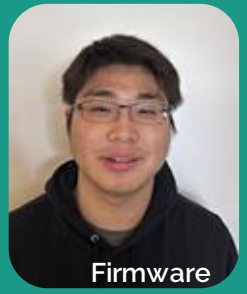
# Embedded Sensing System

# Meet the Team




Derek Meng


Steven Zhu


Rahul Lingam


Reginald Wang


Yiguang Zhu

# John Deere: Blue River See & Spray

- Blue River's See & Spray™ uses real-time visual analysis to only target weeds with herbicides
- Our capstone project allows Blue River to gather experimental accuracy data

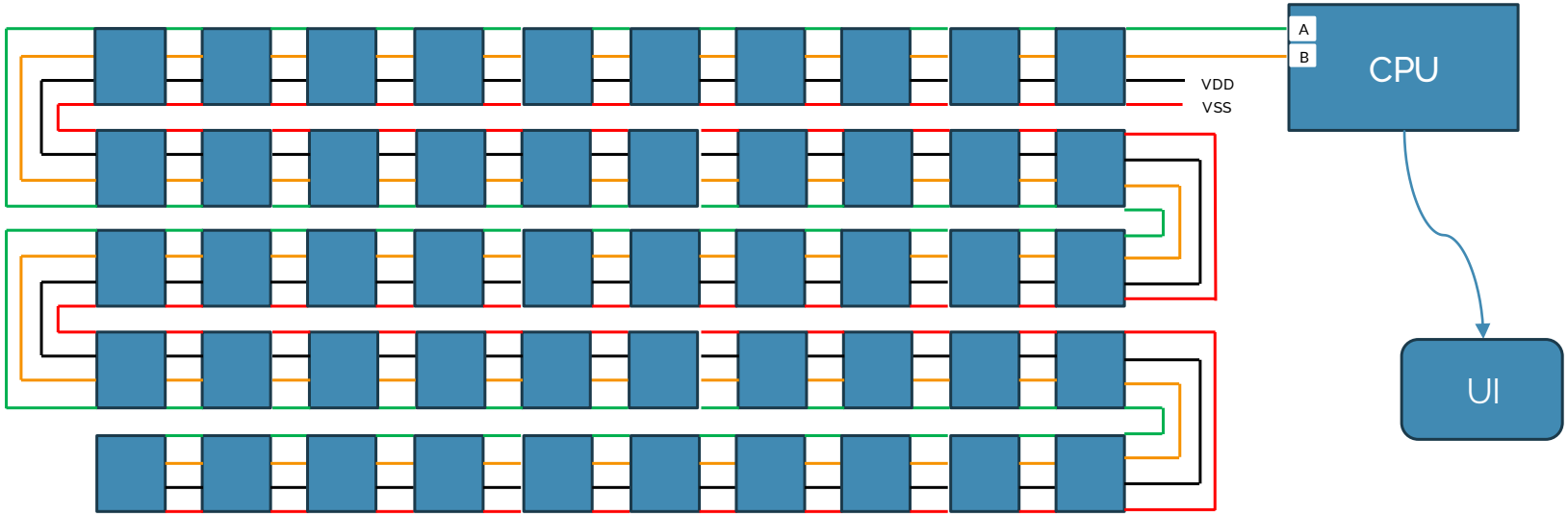
# John Deere: Blue River See & Spray

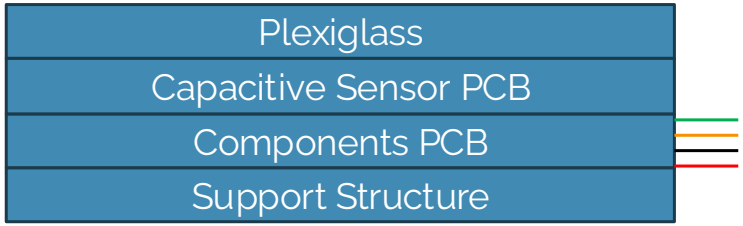
# Project Vision/Requirements

- 10 by 10 cm spatial (pixel) resolution
- IP67 rated
- Software interactivity + Foxglove (data visualization software) compatibility
- Ease to clean
- Calibratable
- <15lbs

