DIY USB-PD Powered MCH Automatic Reflow Hotplate (Open Source!)

by tobychui

Background Story

As an electronic maker, it is getting harder and harder for me to create new projects as parts (mostly IC and surrounding components) are getting smaller and smaller. About 10 years ago, SOP package IC are still easy to find which range from supporting USB2.0 or Serial communications. But in recently years, most ICs other than those require heat dissipation like battery charging or power management ICs, signal ICs are hard to find in SOP packages.

Design Goal

As I always to make something else other than power banks, I need to figure out a way to make soldering smaller packages IC less painful. The issues is that unlike makers from other country who usually have a larger space to work with, I live in cities with workspace smaller than a toilet in western countries. That is why I need to find a solution that is

- Small, compact
- DC powered (as I don't feel comfortable working with AC)
- Fully automatic reflow like an infra-red reflow oven

I did try to look for some solution on the internet, the closest I can get is either a proper reflow oven or those tiny rework hotplate that uses PCB hot-plate, which do not met my requirement regarding my "dream reflow stations".

That is why I decided to make one myself. Though, this is one of my most expensive and hard to complete projects in recent year due to complexity in material sourcing. I will share with you in details in later steps.

What Make This Build Special?

This is probably the first open source USB-PD powered MCH hotplate on the internet, even featuring the automatic reflow profile for Sn63Pb37 but not other specific solder paste design for low temperature reflowing.

The issue is that MCH hotplate is a bit tricky to get and finding one with specific specification always require custom made. This design factors in the difficult of souring such components and design the hotplate components to be swap-able with a PCB hotplate or MCH hotplate with different spec. Just change a few lines of code in the firmware to control the power switching frequency (and hence, adjusting the power to the hotplate), this PCB design basically fits most of the heating element you can find online with suitable sizes and power rating.

Supplies:

General Part Lists

Here are the non-electronic parts list required for this build

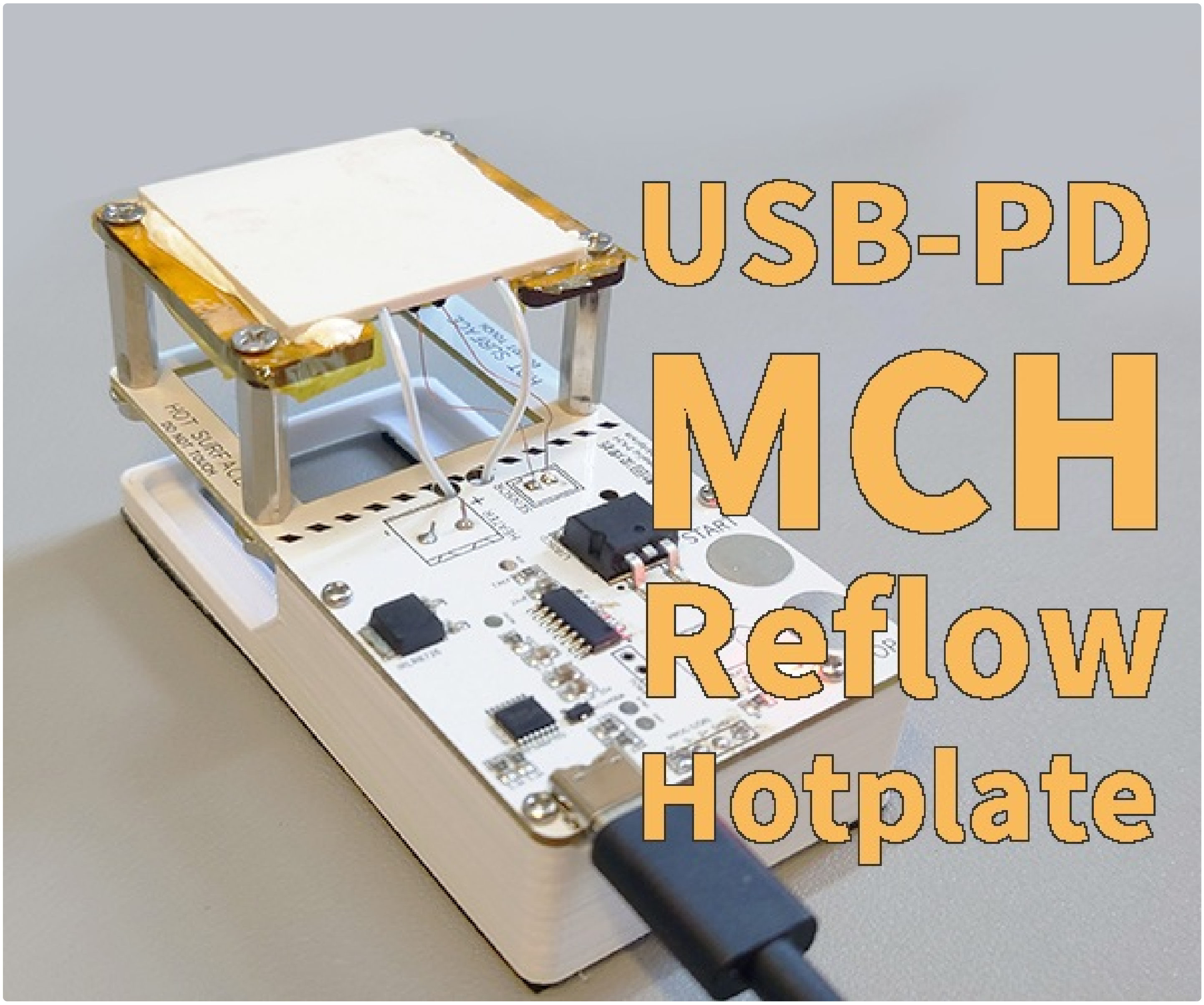
1. 40 x 40mm Metal Ceramic Heater (20V 50W)
2. PCB with components (See component list below)
3. Temperature sensor (I am using 300 degree C, 100k 1% thermistor)
4. M3 x 10 stands off x 4

5. M3 screw x 4
6. M3 nuts x 4
7. MDF board cut to specific shape
8. Kapton tape (I am using one with width 1cm)
9. K704 heat-proof silicon adhesive
10. S-992 heat sink plaster
11. M2 x 10 screws x 4 (to fix the 3D printed base in place)
12. 3D printed base (PLA)
13. A computer with Arduino IDE and CH55x installed in board manager

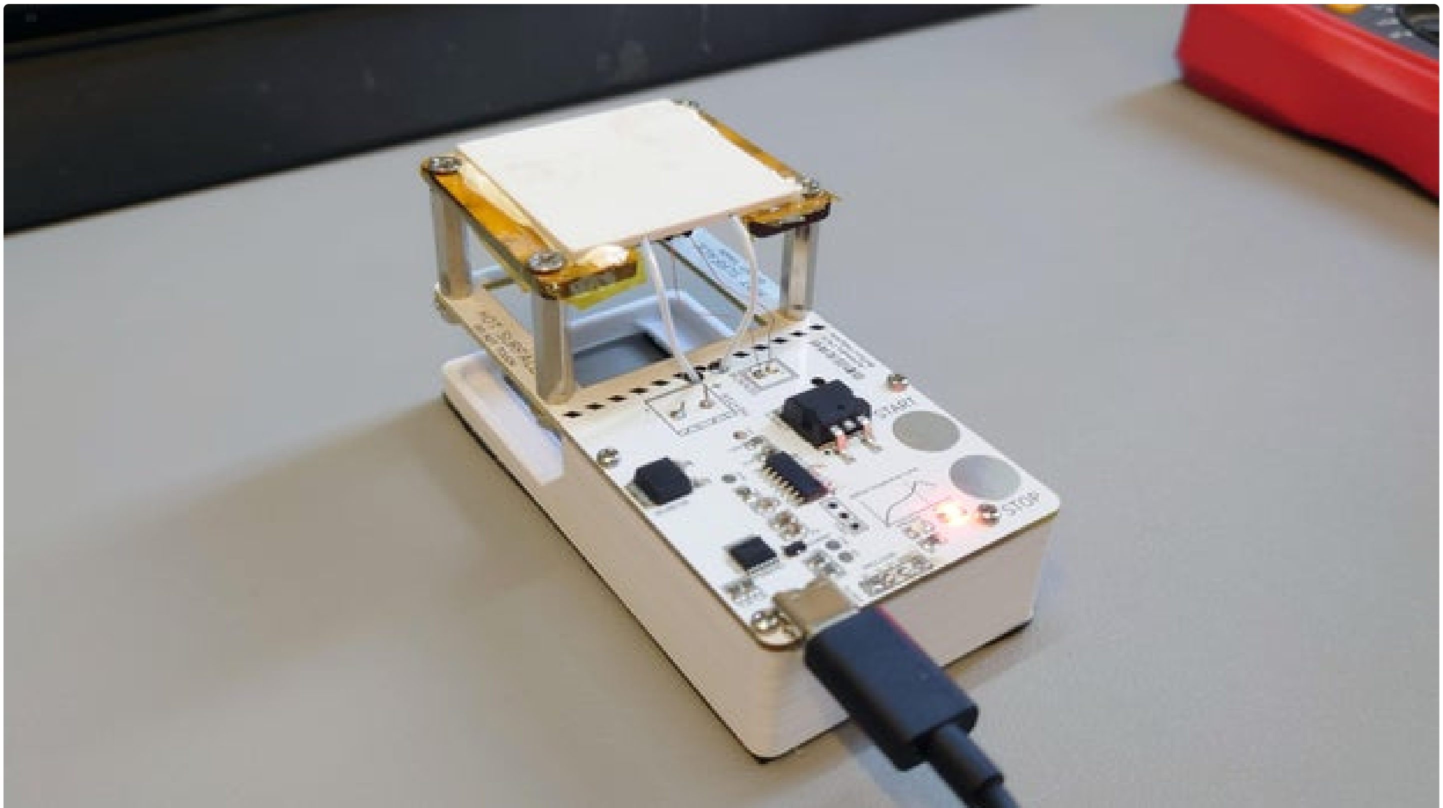
Component List

I am only listing a few main components here, for a full BOM list, see my Github repo.

1. IRLR8726 (MOSFET for switching the heater, can be replaced with solid state relay)
2. CH552G (MCU to run the reflow logic, can be replaced with other Arduino boards)
3. L7805 (LDO for dropping the 20V input to 5V for the MCU, any buck converter or LDO that can handle 20V inputs will do)
4. IP2721 (20V PD trigger chip, skip this if you are using a 19V / 20V DC power input)
5. Type C female port
6. Surrounding components like resistors and LEDs



