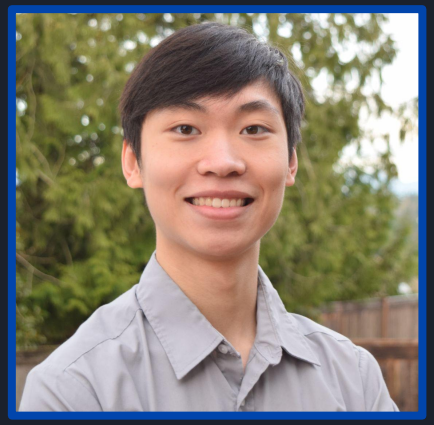
Cost Efficient Reflow Oven

By Radiant Flow

Brandon Hu	CS
Micah Rice	CE
Rohan Mathew	EE
Mihretab Desta	EE

Faculty Advisor:	Dr. Rick Cordray
Industry Sponsor:	Dr. Arnie Berger

Introduction



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Background & Motivation

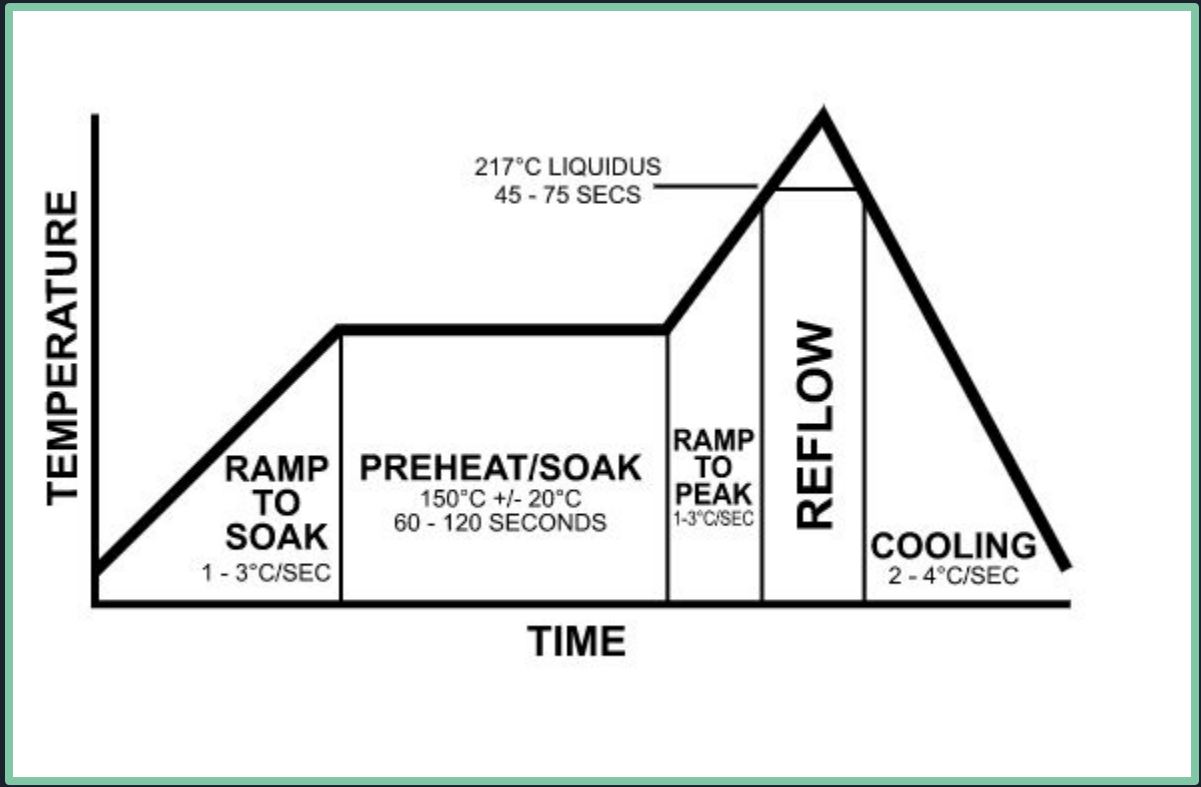
Reflow oven

- Convection oven that performs reflow soldering
- Heating is evenly distributed
- Time efficient
- Cost efficient
- Confirm we protect PCB

Follows a specific thermal profile

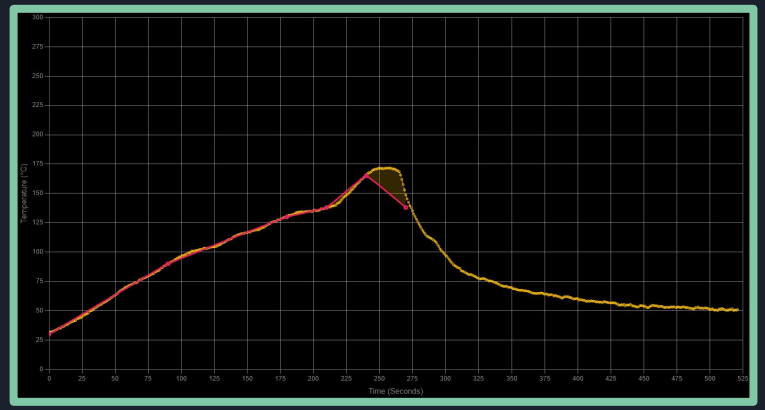
- Preheat/Soak
- Ramp to peak
- Cooling phase

An Example Thermal Profile

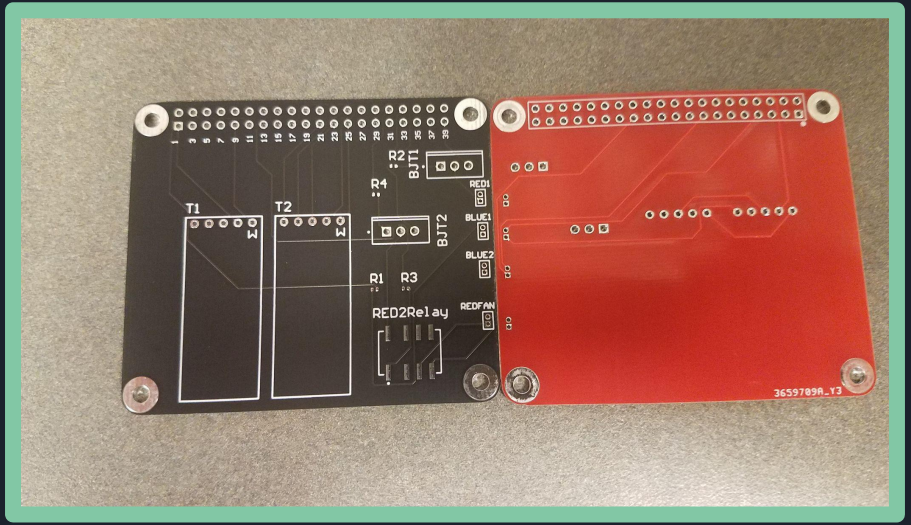


Objective

- Beat the cost of professionally produced reflow oven
- Precisely follow temperature profiles, to support surface mounting onto Printed Circuit Boards
- Programmable temperature profiles, to support many use cases



