User Manual
Radiant Reflow Oven

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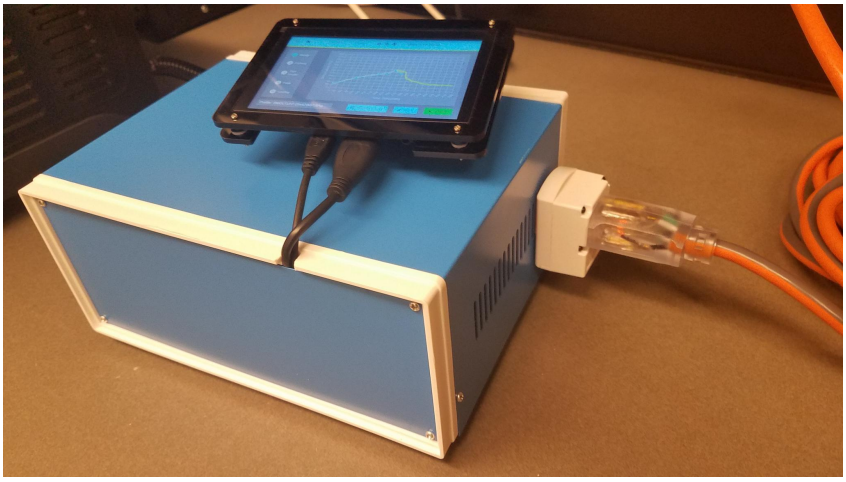
Safety & Instructions

Instructions for Regular Use:

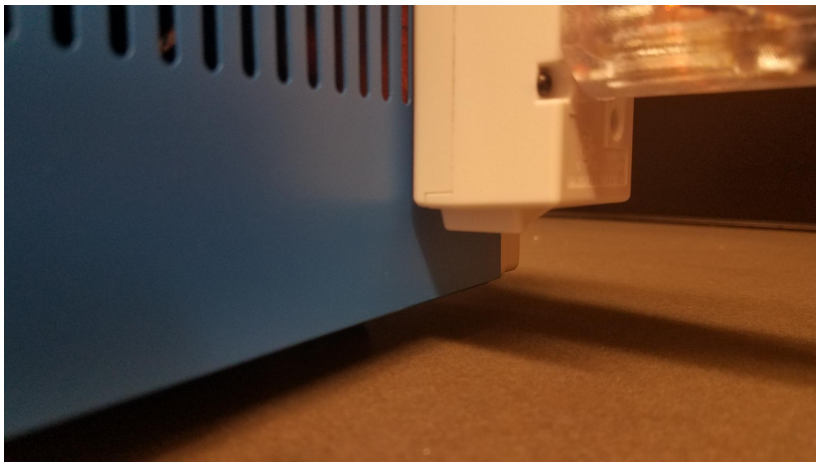
If the oven is OFF/Unplugged:
Before plugging in the oven, inspect for any burning aroma or any marks on the oven. It is important to confirm that the oven is not damaged before it is turned on.

Check Dials on the front of the oven:

- The top dial labeled **TEMP** does not matter
- The middle dial labeled **FUNCTION** should **ALWAYS** be set to Convection
- The bottom dial labeled **TIME** should **ALWAYS** be set at **STAYON**

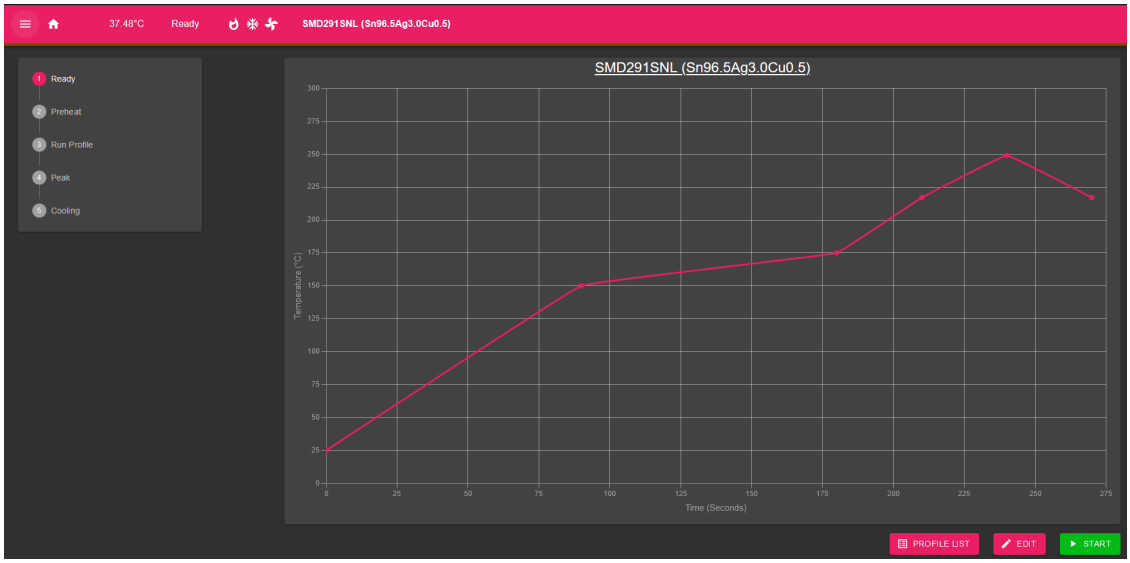


If the screen is OFF, **turn on the switch on the bottom right hand of the case**, on the bottom of the white adapter.