https://youtu.be/5vZM3g0Npoo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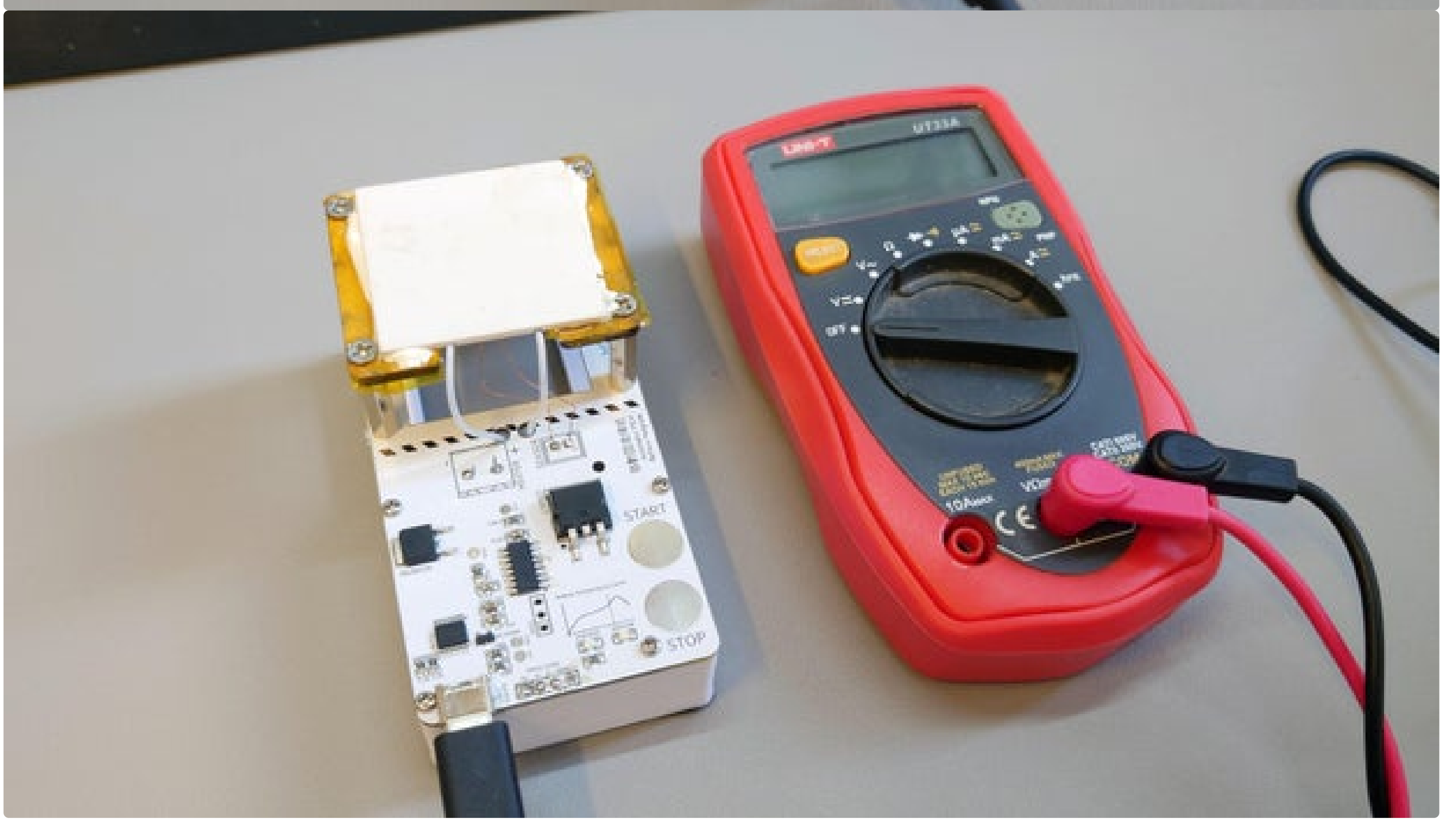
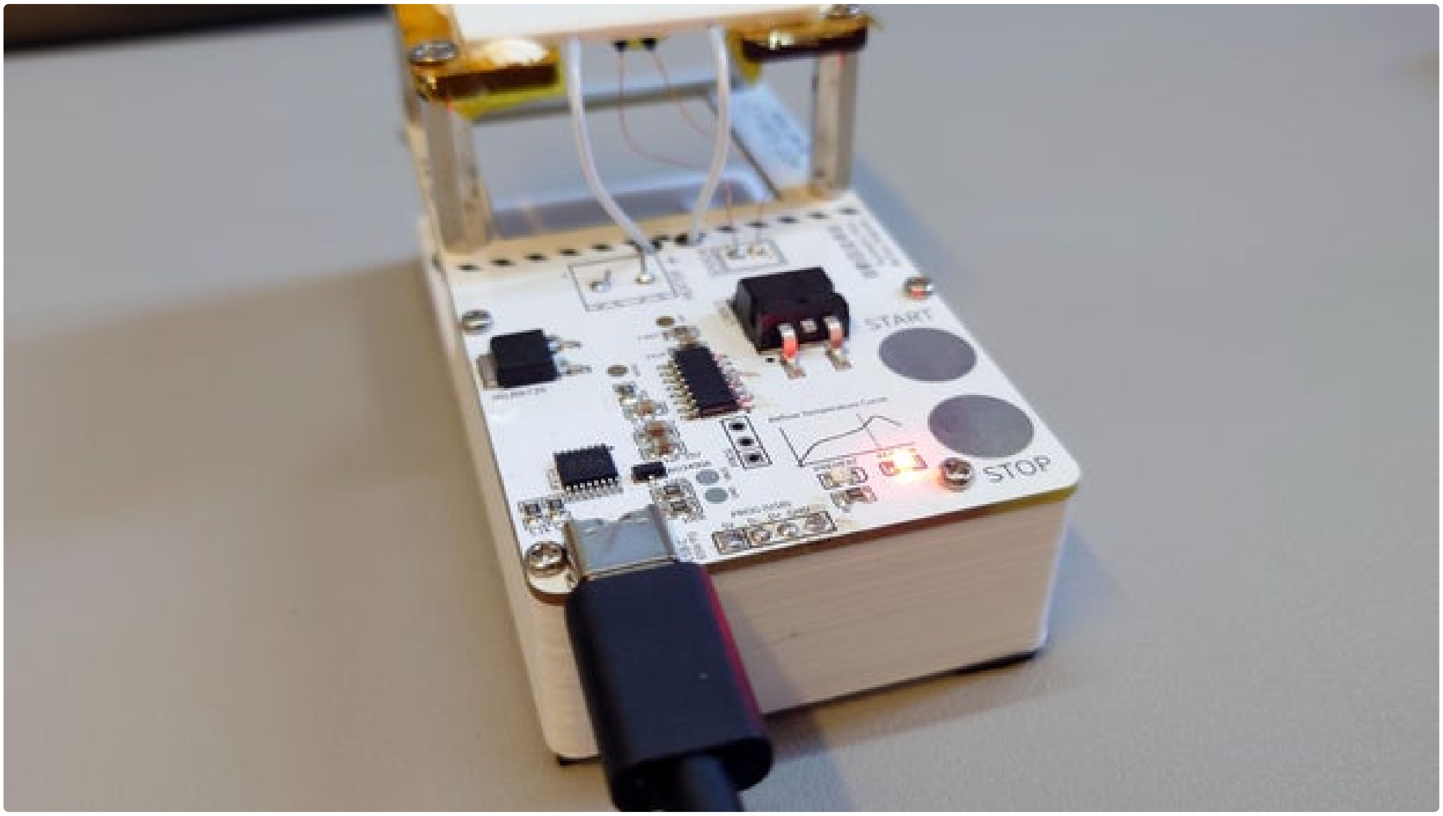
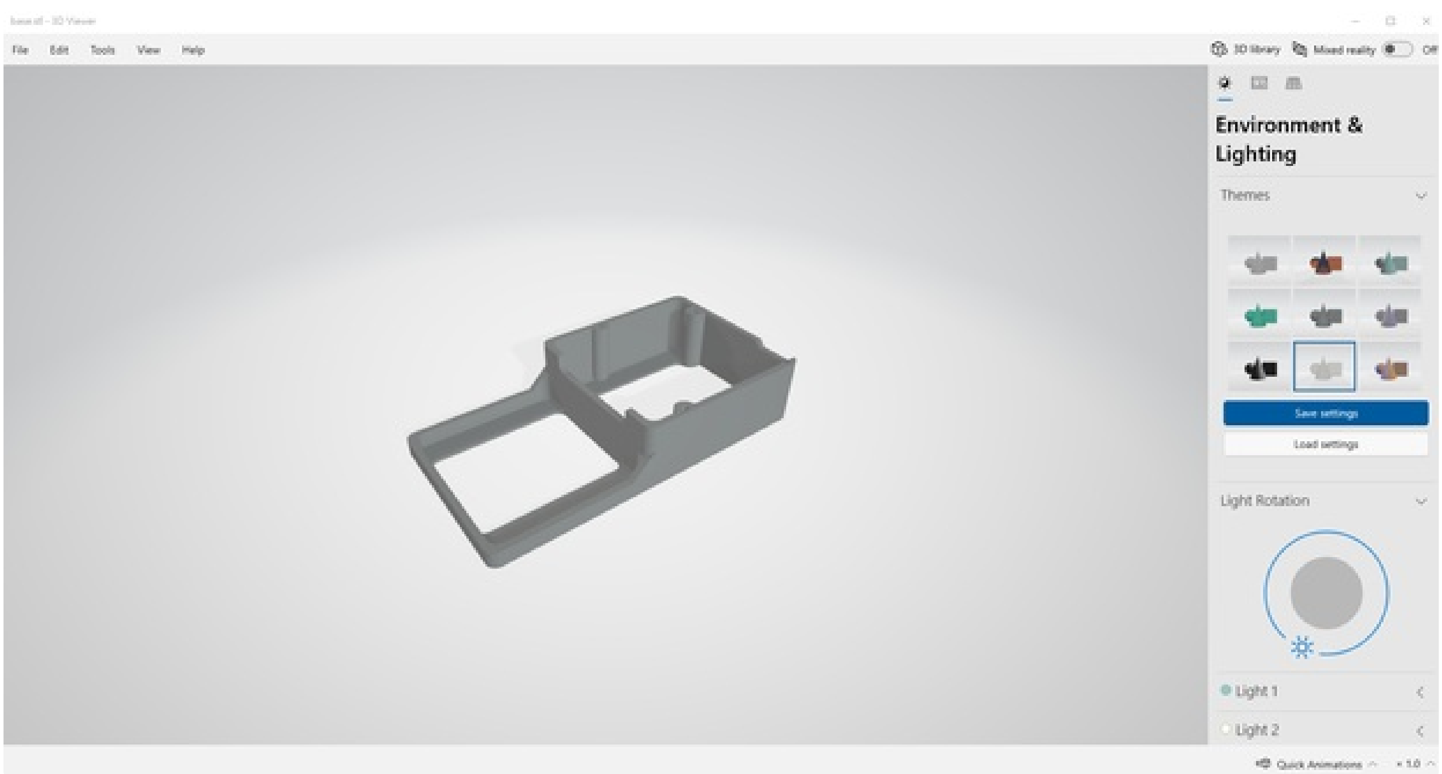
STOP

UT33A
START
STOP



Step 1: 3D Print the Mounting Base

First you can start by 3D printing the base. It is a simple step. Just get the stl file, slice it and send it to a 3D printer.



View in 3D Download

https://www.instructables.com/FVA/55EO/LR0NTG4O/FVA55EOLR0NTG4O.ipt

https://www.instructables.com/FDP/88HZ/LR0NTG4W/FDP88HZLR0NTG4W.stl View in 3D Download

Step 2: Send the PCB to Print

As the PCB is the main component of this build, you can order your PCB at any PCB manufacturer you preferred. This project is sponsored by JLCPCB. If you have never tried to order a PCB before, please feel free to try out JLC services with the link below.

https://jlcpcb.com/

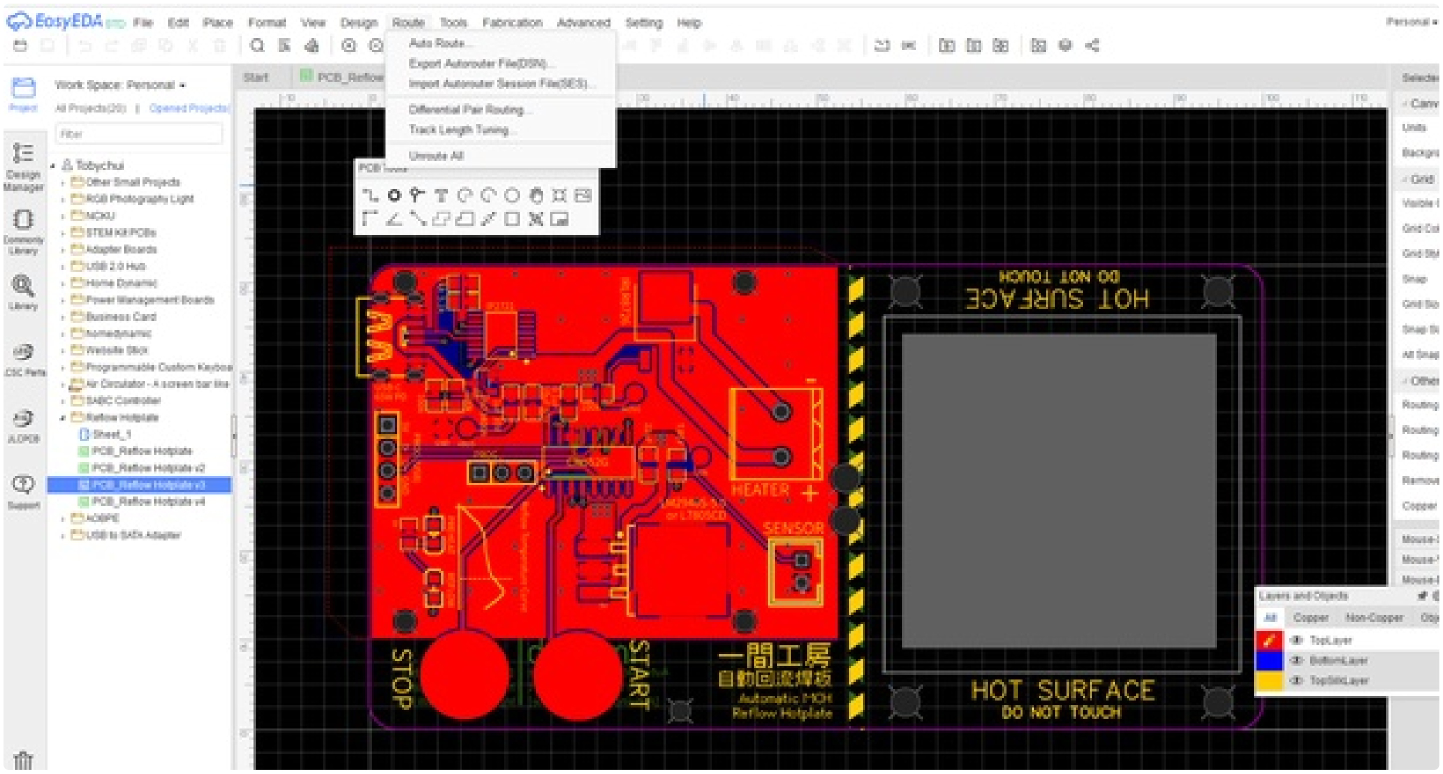
In my case, as the MOQ of the MCH hot-plate is 50 pcs, so I order a bunch of them from JLC so that I could make a few more of them and give them away with only the material costs.

