



Cost Efficient Reflow Oven

By Radiant Flow

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Introduction



Brandon Hu, CS



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Rohan Mathew, EE



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Background & Motivation

Reflow oven

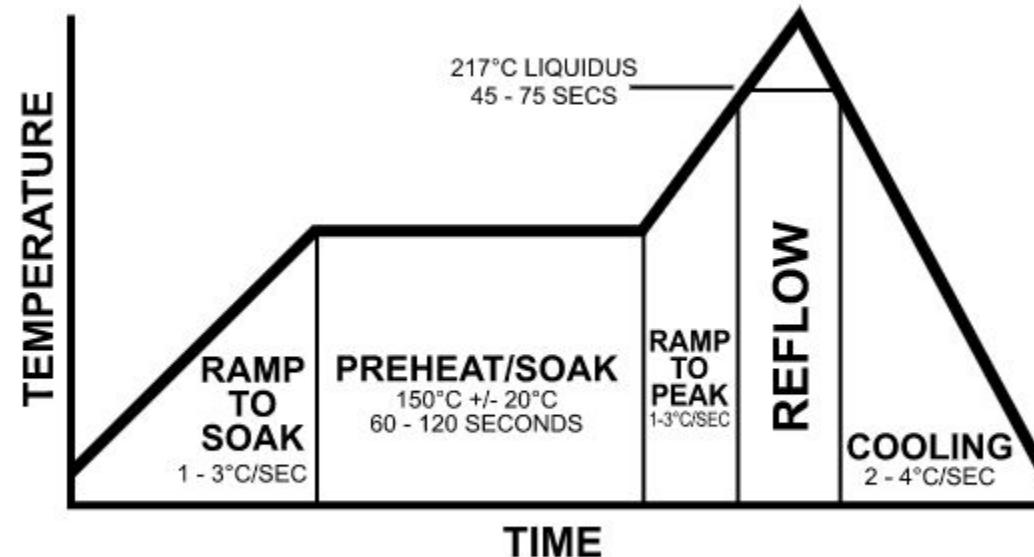
- Convection oven that performs reflow soldering
- Heating is evenly distributed
- Time efficient
- Cost efficient
- Confirm we protect PCB

