DIY REFLOW OVEN

by Vulcaman

In this Instructable I want to show you how you can build your own SMD Reflow Oven for under 60€.

For a few month now, I decided to getting deeper in electronics und PCB-Design. However many SMD components you can buy are so tiny that they are really hard to solder. In the Industry, the standart is an Oven with a predefined Temperature Curve, a so called Reflow-Oven. However a Industrial grade Reflow Oven is really Expensive, so I have searched the Web and I saw a lot of People converting an old Pizza-Oven to a Reflow-Oven. Sadly I couldn't find one which will look that professional I would like. So I started to build my own reflow oven and decided to make it Open Source :-)

The reflow oven has the followings features:

- 1200 W of Power
- Touch Screen
- Modern GUI with Temperature Curve, Keypad and Parameters
- Permanent storage of the settings (Stored in Flash)
- STM32 Microcontroller (Blue Pill)
- PID Temperature Controller
- Overall Cost +-60€

Videos of the Reflow Oven

https://www.youtube.com/embed/BAKA0E_wQRk

https://www.youtube.com/embed/CvY7zXQO4RU

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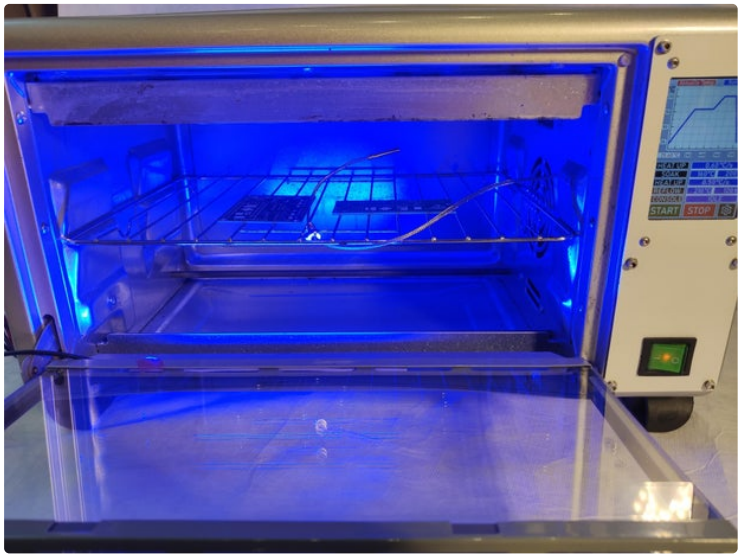
UPDATE:

[27.03.2021] Fixed Integral Wind-Up in PID Controller, Actual Temp will draw longer now