# Solution: B.R.A.S.S

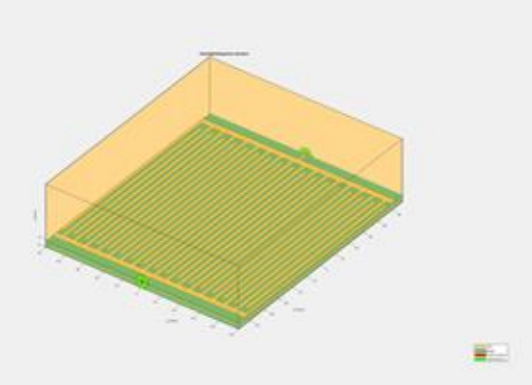
# Block Diagram

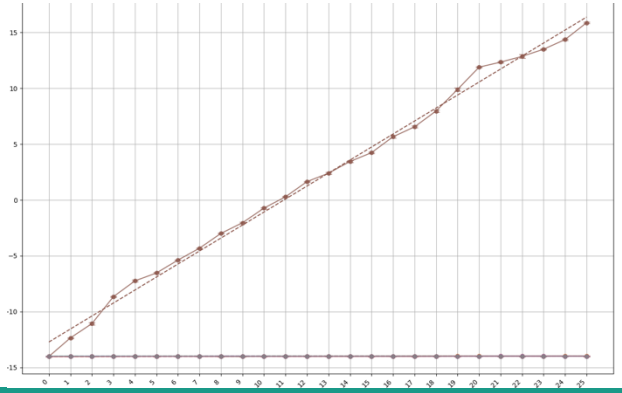





## Block Diagram

# Capacitive Sensor PCB

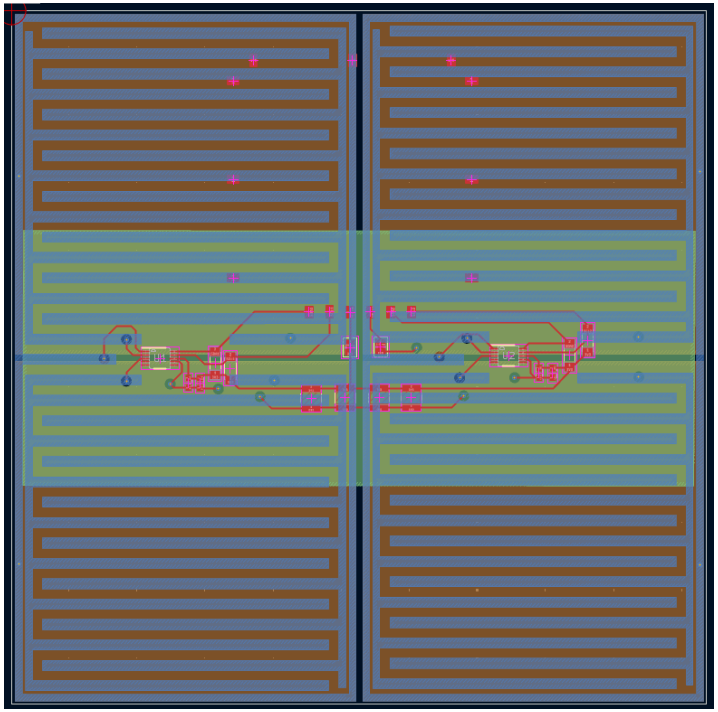




- Interdigitated Capacitor:
  - Sensor outputs capacitance
  - Linear relationship between amount of water and capacitance
  - Is easily scalable to cover 0.5 $m^2$
  - Change dimensions between iterations

## Block Diagram

# Capacitive Sensor PCB

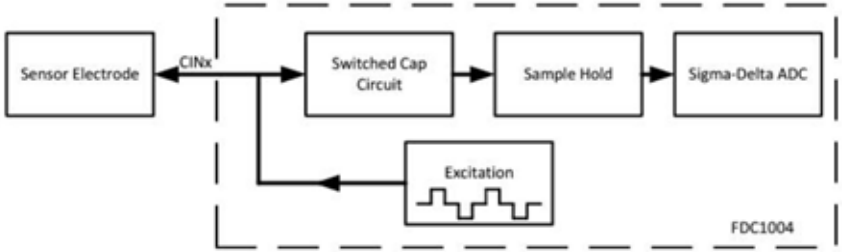


- A shield ring and layer is used to maximize fringing fields
- Layer stack:

1. Sensor + ring
2. Shield plane
3. GND plane
4. ICs + traces

FDC1004DGSR

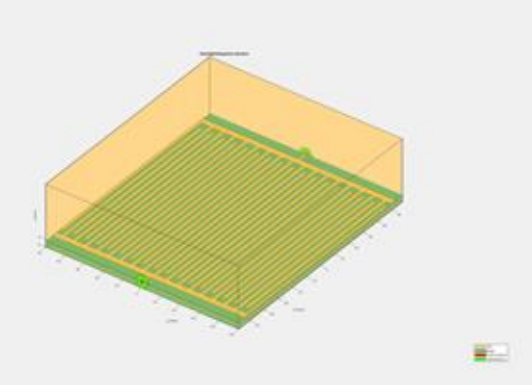
## Capacitive Sensor PCB

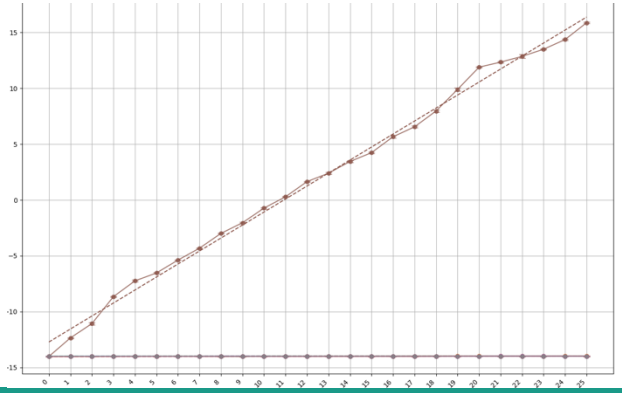



- 25-kHz excitation waveform → sensor electrode charging
- Switched capacitor circuit → charge transfer from electrode
- Sample-and-hold stage → temporary analog voltage storage
- Sigma-delta ADC → analog-to-digital conversion + digital filtering