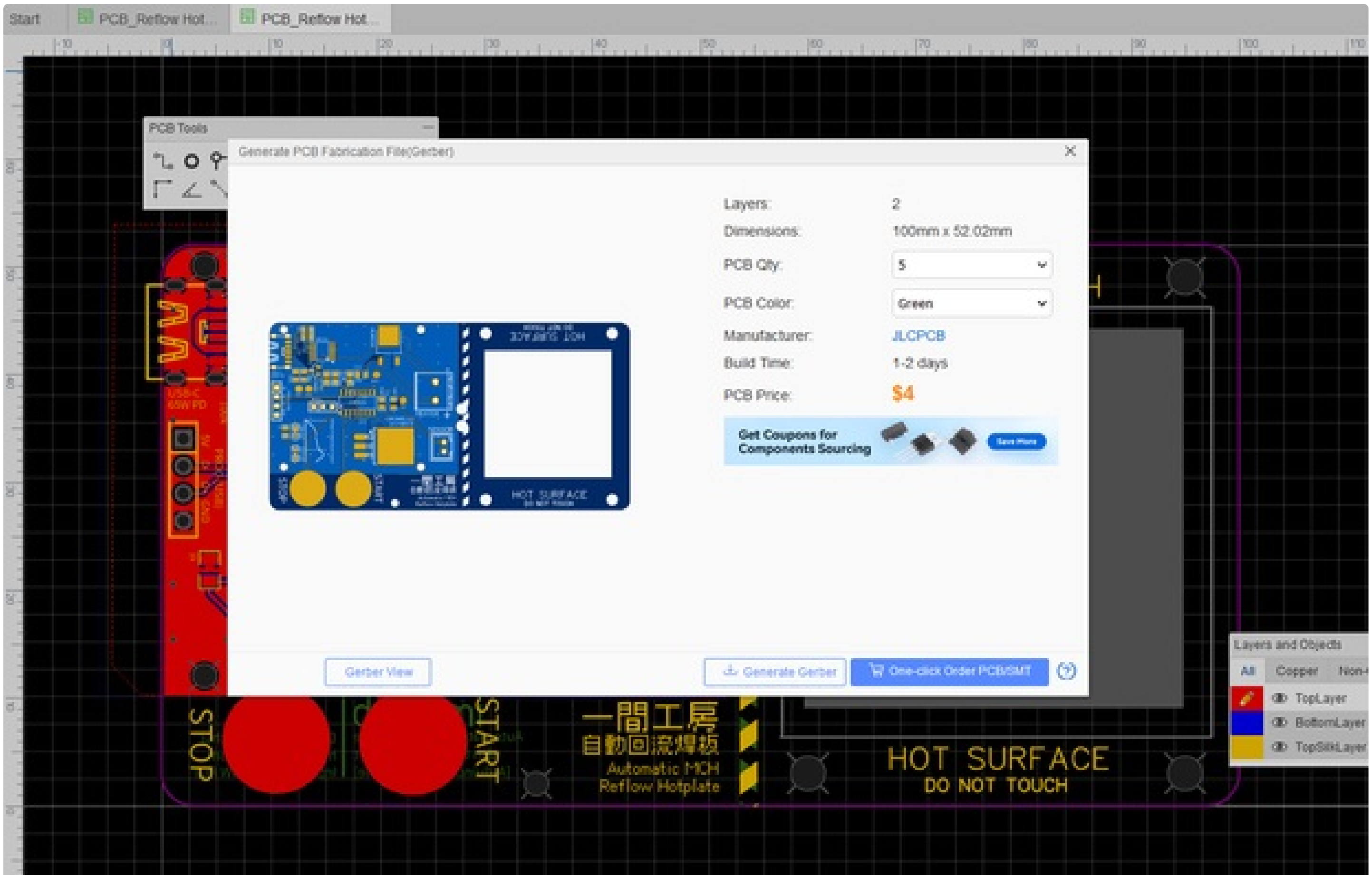
You can find everything you need for the PCB over here on my github repo.

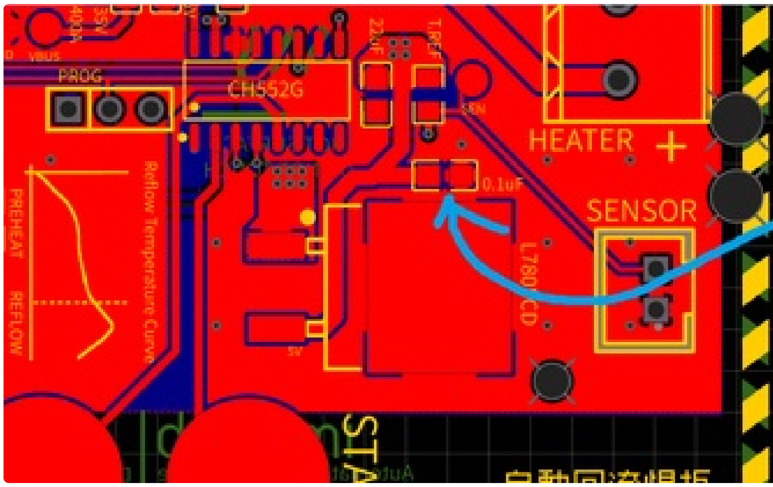
https://github.com/tobychui/MCH-PD-Automatic-Reflow-Hotplate/tree/main/pcb

Side Note

In this instructable, I am using the v3 design but later I found that adding a small 0.1uF caps over the output of the L7805 improve the overall stability when using cheap / low quality GaN charger with large ripples. This is optional but I recommend adding it if you are making one for yourself.



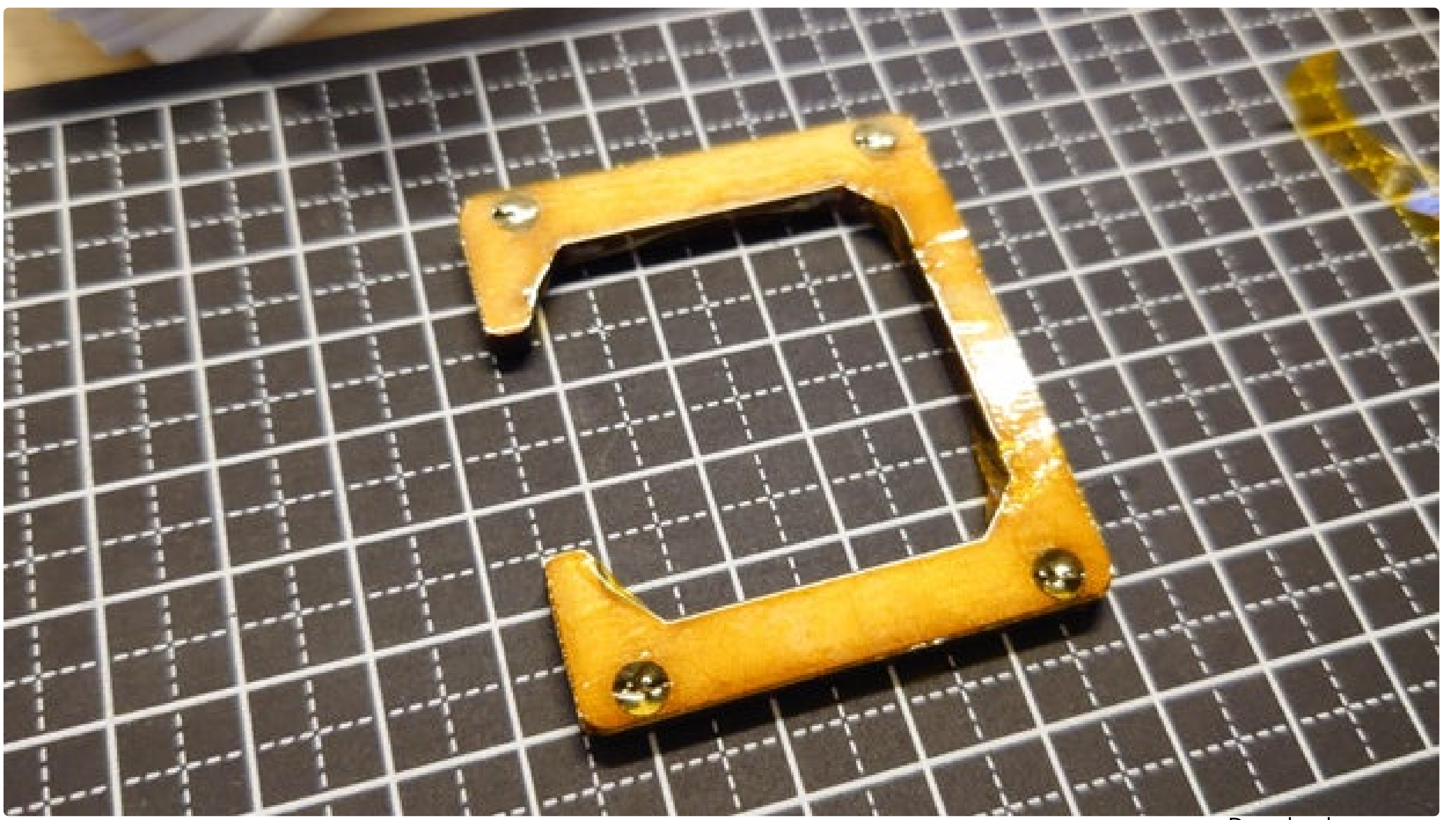

Start
PCB_Reflow Hot...
PCB_Reflow Hot...
PCB Tools
Generate PCB Fabrication File(Gerber)
Layers: 2
Dimensions: 100mm x 52.02mm
PCB Qty: 5
PCB Color: Green
Manufacturer: JLCPCB
Build Time: 1-2 days
PCB Price: $4
Get Coupons for Components Sourcing
Gerber View
Generate Gerber
One-click Order PCB/SMT
Layers and Objects
All
Copper
TopLayer
BottomLayer
TopSilkLayer
STOP
START
一間工房
自動回流焊板
Automatic MCH
Reflow Hotplate
HOT SURFACE
DO NOT TOUCH



For v4 I added a small caps here to improve stability when using cheap / low quality GaN charger

Step 3: Laser Cut the Hot-plate Support Structure

The hotplate support structure is a piece of 3mm MDF that is wrapped in Kapton tape. This prevent the MDF from smoking and turning black after long period of uses.