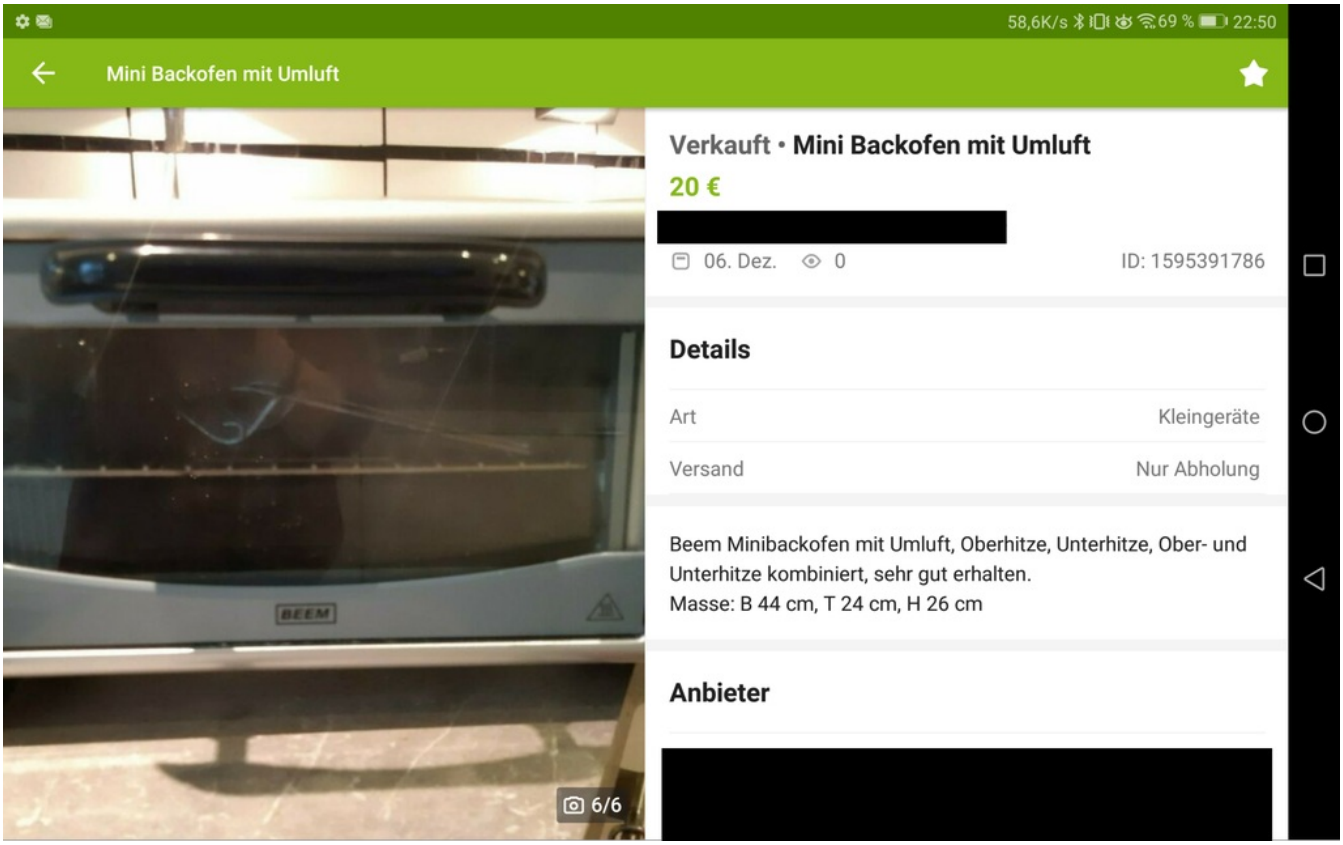
--> Updated STM32 Source Files



Step 1: Required Parts

The Base

For base the of the reflow oven you will need a cheap Pizza Oven, the more power, the better is oven is suited for an reflow oven, also an integrated ventilator is a plus point. I have found a used one on Ebay Kleinanzeigen for 20€ in my neighborhood which fits perfectly**:**



Electronic Parts:

Here are all the requierd components, for the reflow oven

Quantity	Description	Link	Price
1x	Nextion Display 3.5" Basic Version	Banggood	25,32 €
1x	STM32F103C8T6 "Blue Pill"	Aliexpress	2,75 €
1x	MAX6675 Thermocouple Modul	Aliexpress	2,28 €
1x	Level-Shifter 3.3V to 5V	Aliexpress	3,01€ for 10pcs
1x	5V Powersupply	Aliexpress	1,40€
1x	SSR Relay 25A	Aliexpress	2,93€
1x	Main Switch Green	Aliexpress	0,9€
some	Terminals and Pinheaders		
some	Wires		

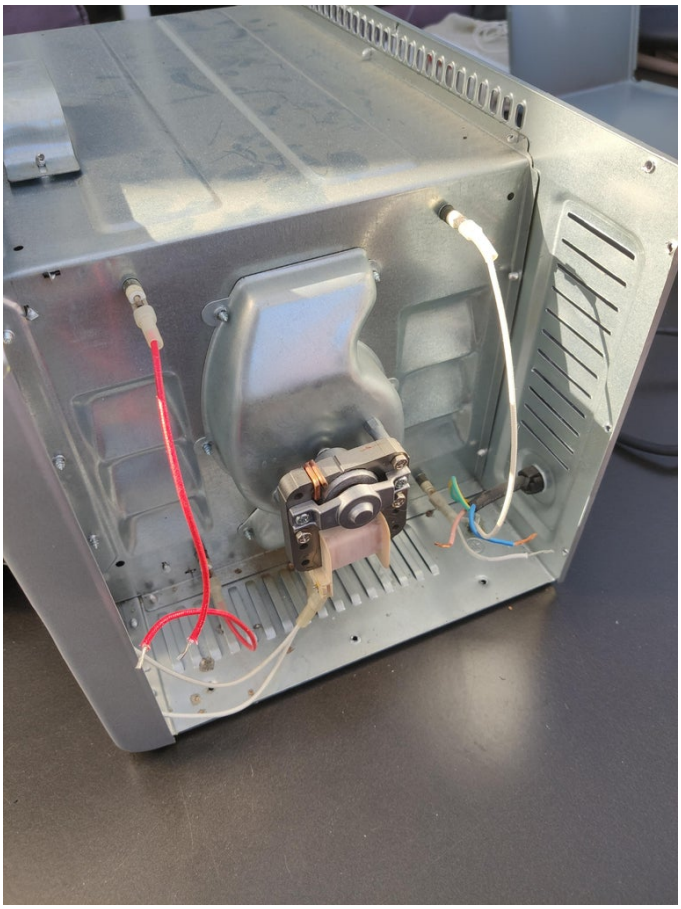
Mechanical Parts:

