Watershed Project

Presented by :

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RCET 3375 - Final Semester Project - Fall2025

Overview

This project focuses on creating a scale model of a watershed system that includes a mountainside, reservoir, spill gate, and floodplain. The model combines physical landscape construction with integrated electronics to simulate and control water flow and system behavior.

The project began when the Farm Bureau approached Idaho State University with a proposal to develop a portable, functional watershed model for demonstrations at local schools. Our team was tasked with designing and building a prototype that illustrates both the environmental processes and the electronic control system.

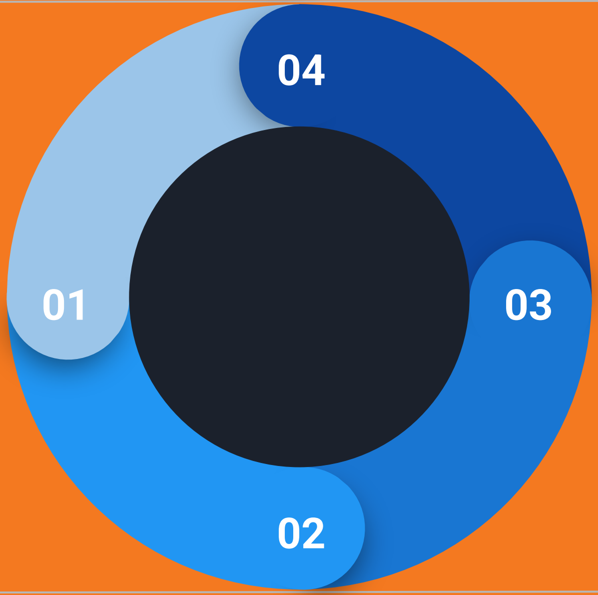
Cycle diagram

Snow Melt

Melting snow on mountain slope causes water to drain down to the reservoir.

Reservoir Overflows

Once the reservoir fills to capacity the water needs to be released.



Water Released

With reservoir at limit the spillway is opened to prevent damage.

Flood

The adjacent plane is flooded - residential area under water.

Project Goals

01 Develop a functional prototype that meets the project requirements by accurately representing the watershed system and demonstrating controlled water flow using integrated electronics.

02 Explore and evaluate design approaches for the electronics, programming, and physical model to determine the most efficient, reliable, and cost-effective solutions.

03 Gain hands-on experience through prototype development to inform the design and construction of a refined final version of the project.

Understanding the challenges

No prior work available – The project began with no existing designs or reference material, requiring development entirely from scratch.

Short timeline – Only four weeks were available to complete the project while balancing other course assignments.

Limited part availability – Delivery constraints required maximizing the use of materials and components already available on hand.

Methodology

Aim for ‘quick wins’ and prioritize fast prototyping.

< BOTH>

Plan for long term goals and continuous development.

Project timeline

Week 12

Week 13

Week 14

Week 15

Week 16

Parts List

Prepare parts list for Shane to order for us. Design and place order for the PCB.

Holiday

Thanksgiving break.

Electronics

Instal and connect all electronics in the project control box.

Model

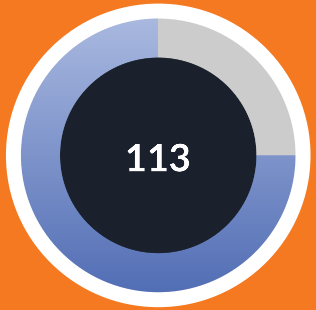
Build a physical model of the watershed.

Test

Assemble and test the prototype.

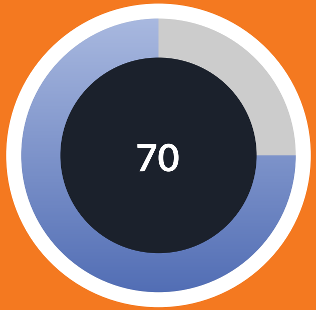
Work Hours

Our team tracked the hours each one of us spent working on this project.



Jacob

Christopher



Noah

Schematic

Modified PIC Development Board:

