Comprehensive Design Review - March 2021

Active Windows Project

Team #15

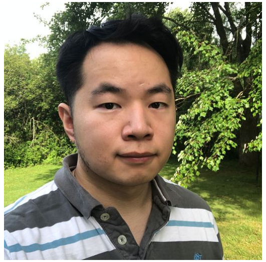
Michael Chan, Dingbang Chen, Nathan Johnson, Tien Li Shen

Advised by Professor Yao

University of Massachusetts Amherst

Team members

All



Michael Chan
EE

Dingbang Chen
CompE

Nathan Johnson
CompE

Tien Shen
CompE

Problem Statement

Tien

Building automation systems can help reduce operational costs and carbon emissions by improving energy efficiency. However, many current solutions are manufacturer specific and expensive, making widespread adoption difficult.

Tien

Our Solution

Our project aims to assist the non-profit Manhattan-2 company develop "electrical and communications standards that define how devices interconnect within the building of the future."

This entails:

- Help with the development of an open-source software framework (BuildingBus) to enable easy smart home device development
- Develop a new CAN transceiver circuit that emphasizes smart building network priorities, particularly higher-reliability and lower operational power compared to existing CAN transceivers

CDR Deliverables

All

Michael Chan

- ❑ Physical Layer
- ❑ Transceiver
- ❑ Power Supply

Nathan Johnson

- ❑ Implement packetization for data on the network
- ❑ Add packet forwarding between non-adjacent nodes
- ❑ Node-to-node packet addressing

Dingbang Chen

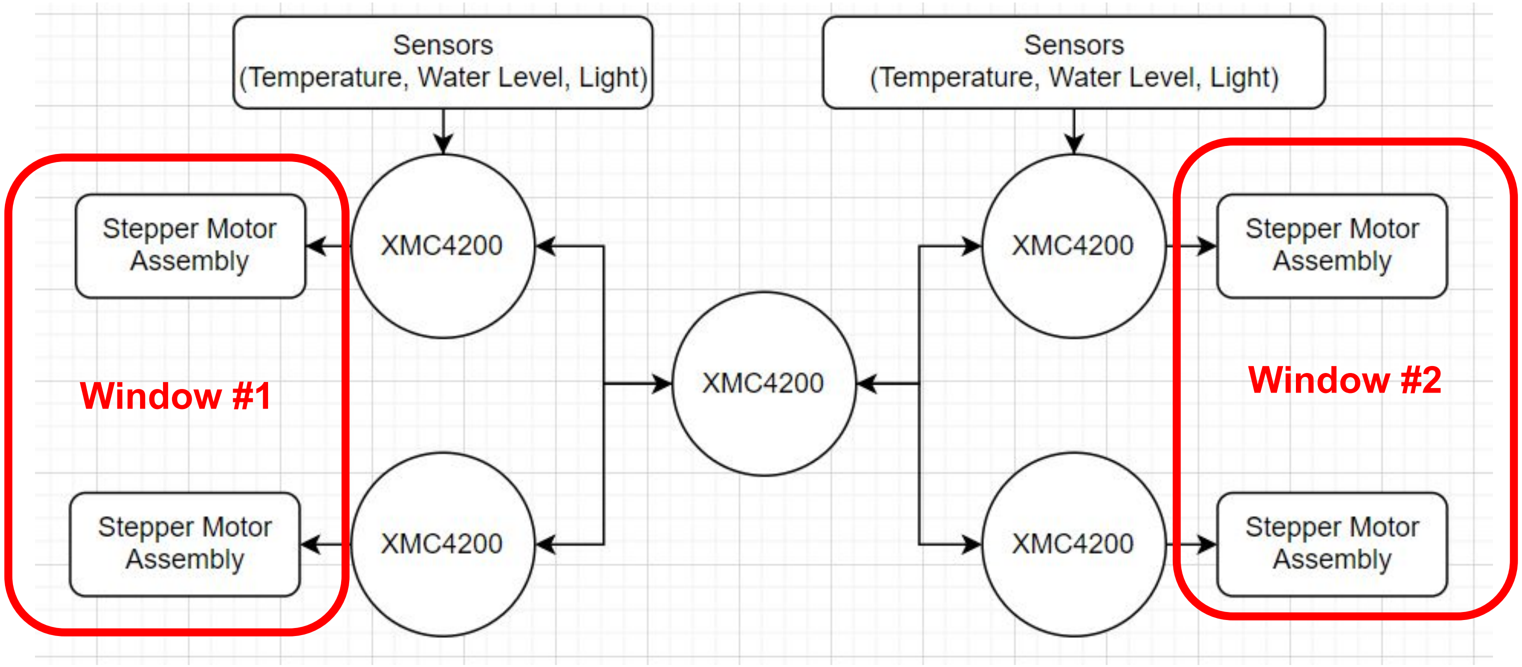
- ❑ Step Motor Logic Implementation
- ❑ Website Build