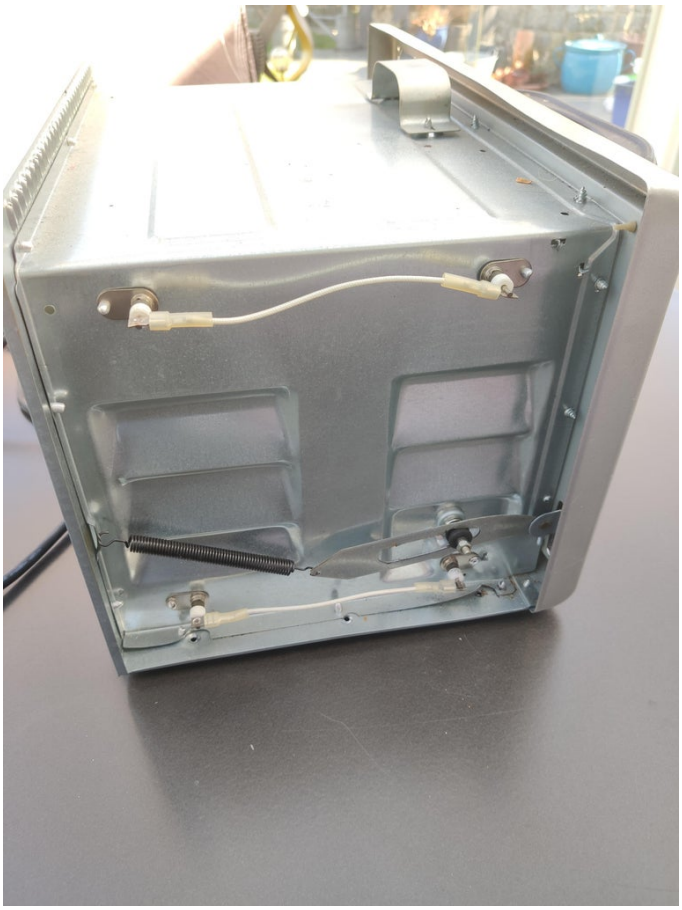
You will need some screws to mount the display and the front panel

Quantity	Description	Link
10x	M3x16mm DIN912	local hardware store
some	M3 Hex Nut	local hardware store
1x	Sheet of Alu-Dibond / Aluminium for the Frontpanel	local hardware store

Step 2: Remove All the Electronics From the Oven

At first you will need to remove everything of the old electronics from the oven. Take care about the sharp edges from the sheet metal!