Download
https://www.instructables.com/F5U/T0EM/LR0NTH3P/F5UT0EMLR0NTH3P.dwg

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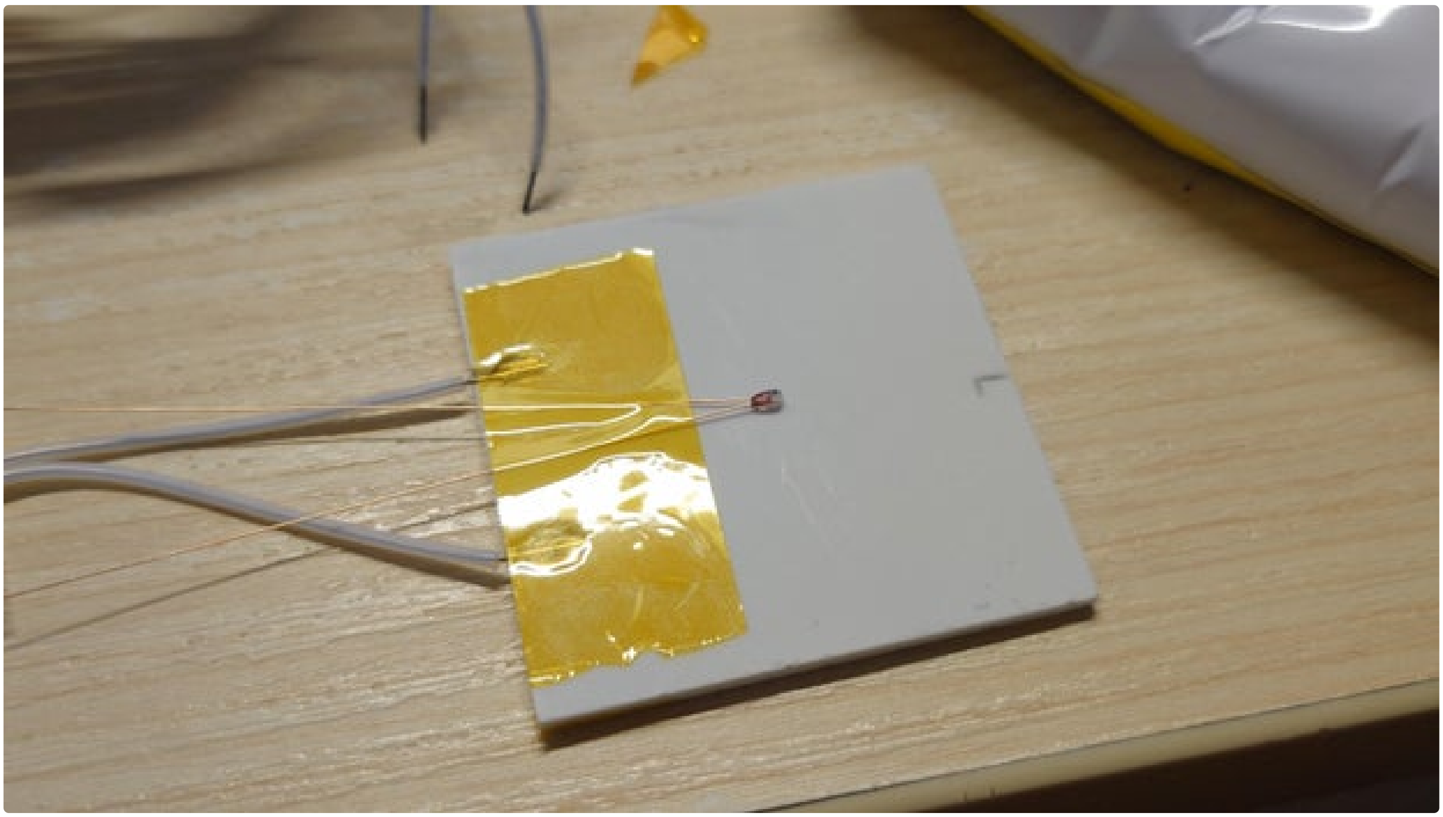
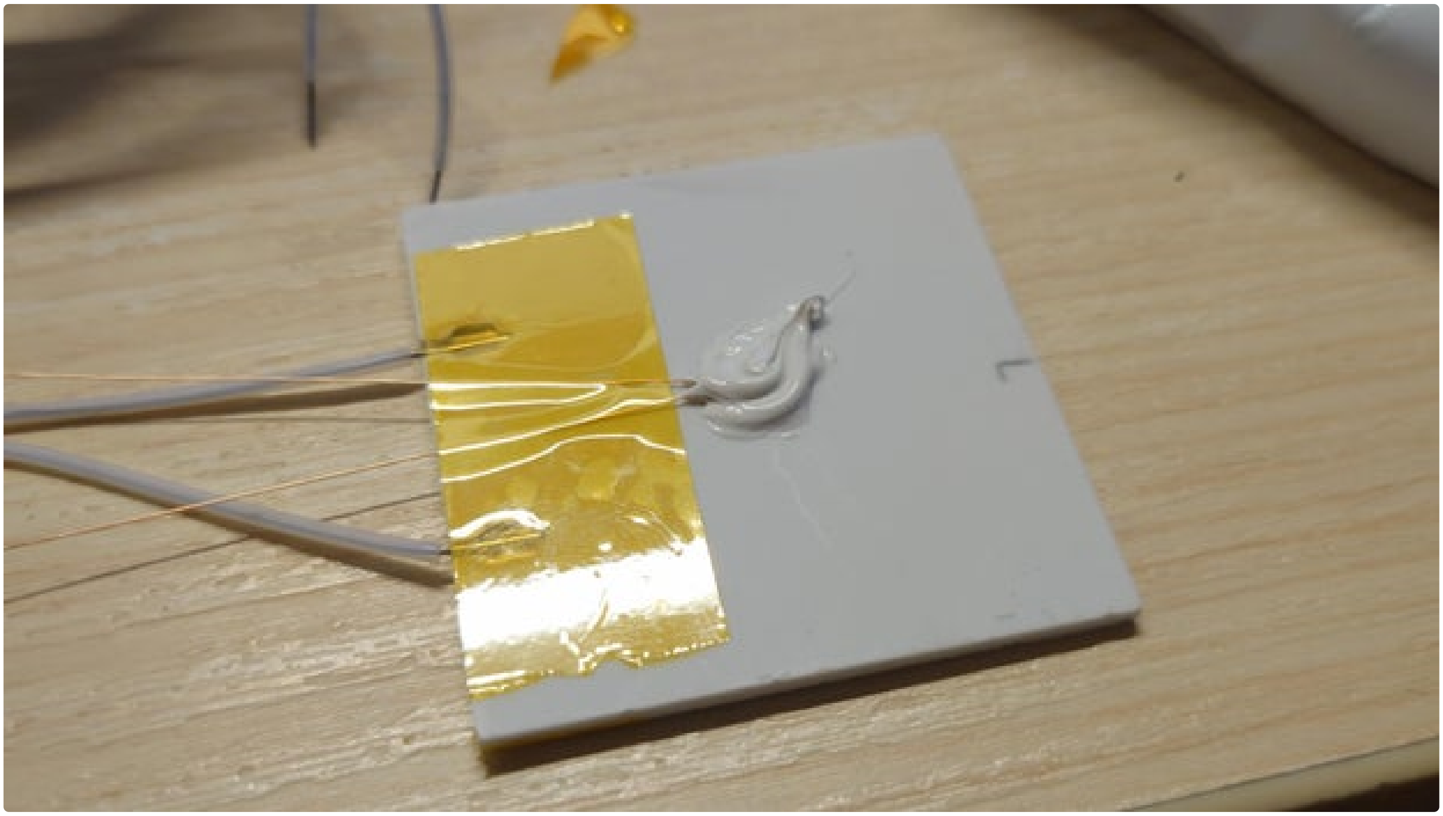
View in 3D Download
https://www.instructables.com/FFE/2SJZ/LR0NTH4U/FFE2SJZLR0NTH4U.ipt

Step 4: Assemble the Temperature Sensor Element

The temperature sensor (glass bulb part only) is glue to the back of the MCH hot-plate with heat-sink adhesive. Note that there are a lot of S922 heat sink adhesive clone out there that cannot handle the temperature stated in its datasheet. So make sure you get them from a seller with good reputation.

You will want to place the thermistor on the bottom side of the MCH and fix it in place with a piece of Kapton tape. **Next, slightly bend the glass bulb so it is touching the surface of the MCH**. Finally seal if off with a glob of heat sink adhesive.