-Comms

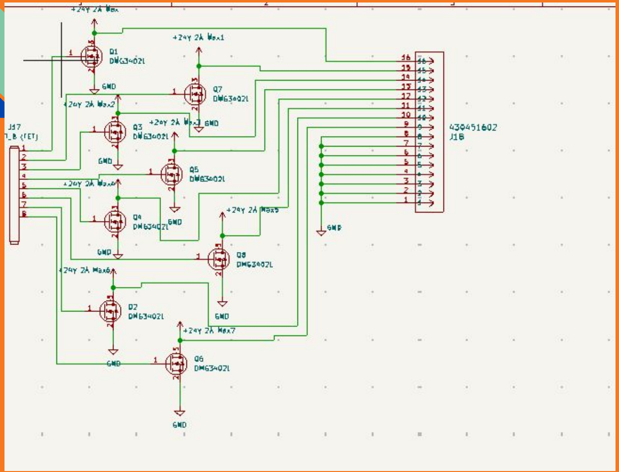
-Power

-IO Ports

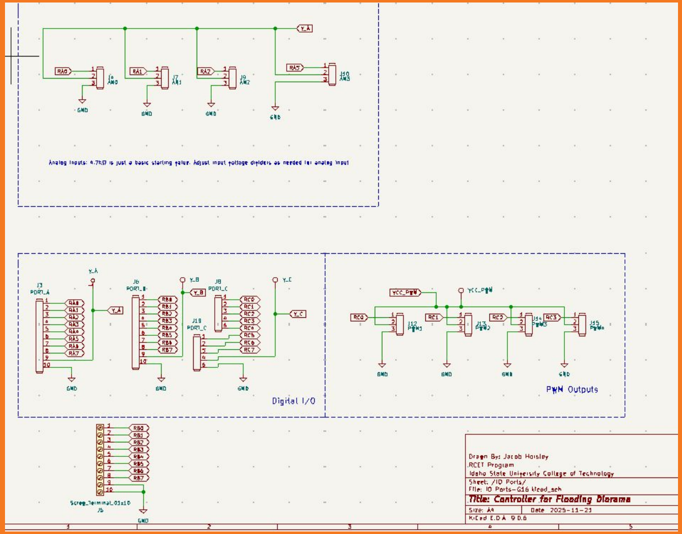
-Microcontroller

-FET Drive (We added this)