Follows a specific thermal profile

- Preheat/Soak
- Ramp to peak
- Cooling phase



An Example Thermal Profile

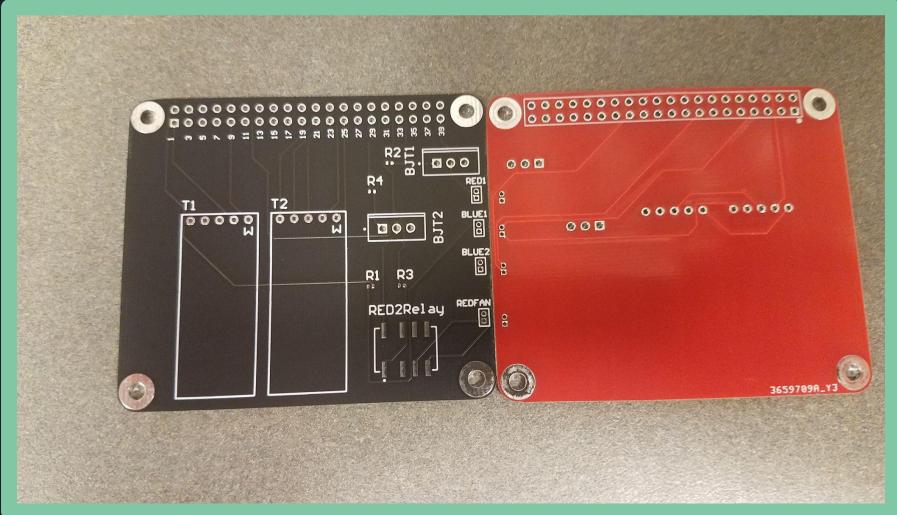


Objective

- 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



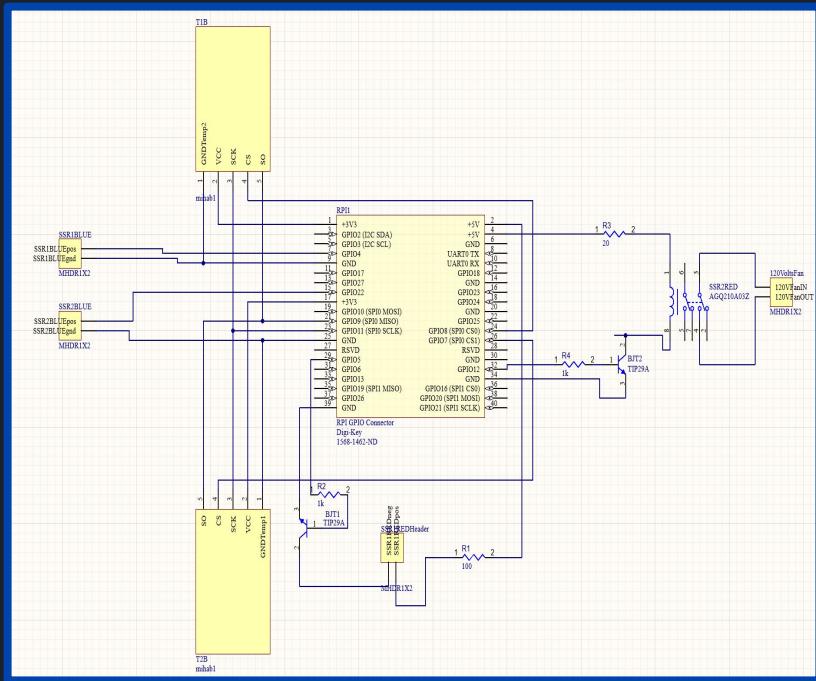
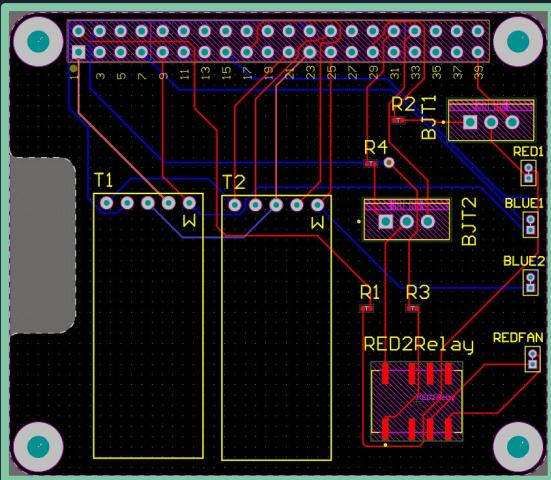
Device/System Description



```
100
101
102     appIdle() {
103         if (this.state.isLocal) {
104             this.setState({ locked: true });
105             localStorage.setItem('locked', 'true');
106         }
107     }
108
109     handlePasswordEnter(e) {
110         this.setState({ password: e.target.value });
111     }
112
113     handleKeyboardInput(button) {
114         if (button === '{lock}') {
115             if (this.state.keyboardLayout === 'caps' || this.state.keyboardLayout === 'shift') {
116                 this.setState({ keyboardLayout: 'default' });
117             } else {
118                 this.setState({ keyboardLayout: 'caps' });
119             }
120         } else if (button === '{shift}') {
121             if (this.state.keyboardLayout === 'caps' || this.state.keyboardLayout === 'shift') {
122                 this.setState({ keyboardLayout: 'default' });
123             } else {
124                 this.setState({ keyboardLayout: 'shift' });
125             }
126         } else {
127             let tempPassword = this.state.password;
128             if (button === '{bksp}') {
129                 tempPassword = tempPassword.substring(0, tempPassword.length - 1);
130             } else if (button === '{space}') {
131                 tempPassword += ' ';
132             } else if (button === '{enter}') {
133                 this.submitPassword();
134                 return;
135             } else {
136                 if (button !== '{tab}') {
137                     tempPassword += button;
138                 }
139             }
140             this.setState({ password: tempPassword });
141             if (this.state.keyboardLayout === 'shift') {
142                 this.setState({ keyboardLayout: 'default' });
143             }
144         }
145     }
146 }
```