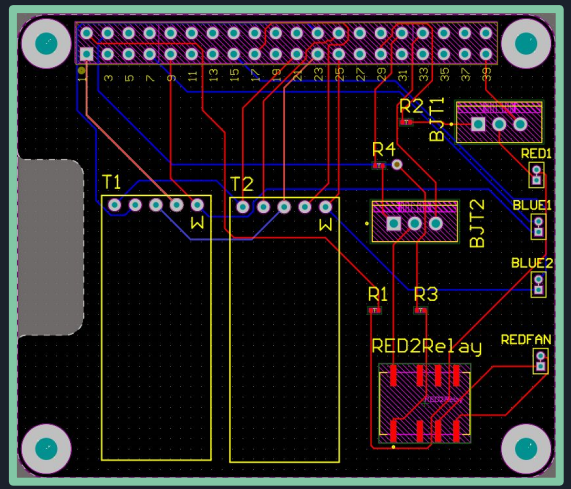
Device/System Description

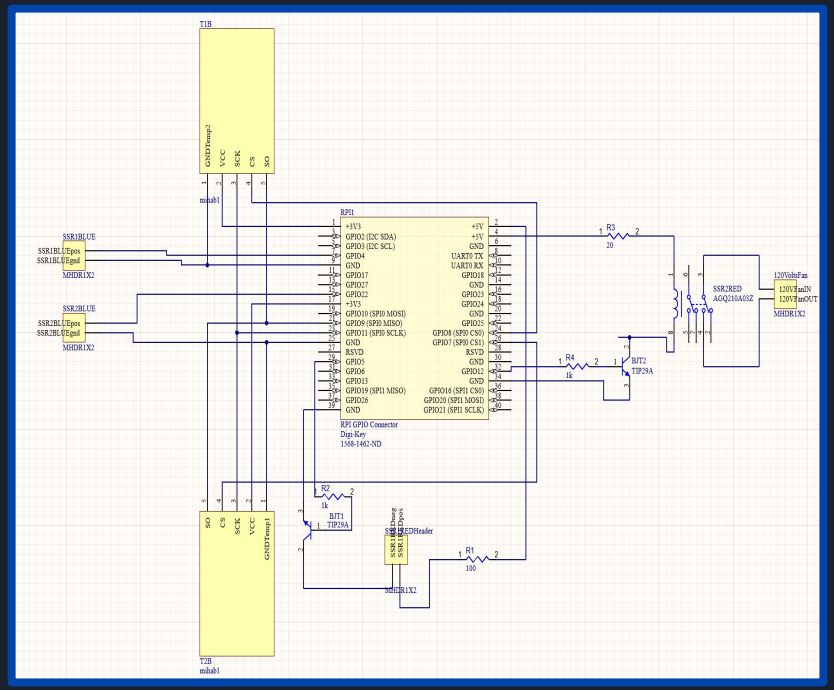



```
  }

  appIdle() {
    if (this.state.isLocal) {
      this.setState({ locked: true });
      localStorage.setItem('locked', 'true');
    }
  }

  handlePasswordEnter(e) {
    this.setState({ password: e.target.value });
  }

  handleKeyboardInput(button) {
    if (button === '{lock}') {
      if (this.state.keyboardLayout === 'caps' || this.state.keyboardLayout === 'shift') {
        this.setState({ keyboardLayout: 'default' });
      } else {
        this.setState({ keyboardLayout: 'caps' });
      }
    } else if (button === '{shift}') {
      if (this.state.keyboardLayout === 'caps' || this.state.keyboardLayout === 'shift') {
        this.setState({ keyboardLayout: 'default' });
      } else {
        this.setState({ keyboardLayout: 'shift' });
      }
    } else {
      let tempPassword = this.state.password;
      if (button === '{bksp}') {
        tempPassword = tempPassword.substring(0, tempPassword.length - 1);
      } else if (button === '{space}') {
        tempPassword += ' ';
      } else if (button === '{enter}') {
        this.submitPassword();
        return;
      } else {
        if (button !== '{tab}') {
          tempPassword += button;
        }
      }
      this.setState({ password: tempPassword });
      if (this.state.keyboardLayout === 'shift') {
        this.setState({ keyboardLayout: 'default' });
```

PCB Design

- Altium
- Raspberry Pi Shield





Software

Environment

- Used Raspberry Pi instead of Arduino
- Profiles are stored locally
- Touchscreen Display

