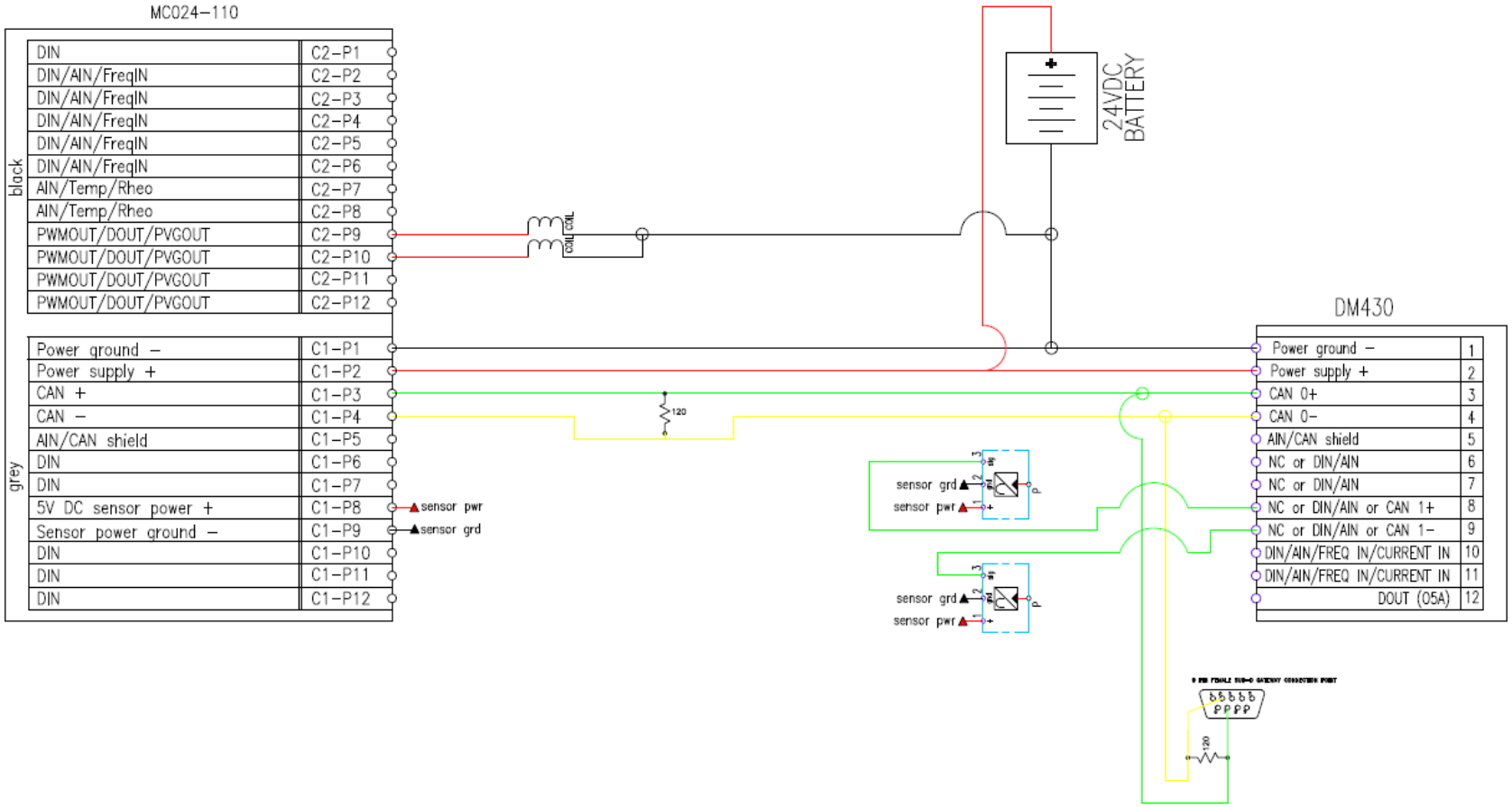
Accumulator Pressure

0 PSI

Solenoid 1	Solenoid 2
OFF	OFF
ON	ON

Both OFF - Manual Pedaling
S1 ON/S2 OFF - Discharging
S1 OFF/S2 ON - Charging

Wiring Diagram



Testing

Testing:

- Vehicle was operated utilizing all modes on the circuit
  - University of Akron campus used as testing ground
- Tested chain alignment and adjustments to ensure chain stays on track
- Data
  - Top speed of bike on flat ground: ~20 mph
  - Accumulator charges to 3000 psi with little leakage
- Weather prevented further quantitative testing

Results & Conclusion

Results

- Bike was able to reach a top speed of roughly 20 mph
- Vehicle maintained stability
- Accumulator had little leakage when fully pressurized
- Reservoir did not have any leakage
- Bike fully operates in all three modes

Lessons Learned

- Communication is key
- Maintain a schedule that keeps the process on track
- Divide tasks
- Plan ahead
- Test often

Thank You's

- Pat Green
- Ernie Parker
- Scott Sawyer
- Saikishan Suryanarayanan
- Aaron Trexler
- Bill Wenzel
- Paul Skrant
- Steve Gluck
- Chris Yanda
- Ben Quade
- Peter Rosza