PCB Design

- Altium
- Raspberry Pi Shield



Software

Environment

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



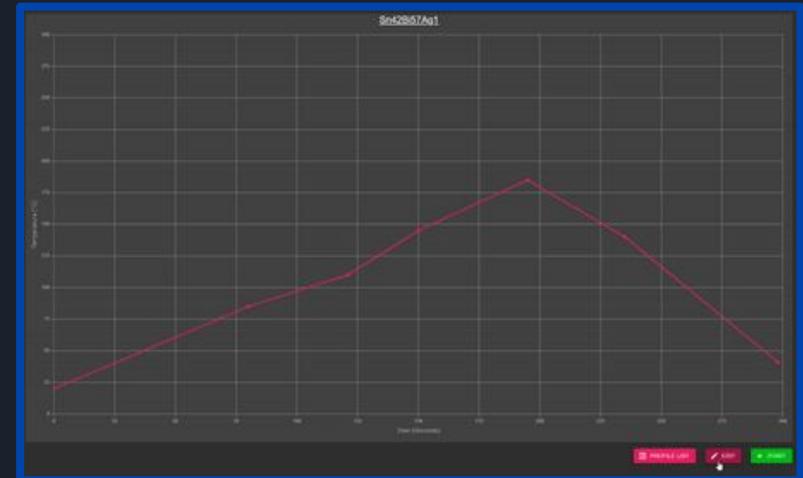
Backend

- 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?