Tien Shen

- ❑ Altium Lead
- ❑ Temperature sensor
- ❑ Rain/snow sensor
- ❑ Light sensor
- ❑ Motion sensor

Overall System Diagram

Nathan



Nathan

System Specifications

- Custom PCB CAN transceiver for physical layer communication

- 2 mock windows are driven by two stepper motors each
  - One motor drives the window itself
  - The other raises and lowers a cloth blind
  - These two motors are driven by two different microcontrollers

- 5 microcontroller (Infineon XMC4200) nodes in our network
  - 4 edge nodes on 2 different electrical CANBus networks
  - 1 repeater node to connect the two networks together

- Water level sensor, temperature sensor, light sensor provide stimulus to network
  - All three sensors on only 2 edge nodes
  - Other 2 edge nodes have no sensors

Nathan

System Specifications

- Satisfied CDR deliverables:
  - Rain/water level sensor
  - Temperature sensor
  - PCB designed, manufactured, in-hand
  - Tree topology CAN bus network (communication between 5 nodes)
  - Motor ouput
- Unsatisfied CDR Deliverables:
  - Node-to-node network addressing
  - Permanent power supply
  - Motion sensor

Hardware List

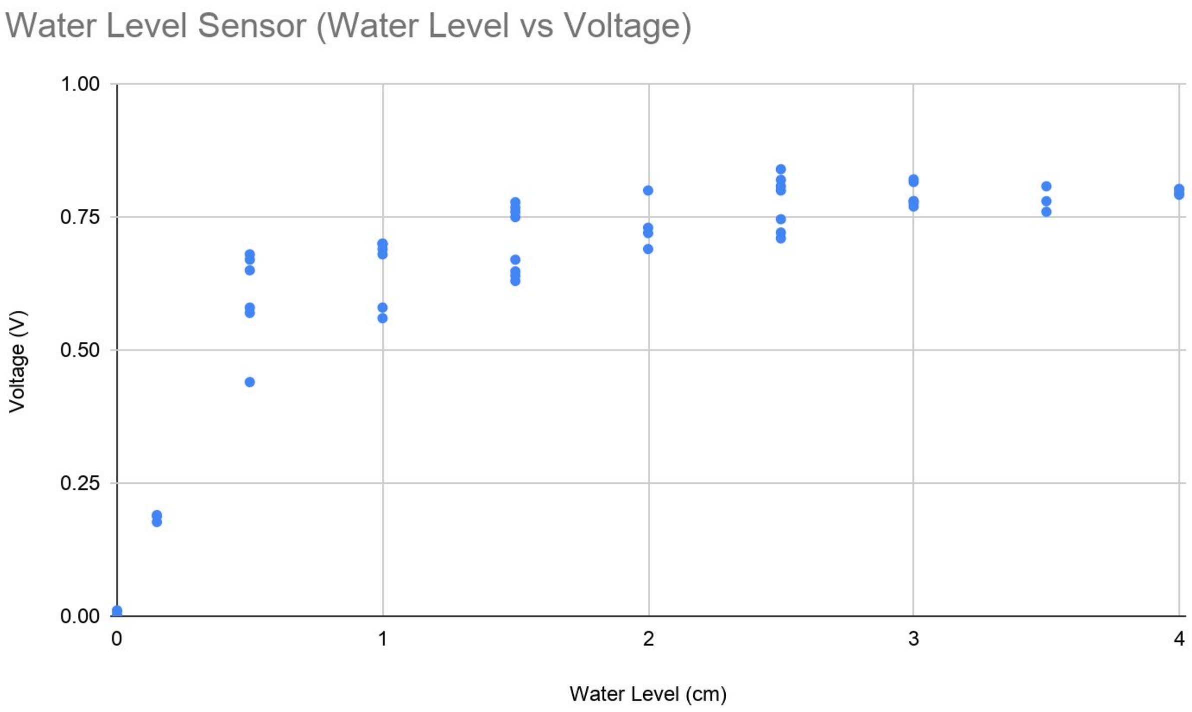
Mike

- 5 - Infineon XMC4200 development boards
- 6 - Custom CAN Transceiver on PCB
- 6 - Small breadboards
- 4 - Step motors and Drivers
- 2 - Photoresistor
- 2 - Water Level Sensor
- 2 - TMP36 temperature sensor
- Power Adapters
- Lab power supply