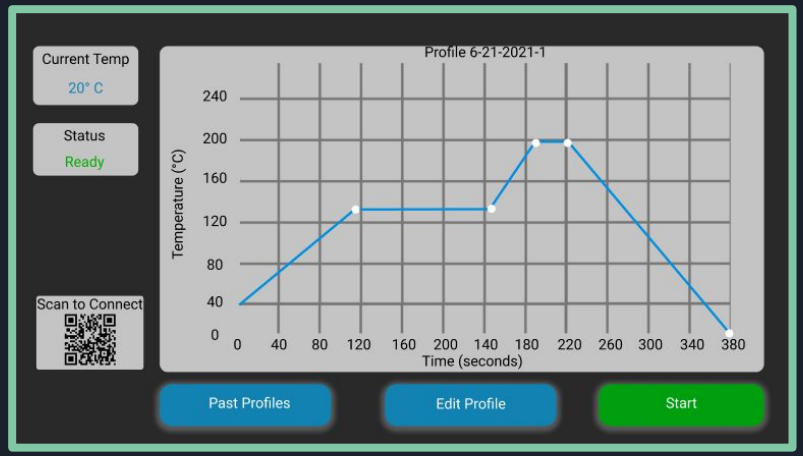
Backend

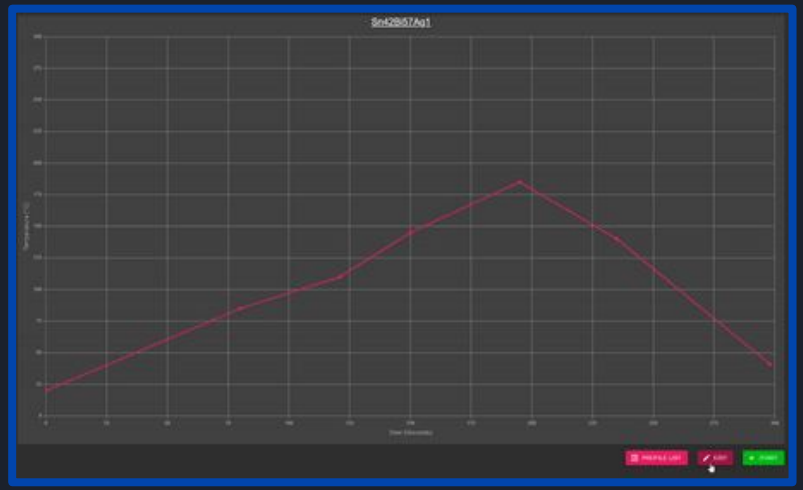
- JavaScript and Node.js
  - PID Controller library
  - Serial Peripheral Interface (SPI) library
- Updates every second

```
ctr = new Controller(proportional, integral, derivative, dt);
ctr.setTarget(275);
controlVariable = ctr.update(currentTemperature);
relayOn(controlVariable);
```

Frontend

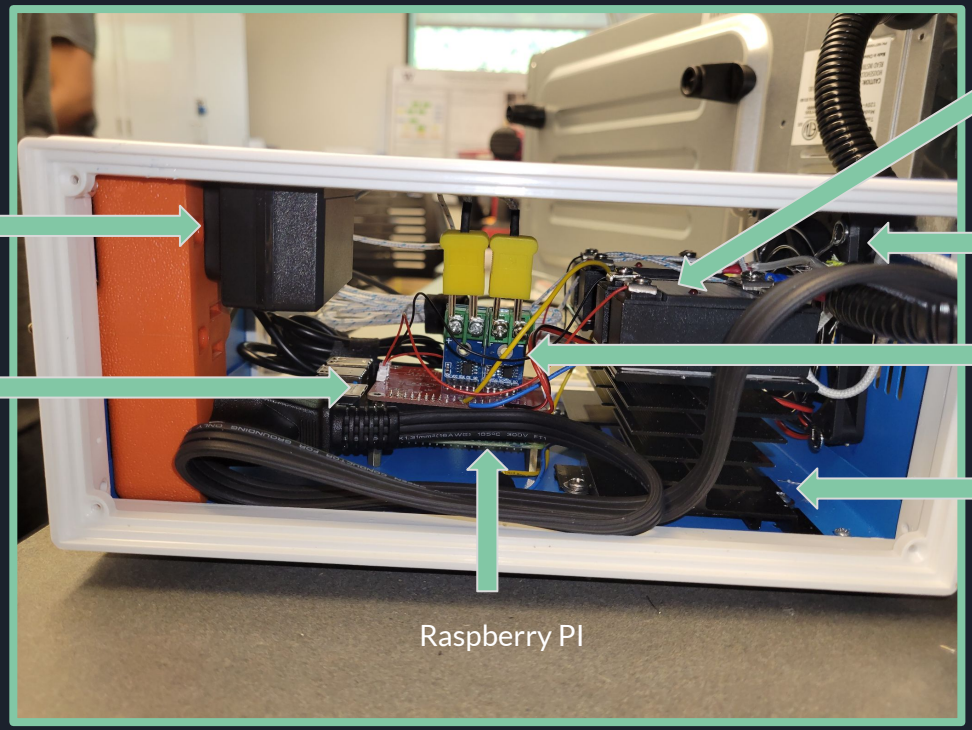
- Prototyped using Figma
- Made with React
- Dragging nodes to make profile
- Easily customizable
- Remote access available