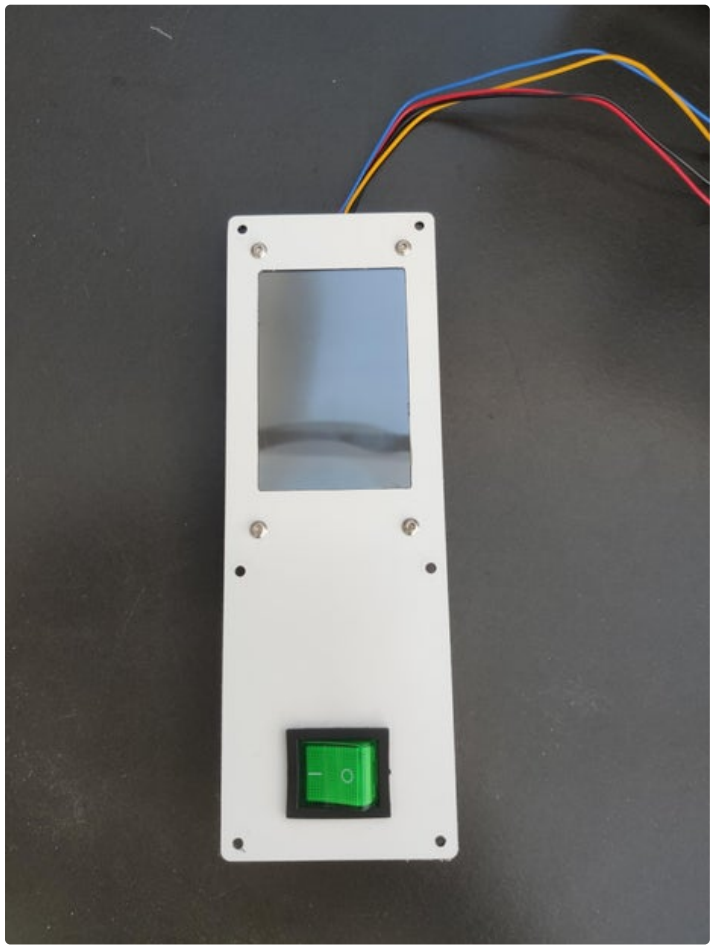


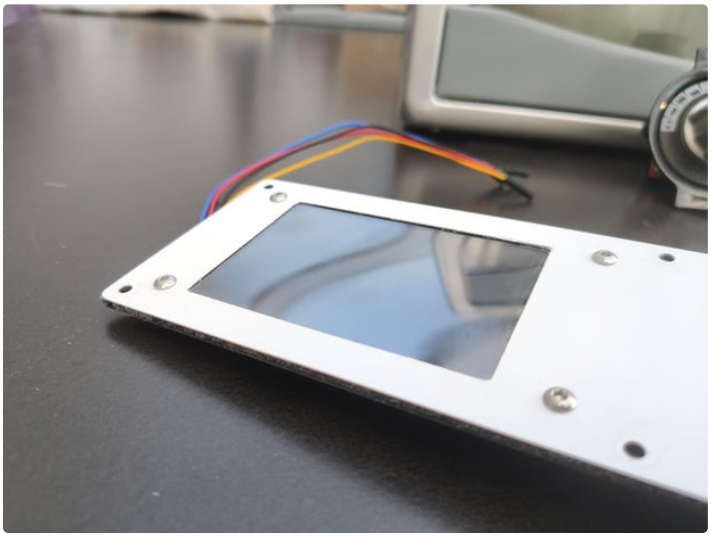


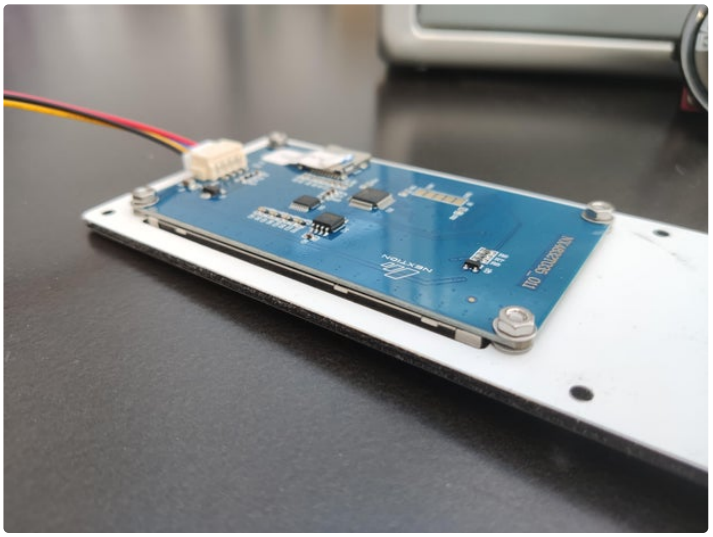
Step 3: Attach the Main Switch and the Nextion Display to the Frontpanel

I wanted a clean look of the reflow oven. No cables, no sharp edges, a oven which can be used as a tool.