The on/off Switch

When plugging in or switching on the oven, allow the boot process to fully complete to the point of displaying the control panel Home Screen as shown below(color may differ):



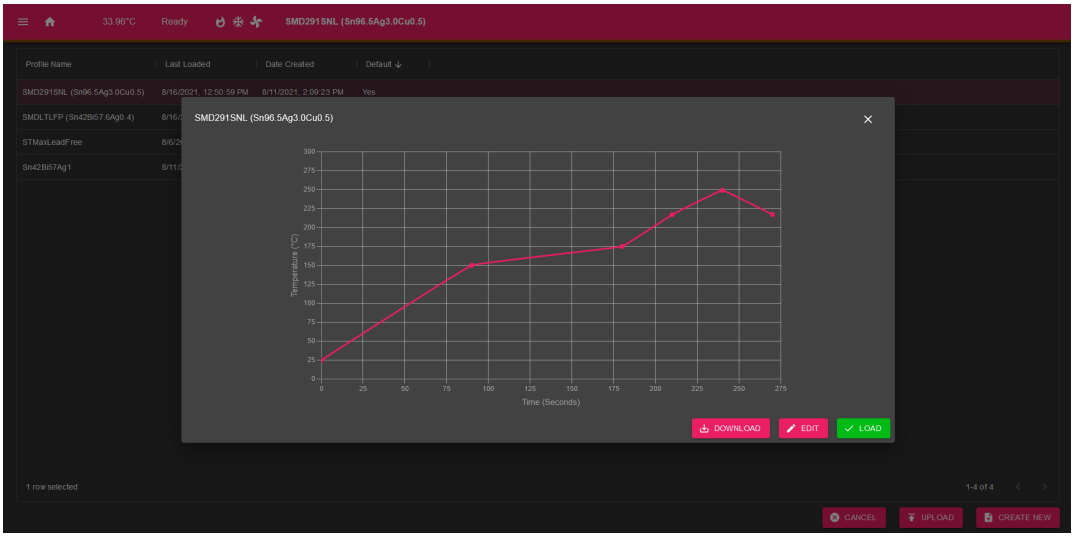
Home Screen for Profile Control.

Oven is ON:

Confirm that the temperature inside the oven is safe to open before placing your desired PCB with solder paste applied and components ready on the board. After placing the PCB inside on the metal rack in the middle of the oven, close the oven door completely.

Confirm that the selected profile matches the needed profile for the solder paste you are using.

Open the profile list as seen on the home screen in the bottom right, or by hitting the  button displayed at the top left and selecting Profile List from the drop down menu.



Screen displayed after navigating to the Profile List, and tapping your preferred profile

Load your desired profile by clicking ‘Load’ in the bottom right of the popup display.

Additional features can be explored in the Settings Menu at this time for advanced users in special cases. Read the Settings section of the User Manual to gain an understanding of your options here, as well as the default settings.

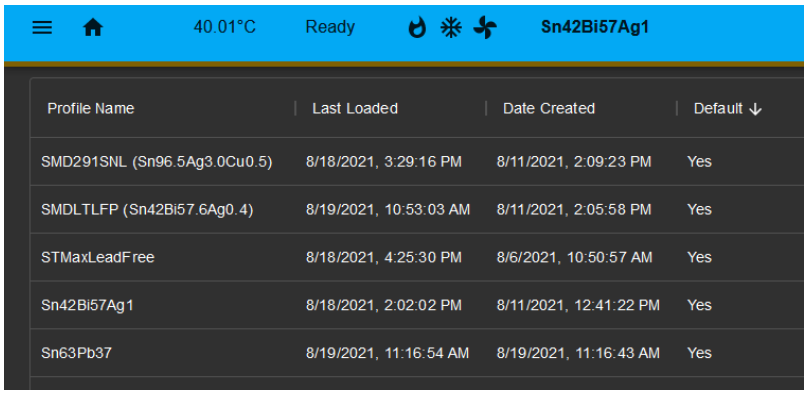
Hit Start at the bottom right to **begin the profile.**

While the oven is on, the user and anyone else in close contact with the oven **must** be aware of the temperature inside the oven based on what is shown on the display screen. While the reflow profile is running be sure to keep an eye on the trend of the measured profile and that it is following the desired profile appropriately. Once the notification to open the oven door appears along with a beeping sound, the user **must** grab only the oven handle and open it to the first or second notch. **DO NOT** touch any other part of the oven because it could be extremely hot and may very likely burn your skin on prolonged contact. While the oven doors are open, be sure to maintain a foot or two distance from the oven until the cooling phase is done.

The cooling phase continues from the user prompt to open the door until the temperature reaches 30 C. Depending on your equipment, you may choose to remove the PCB prior to reaching 30 C, but beware of burns. It is recommended to use tongs to remove the PCB if done before 30 C and allow it to cool to room temperature on a safe surface such as the foil covered open door of the oven, which should cool much faster than the rest of the oven if opened to 100%.
Note that this product was designed and tested to be a reflow oven. Do not put any other items other than a circuit board with the appropriate components on the oven tray. This product is a tool and not a toy, and is not for food. Always be aware of what is around the reflow oven. Make sure the area is clean and free of anything which reacts negatively to heat.