## Block Diagram (Main Board)

## Capacitive Sensor PCB





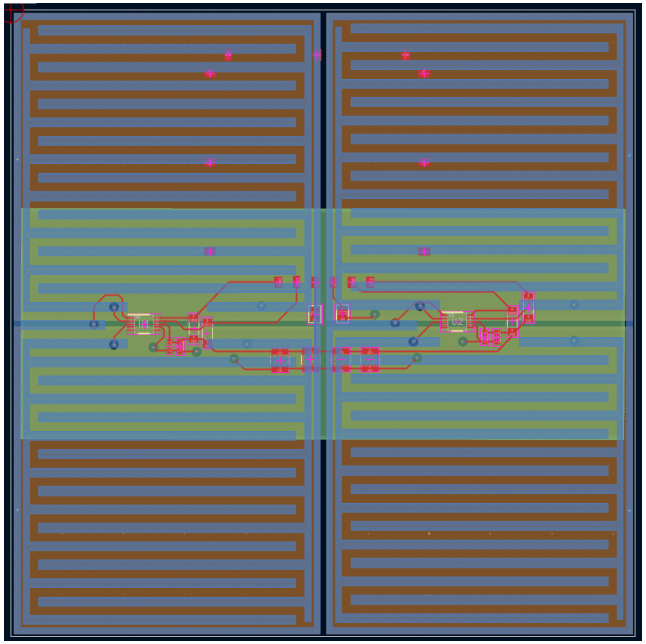
## Plexiglass

- Dielectrics
  - Air, Plexiglass: ~1-3
  - Water: 80
- Thicker plastic = less gain
- Can tune sensitivity of sensor

**Block Diagram**

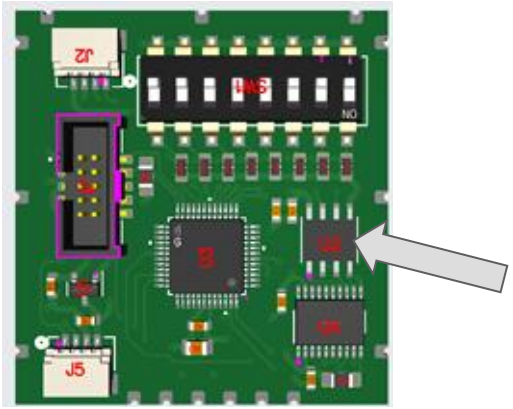
## Components PCB

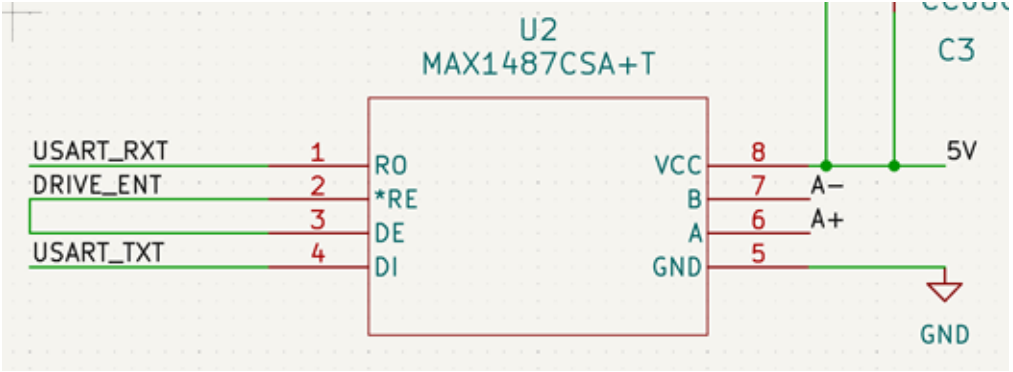
- Due to space constraints and the sensitivity of capacitive sensing, we made the design choice to make a second PCB to attach to the Sensor PCB using castellations



## Components PCB

- **List of components:**
  - **Transceiver (MAX1487CSA+T)**
  - Level Shifter (TXB0108PWR)
  - DIP Switch (A6S-8104-H)
  - Linear Regulator (DI62063.3S2)
  - MCU (STM32C051C8T6)