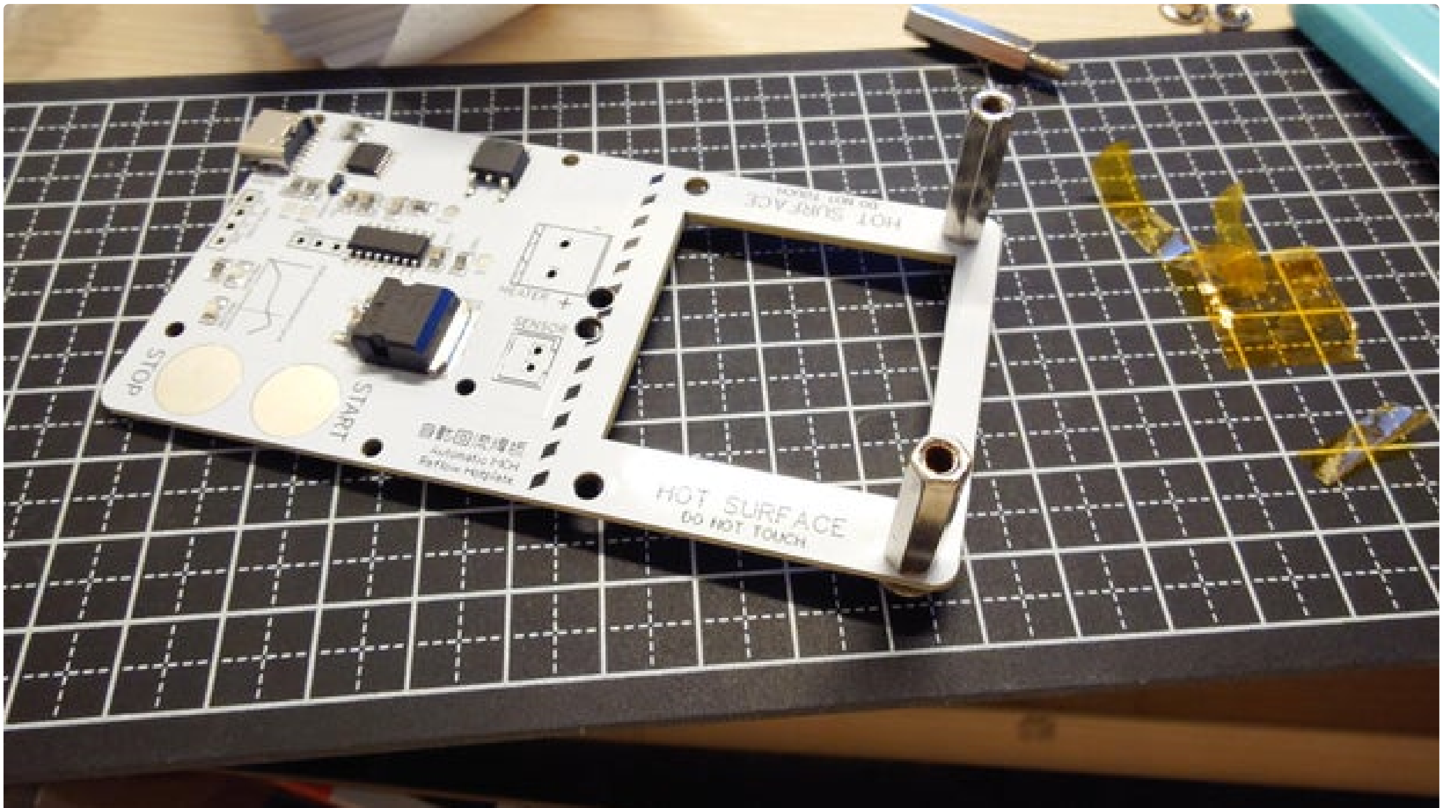


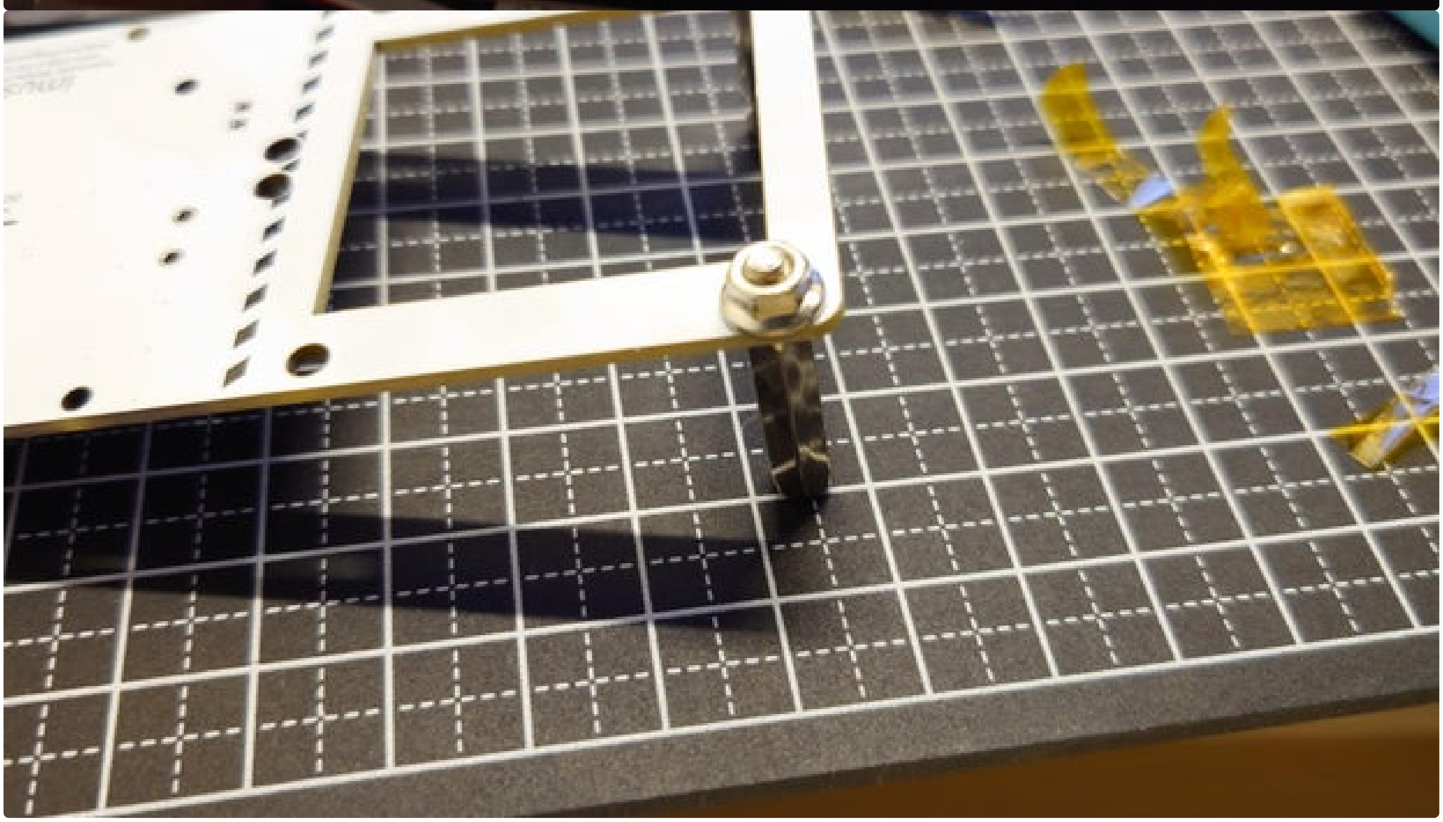


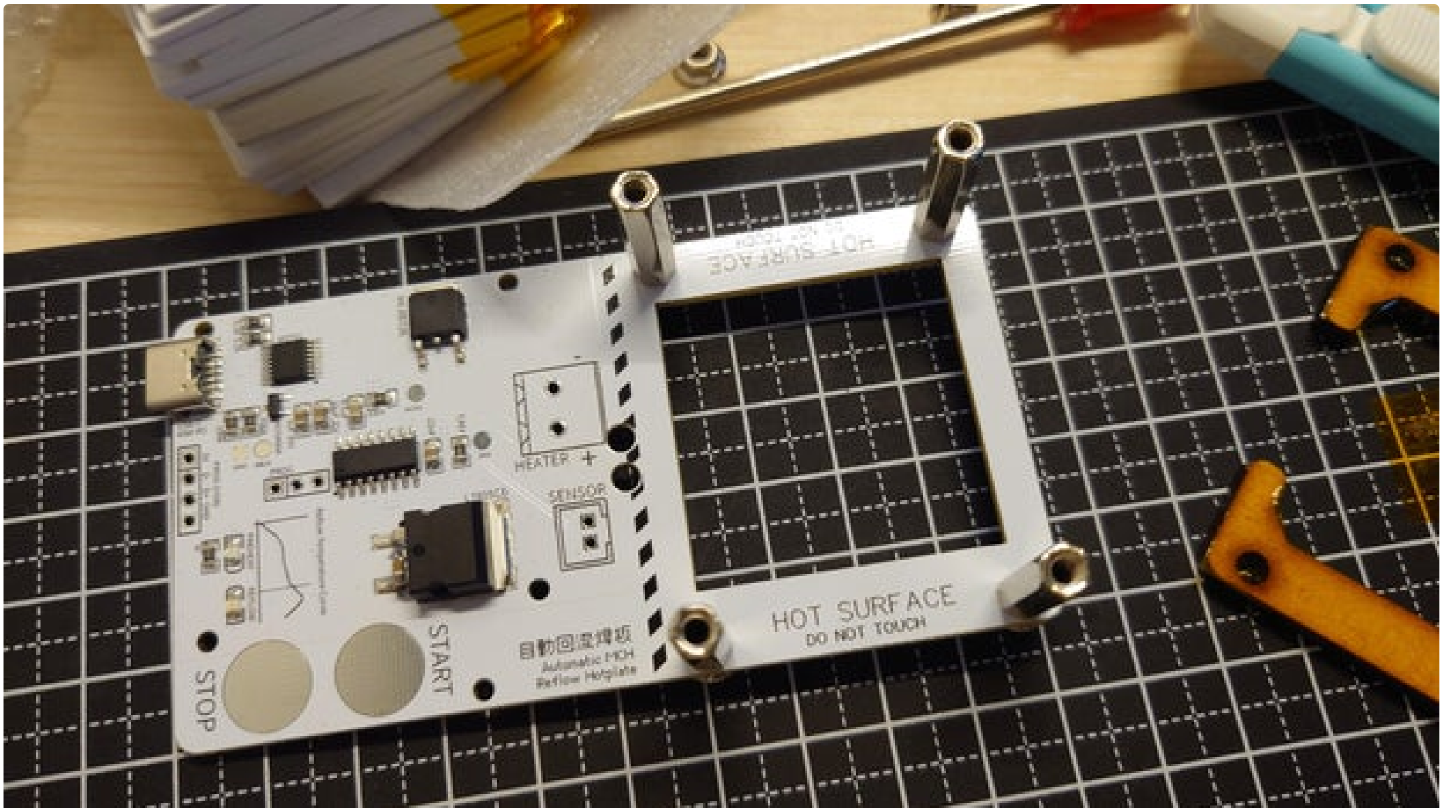
Step 5: Assemble the Heater Support Structure

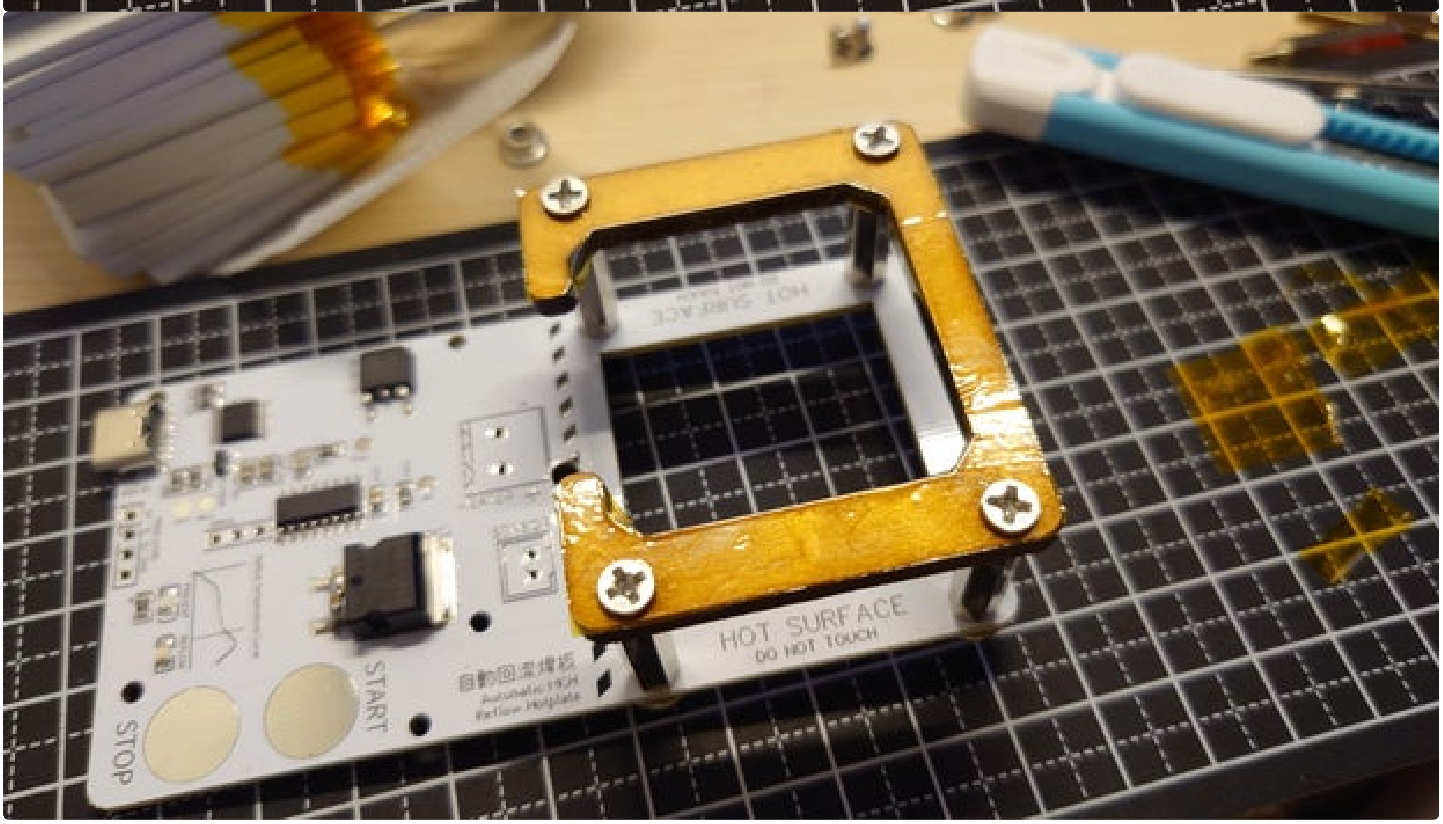
Screw the 4 M3 stands off into the PCB and secure them with M3 nuts. Next, fix the MDF heater support structure on top of the stand offs. Make sure not to screw it too tight and leave some space for the thermal expansion.

After complete, you will see something like this as shown in the photo above.


HOT SURFACE
DO NOT TOUCH
STOP
START
HEATER
SENSOR
Automatic MCH
Reflow Hotplate



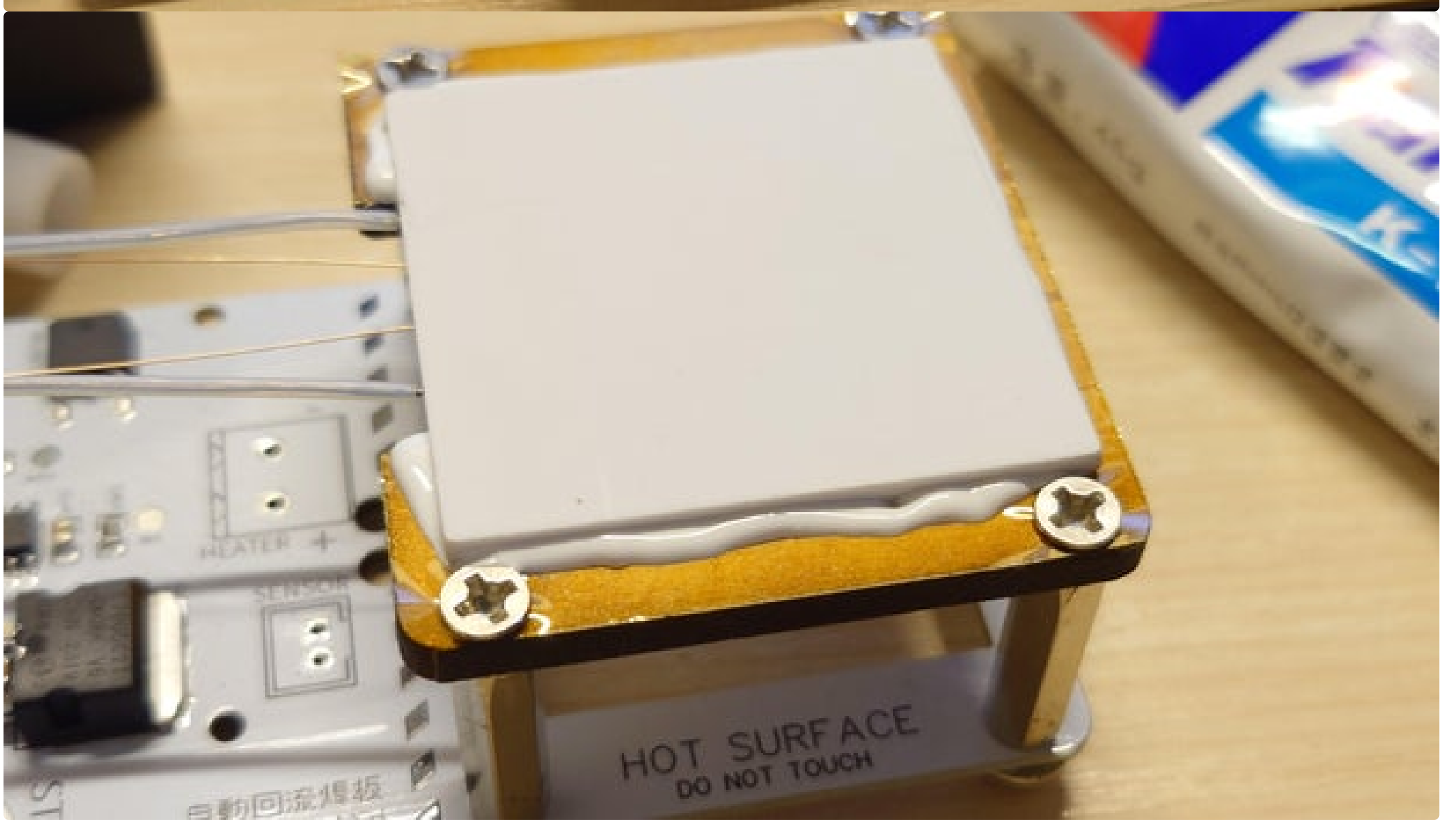

HOT SURFACE
DO NOT TOUCH
HEATER
SENSOR
START
STOP
自動回流焊板
Automatic MCH
Reflow Hotplate


HOT SURFACE
DO NOT TOUCH
START
STOP
自動回流焊板

Step 6: Glue the MCH Hot-plate in Place

Use K-704 heat-proof silicone adhesive to glue the MCH hot-plate in place. Make sure to give it a generous amount of glue and make sure all the surface where the hot-plate is touching the MDF is covered with a thick layer of heat-proof glue. If you do not give it enough heat-proof layer, the heater will fall off after a few uses and you will need to redo Step 3, 5 and 6 again to replace the Kepton adhesion layer.

Wait for the glue to dry before proceed to the next step.