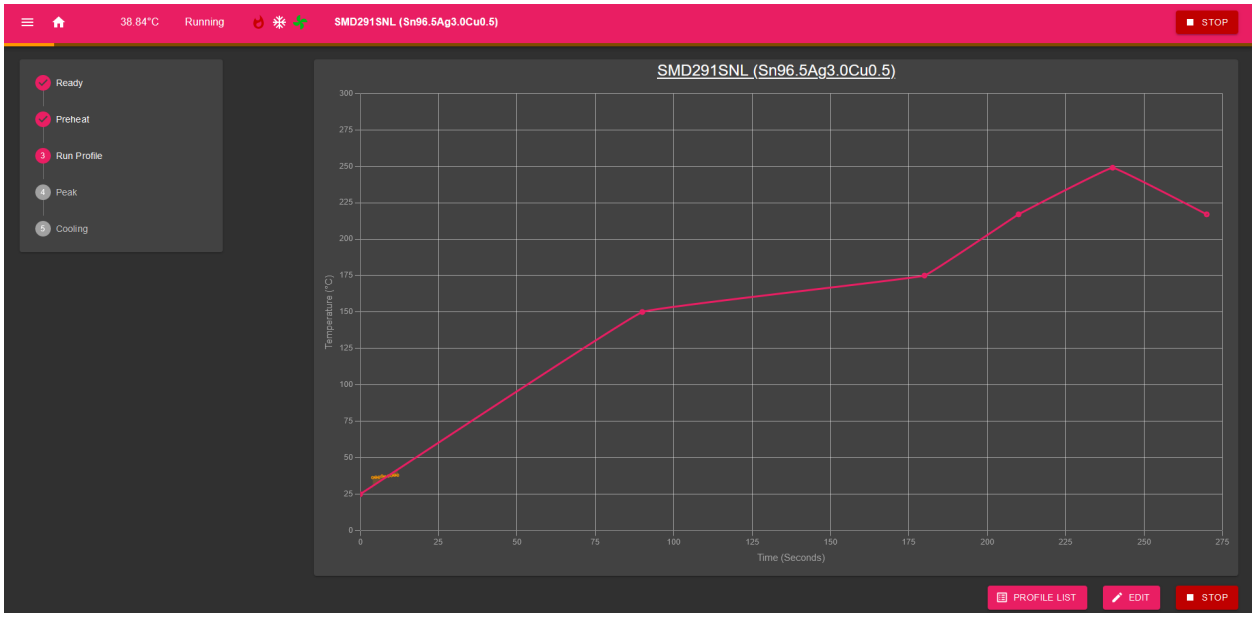
Rules & Recommendations:

- **DO NOT** change the PID settings unless you know exactly what you are doing. **Default PID: P = 300, I = 0.075, D = 1360**
- When prompted by the oven during cooling, open the door to the first or second notch, which is 10-25% open. It is not recommended to immediately open the door 100%.
- **Do Not** leave cooling oven unattended with door open
- **Do Not** leave any items on top of the oven at any time.
- **Do Not** Touch the oven flat surfaces during heating or cooling. Surfaces will be very HOT!
- **Do Not** attempt to run/program heat profiles above 300 C
- Ensure the materials you are using can survive the Temperature Profile selected.
- Make sure your Temp Profile matches your solder Paste
    - The Oven has default profiles for the following compounds, shown below accessible in the Profile List:
        - Sn96.5Ag3Cu.05
        - Sn42Bi57.6Ag0.4
        - Sn63Pb37
        - Sn42Bi57Ag1
        - STMaxLeadFree(an example custom profile)



    - **Caution**: Program new profiles for other compounds using diligent research and at your own risk. **Our oven is not capable of achieving slopes higher than 2.17 degrees C/s. Program higher slopes at your own peril.**

- **IN CASE OF FIRE** or Damage to parts, **IMMEDIATELY press the STOP button** on the touchpad control screen located at the **TOP RIGHT or the BOTTOM RIGHT** of the display. Wait for parts to cool before removal. The internal temperature of the oven can be read at the TOP LEFT of the home control screen.
    - STOP buttons appear while the profile is actually running. If you do not see a STOP button in these locations, the profile is not active, but **THE OVEN MAY STILL BE HOT**.

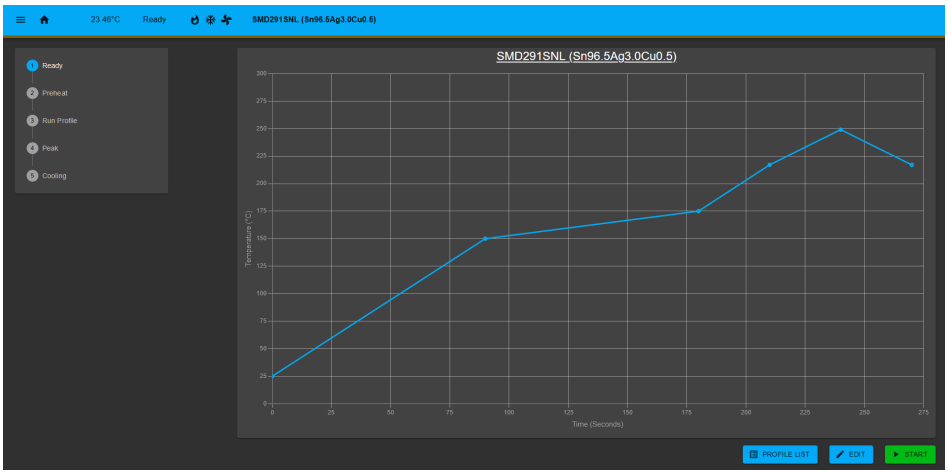


STOP located in top and bottom right locations & temperature reading at top left.

TIP: For **Settings panels**, remember to **always hit the Save button** on all settings screens once you have input your new preferred values.

User Interface

Home Screen



Start (Bottom Right in Green)

This green button starts the profile that is currently loaded.

Edit (Bottom Right)

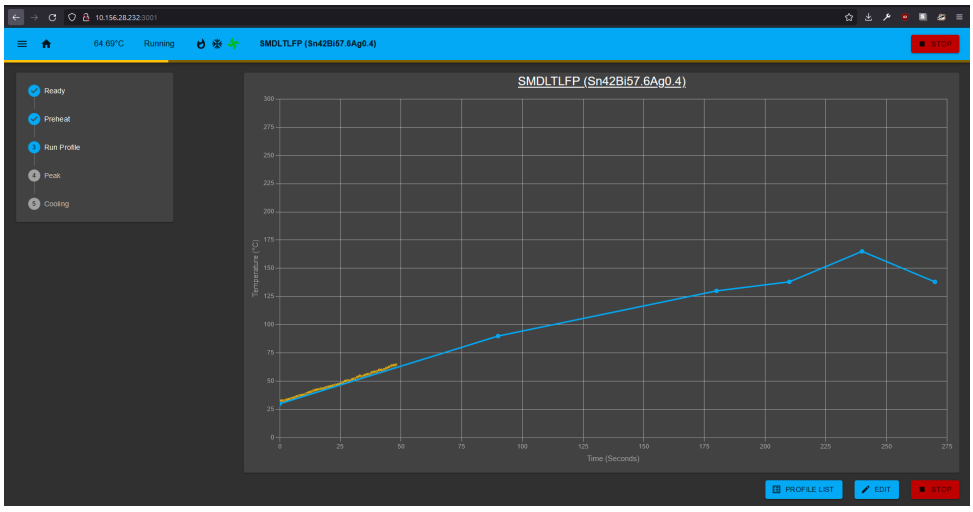
This button opens the Profile editor screen.