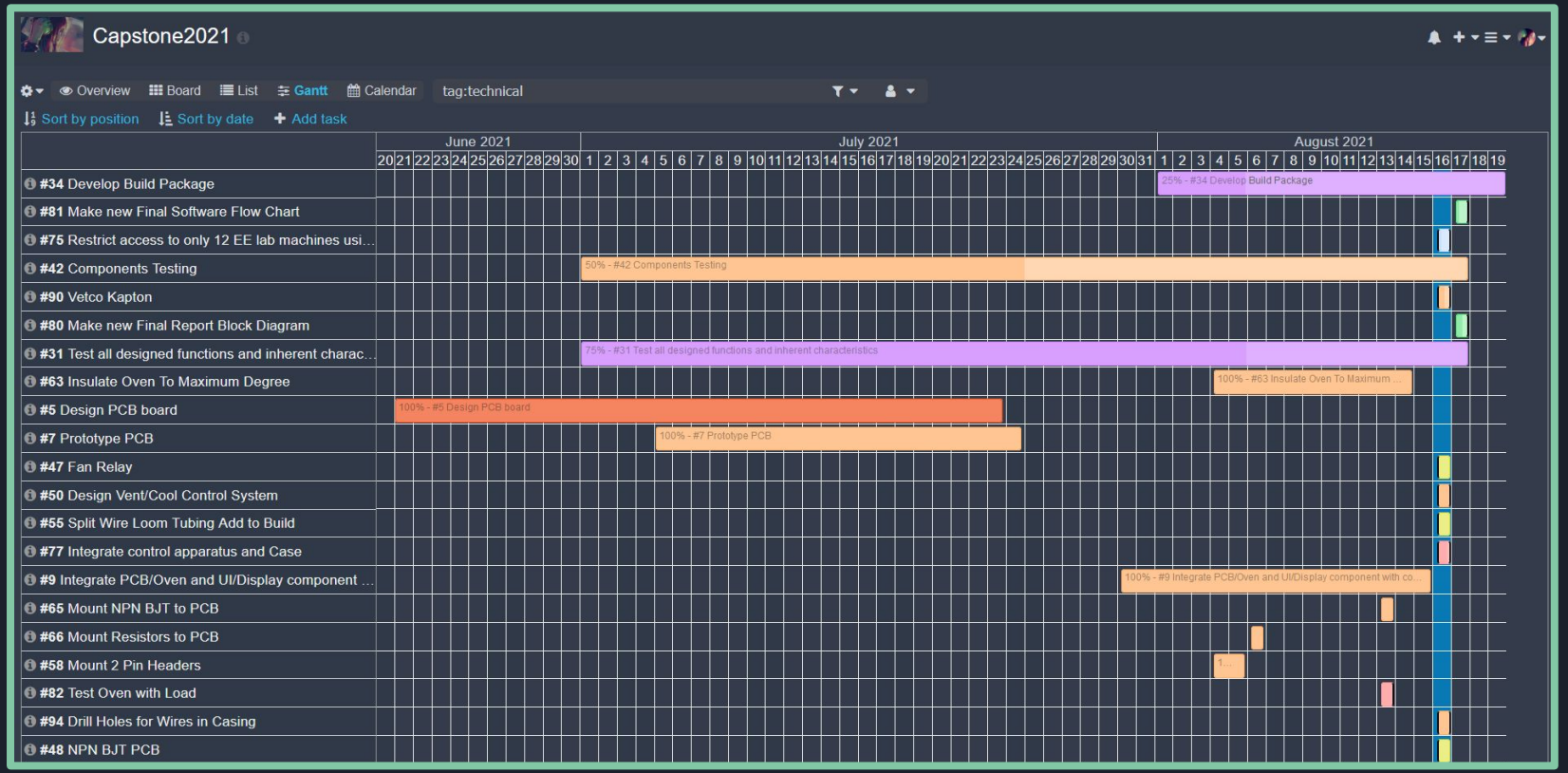


Oven & Package

What's in the box?



Engineering Process

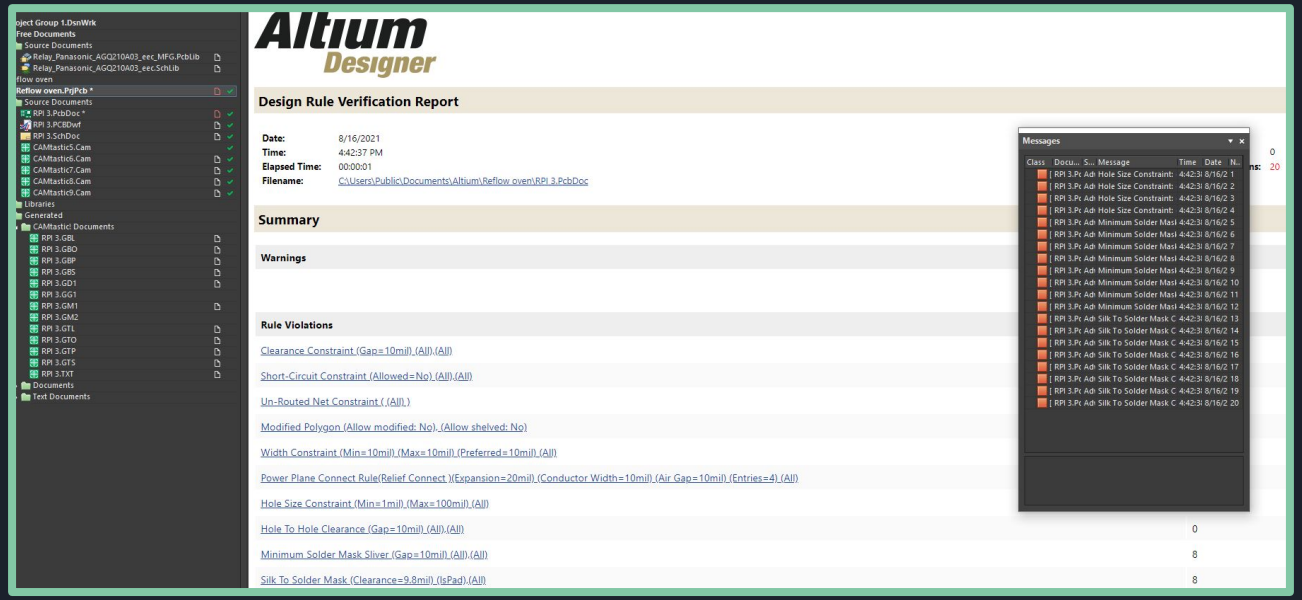


Design Reviews

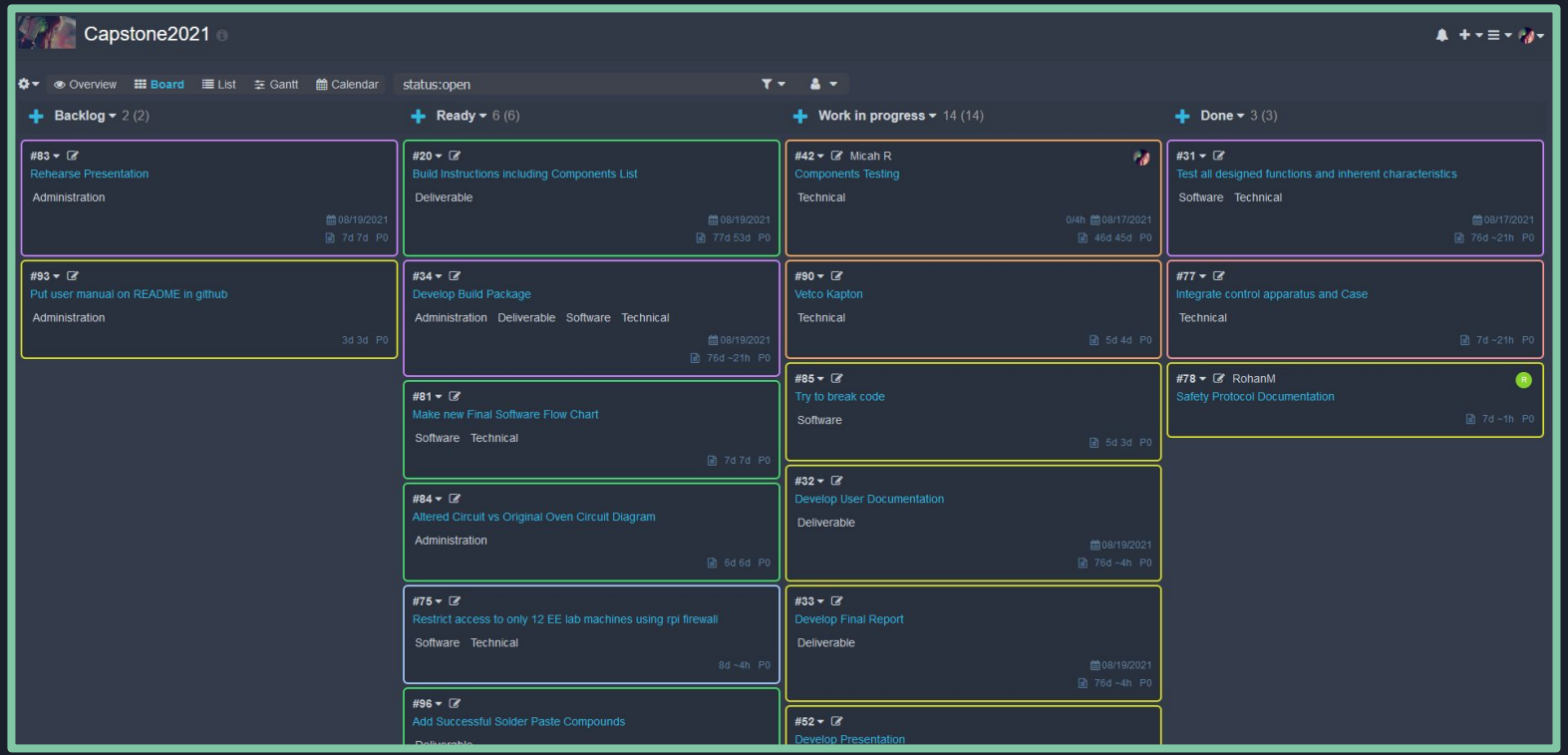
Design Review process before sending final board Gerber Files to manufacturer in Hong Kong.