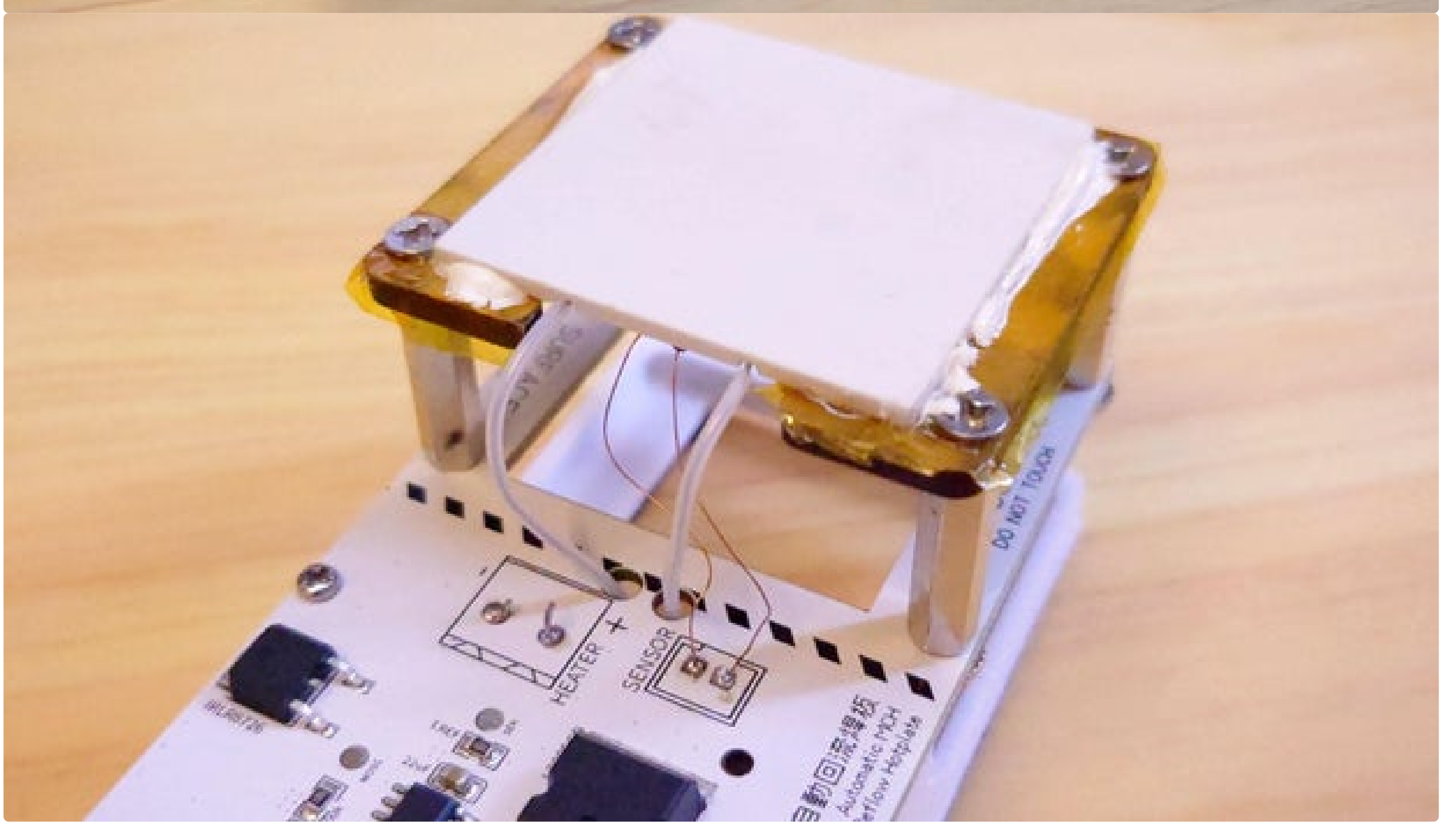


Step 7: Solder the MCH and Thermistor to the PCB

After the glue dry, you can route the leads of the MCH through the two large circular holes near the square hole to the back side of the PCB and solder the hot plate power wire to the PCB from the other side.

For the thermistor, you will need to use a lighter to burn off the outer protection layer and expose the inner conductive metal layer before soldering them to the sensor pins on the PCB.

Make sure the two thin wires of the thermistor do not touch or get any close to gether. Otherwise, this might effect the reading of the MCH hot-plate temperature.



Step 8: Flashing the Hotplate Firmware

I am assuming you have basic knowledge on how to use Arduino IDE and install new boards from board manager.

You will need to install this board manager in order to flash the firmware to the hotplate.

https://github.com/DeqingSun/ch55xduino

If your chip is new and there are no code inside, you can flash it directly via the USB 2.54 pins at the bottom of the PCB. As I am lazy at soldering 50 boards I am making, I bought a custom pogo-pin flashing tool to help me with that. However, you can also just solder a standard USB 2.0 (male) header to the pins and plug it into your computer's USB port.

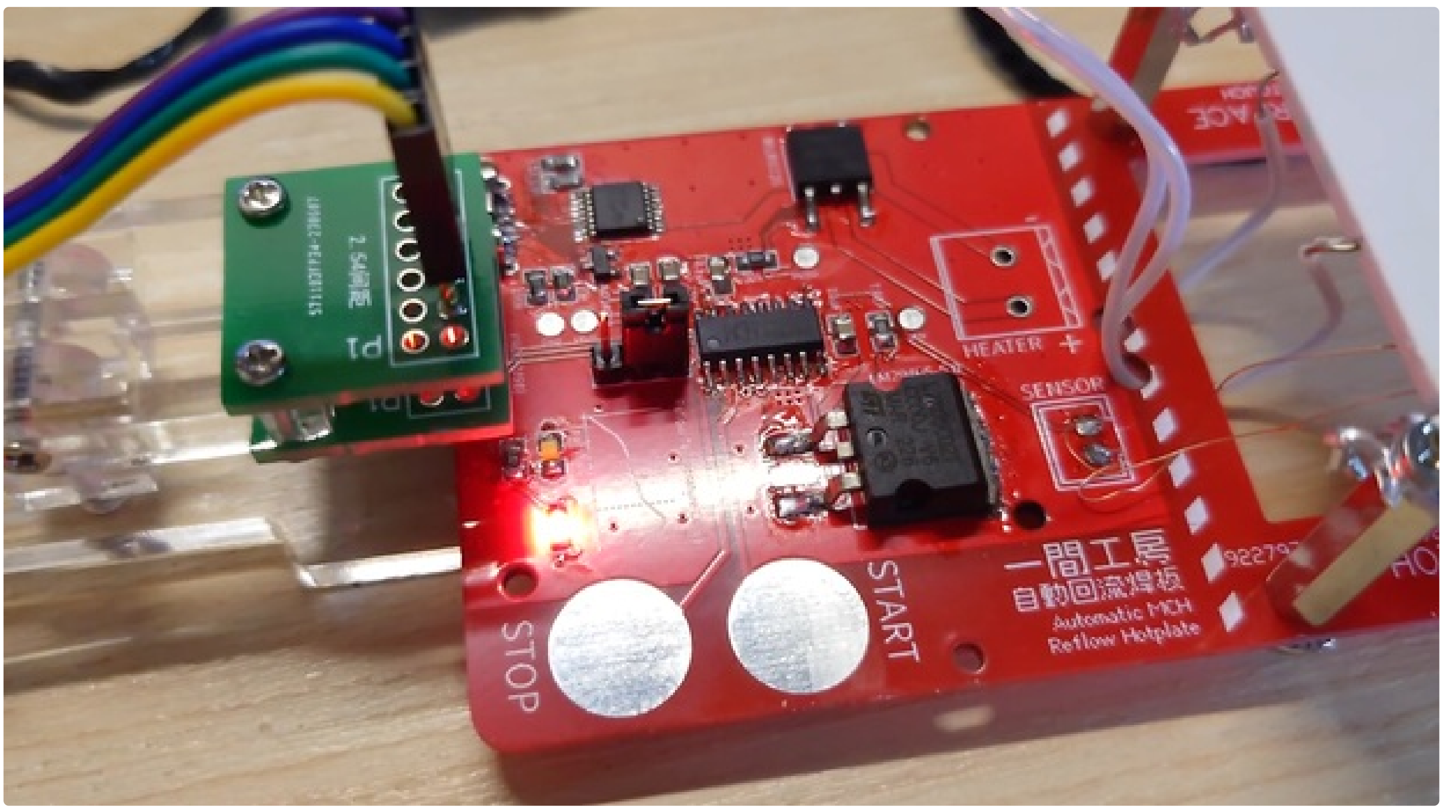
If your CH552 has been flash before, follow detail instruction on my Github repo for overwriting the build-in firmware.

The recommend board settings are as follows.

- CH552
- 16Mhz (internal, 3.3V or 5V)
- Upload Method: USB

The firmware can be found over here

https://github.com/tobychui/MCH-PD-Automatic-Reflow-Hotplate/tree/main/firmware/reflow



Step 9: Thermal Testing

In order to test the hotplate, screw the base to the PCB assembly and stick a temperature sensor to the surface of the hotplate with Kapton tape.

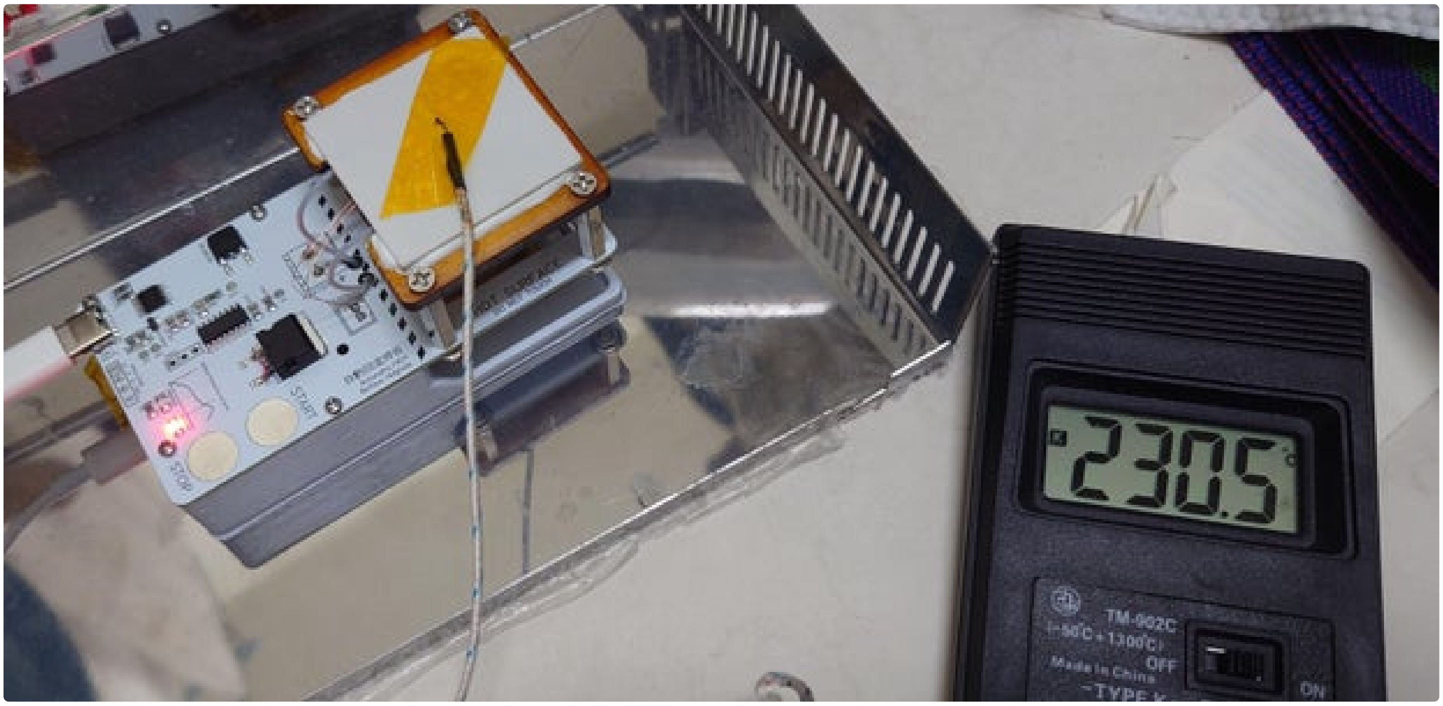
Press and hold the "START" button to start reflowing. The yellow LED should start fast blinking indicating the reflow will start in a few seconds.