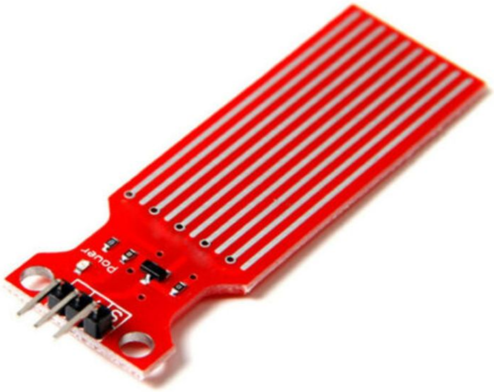
Software List

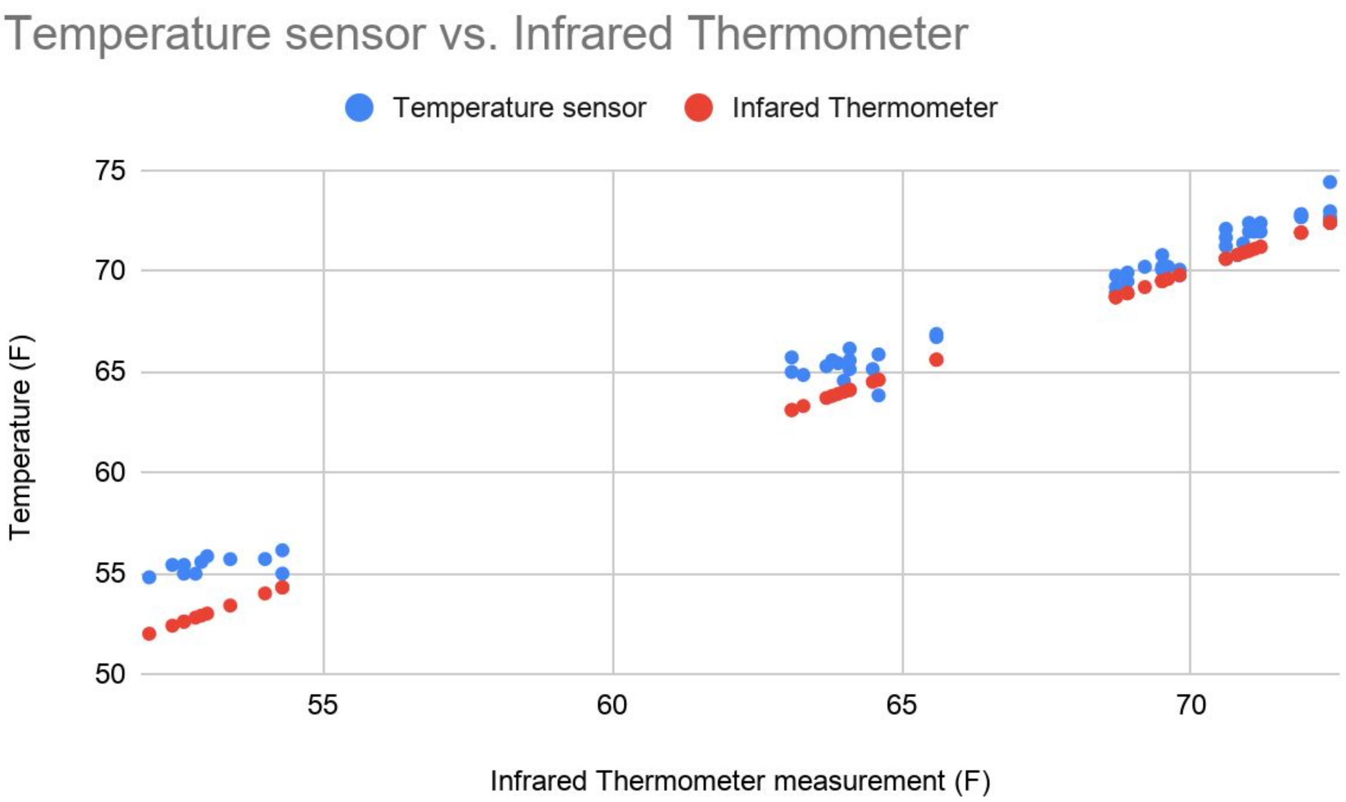
- DAVE IDE (Eclipse based IDE for programing and debugging embedded systems)
- TINA (Toolkit for Interactive Network Analysis - Circuit Simulator)
- Altium (PCB design tool)