Power supply for PI

Designed PCB

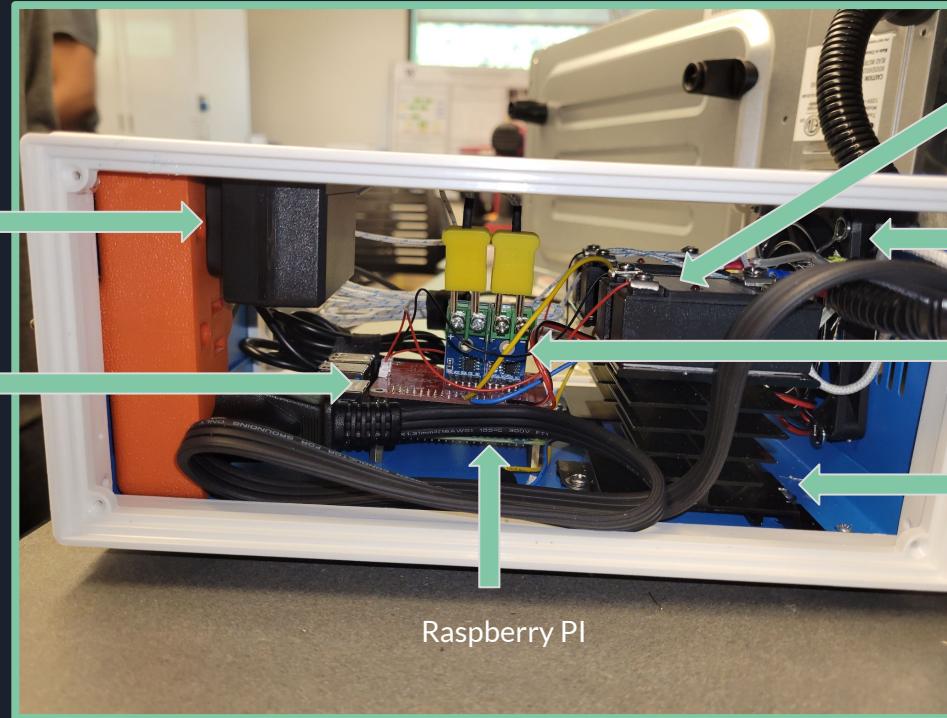
SSR

Case Cooling fan

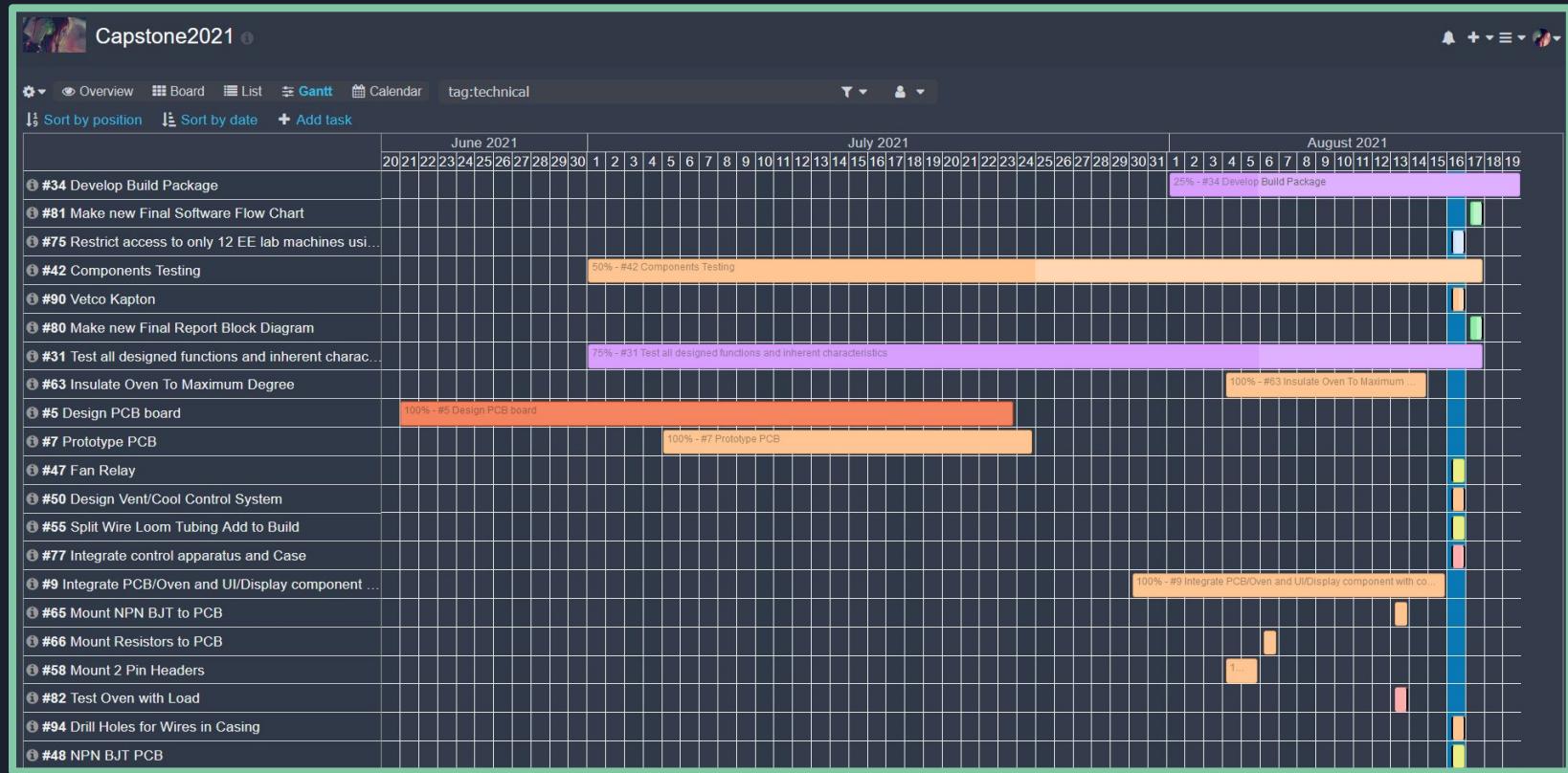
Thermocouple Modules

Heatsink for SSR

Raspberry PI



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

The screenshot shows the Altium Designer interface during a Design Rule Check (DRC) process. On the left, the Project Explorer displays various documents and libraries. The main workspace shows the 'Design Rule Verification Report' with sections for 'Summary', 'Warnings', and 'Rule Violations'. The 'Rule Violations' section lists several errors related to drill holes and solder mask. To the right, a 'Messages' window displays a detailed log of the violations, each with a severity level (e.g., RPI 3.Px), document name, message description, time, date, and line number.