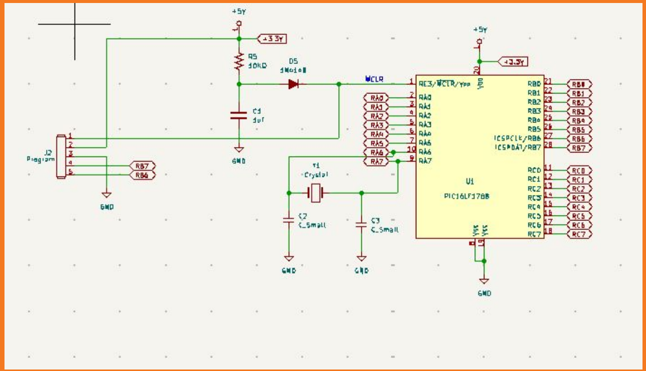
FET Drive



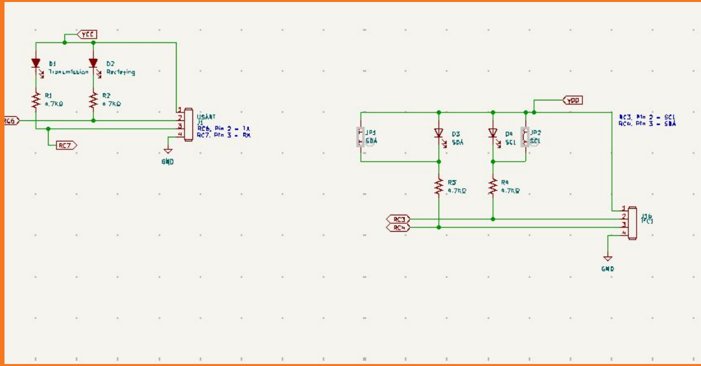
IO Ports



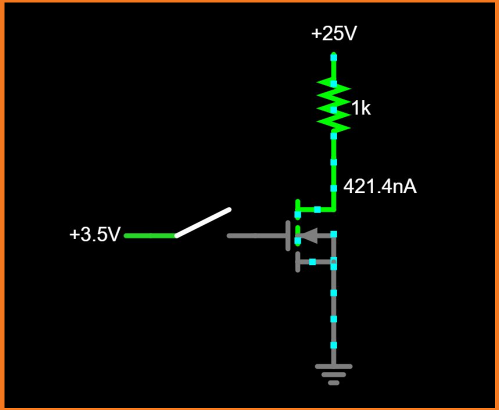
PIC16F1788 Configuration



Comms setup



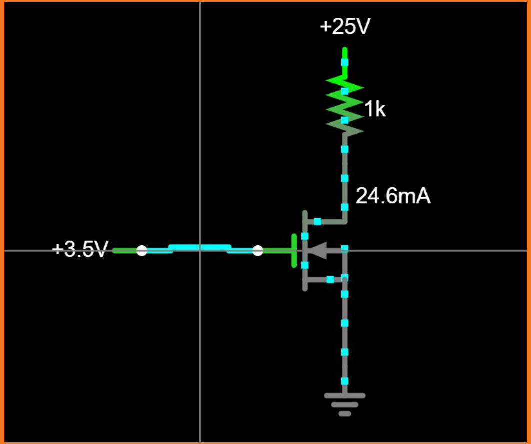
FET operation explained

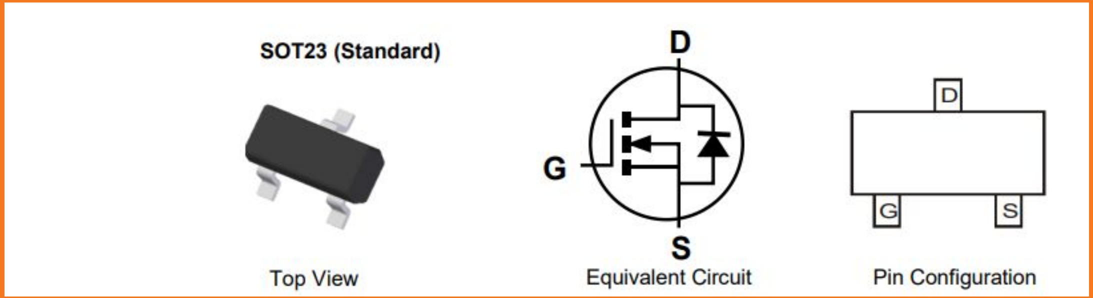


-Any device can connect to 25V

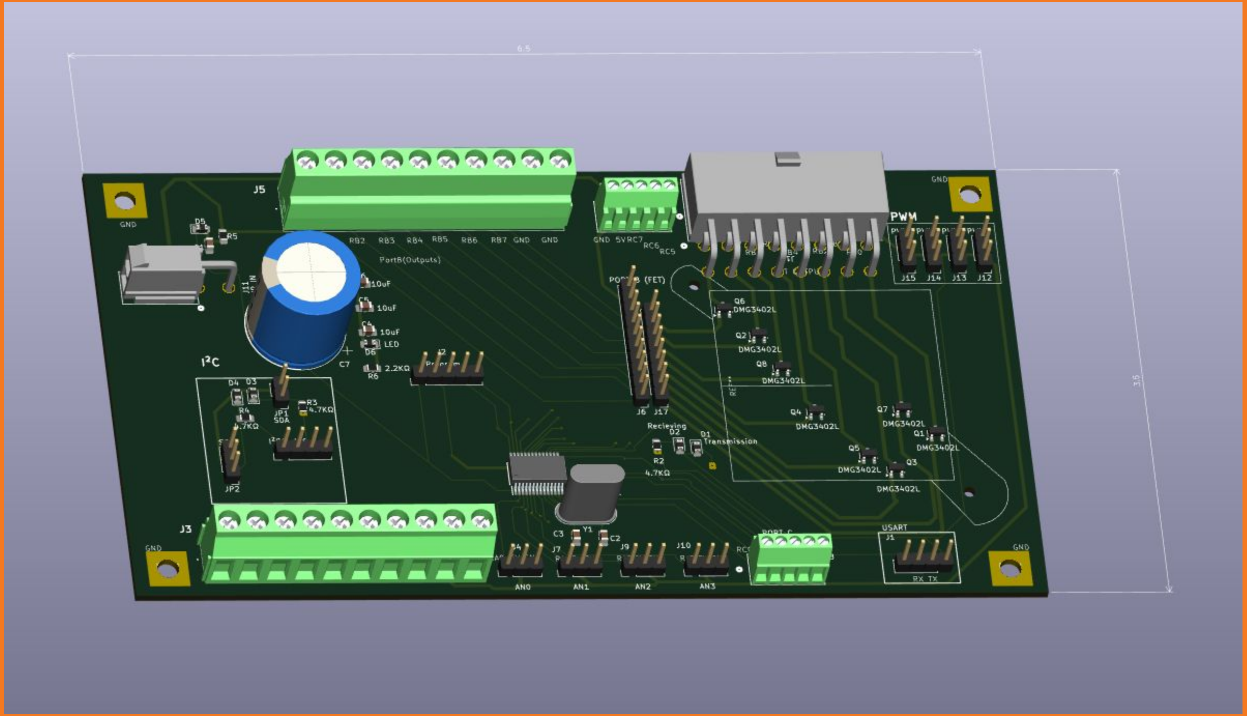
-The ground of the device connects to the FET connection of the board