So I have milled a front panel out of aluminum dibond, where I have placed the nextion display and a power switch

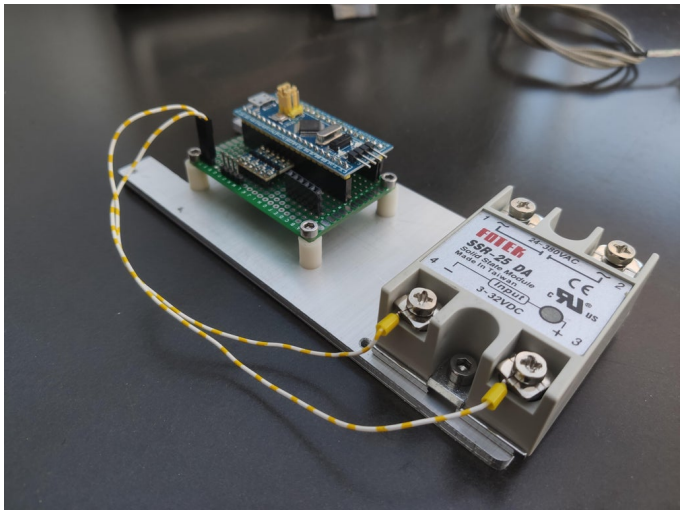


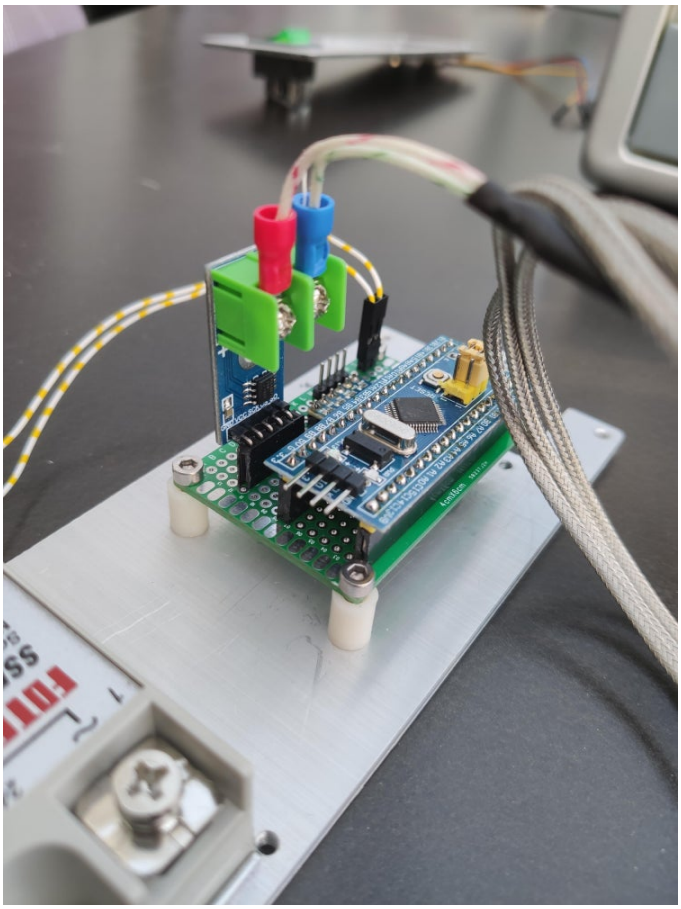


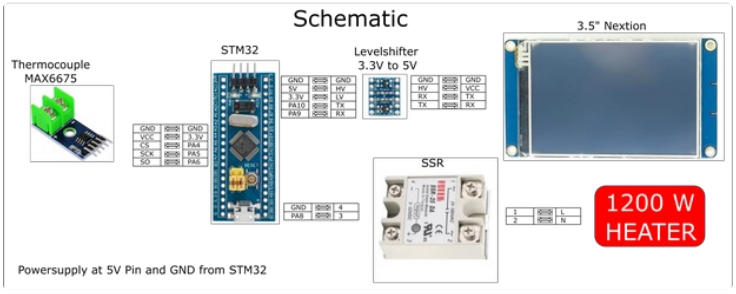


Step 4: Build the Electronics

The electronics of the reflow oven is really simple. It is just a STM32 Bluepill board, with a MAX6675 thermocouple module, a Nextion 3.5" display and a solid state relay. You will find the schematic above. The level shifter in front of the nextion display is required, beacuse the STM32 works with 3.3V and the Nextion with 5V. I have mounted the electronics on a 3mm Aluminum sheet.