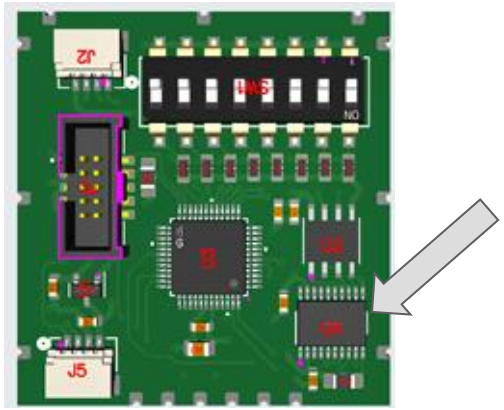


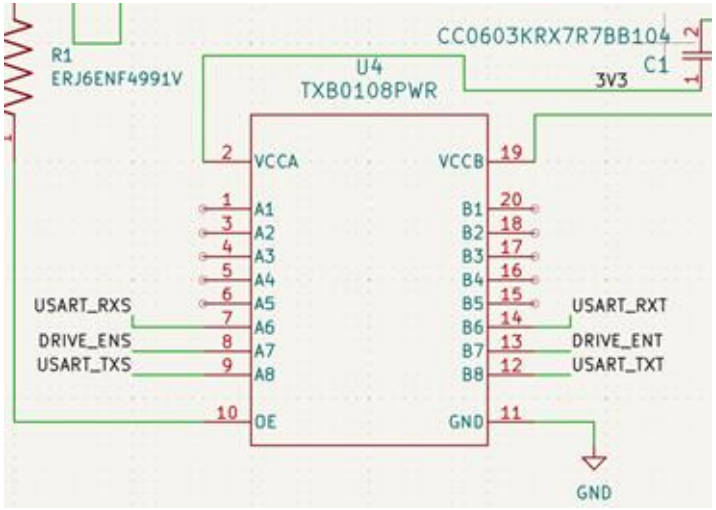




**Block Diagram (Daughter Board)**

## Components PCB

- **List of components:**
  - Transceiver (MAX1487CSA+T)
  - **Level Shifter (TXB0108PWR)**
  - DIP Switch (A6S-8104-H)
  - Linear Regulator (DI62063.3S2)
  - MCU (STM32C051C8T6)

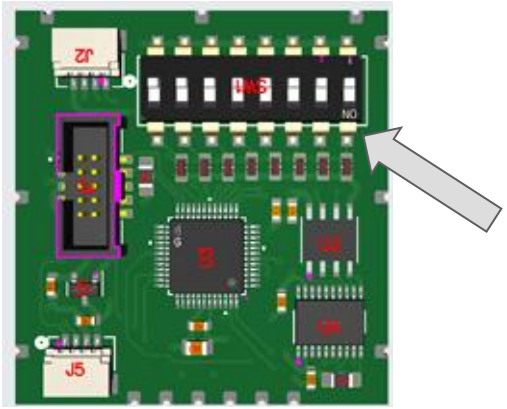


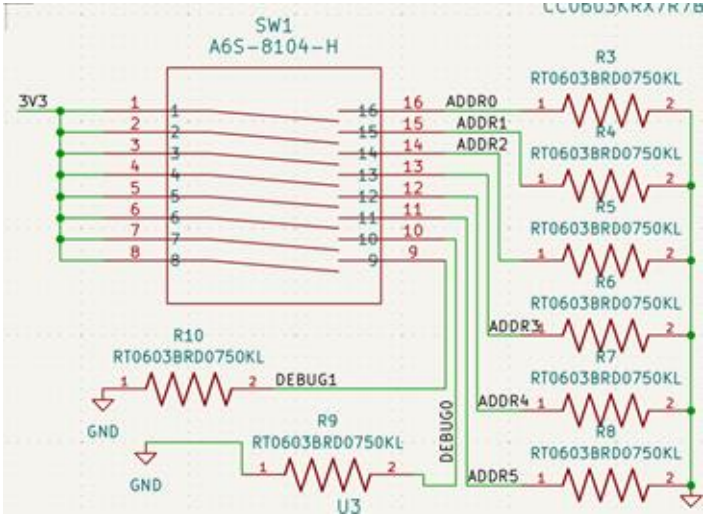




**Block Diagram (Daughter Board)**

## Components PCB

- **List of components:**
  - Transceiver (MAX1487CSA+T)
  - Level Shifter (TXB0108PWR)
  - **DIP Switch (A6S-8104-H)**
  - Linear Regulator (DI62063.3S2)
  - MCU (STM32C051C8T6)