-The FET acts as a switch and isolates PIC from high voltage

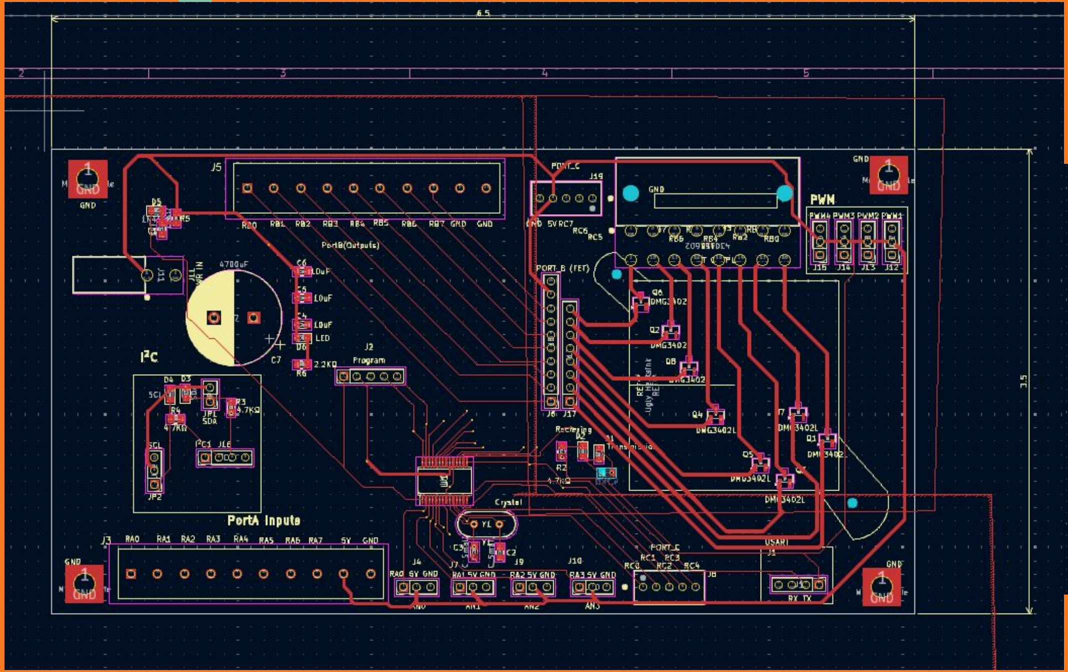


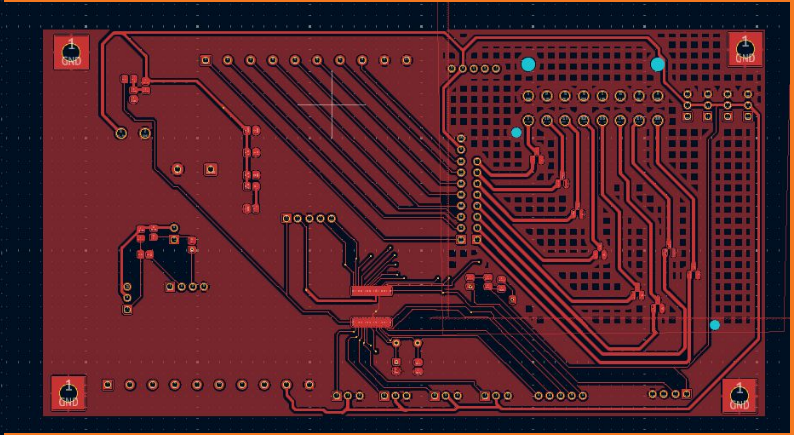


Finalized PCB



PCB Editor view





Features that we wanted to implement (Code)

- Acts as a control and data acquisition system
- Real time data streaming
- Priority interrupts for safety
- UART error Handling
- Indirect Addressing (For decoupling)
- PID (Proportional integral derivative)

Configuration

-16 MHz internal oscillator with PLL activated

-Global variables are in the General Purpose register (Store analog, timer delays, and packet config)

The Code

Features Implemented

-PSMC module (For PWM)

-ADC Module working on 5 inputs

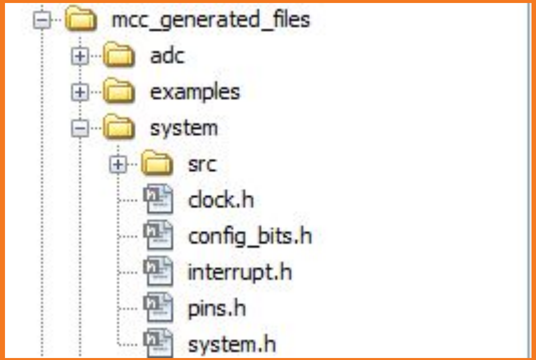
-3 digital inputs

-8 Digital outputs

-UART (RX and TX enabled)

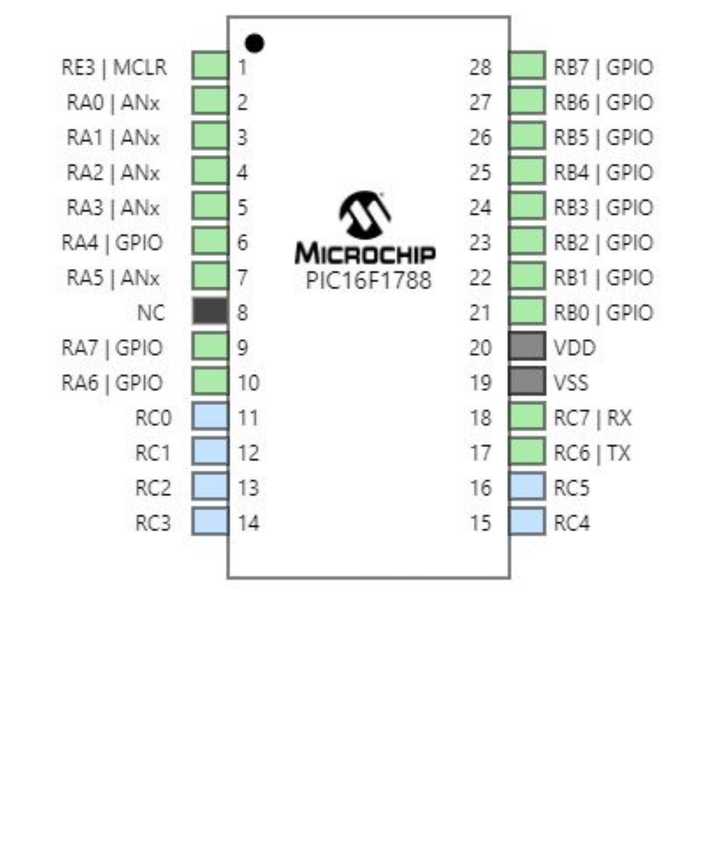
-Timer0 and Timer1 enabled

-Interrupt on change enabled



Pinout

RA0- Tank water level
RA1- Reservoir water level
RA2- Town water level
RA3- MOSFET Temperature
RA4- Start/Stop button
RA5- Heating element temp
RA6- Abort button
RA7- Return from Abort