Profile List (Bottom Right)

This button opens the Profile List, to select another Solder Paste Profile.

Dropdown Menu (Top Left)

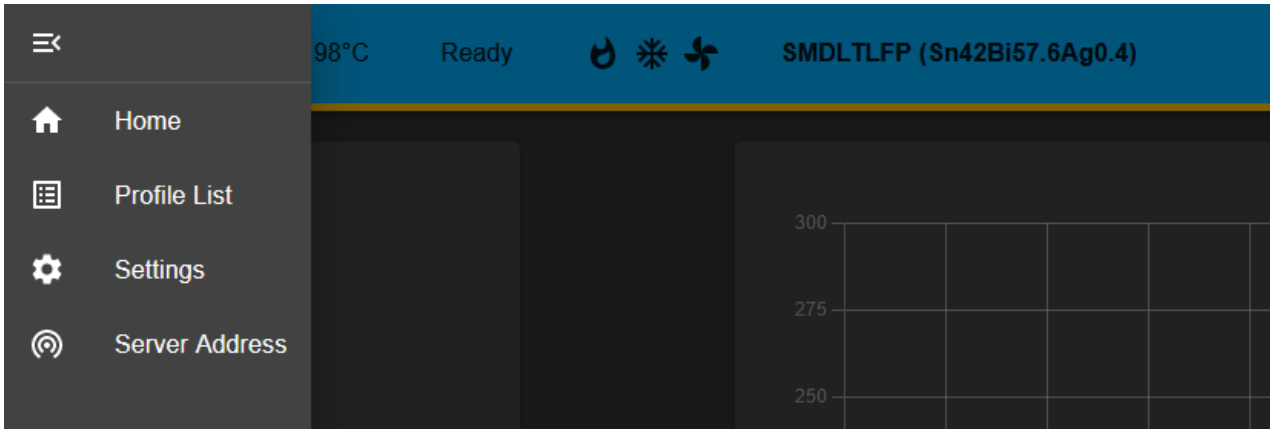
This button opens the dropdown menu, which contains access to the Home page, the Profile List, the Settings for PID, Hardware, Network, and Appearance, and the Server Address display.



*The **STOP** buttons are located in the **bottom right & top right** of an active profile on the **Home Screen.***

The current temperature in the oven is in the top left, to the right of the drop down menu and home button.

Drop Down Menu



Home

This button brings you to the Home screen, which is where you Load and Start a profile.

Profile List

This button opens the Profile List, to select another Solder Paste Profile.

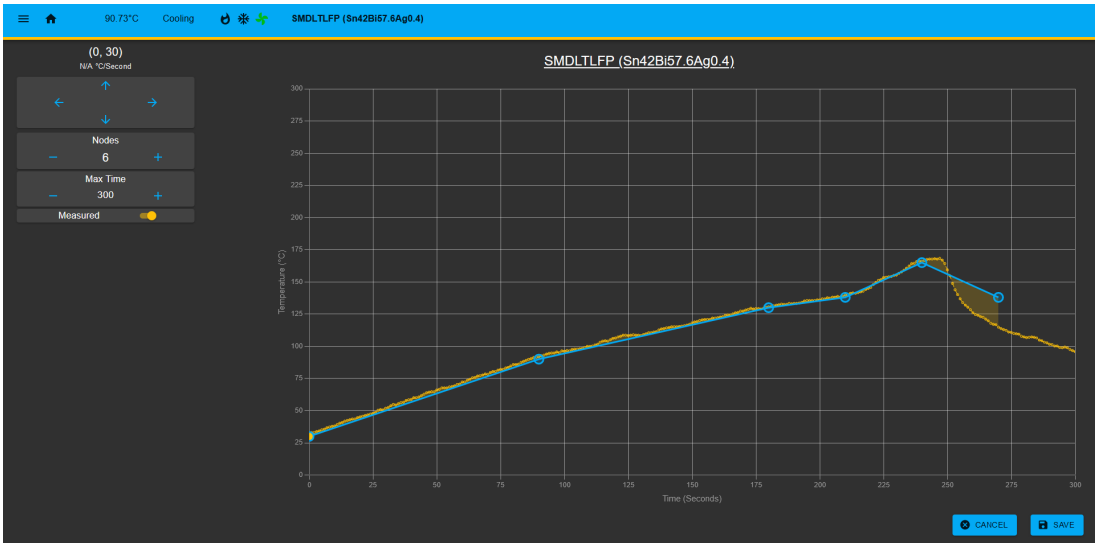
Settings

This button opens all adjustable settings for the display screen. Here the user can customize the profile line color as well as the actual temperature curve that represents the temperature inside the oven at that time.