Class	Docu...	Severity	Message	Time	Date	No.
RPI 3.Px	Adl	Warning	Hole Size Constraint: 4.42:3 8/16/2	4:42:3	8/16/2	0
RPI 3.Px	Adl	Warning	Hole Size Constraint: 4.42:3 8/16/2	4:42:3	8/16/2	1
RPI 3.Px	Adl	Warning	Hole Size Constraint: 4.42:3 8/16/2	4:42:3	8/16/2	2
RPI 3.Px	Adl	Warning	Hole Size Constraint: 4.42:3 8/16/2	4:42:3	8/16/2	3
RPI 3.Px	Adl	Warning	Hole Size Constraint: 4.42:3 8/16/2	4:42:3	8/16/2	4
RPI 3.Px	Adl	Warning	Minimum Solder Mask Sliver: 4.42:3 8/16/2	4:42:3	8/16/2	5
RPI 3.Px	Adl	Warning	Minimum Solder Mask Sliver: 4.42:3 8/16/2	4:42:3	8/16/2	6
RPI 3.Px	Adl	Warning	Minimum Solder Mask Sliver: 4.42:3 8/16/2	4:42:3	8/16/2	7
RPI 3.Px	Adl	Warning	Minimum Solder Mask Sliver: 4.42:3 8/16/2	4:42:3	8/16/2	8
RPI 3.Px	Adl	Warning	Minimum Solder Mask Sliver: 4.42:3 8/16/2	4:42:3	8/16/2	9
RPI 3.Px	Adl	Warning	Minimum Solder Mask Sliver: 4.42:3 8/16/2	4:42:3	8/16/2	10
RPI 3.Px	Adl	Warning	Minimum Solder Mask Sliver: 4.42:3 8/16/2	4:42:3	8/16/2	11
RPI 3.Px	Adl	Warning	Silk To Solder Mask: 4.42:3 8/16/2	4:42:3	8/16/2	12
RPI 3.Px	Adl	Warning	Silk To Solder Mask: 4.42:3 8/16/2	4:42:3	8/16/2	13
RPI 3.Px	Adl	Warning	Silk To Solder Mask: 4.42:3 8/16/2	4:42:3	8/16/2	14
RPI 3.Px	Adl	Warning	Silk To Solder Mask: 4.42:3 8/16/2	4:42:3	8/16/2	15
RPI 3.Px	Adl	Warning	Silk To Solder Mask: 4.42:3 8/16/2	4:42:3	8/16/2	16
RPI 3.Px	Adl	Warning	Silk To Solder Mask: 4.42:3 8/16/2	4:42:3	8/16/2	17
RPI 3.Px	Adl	Warning	Silk To Solder Mask: 4.42:3 8/16/2	4:42:3	8/16/2	18
RPI 3.Px	Adl	Warning	Silk To Solder Mask: 4.42:3 8/16/2	4:42:3	8/16/2	19
RPI 3.Px	Adl	Warning	Silk To Solder Mask: 4.42:3 8/16/2	4:42:3	8/16/2	20

KanBoard

Capstone2021

Overview Board List Gantt Calendar status:open

Backlog 2 (2) Ready 6 (6) Work in progress 14 (14) Done 3 (3)

The KanBoard interface displays a project titled "Capstone2021". The top navigation bar includes links for Overview, Board, List, Gantt, Calendar, and status:open. Below the navigation is a header with four main columns: Backlog (2 tasks), Ready (6 tasks), Work in progress (14 tasks), and Done (3 tasks). Each column has a plus sign icon to add new tasks.

Backlog:

- #83 Rehearse Presentation (Administration)
- #93 Put user manual on README in github (Administration)

Ready:

- #20 Build Instructions including Components List (Deliverable)
- #34 Develop Build Package (Administration, Deliverable, Software, Technical)
- #81 Make new Final Software Flow Chart (Software, Technical)
- #84 Altered Circuit vs Original Oven Circuit Diagram (Administration)
- #75 Restrict access to only 12 EE lab machines using rpi firewall (Software, Technical)
- #96 Add Successful Solder Paste Compounds (Deliverable)

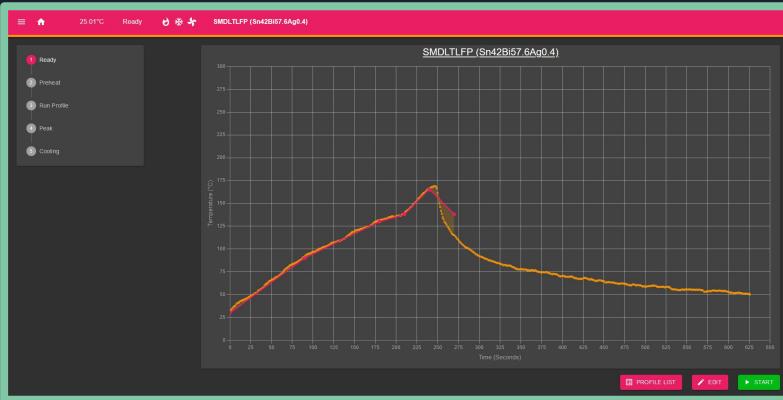
Work in progress:

- #42 Micah R Components Testing (Technical)
- #90 Velco Kapton (Technical)
- #85 Try to break code (Software)
- #32 Develop User Documentation (Deliverable)
- #33 Develop Final Report (Deliverable)
- #52 Develop Presentation (Deliverable)

Done:

- #31 Test all designed functions and inherent characteristics (Software, Technical)
- #77 Integrate control apparatus and Case (Technical)
- #78 RohanM Safety Protocol Documentation (R)

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

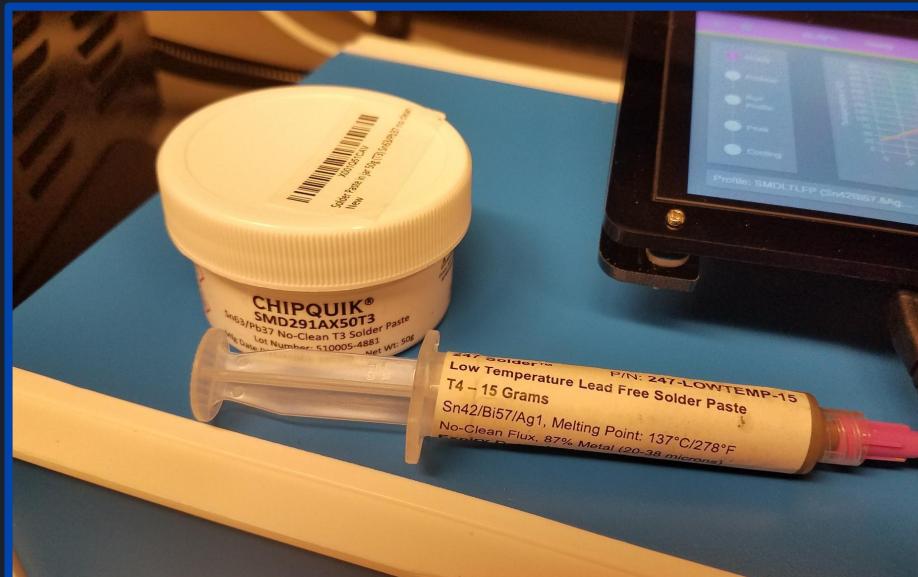
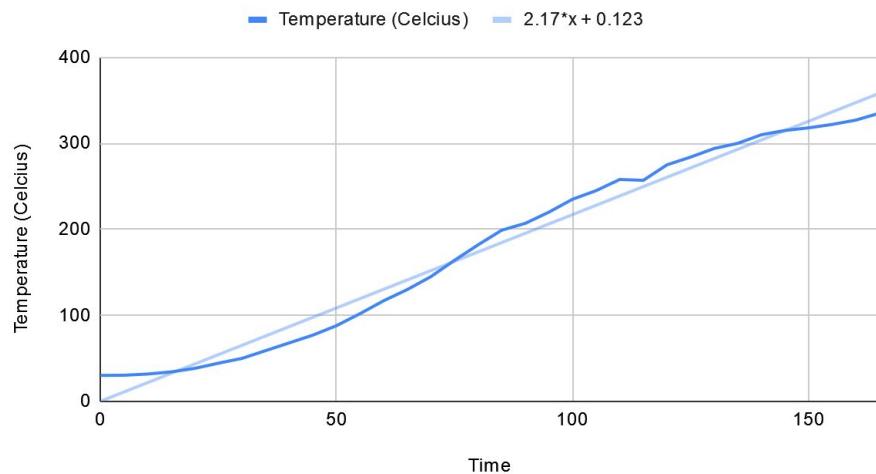
Temperature Adjustment

Constant offset: -7 °C, Percent offset: 8.5 %

Use Highest Temperature

Higher Temperature Curve Slope allows more flexibility

Temperature on PCB vs Time (s)





102.94°C

Cooling



SMD291SNL (Sn96.5Ag3.0Cu0.5)

- Ready
- Preheat
- Run Profile
- Peak
- Cooling

SMD291SNL (Sn96.5Ag3.0Cu0.5)