RB7- Water Pump
RB6- Heating Element
RB5- Servo power
RB4- Gate lights
RB3- Reservoir Valve
RB2- City Lights
RB1- Valve for the City
RB0- Unused pin

RC7- Receive for UART
RC6- Transmit for UART
RC5- PWM output

Proposed and implemented state machine

1. Wait for start button to be pressed
2. Turn on heating element, city, and dam lights
3. Water pump starts pumping water*
4. Pump stop moving water and heat turns off*
5. Dam gate opens and the gate lights turn off (simulating fail)*
6. Valve for the plains/town opens*
7. All valves open to drain leftover water and lights turn back on*

(Process repeats until paused or shut off.)

*Any steps with an asterisk reduce the timer time when analog water sensor reaches a certain level

Mainloop

-Processes packets

-Updates one second events

A. Timers
B. Servo
C. Case patterns

- Abort condition check

-Sends the UART Transmission protocol

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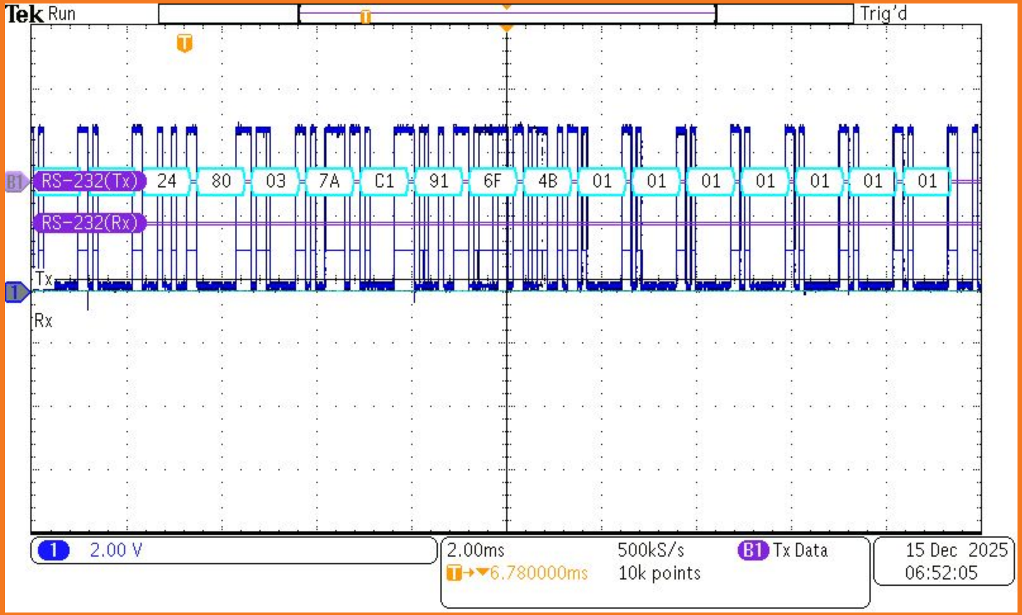
UART Transmission Protocol



<Handshake><Digital Inputs><Digital Outputs><ADC 1 Data><ADC2 Data><ADC3 Data><ADC4 Data><ADC5 Data><Delay for case 1><Delay for case 2><Delay for case 3><Delay for case 4><Delay for case 5><Delay for case 6><Delay for case 7>