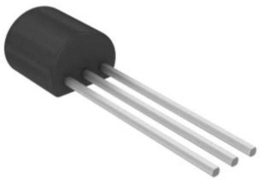
Tien



Water Level Sensor (Water Level vs Voltage)
1.00
0.75
0.50
0.25
0.00
Voltage (V)
0
1
2
3
4
Water Level (cm)




Temperature sensor vs. Infrared Thermometer
Temperature sensor
Infared Thermometer
75
70
65
60
55
50
Temperature (F)
55
60
65
70
Infrared Thermometer measurement (F)



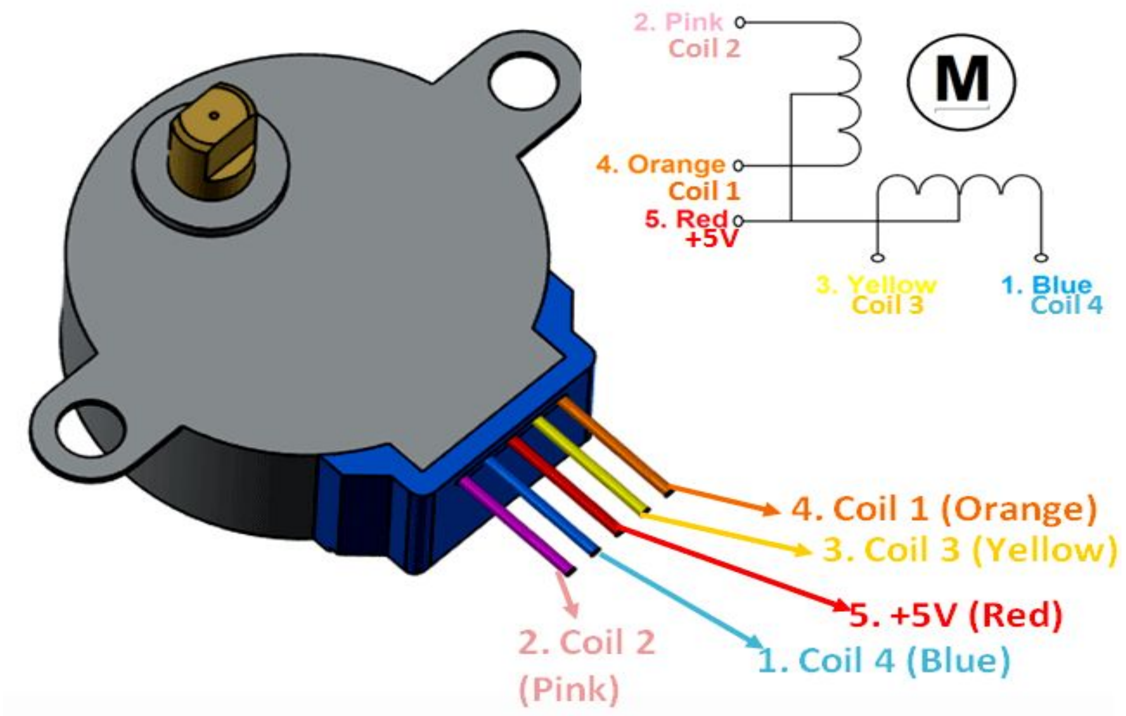
TMP36

Tien

Documentation of Current Prototype