Reviewing the Design Rules & performing Design Rule check through Altium

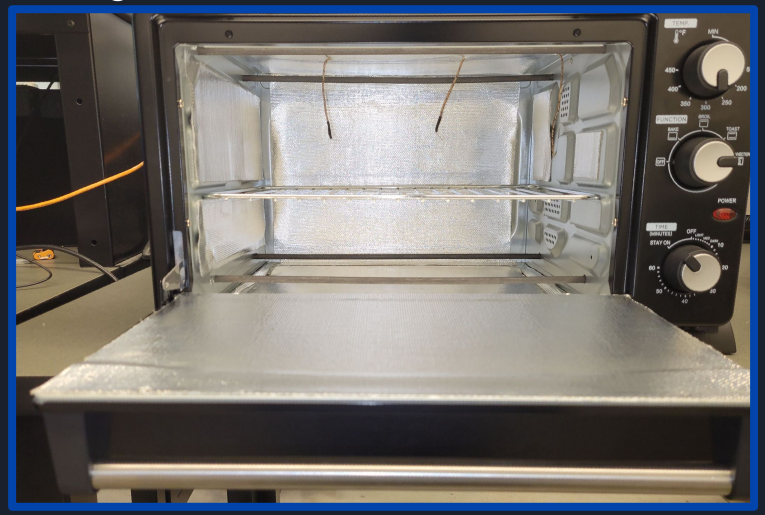
Issue with Drill Hole misalignment, corrected and sent to manufacturer

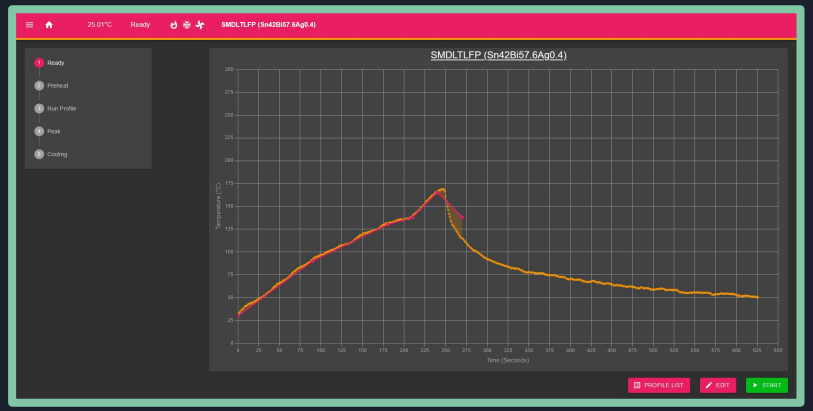


KanBoard


Capstone2021
Overview
Board
List
Gantt
Calendar
status:open
Backlog 2 (2)
#83 Rehearse Presentation
Administration
08/19/2021
7d 7d P0
#93 Put user manual on README in github
Administration
3d 3d P0
Ready 6 (6)
#20 Build Instructions including Components List
Deliverable
08/19/2021
77d 53d P0
#34 Develop Build Package
Administration Deliverable Software Technical
08/19/2021
76d ~21h P0
#81 Make new Final Software Flow Chart
Software Technical
7d 7d P0
#84 Altered Circuit vs Original Oven Circuit Diagram
Administration
6d 6d P0
#75 Restrict access to only 12 EE lab machines using rpi firewall
Software Technical
8d ~4h P0
#96 Add Successful Solder Paste Compounds
Work in progress 14 (14)
#42 Micah R
Components Testing
Technical
0/4h 08/17/2021
46d 45d P0
#90 Vetco Kapton
Technical
5d 4d P0
#85 Try to break code
Software
5d 3d P0
#32 Develop User Documentation
Deliverable
08/19/2021
76d ~4h P0
#33 Develop Final Report
Deliverable
08/19/2021
76d ~4h P0
#52 Develop Presentation
Done 3 (3)
#31 Test all designed functions and inherent characteristics
Software Technical
08/17/2021
76d ~21h P0
#77 Integrate control apparatus and Case
Technical
7d ~21h P0
#78 RohanM
Safety Protocol Documentation
7d ~1h P0

Project results





PID

Proportional 300

Integral 0.075

Derivative 1360

Use cooling fan with PID

Look Ahead 5 Seconds

Enable Preheat

Preheat Power 70 %

Always Hit Peak

Hardware

Relay GPIO 4 (pin 7)

Cooling Fan GPIO 16 (pin 36)

Convection Fan GPIO 22 (pin 15)

Buzzer GPIO 24 (pin 18)