Interrupt Service Routine

-Handles 1 second counter for state machine

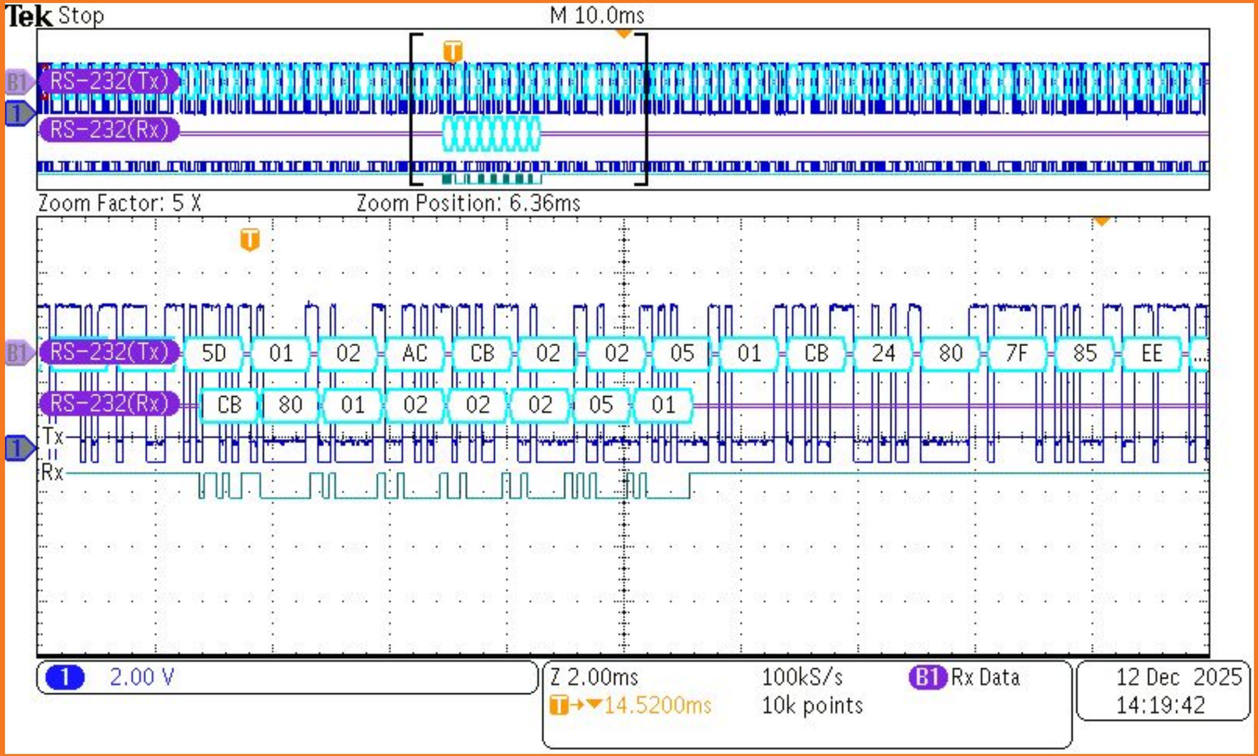
-Handles inputs and changes associated variables

A. These changes prioritize Abort conditions
B. Analog inputs affect timer for state machine

-UART RX Handling

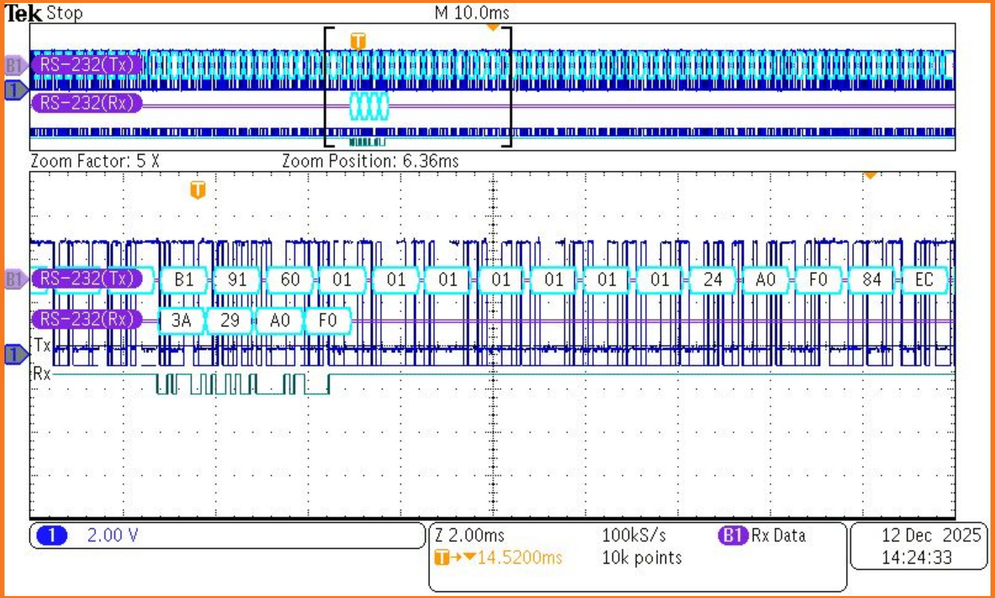
-Short enough to not disrupt mainloop

RX Processing (Command)



<Change Handshake><Digital inputs><Delay1><Delay2><Delay3><Delay4><Delay5><Delay6>

RX processing (Debug Outputs)