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

SMDLTLPF (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

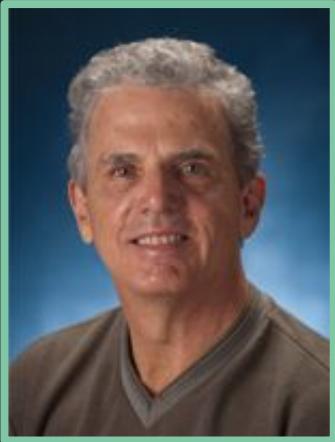
Improvements

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

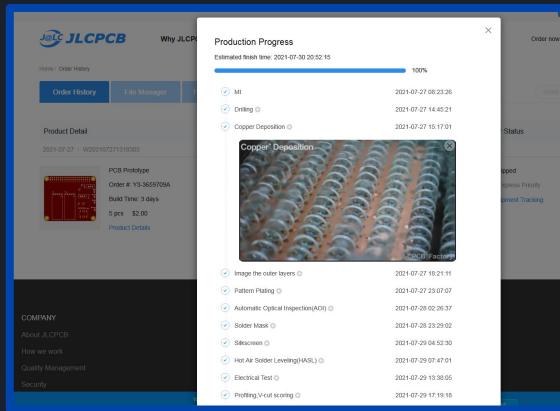
Process Reflection

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

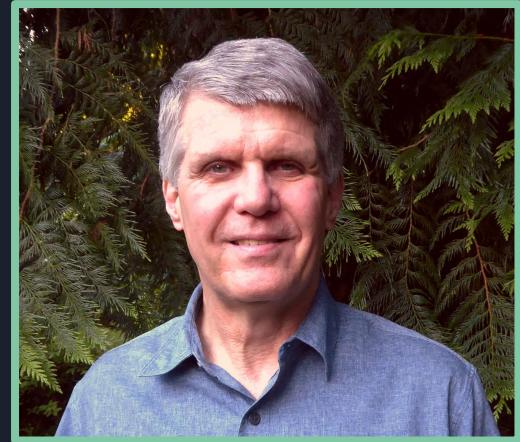
Acknowledgements



Dr. Arnie Berger
Industry Sponsor



JLPCB.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://mikuwp94.tumblr.com/>

Kanboard Open Source Project Management:

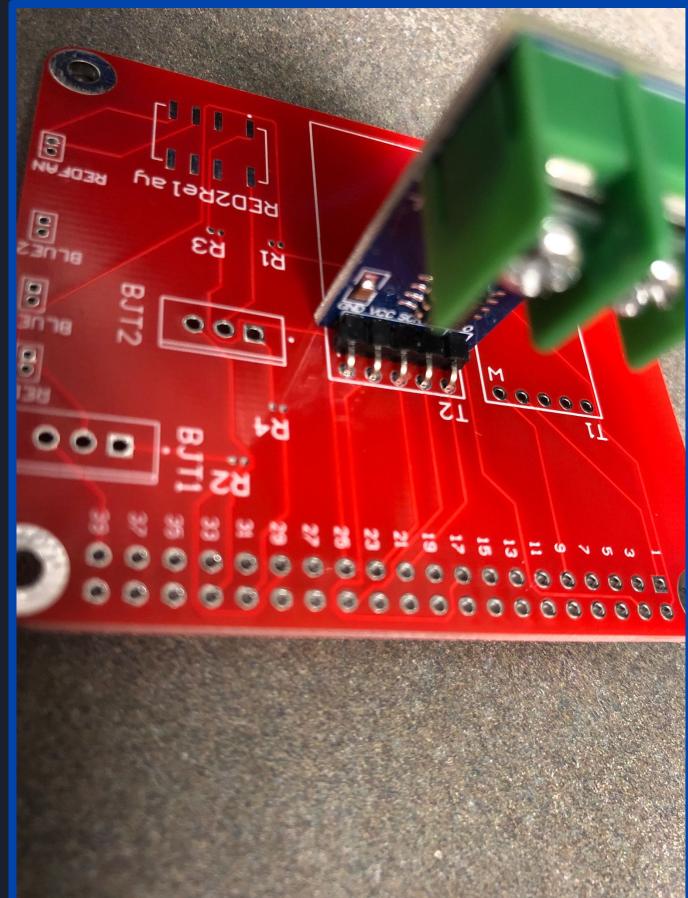
<https://kanboard.org/>

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?