Chen

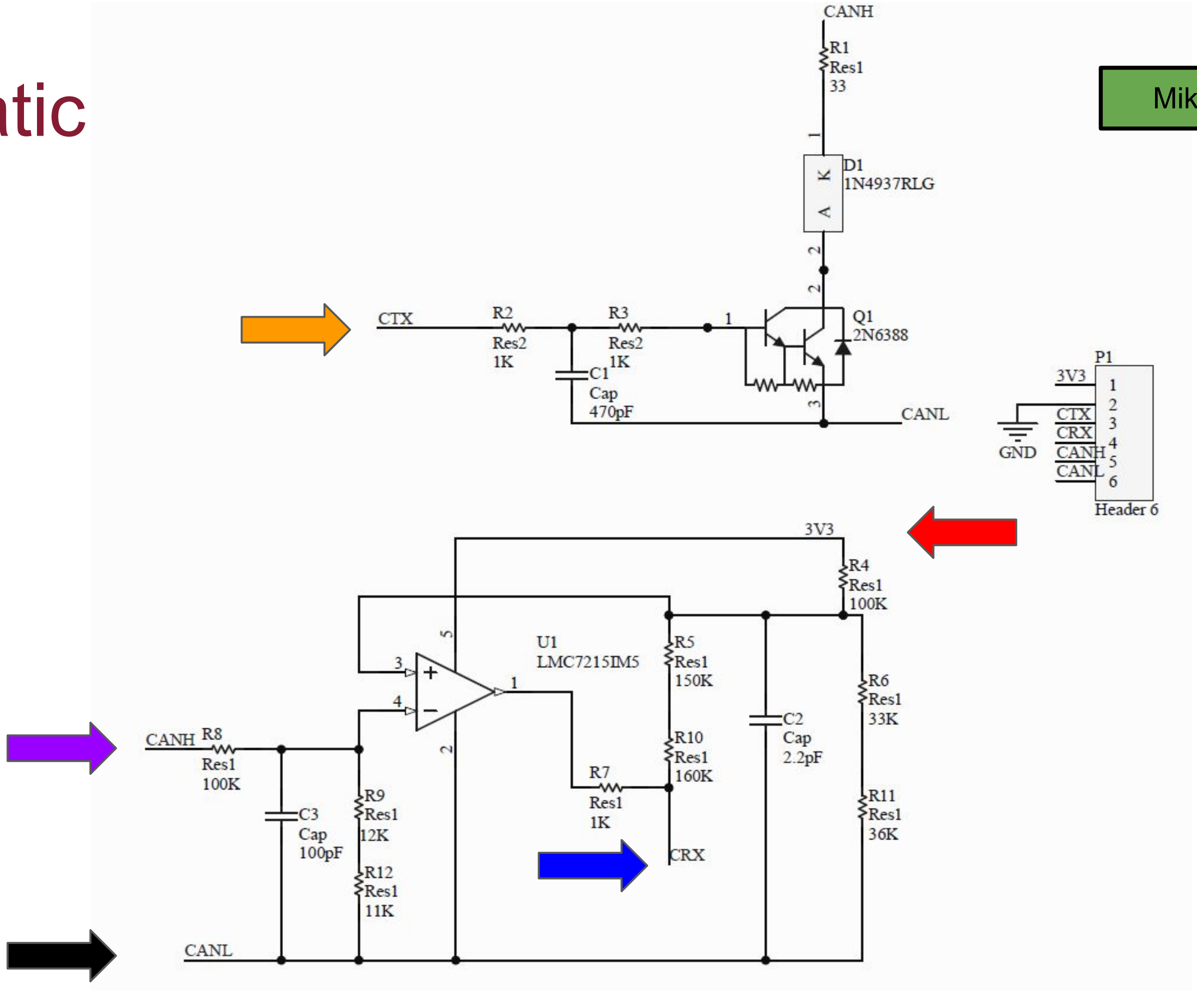
Step Motor



PCB Schematic

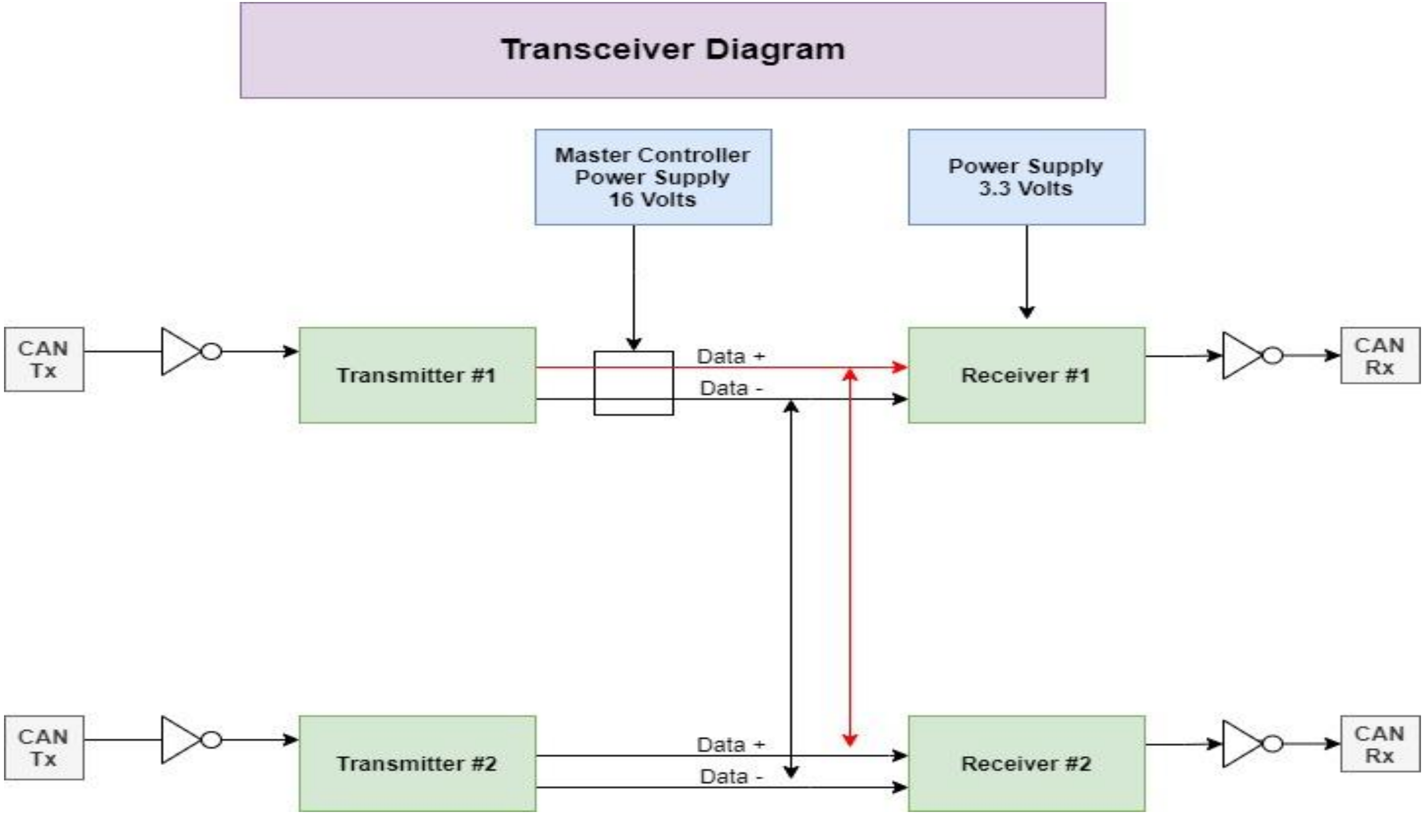
- CAN bus transceiver
  - Transmitter
  - Receiver
- Altium PCB designer