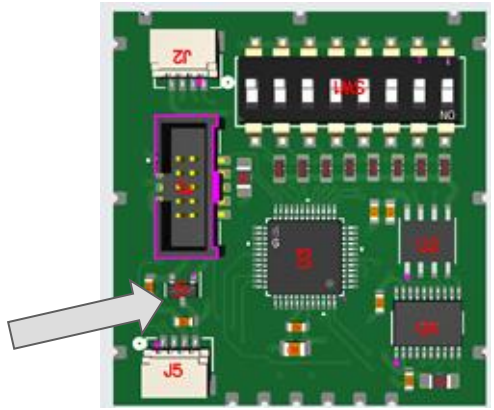


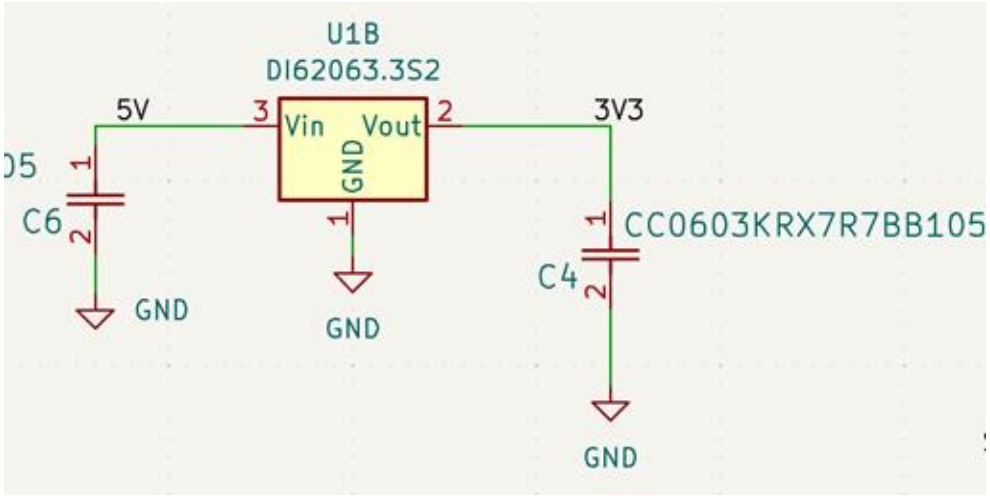




**Block Diagram (Daughter Board)**

## Components PCB

- **List of components:**
  - Transceiver (MAX1487CSA+T)
  - Level Shifter (TXB0108PWR)
  - DIP Switch (A6S-8104-H)
  - **Linear Regulator (DI62063.3S2)**
  - MCU (STM32C051C8T6)

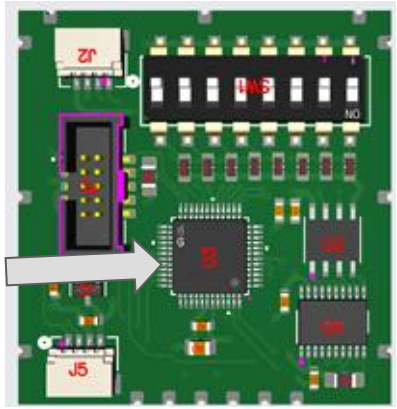


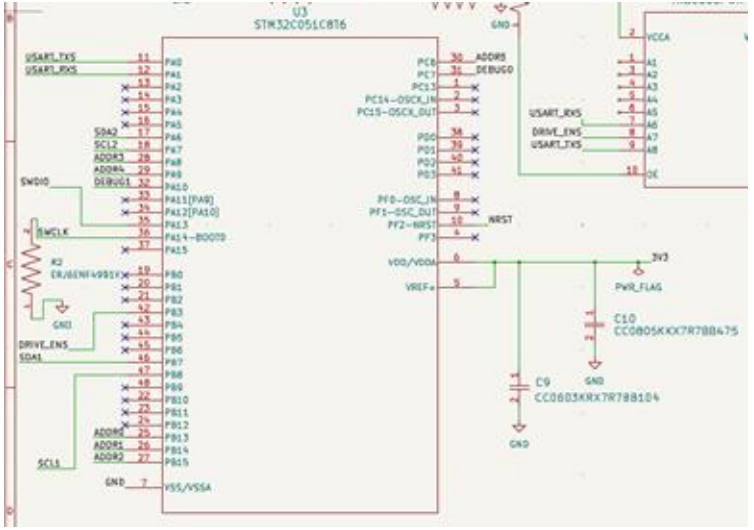




**Block Diagram (Daughter Board)**

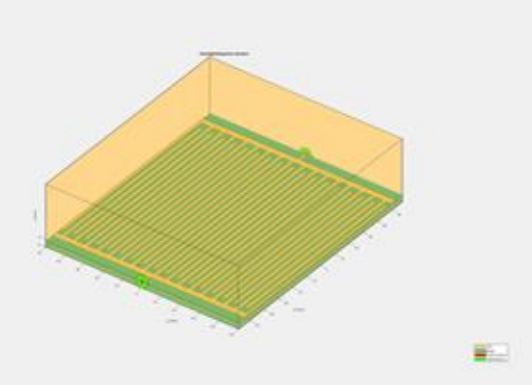
## Components PCB

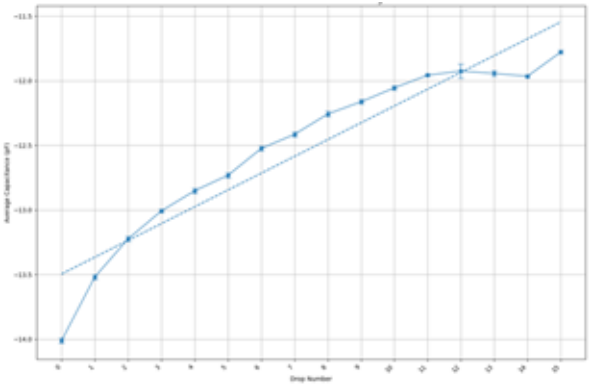
- **List of components:**
  - Transceiver (MAX1487CSA+T)
  - Level Shifter (TXB0108PWR)
  - DIP Switch (A6S-8104-H)
  - Linear Regulator (DI62063.3S2)
  - **MCU (STM32C051C8T6)**