For detail usage guide, see here

https://youtu.be/MRUAOw6HJlw

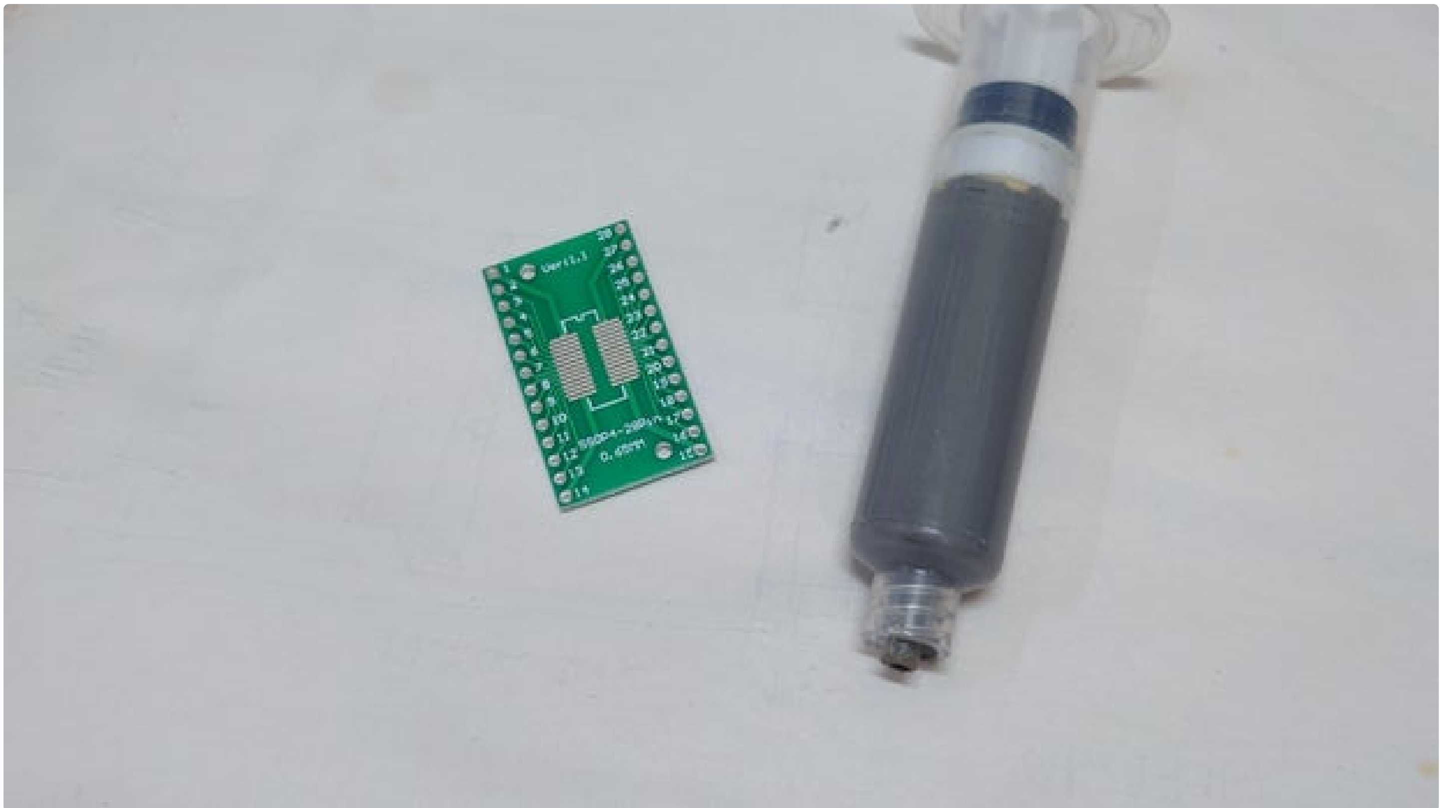
If everything is working, the temperature will peak at around 235 - 245 degree Celsius when the hotplate entered reflow stage. Note that the temperature on the hotplate is slightly hotter than what is recommended by the reflow profile as it is not a reflow oven but an open-air hotplate which I need to accounts for thermal lost to surrounding.

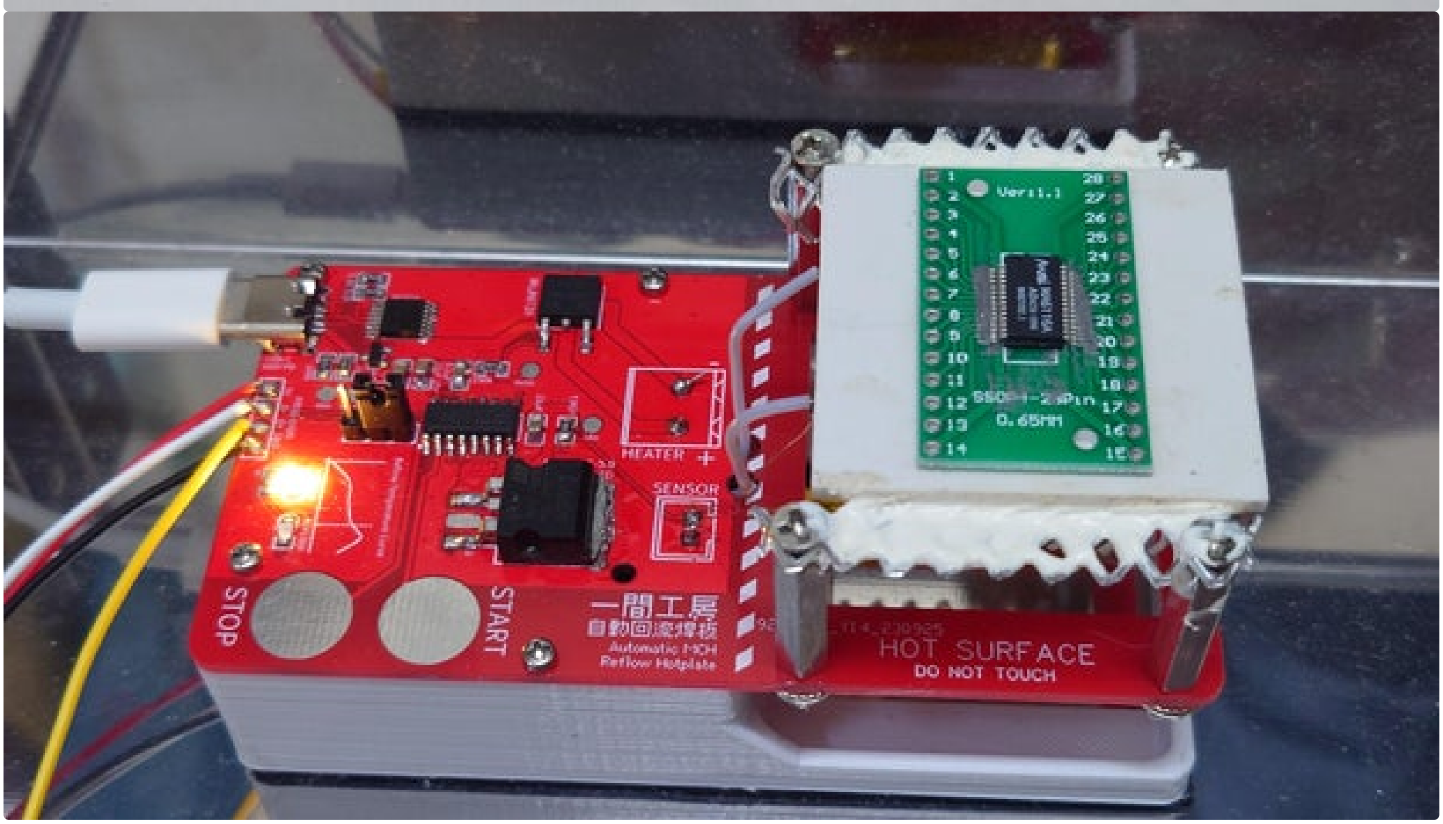
If the reflow seems completed, you can always early-stop the hotplate by pressing the "STOP" button.

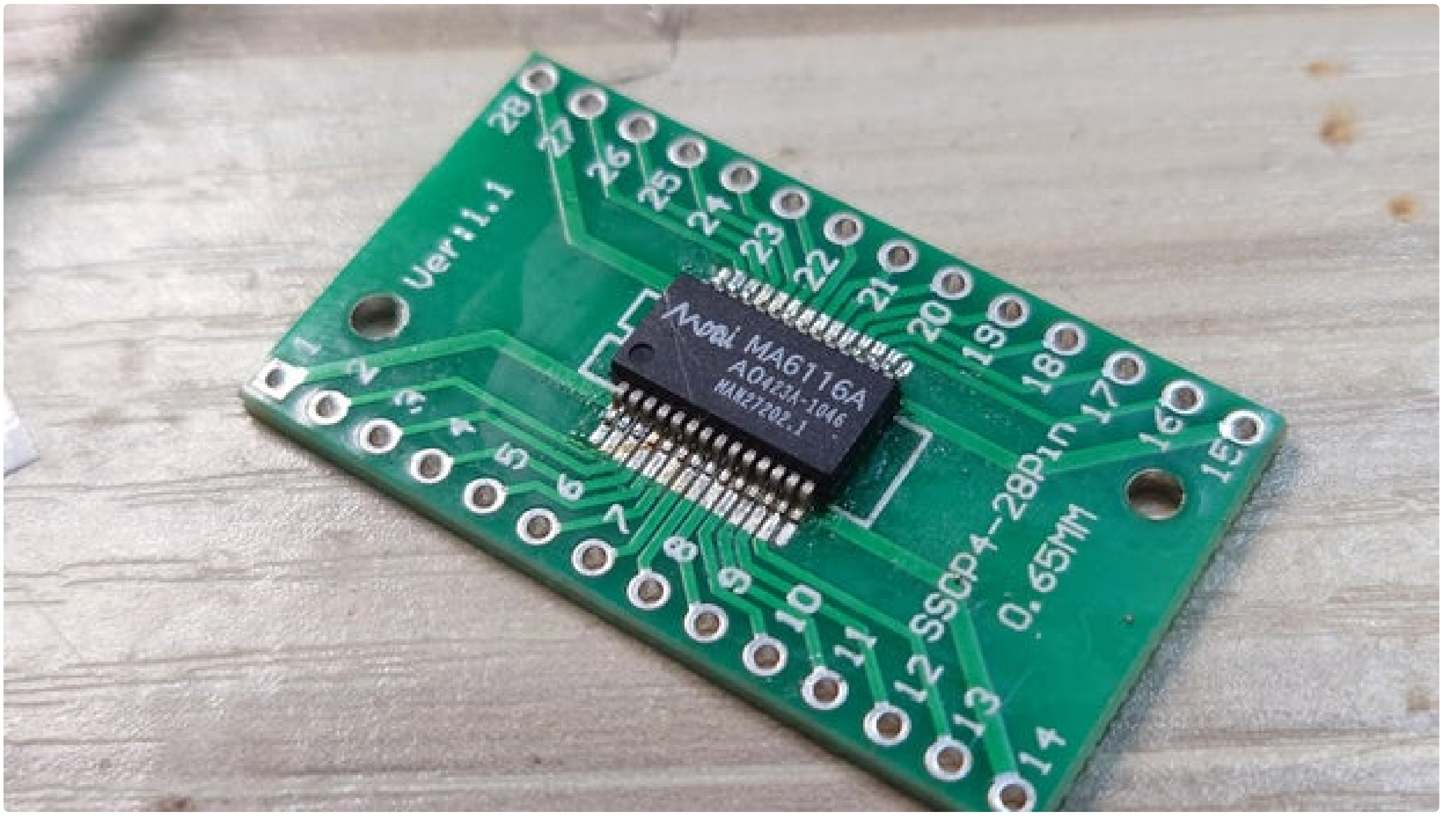


Step 10: Reflow Test

After thermal testing seems great, now you can try reflow something. Here I am using a SSOP chip with an adapter PCB to try out my reflow hotplate prototype. The last photo shows the result of reflow after some cleaning.