Stop cooling at: 50 °C

Temperature Adjustment

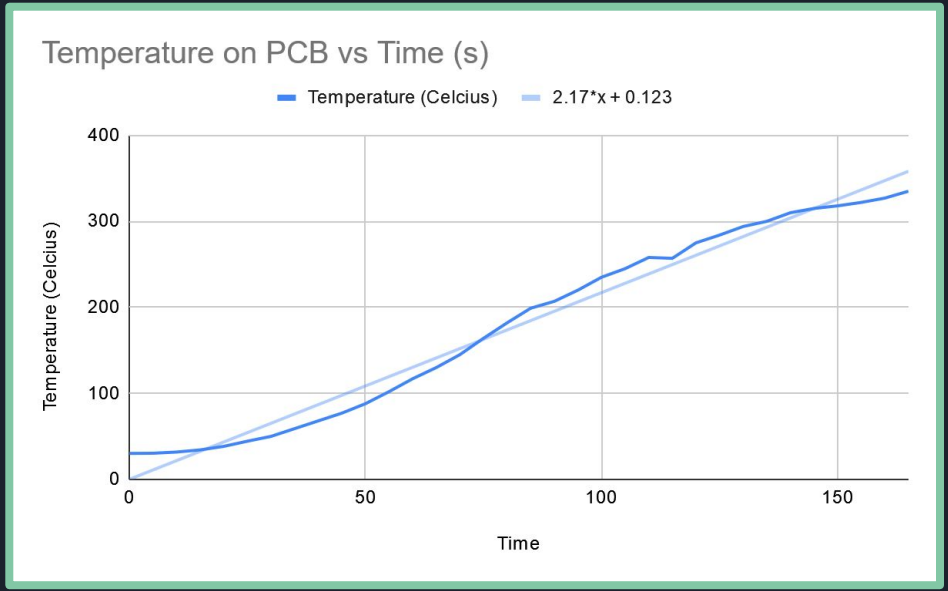
Constant offset -7 °C

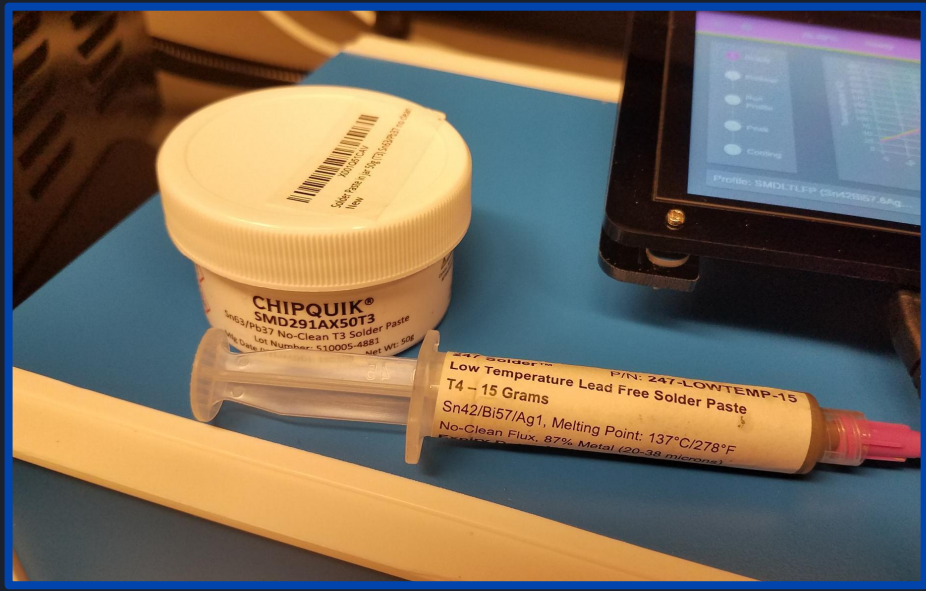
Percent offset 8.5 %

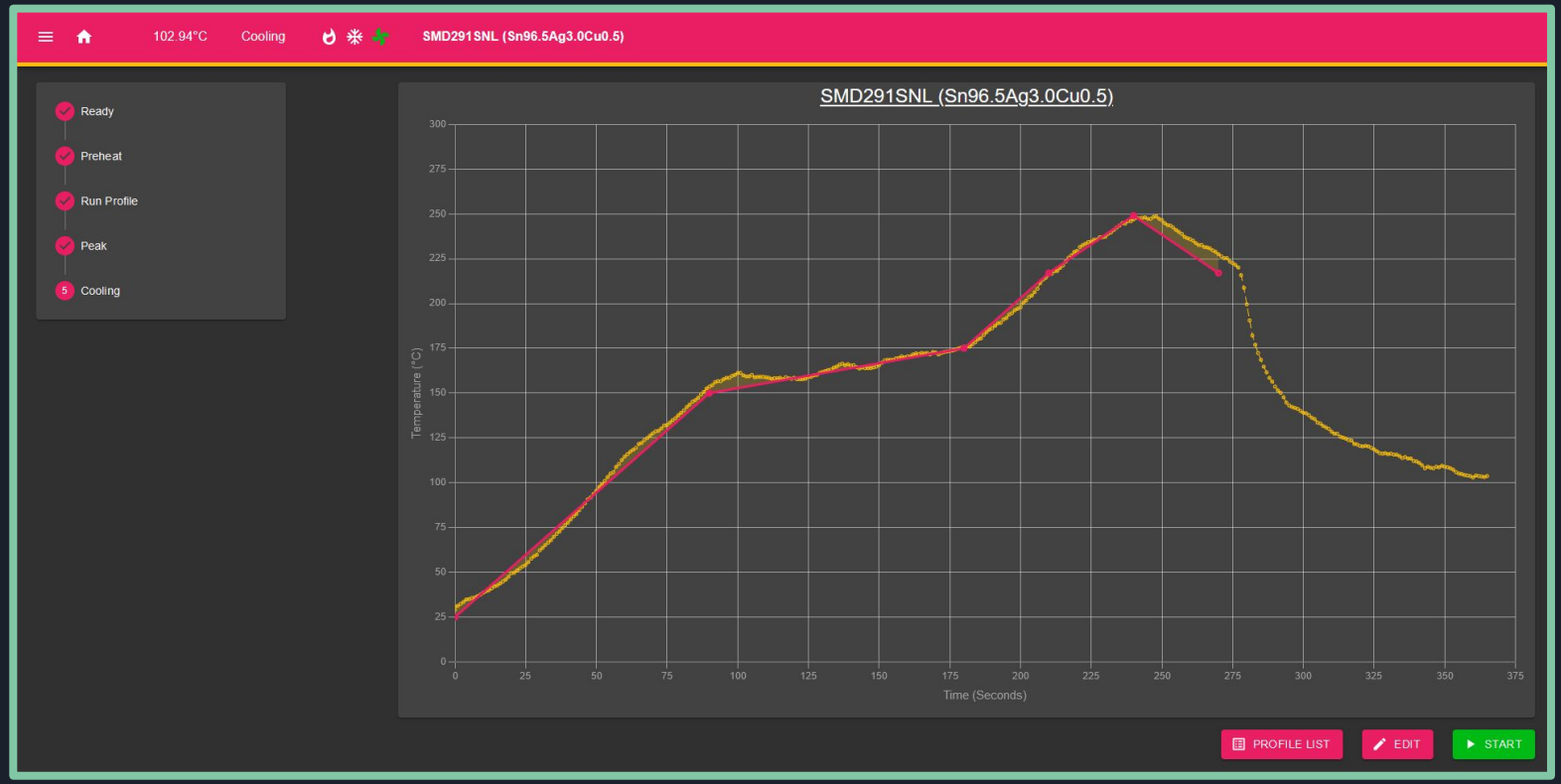
Dual Thermocouple

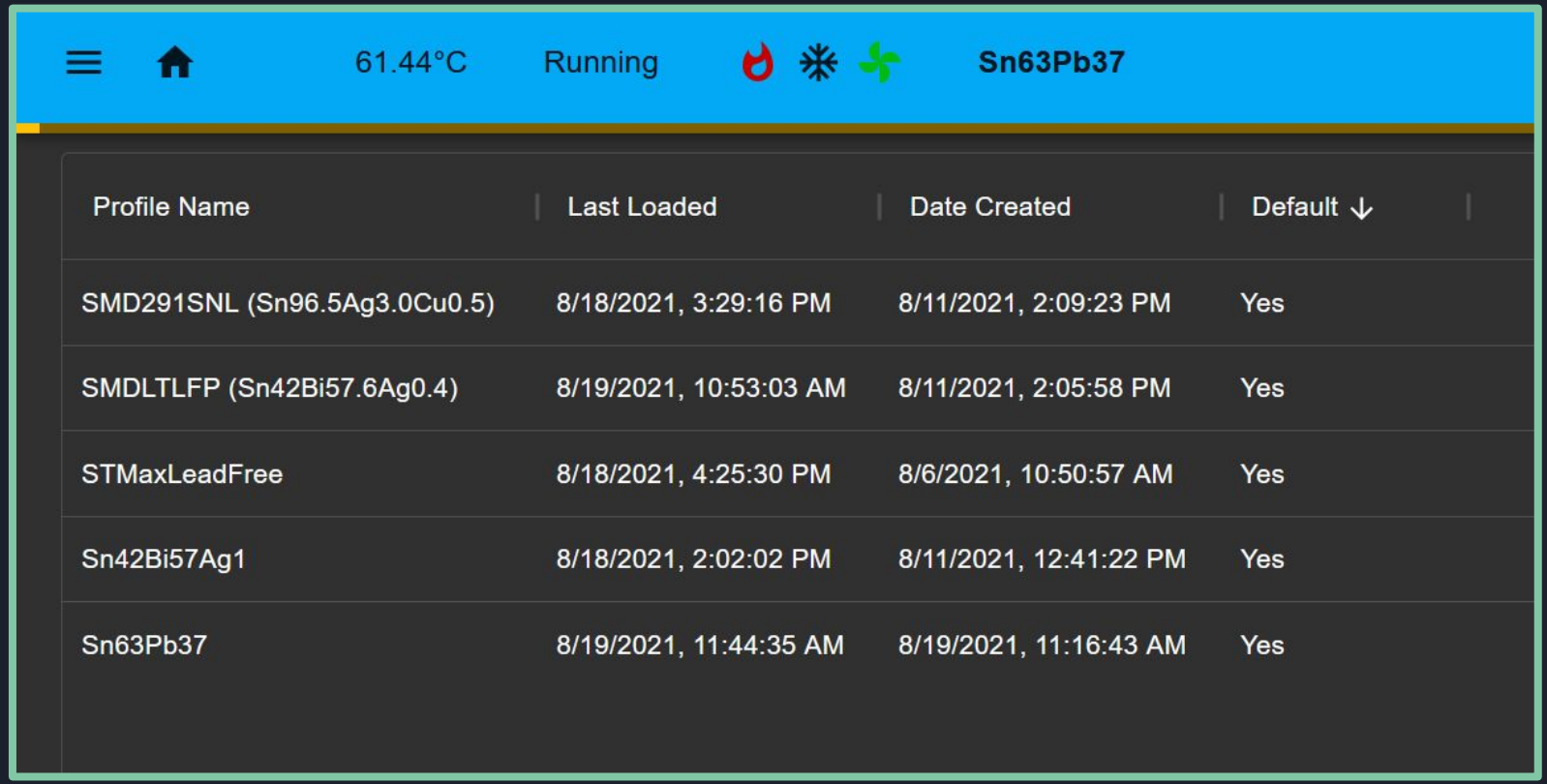
Use Highest Temperature

Higher Temperature Curve Slope allows more flexibility






102.94°C
Cooling
SMD291SNL (Sn96.5Ag3.0Cu0.5)
Ready
Preheat
Run Profile
Peak
5
Cooling
SMD291SNL (Sn96.5Ag3.0Cu0.5)
Temperature (°C)
Time (Seconds)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
PROFILE LIST
EDIT
START


61.44°C
Running
Sn63Pb37
Profile Name
Last Loaded
Date Created
Default
SMD291SNL (Sn96.5Ag3.0Cu0.5)
8/18/2021, 3:29:16 PM
8/11/2021, 2:09:23 PM
Yes
SMDLTLFP (Sn42Bi57.6Ag0.4)
8/19/2021, 10:53:03 AM
8/11/2021, 2:05:58 PM
Yes
STMaxLeadFree
8/18/2021, 4:25:30 PM
8/6/2021, 10:50:57 AM
Yes
Sn42Bi57Ag1
8/18/2021, 2:02:02 PM
8/11/2021, 12:41:22 PM
Yes
Sn63Pb37
8/19/2021, 11:44:35 AM
8/19/2021, 11:16:43 AM
Yes