Server Address

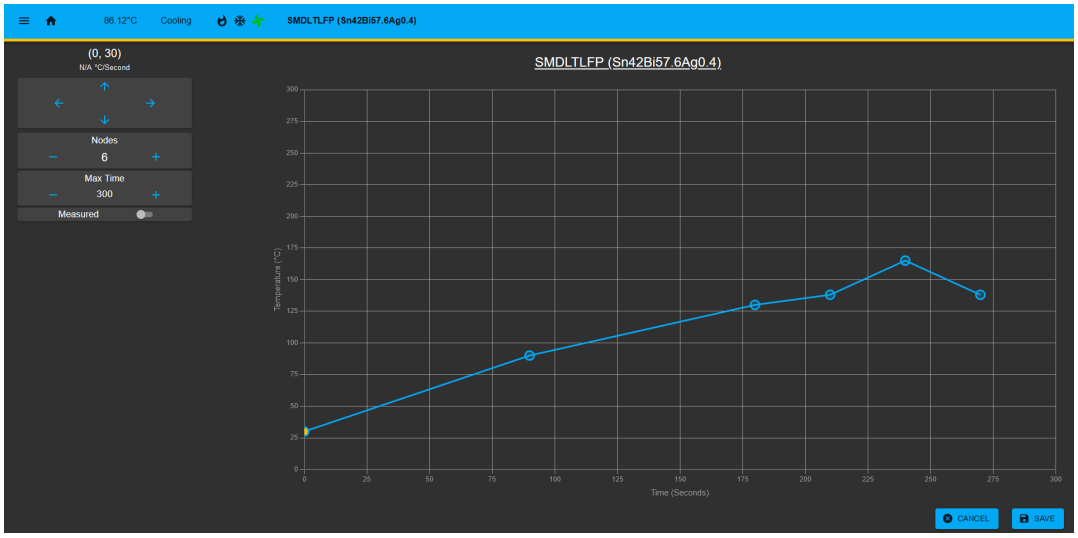
This button will display a popup showing the current server address of the oven. The default server address of our particular installation is **10.156.28.232**

Edit Profile Screen



Measured (Middle left, yellow switch)

This will show up if you are editing a profile you have just run. It allows you to edit the profile with knowledge of how the existing profile actually performed due to oven characteristics.



Save(bottom right)

Save will save the profile as it currently exists in the editor. If a profile already exists named exactly the same thing, a (1) will be appended.

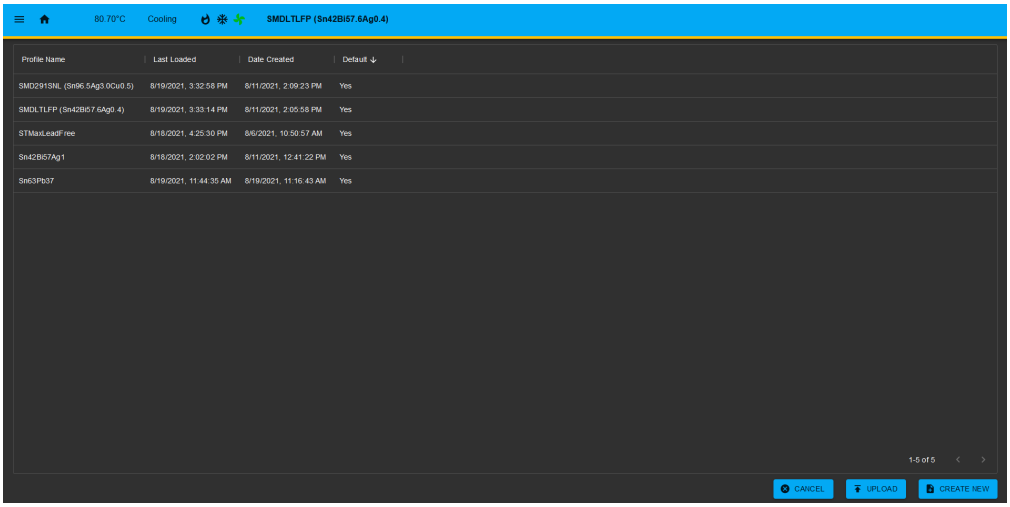
Cancel(bottom right)

This button will cancel the editing process and not save the current profile's edited version.

Control Panels(top left)

The ordered pair at the top shows the current location of the point that is selected. The arrows below will move that point by one unit in the prescribed direction.
The number of nodes available can be adjusted using the - or + in the next panel below.
The Max Time - or + will move the x axis max value between 300 up to a max of 20000.

Profile List Screen



This screen is a list of all currently programmed profiles. There are 5 default profiles. 4 are for different Solder paste compounds, and one is an example of a custom profile. You may create your own profiles and save it to run it.

Upload (bottom right)

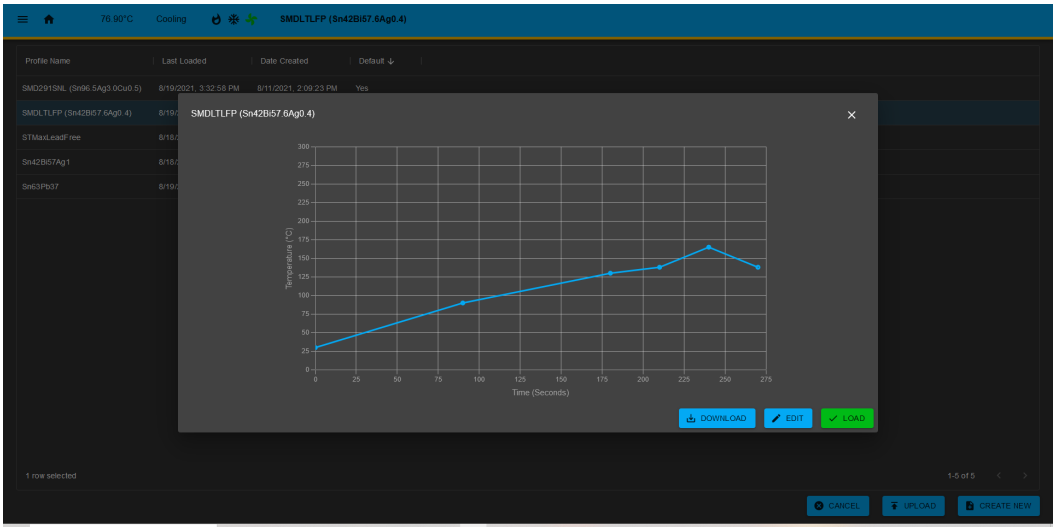
If you have a .json profile already stored locally, you can upload it by pressing this button and selecting the .json profile.