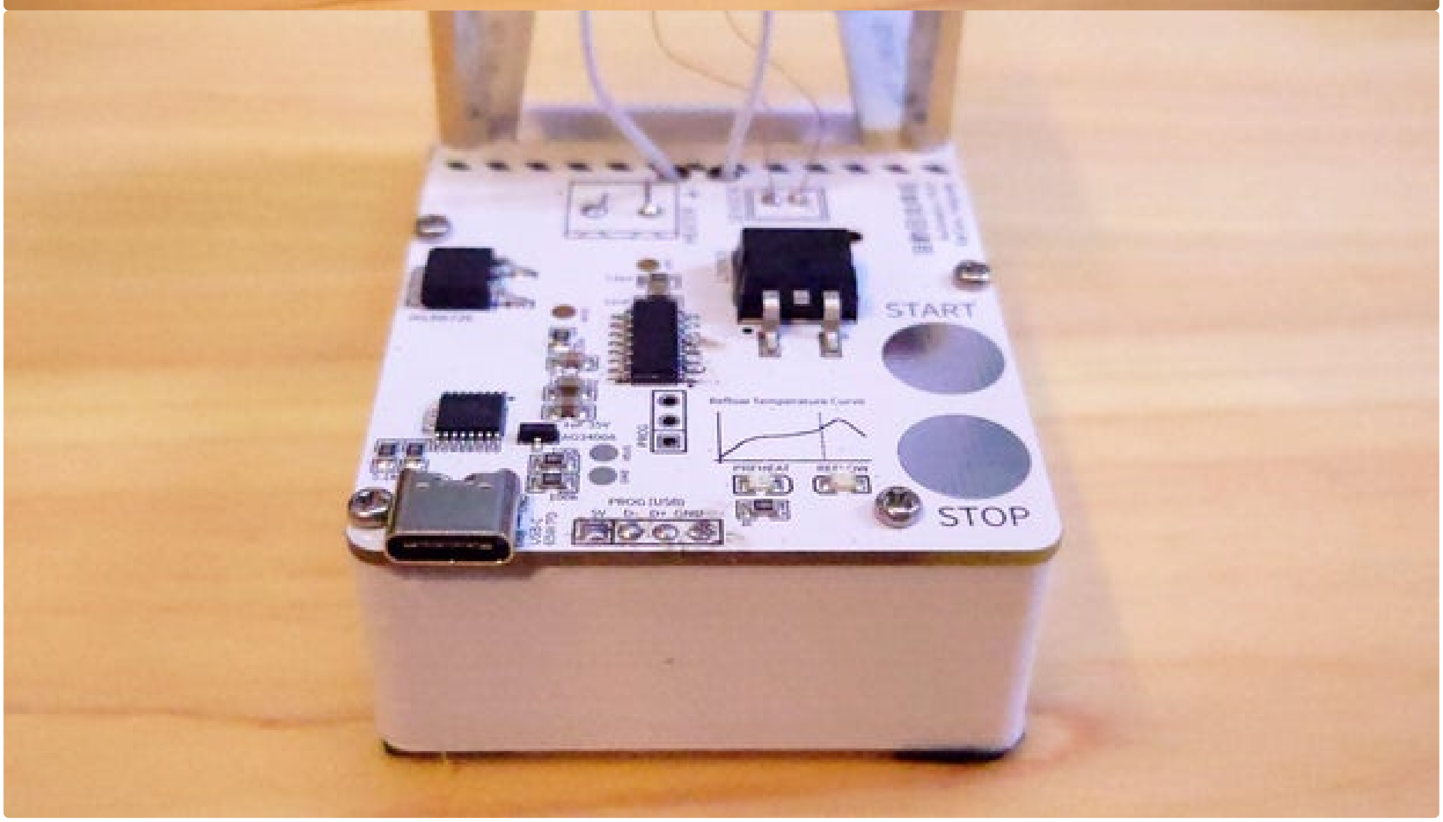


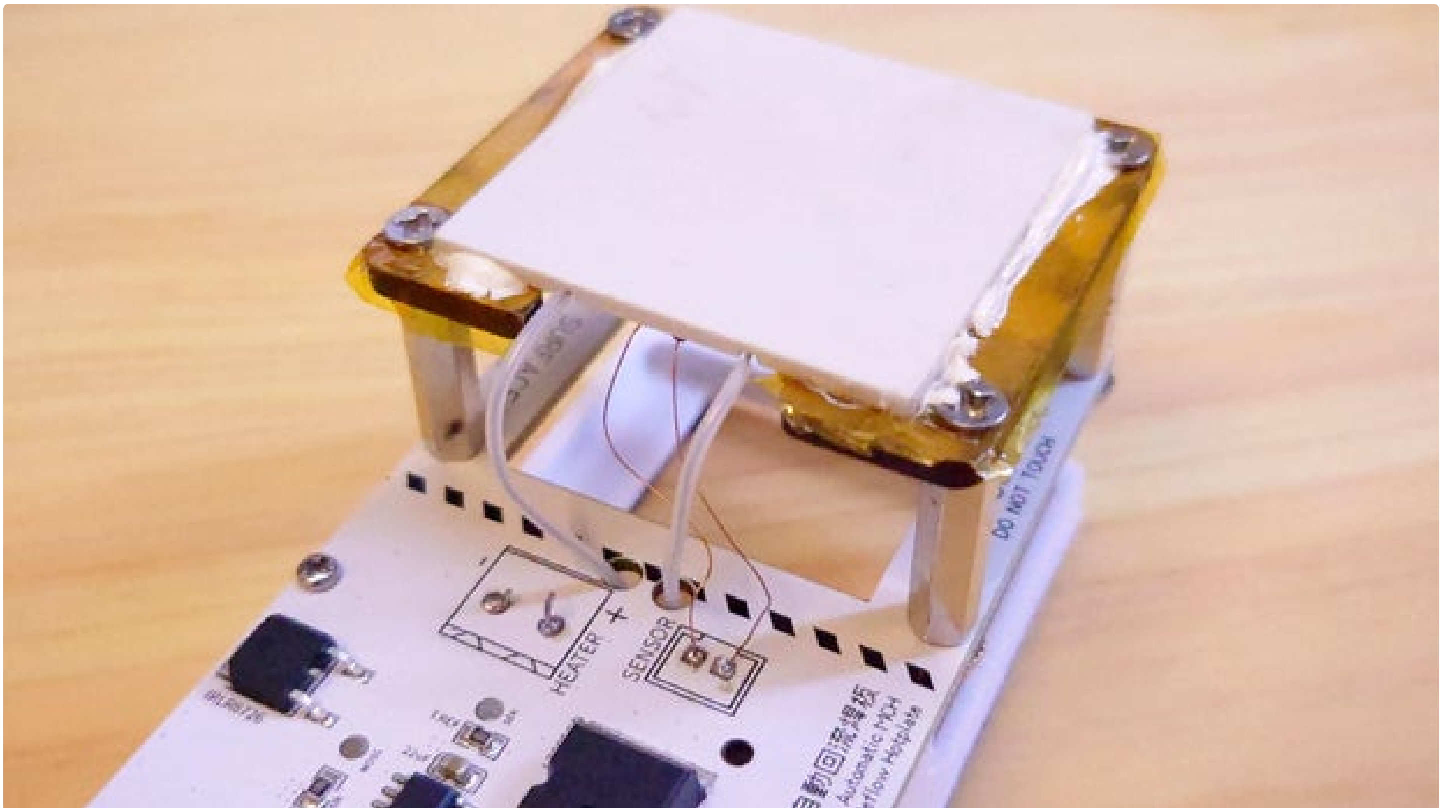

Ver:1.1
0.65MM
HEATER
SENSOR
STOP
START
一間工房
Automatic MCH
Reflow Hotplate
HOT SURFACE
DO NOT TOUCH



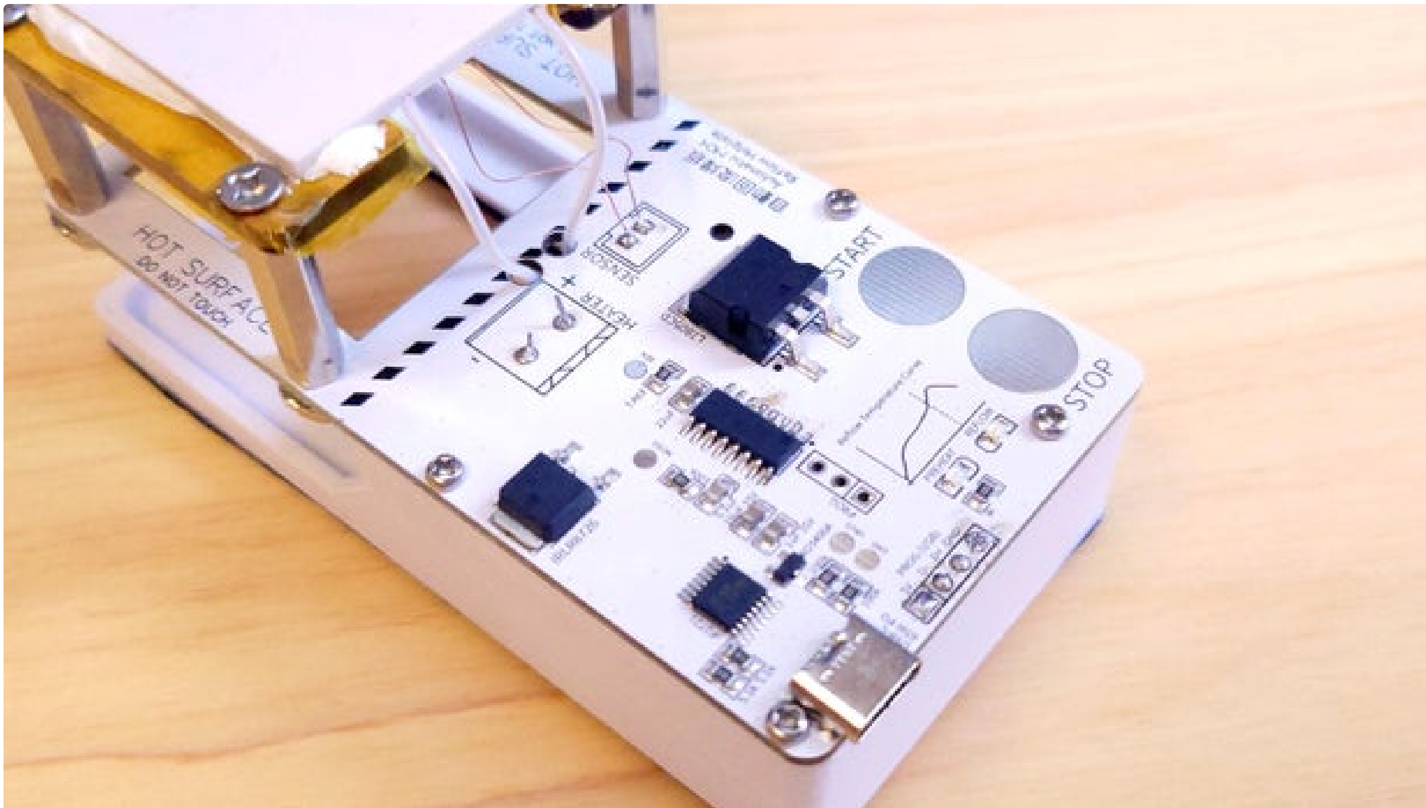
Step 11: Reflow Hotplate Complete!

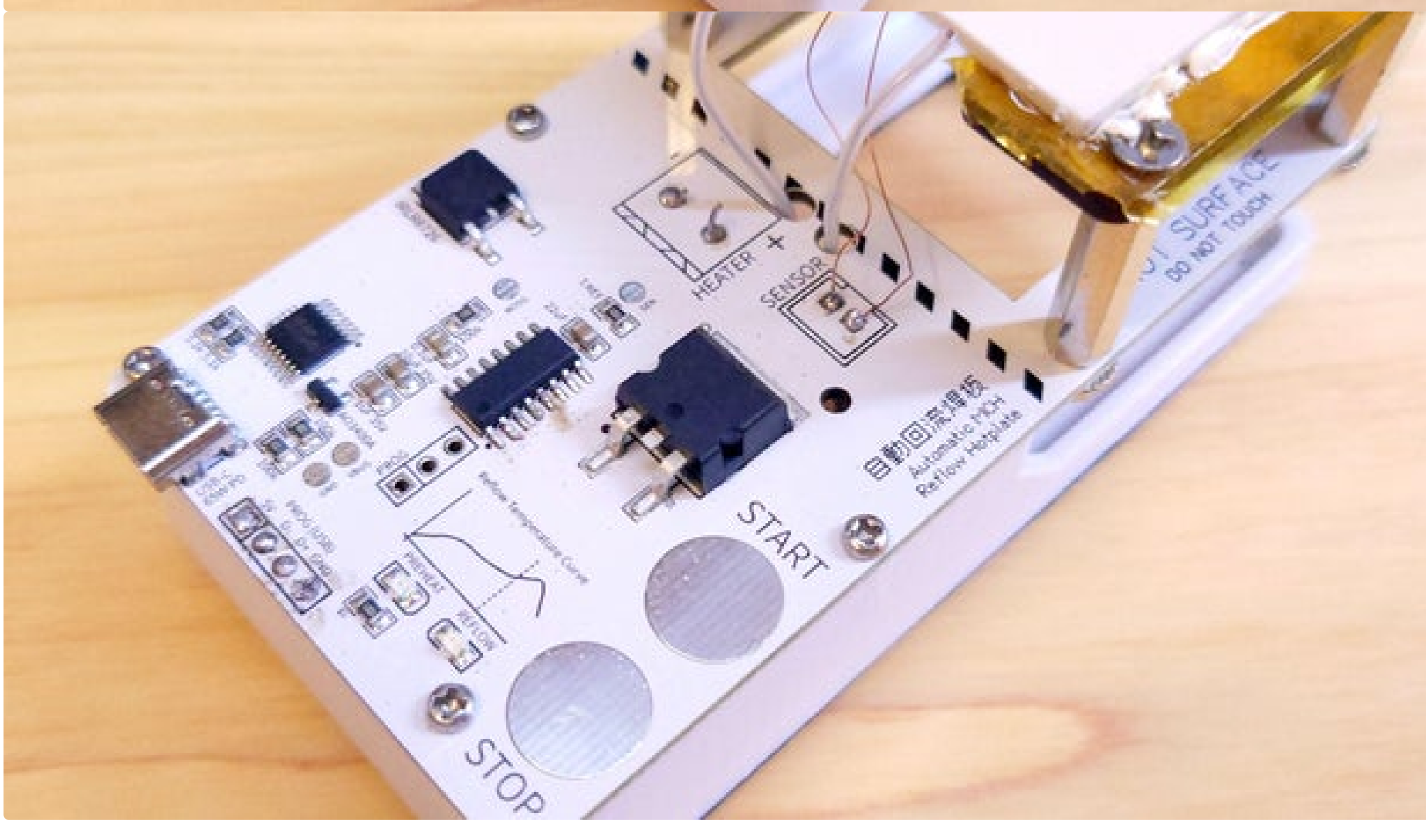
Now you have completed your DIY MCH PD powered automatic reflow hotplate! (Maybe I will just call its Toby's reflow hotplate in the future as its name is a bit too long :P)


START
STOP
HOT SURFACE

START
STOP


HEATER
SENSOR
Automatic MCH
Reflow Hotplate
DO NOT TOUCH


START
HOT SURFACE
DO NOT TOUCH


DO NOT TOUCH
HEATER
SENSOR
START
STOP


DO NOT TOUCH
HEATER
SENSOR
自動回流焊板
Automatic MCH
Reflow Hotplate
START
STOP