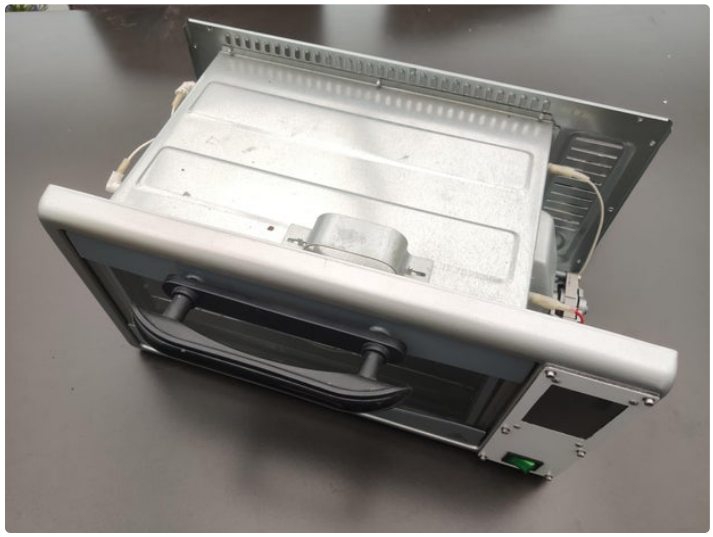


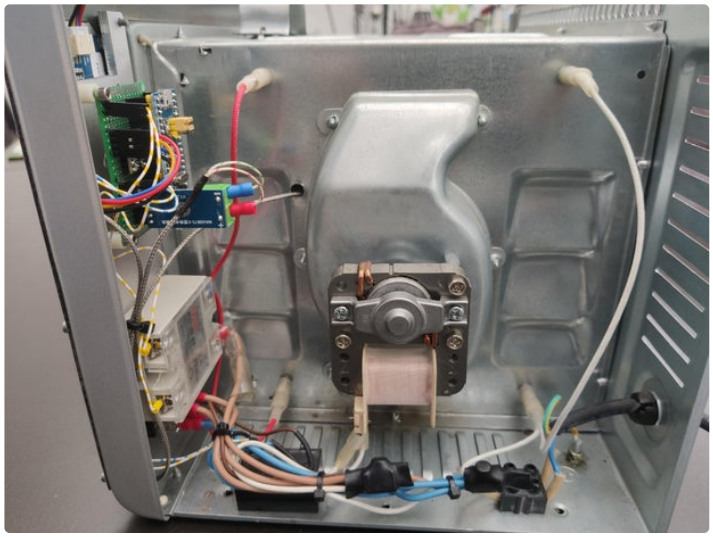




Step 5: Attach the Display to the Case

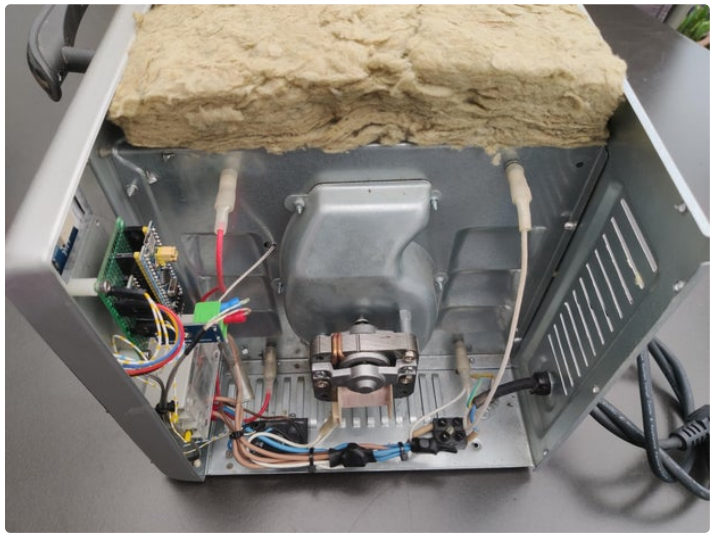
Now it's time to put the electronics back to the oven. Try to wire everything as nice as possible. However take a lot of care, because you will work with Main Voltage (230 V) which can potentially kill you!!!