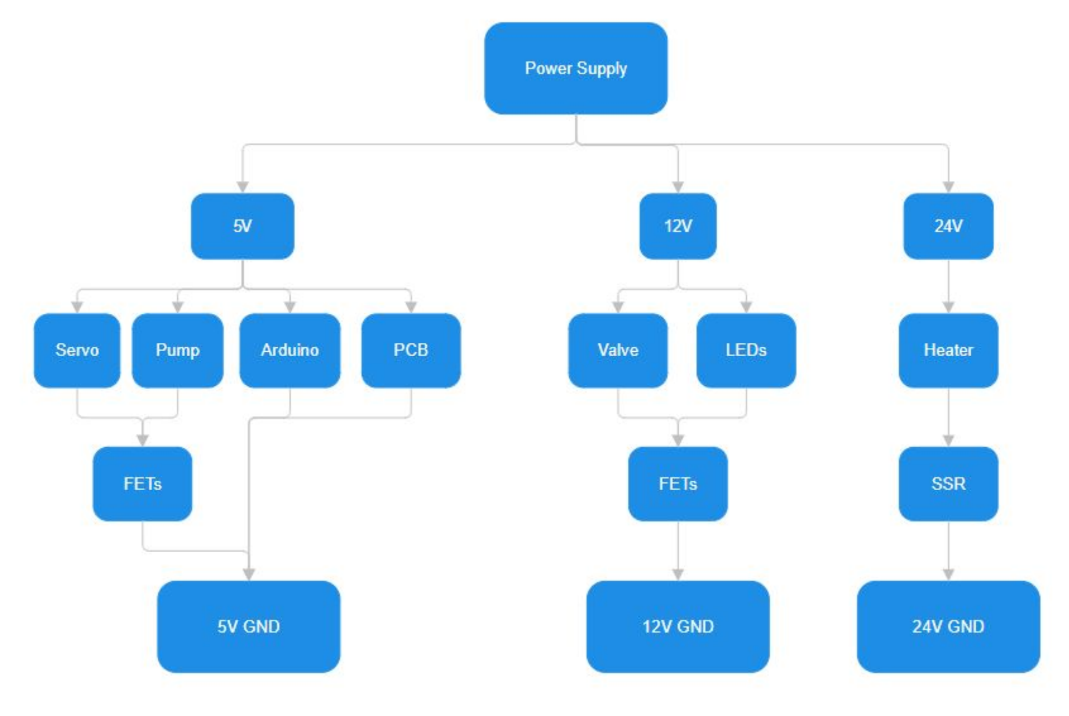


<Debug Handshake><Debug handshake part 2><Digital Input command><Digital Output command>

Hardware Integration

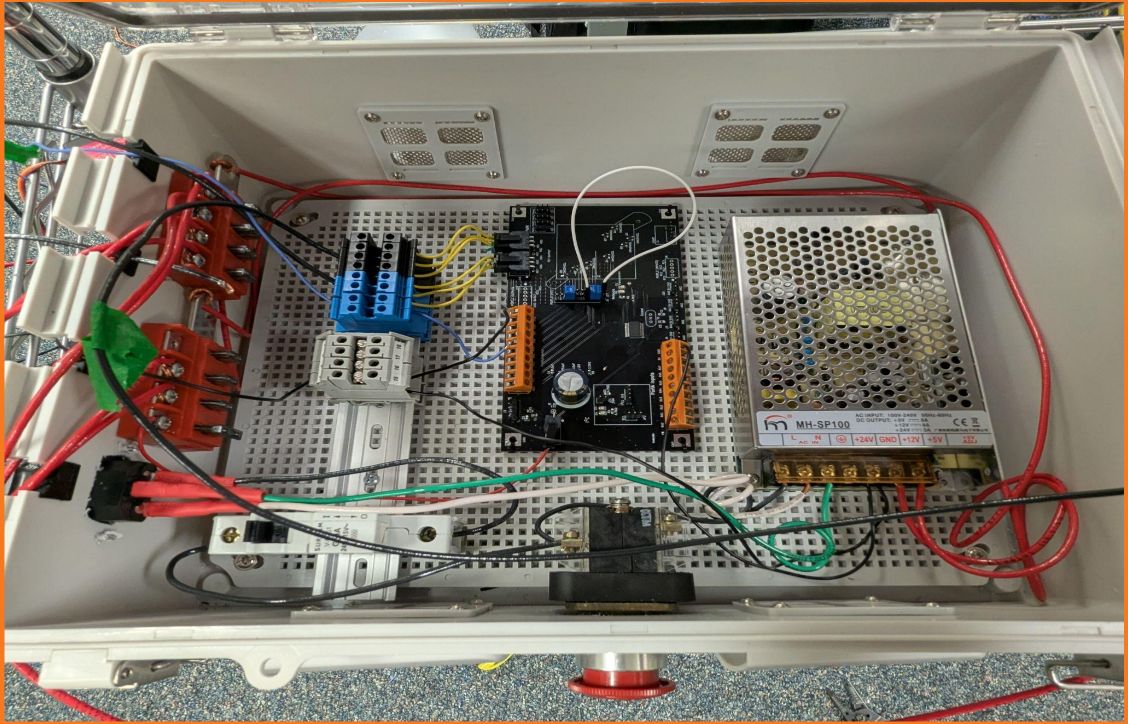
- Initial current testing
- Underrated banana cables
- Design takeaway