Mike



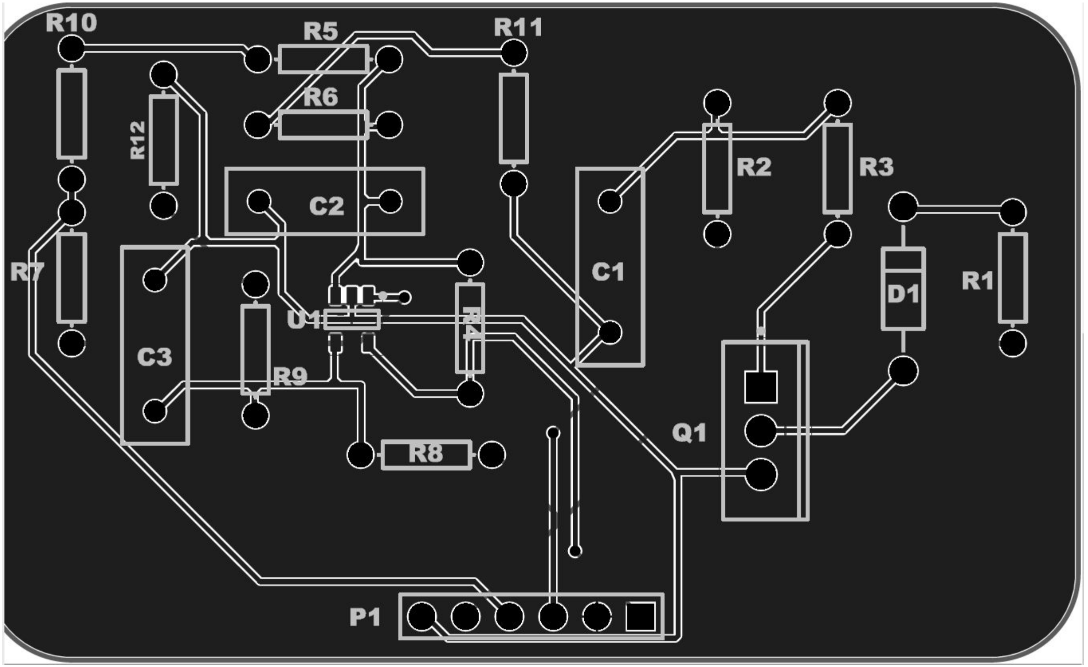
Transceiver Integration

Mike

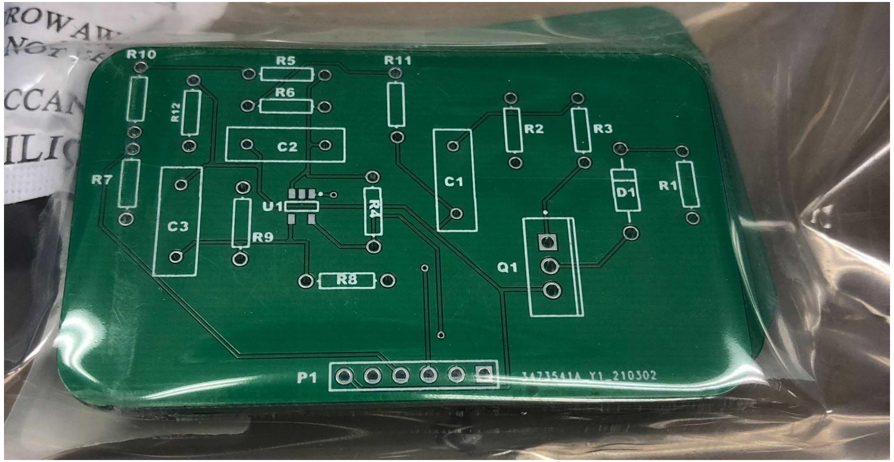


PCB Design

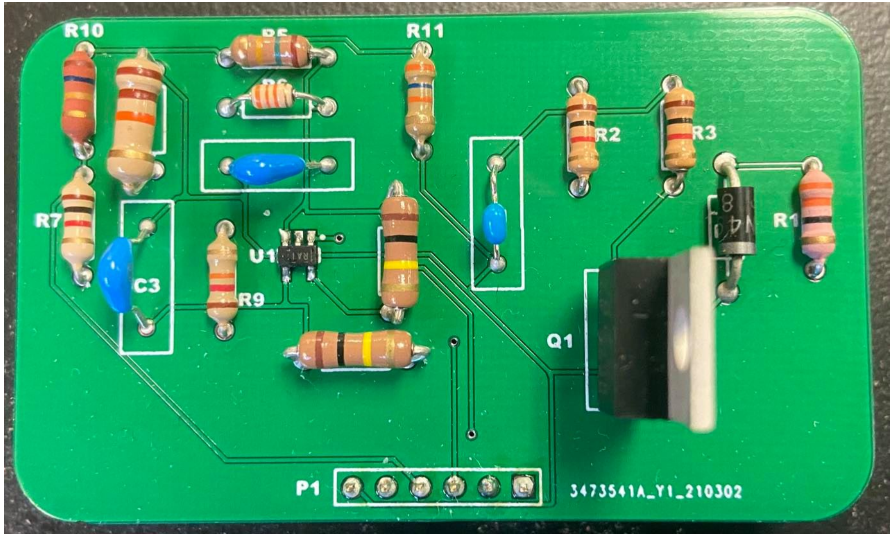
Tien



PCB in hand



Bare boards received



Soldering completed

*ordered through JLCPCB

Project Expenditures

Chen

○ 5 XMC4200 Dev. Board	$ 298.10
○ Transceiver components	$ 18.92
○ PCB Fabrication	$ 23.34
○ Step Motors	$ 12.50

Software Plan for FPR

Nathan

- Modify sensor data acquisition to collect analog values
    - Current system decides if a sensor is in state 0 or 1 based on a decided voltage threshold
    - Binary data was fine for testing out basic network communication, but is very limiting in terms of possible system states
- Add databases to the motor nodes that store most recent sensor data from across the network
    - Enables nodes to make decisions based on multiple sensors
    - Current system is only capable of making instantaneous decisions on most recently seen sensor data
- These two improvements will allow for a wider variety of physical reactions with minimal additional coding
- Make data acquisition more robust to noise