Create New (bottom right)

This will open the editor to create a new profile from scratch.

Cancel (bottom right)

Brings you back to the home screen.



When you click on a profile, a popup will appear showing the profile you selected.

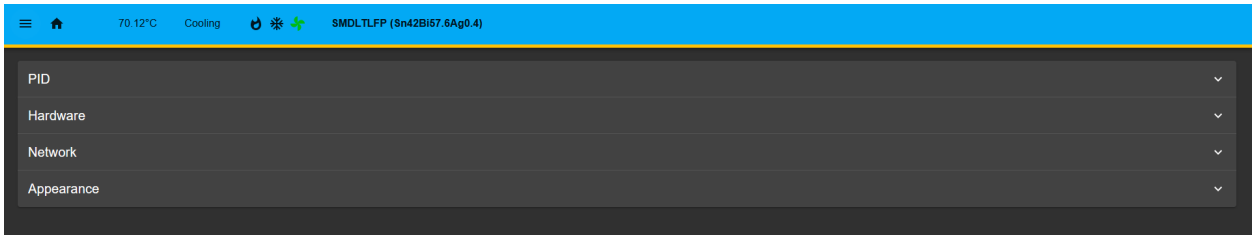
Load

This will open the home screen with this profile loaded and ready to start.

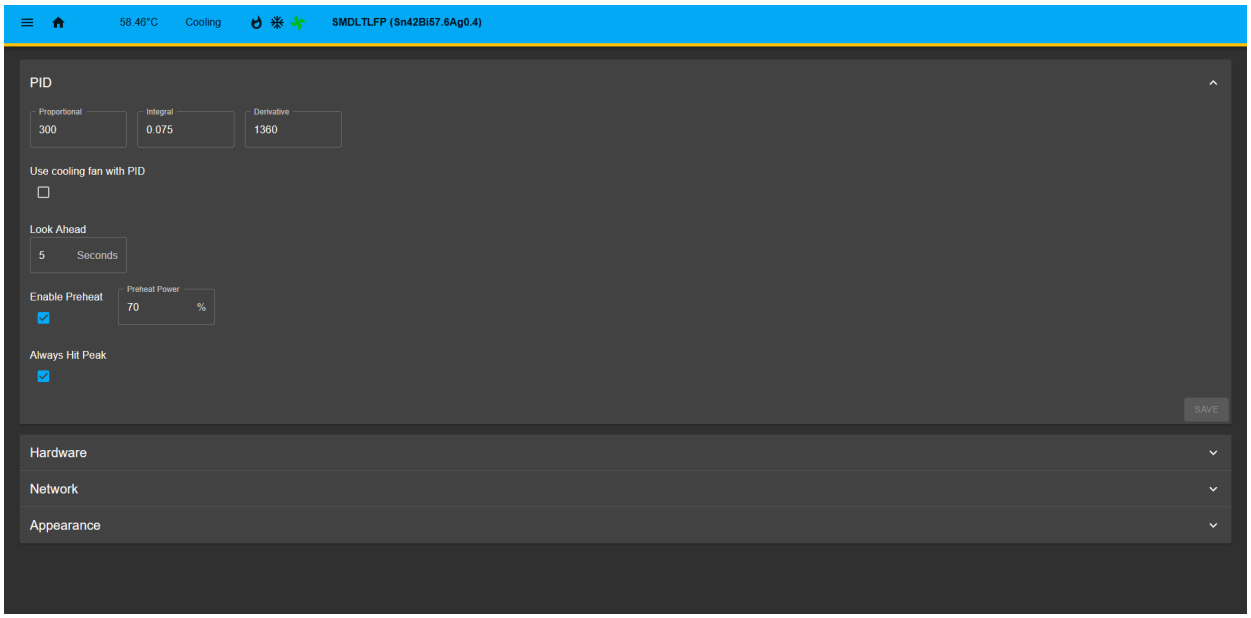
Edit
This will open the profile editor with this profile loaded and ready to edit.

Download
This will download a .json file locally. Useful if you have nearly 50 profiles stored. The maximum number of profiles the controller will store is 50, after which it begins deleting non default profiles to store additional ones.

Settings Screen & Defaults



The Settings screen gives you access to settings and information for 4 different categories. PID controller, Hardware(GPIO ports, Temperature Readings, preheat control/profile behavior control), Network(default Port for Web UI connections), and Appearance(Colors, dark mode).



Proportional, Integral, Derivative
One of the most important settings on the Reflow Oven. These constants control the weighting of the PID algorithm and are tested to specifically follow precisely the temperature profile. In most cases, altering these values is NOT RECOMMENDED. If you have trouble following a profile, first investigate whether the slope is too steep for the oven(in our case above 2.17 degrees C per second), or the cooling is too steep(faster than 0.5-1 degree per second).
Default Values: Proportional = 300, Integral = 0.075, Derivative = 1360