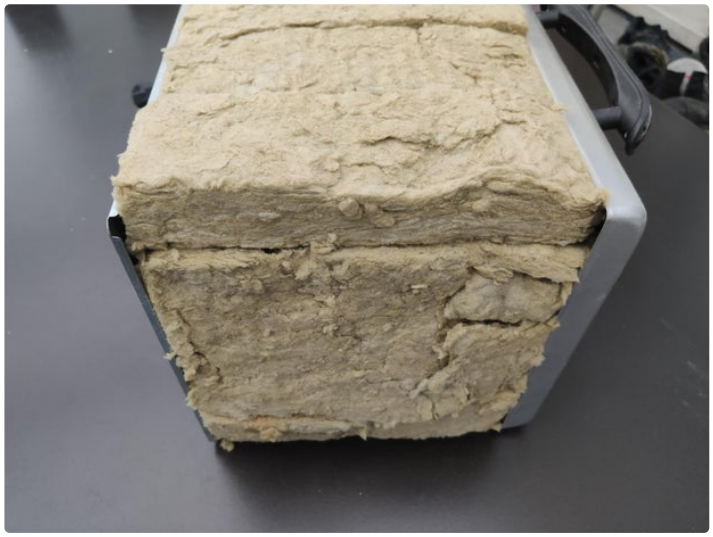




Step 6: Isolate It

For a better heat management, I have put some Rock Wool between the heating chamber and the outside of the oven. This way I could achieve that the oven only gets hand-warm on the outside of the oven.



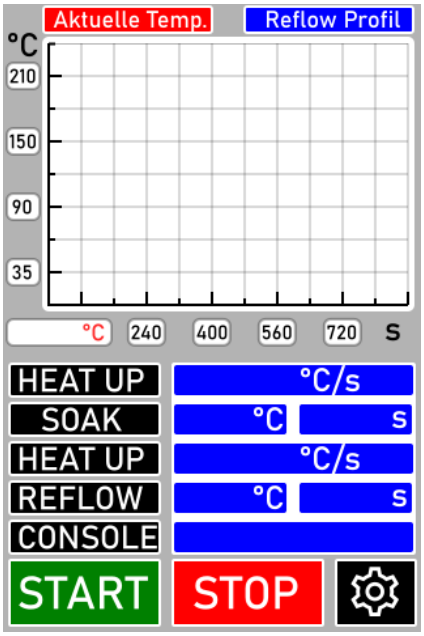


Step 7: Put the Original Enclosure Back on the Oven

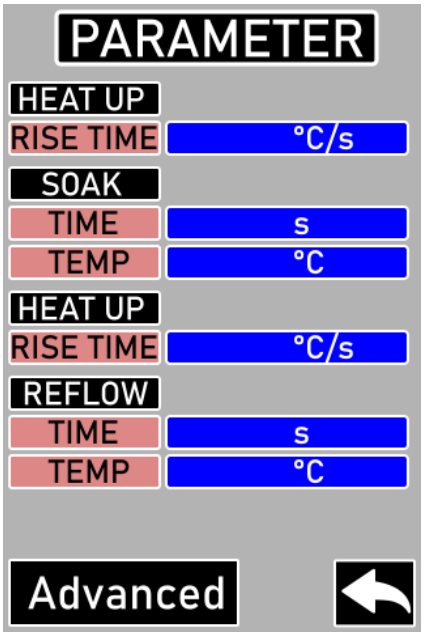
Step 8: Programm the Nextion Display

For the User Interface, I have designed my own GUI in the Nextion Editor. The GUI consist of four pages, which are shown below:

The first Page shows all the necessary Information which are important for the Reflow Soldering

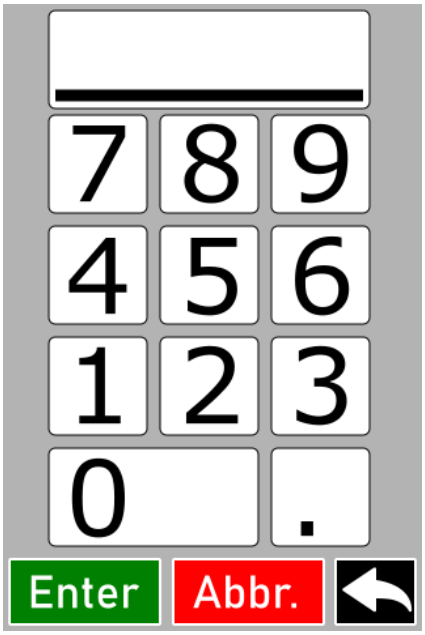


If you press on the Settings Button, you will be forwarded to the Parameters Page. There you can define all the Settings for the Profile