Hardware Plan for FPR

Chen

- Polish our existing presentation setup
  - Add more realistic water sensor setup to detect simulated rain
  - Drill through board to reroute power supply wires out of the way
- Add permanent power supplies (wall brick or DC voltage regulator) so we no longer need to depend on the lab's adjustable power supply which is cumbersome
- Add wire spools between nodes to emulate longer transmission distance (already tested in lab with our PCB)
- All our PCBs are already soldered, so there's no need to continue work there

FPR Deliverables

All

<u>Michael Chan</u>

- ❑ Team Coordinator
- ❑ System Wiring
- ❑ PCB to XMC4200 Integration

<u>Nathan Johnson</u>

- ❑ Analog sensor data collection
- ❑ Sensor databases
- ❑ More sophisticated stimulus/reaction logic
- ❑ Software Team Lead

<u>Dingbang Chen</u>

- ❑ Budget Management Lead
- ❑ Team Website
- ❑ Step Motor Implementation

<u>Tien Shen</u>

- ❑ Finely calibrate sensors
- ❑ Determine voltage/temperature thresholds for multiple output states.
- ❑ Design and build a better mounting system for water level sensor

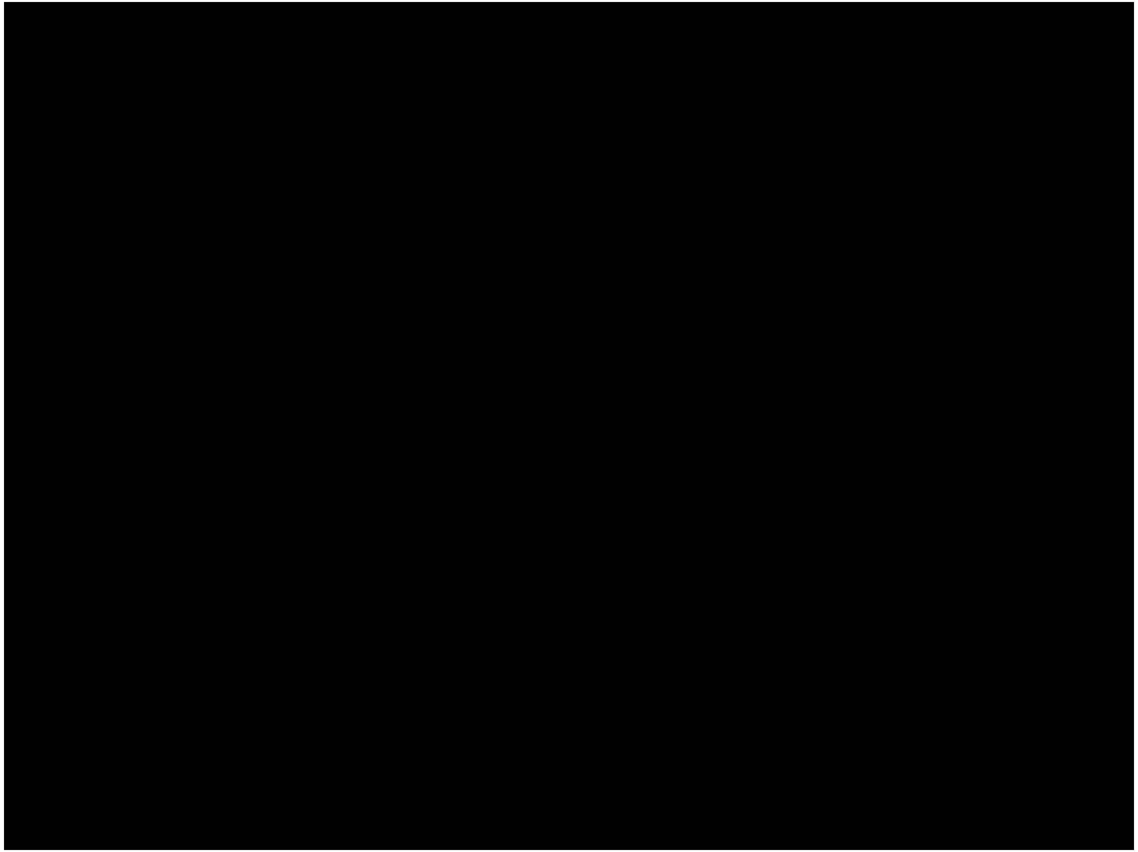
Gantt Chart

All

	Week 1	Week 2	Week 3
Harden physical system			
- Reroute wires			
- Transition to solid core wire			
- Move to permanent power supply			
Improve software			
- Sensor database			
- Device addressing			
- More sophisticated reaction logic			

Back-up Demo Video

All



Thank you for your time

Questions?