**Block Diagram (Daughter Board)**





| Plexiglass |
| --- |
| Capacitive Sensor PCB |
| Components PCB |
| Support Structure |

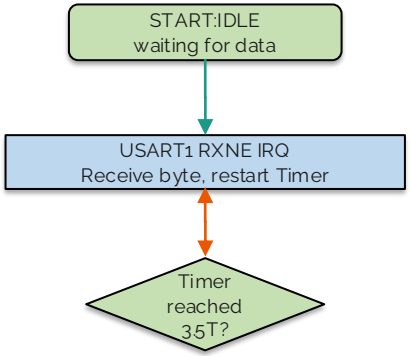
- Minimizes intervariation
  - Plexiglass flushness
  - Level/tilt
- <15lbs
- Easy to carry
- IP67 rated

## Block Diagram

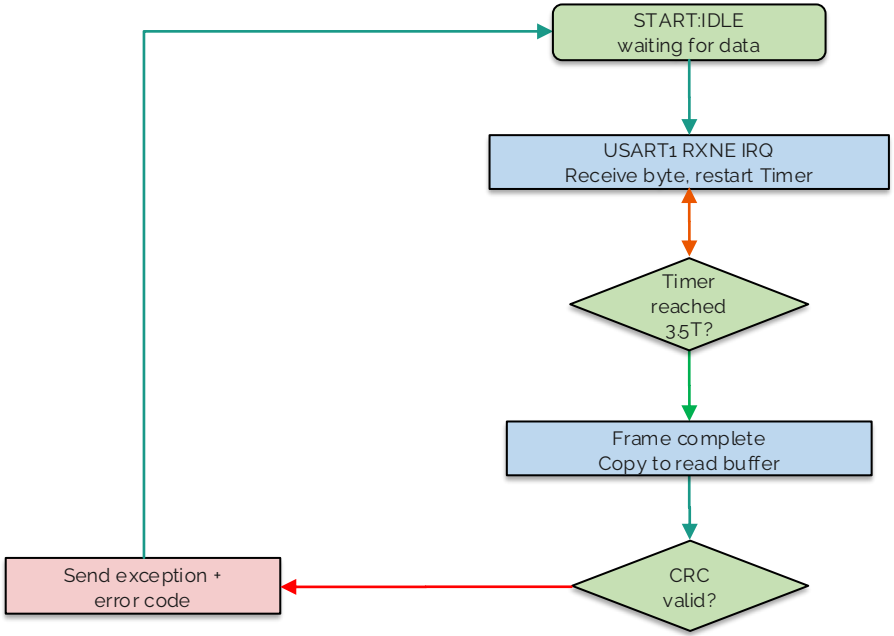
# Firmware

# Firmware Architecture & Modules

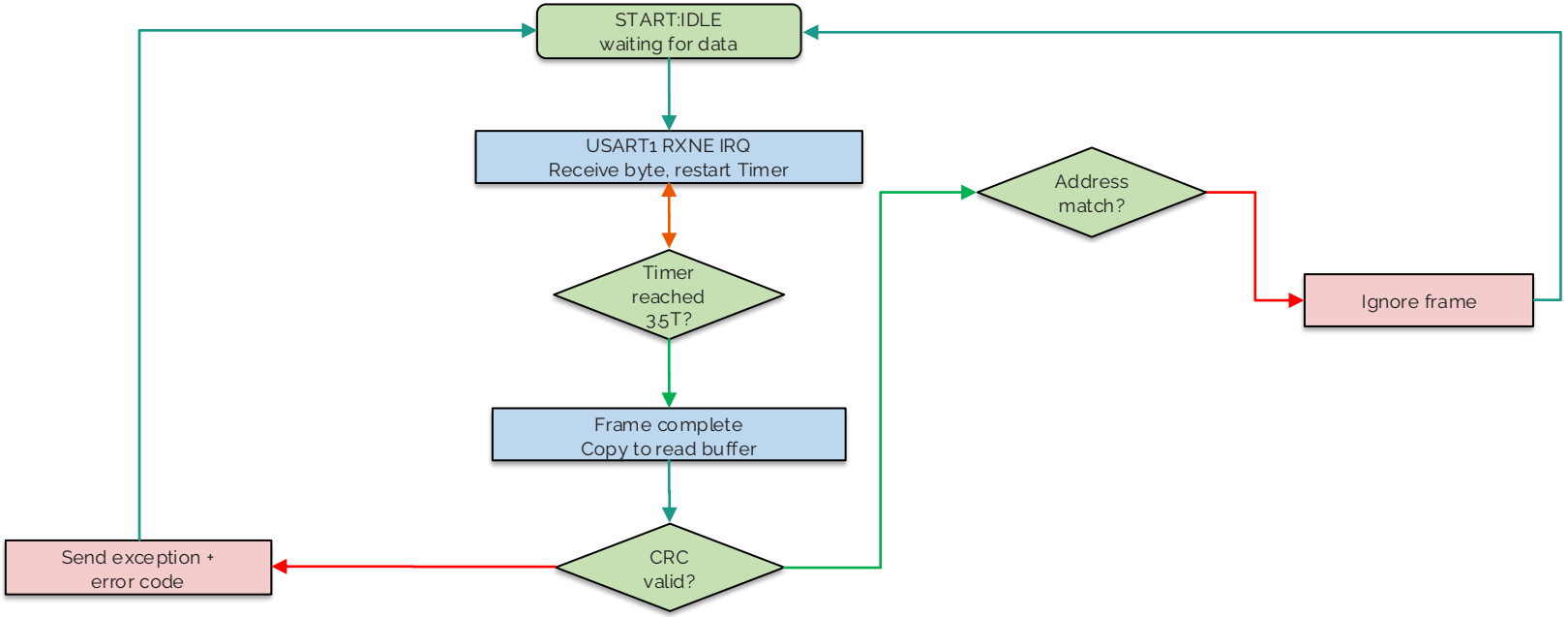
# Firmware Architecture & Modules



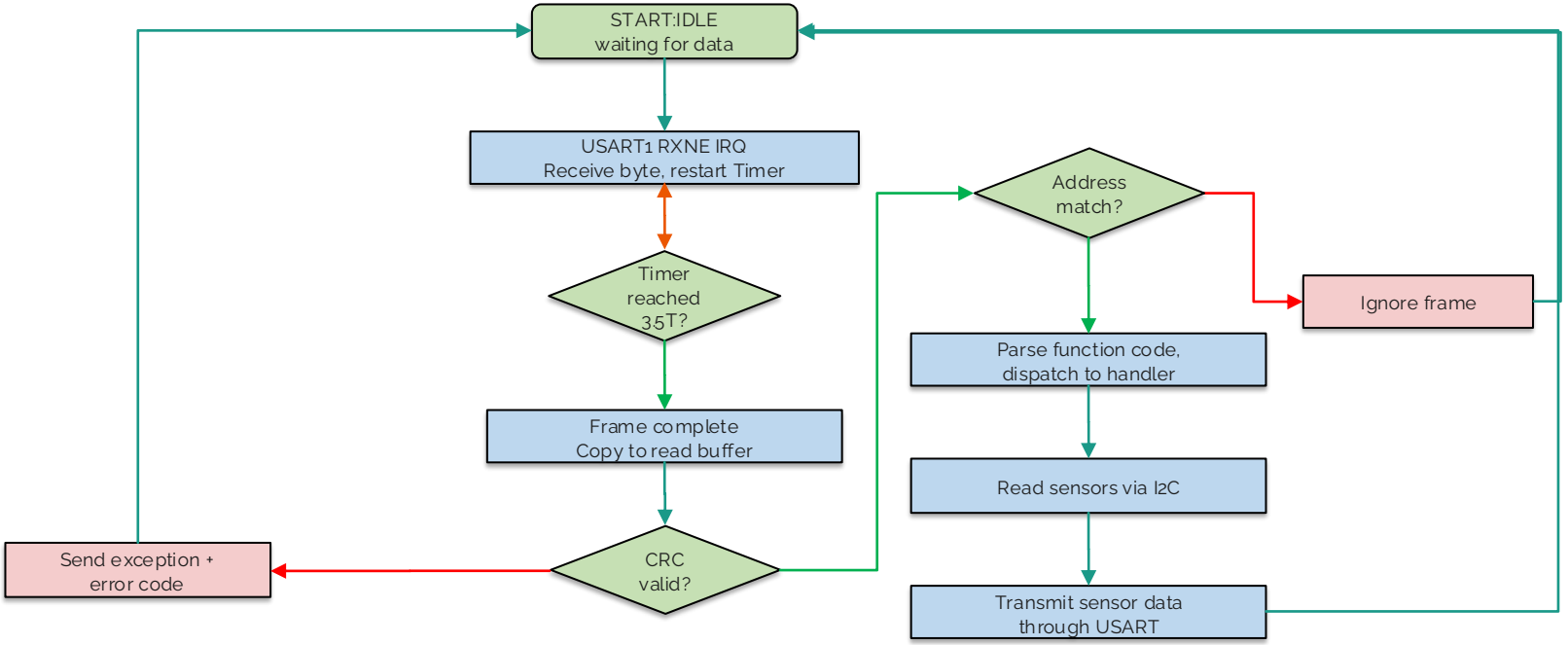