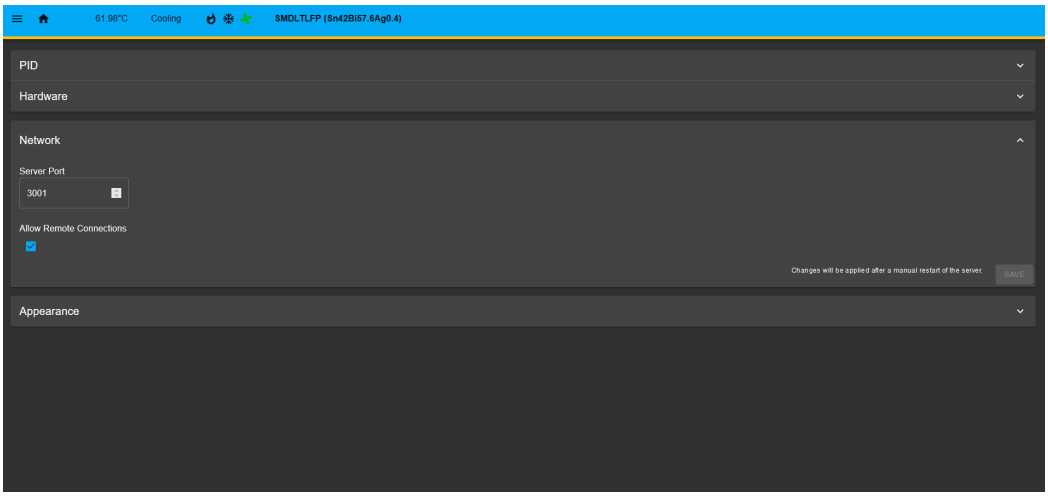
Use Cooling fan with PID
This setting is only useful if you have installed a cooling fan. No fan is currently installed in our build.

Look Ahead
Default value: 5 seconds. This causes the profile PID controller to look ahead X amount of seconds in the profile and target that value. This is useful because the thermal inertia of the oven may cause a delay in responding to inputs.

Enable Preheat
This setting allows the oven to preheat to the temperature prescribed in the profile adjusted by the look ahead value. This is highly useful for **profiles that start at above room temperature**! Based on the initial slope of a profile that begins after preheat, you may wish to adjust the % power delivered during preheat to adjust the thermal inertia at the moment of beginning the profile.
Default values: Preheat= ON Power = 70%

Always hit peak
This setting ensures that even in the case where the slope is not being matched perfectly or the actual temperature curve is delayed behind the profile prescription, the oven will still ensure it hits the max temperature prescribed and holds for the amount of time the profile indicates from the intended initial point of temperature peak. This setting is largely irrelevant unless the profile has sections with unachievable slopes. For our oven, any slope **above 2.17** ℃ **per second** is **not achievable.**
Default value: ON

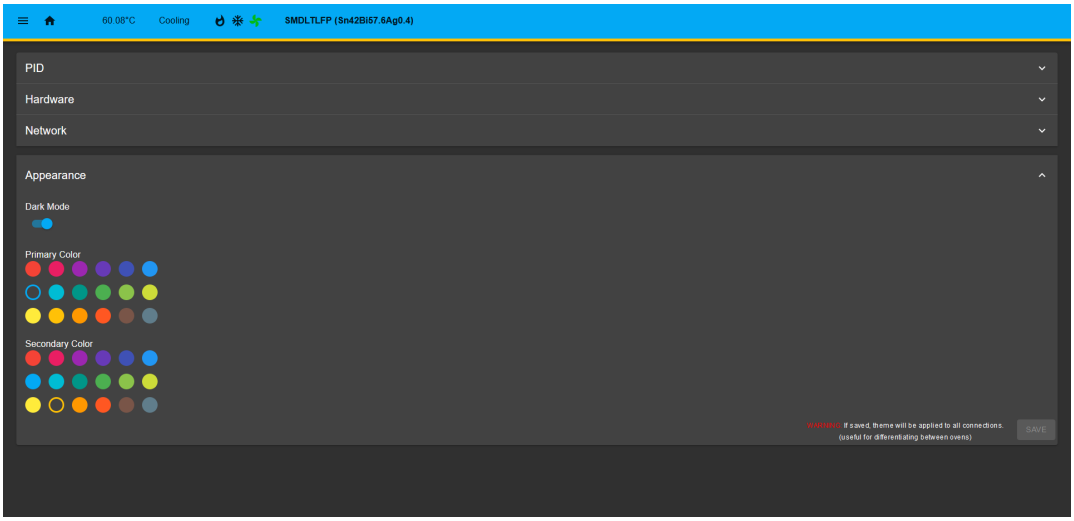
Network Settings



Server Port
This setting defines what port the UI will be hosted on. Please ensure that the port is not taken by a different application.
Default value: 3001

Allow Remote Connections

Allows connections to the WebUI to allow for monitoring and control of the oven from a different computer within the same network. These connections would occur by navigating to the IP address dictated in the Server Address panel, with the :PortNumber added on which is dictated here. For our implementation of the oven for example, this is found at **10.156.28.232:3001**



Dark Mode

Dark mode switch, turns on and off a darker vs lighter UI background.

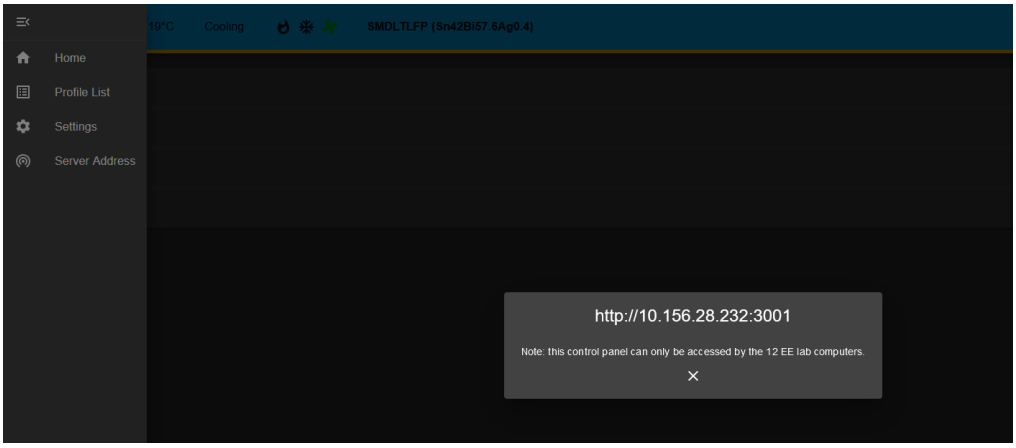
Primary Color

The profile line color and UI highlight color are determined by this value.