Hardware Block Diagram



Safety & Design

- Breaker after wall power
- Abort switch
- Power Supply
- Fuse protection



Current Ratings

- Measured max currents
- Fuse sizing

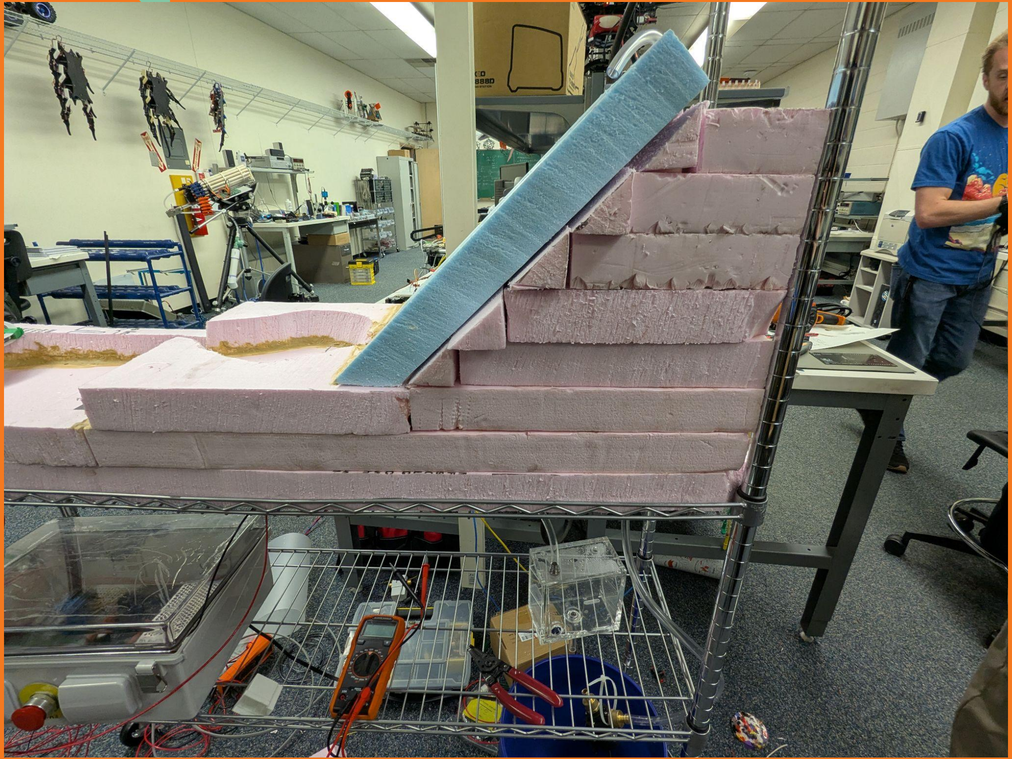
Wire Distribution

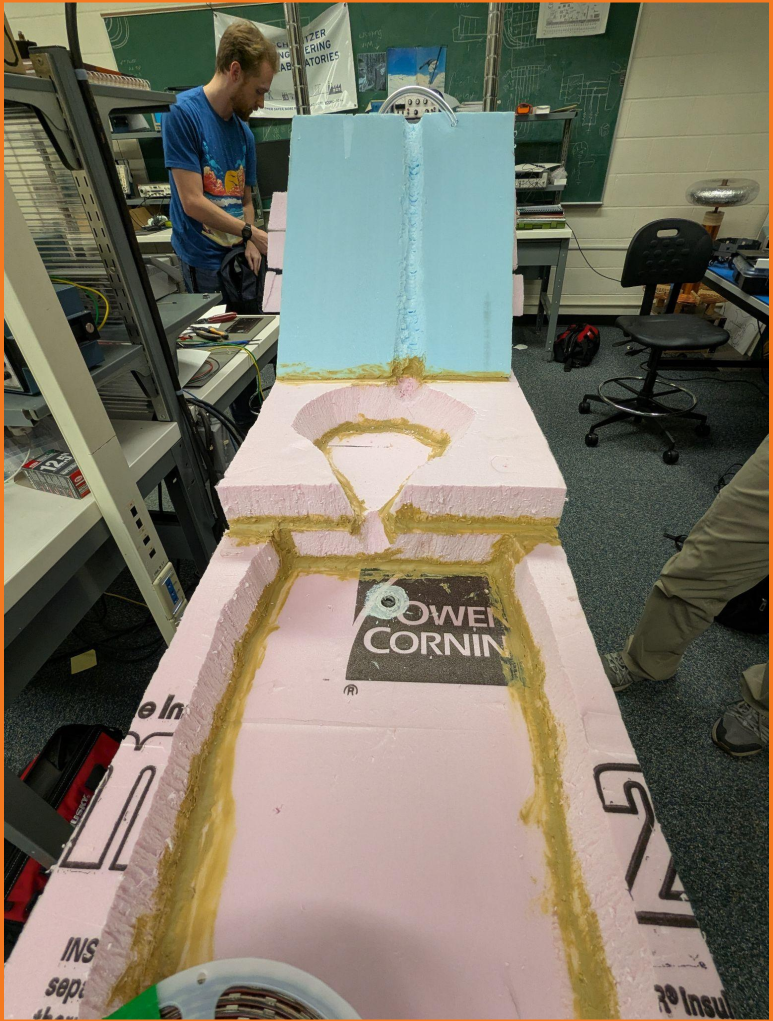
- 14 AWG high current
- 20 AWG low current
- DIN rail transitions

Outputs

- Water pump (snowmelt)
- Servo (spillway gate)
- Valve (drainage)
- LEDs (town lights)

Model Construction





Challenges

- Water + electricity = long nap
- Cable connectivity/ management
- Accessibility

Future Recommendations

- Safety First
- Measure twice, cut once