# Firmware Architecture & Modules



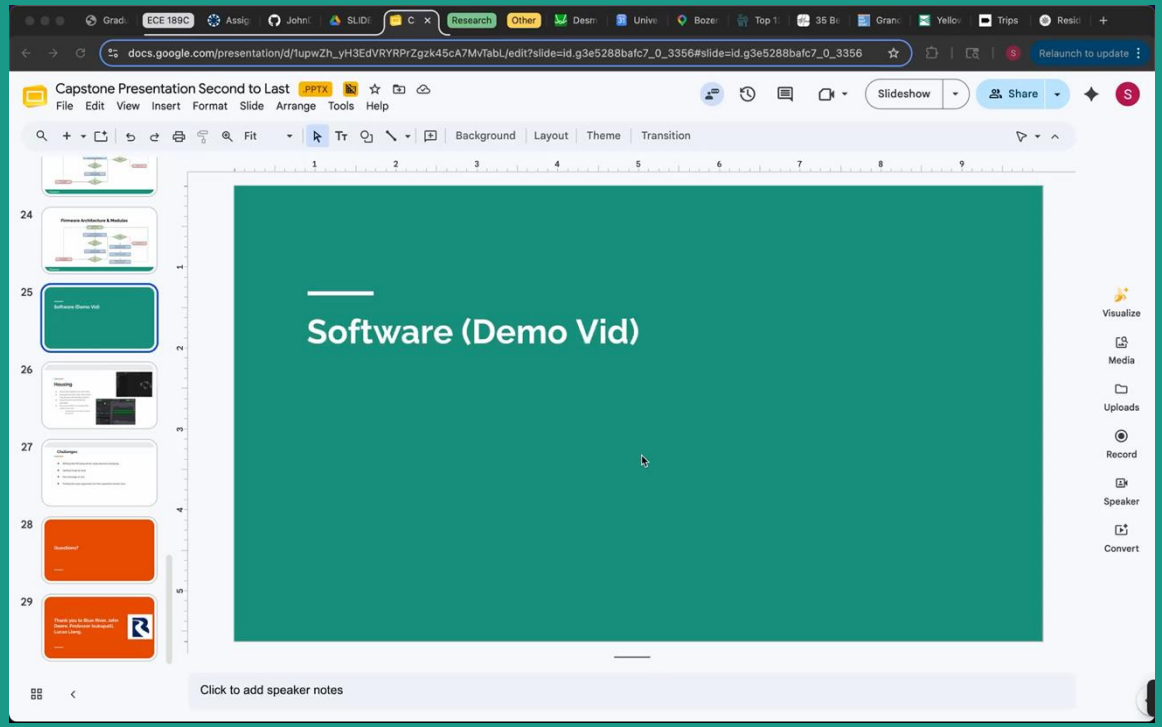
# Firmware Architecture & Modules



# Firmware Architecture & Modules

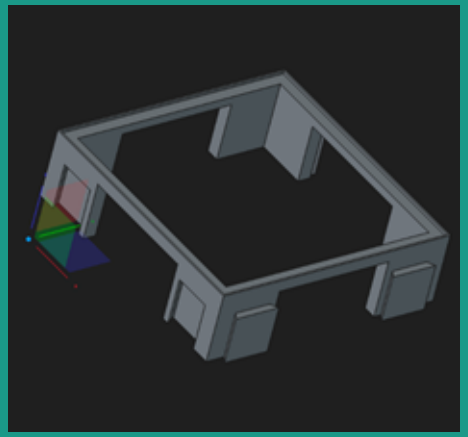


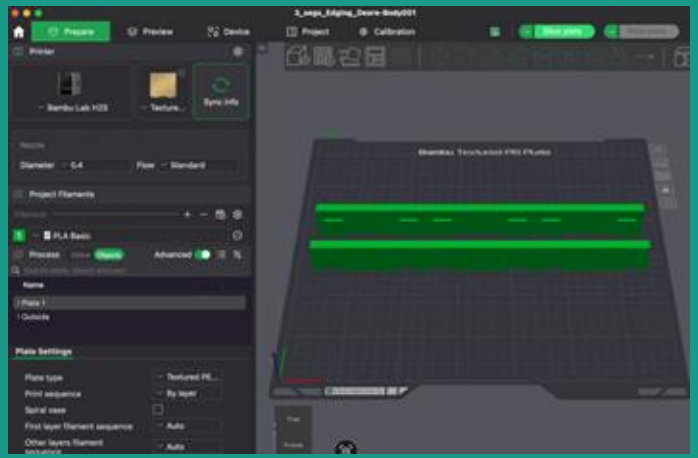
# Software (Demo Vid)



# Housing

- 3D printed platform for the PCBs
- Designed via FreeCAD, then sliced and printed with Bambu printers
- Housings are connected via dovetails
- Plywood bottom to support the entire structure,
    - Nailed down and water-proofed by sealant





# Challenges

- Writing the FDC1004 driver required extensive studying of datasheet
- Getting .mcap file output to work as required for Foxglove compatibility
- Part shortage at JLC necessitated manual soldering
- Finding the exact geometry for the capacitive sensor face
- Flush Plexiglass

# Demo Video

**Thank you to our sponsor:**

- John Deere
- Caio Motta

**Thank you to our ECE mentors:**

- Professor Isukapalli
- Lucas Liang
- Tien Nguyen
- Kriteen Shrestha