Secondary Color

The actual temperature curve experienced is tracked in this color value.

Server Address Panel



The IP address displayed allows you to access the web UI interface from a remote computer in the same network, so long as “allow remote connections” is ON in the Network panel of the Settings Screen.

Operating Specifications

Characteristic	Value
Max Recommended Operating Temp	**300 C**
Max Temperature Ramp Slope	**2.17 ℃/s**
Max Profile Duration	**20,000 seconds (5.56 hours)**
Max Cooling (Closed Door) (300-200)	**1 ℃/s**
Max Cooling (Closed Door) (200-30)	**0.5 ℃/s**
Max Cooling (Open Door) (200-30)	Determined by PCB thermodynamic characteristics. I.e surface area, materials. The air in the oven itself will cool rapidly toward 100 degrees, then **1 ℃/s** .
Max Number of Thermo Profiles	**50**
Default PID Settings:	**P = 300, I = 0.075, D = 1360**
Default Temp offsets:	**-8℃ and +8.5%**
GPIO PORT Defaults:	**Relay: GPIO 4 (Pin 7)** **Convection Fan: GPIO 22 (Pin 15)** **Buzzer: GPIO 24 (Pin 18)**
Default Network Port	**3001**
IP address **specific to OUR implemented Oven:**	**10.156.28.232** To access WebUI from PC, go to YourIP:YourPort **For us, that is:** **10.156.28.232:3001**

Build Package

Bill of Materials

Id	Description	Quan	Supplier	Supplier Part #	Mfr. Part #	Price Each	Totals
1	Rasberry Pi 4 GB with heatsinks	1	Amazon	B07TXKY4Z9	CanaKit	$74.99	$74.99
3	Convection Oven: Preference 1	1	Amazon	B0847RBPNW	COMFEE - CFO-CC2501	$59.99	$59.99
4	Temp Sensor	3	Amazon	B01HT871SO	HiLetgo	$8.49	$25.47
5	5 inch capacitive touch display	1	Amazon	B082F3K84X	Jun-Electron	$55.99	$55.99
6	MicroSD 32 GB	1	Amazon	B07B98GXQT	MB-MJ32GA/AM	$7.99	$7.99
8	SSR Solution for Fan and Heating Elements	2	Amazon	B08GPJ1V2J	CGELE SSR-25DA	$9.90	$19.80
9	Heat Sink For Relay	2	Amazon	B091HQL9TM	CGELE 1PCS Alum Heat Sink SSR	$6.59	$13.18
10	K - Type Thermocouples, high temp capacity	1	Amazon	B00OLNZ6XI	SZZJ INC 1	$15.99	$15.99
11	Spade Connector Kit	1	Amazon	B08BZ9J757	TICONN 25170000	10.95	$10.95
12	Female Pin Headersn for R-Pi to PCB	1	Amazon	B07DNHS2SJ	Wallfront Ean 0763741503994	9.59	$9.59
13	PCB Print/Deliver	1	https://jlcpcb.com/			15	$15.00
14	High Temp Insulation 16 Gauge Wire	1	Amazon	B07W3D3SL9	Bryne AWG16 10Ft	13.88	$13.88
16	Foil for Insulation	2	Amazon	B00029KC2K	Thermo-Tec 200-10045	25.33	$50.66
21	Extension cord 3 socket	1	Amazon	B000Y4DXLA	Coleman Cable 2451	20.82	$20.82
22	case	1	Amazon	B08BS39P69	Zulkiit Box 9.8 x 7.5 x 4.3 Inch	18.99	18.99
23	Wire sleeve	1	Amazon	B07TCDTFL2	Alex Tech 25ft – 1/2" Loom	9.5	9.5
25	Insulating material for inside oven gaps	1	Amazon	B00GT5Q6X0	CM-Ceramics 31" X 24" X 1" 2400 F	$33.50	$33.50
26	Fan for Cooling R-Pi and Housing Case	1	Amazon	B00N1Y4RLU	Gdstime 80mm x 80mm x 10mm DC 5V	8.99	8.99
						Blue Method	$465.28

Resources:

PCB

- https://github.com/bhu413/reflow/blob/main/FinalReflowOvenController.zip
- We recommend using JLCPCB (jlcpcb.com) for printing the circuit board whose gerber files are enclosed in the above link
- For editing the design files, we recommend using Altium Designer

R-Pi

- https://github.com/bhu413/reflow
- Issues: https://github.com/bhu413/reflow/issues/new
- You may want to comment out a line in the startup.sh which inverts the screen, if it does not fit your use case. At the moment of this writing the script calls this command on line 10 of startup.sh

Oven

- If you wish to achieve 3 degrees C/s ramp speed, we recommend altering the oven with an additional heating rod. Without insulation the oven listed in our Bill of Materials is capable of 1.2 degrees C per second. With insulation, we have 2.17 degrees C per second curve.

Integration

- **Tools needed**
    - Drill
    - Screw driver
    - Metal knockout punch
    - Wire crimpers
    - Hot glue
    - Heat gun
    - Soldering paste and soldering iron
- **Overview steps**
    - Open the oven top and side covers and connect the SSRs to the oven and the convection fan. Assemble the PCB.
    - Insulate the oven and put the oven covers back on with the thermocouple going into the inside of the oven.
    - Put the SSRs, raspberry pi, PCB, outlet extender, and the fan inside the case and secure them in place with screws or hot glue.

Additional Design Recommendations

- Perhaps an extra heating rod to achieve a max slope of 3 degrees Celsius per second
- Perhaps replace fan with extra powerful fan for additional convection and additional cooling control
- Perhaps add a servo motor to control the door to automatically open for cooling Software and PCB already support two more additional controlled outputs, using the RED design which is currently unused.