Conclusions/Reflections

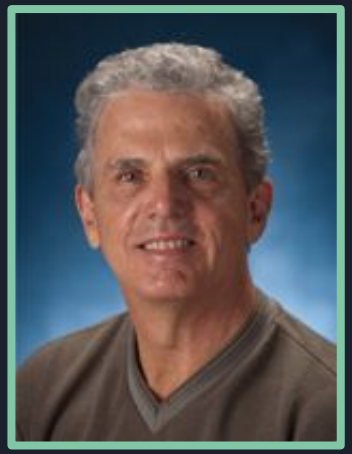
Improvements

- Different approach to measuring temperature of board inside
  - Thermocouple probes placements
- Cooling Phase
  - Need cooling fan built in oven

Process Reflection

- Be prepared to change your initial design
- Problems will arise when incorporating parts
- Keep approaches simple
- Have a plan before attempting anything

Acknowledgements



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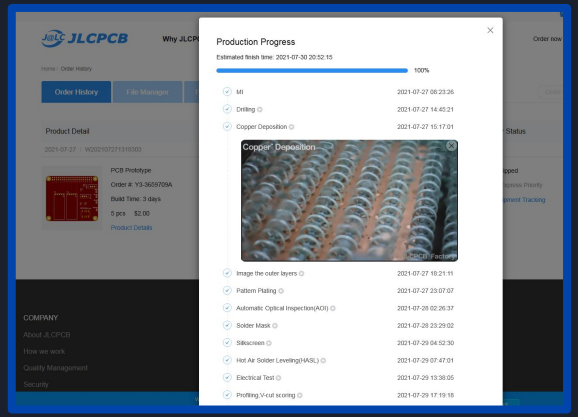


JLCPCB.com

Dr. Rick Cordray
Faculty Advisor

References

Jerry Walker Reflow Oven build:
https://www.youtube.com/watch?v=9026Odx_jOw

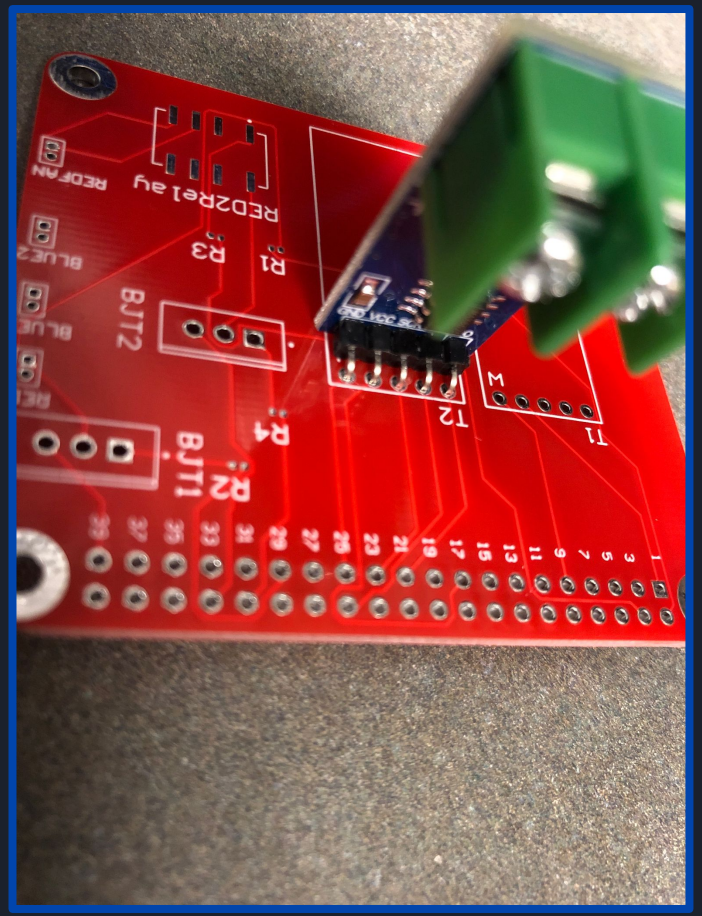
Another Custom Software Build for Reflow oven:
https://mjkuwp94.tumblr.com/

Kanboard Open Source Project Management:
https://kanboard.org/

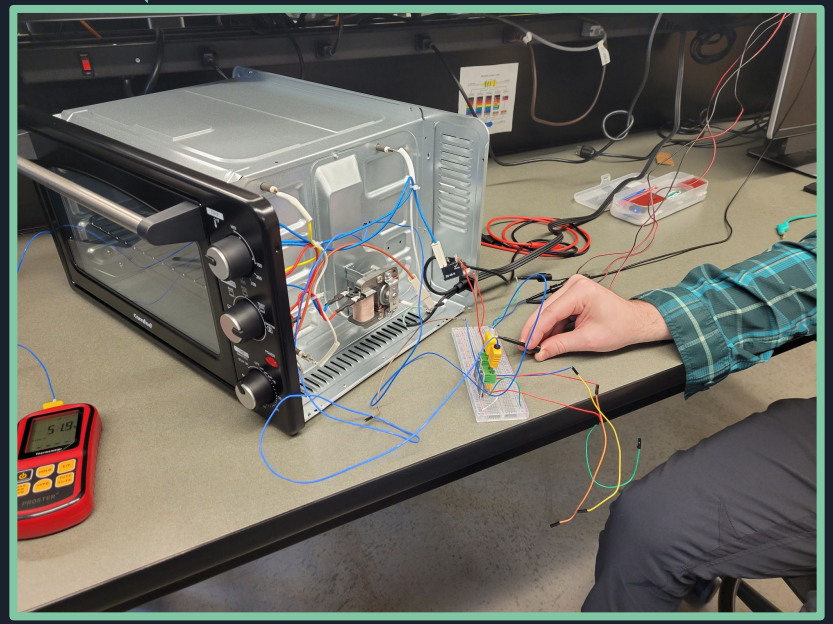
Appendices

Github for our Code: https://github.com/bhu413/reflow

User Manual for our project:
https://github.com/bhu413/reflow/blob/main/Radiant%20Reflow%20Oven%20User%20Manual.pdf



Questions?




Ready
Preheat
Run Profile
Peak
Cooling
Time (Seconds)
Profile: flat
PROFILE LIST
EDIT
START