If you press on Advanced, you will be forwarded to the

The Last Page is the KeyPad. The KeyPad will be opened when you press on the red Button of the Parameters



For a better explenation of the GUI, please watch the Youtube Video from the Beginning

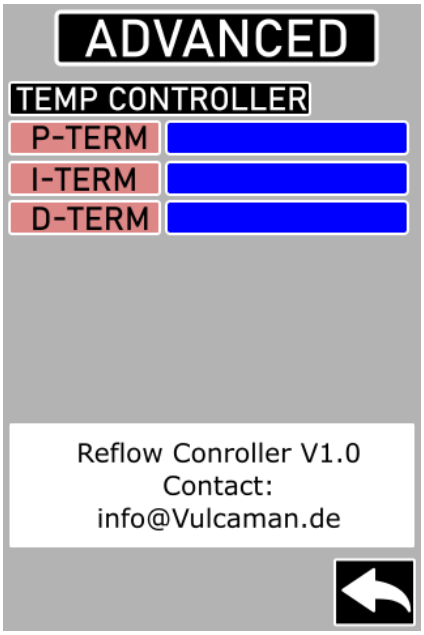
##

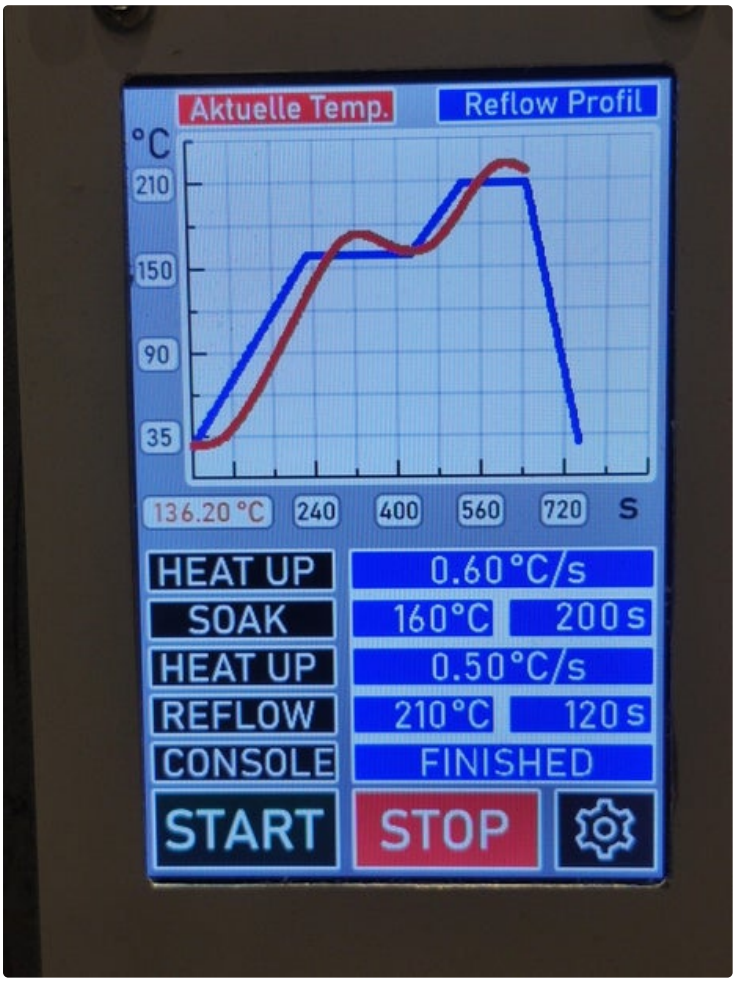
Flash the Nextion Display

To Flash the Nextion Display, you have to download the Nextion Editor.

Then you just open the .HMI File and upload it to the Display

Advanced Settings, where you can adjust the PID-Parameters for the Heater





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https://www.instructables.com/ORIG/FWQ/BBRR/KM7QNC05/FWQBBRRKM7QNC05.rar

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Step 9: Programm the STM32 + Source Code

For this Project, I have used a STM32F103C8T6 Microcontroller, which I have programmed with CUBEMX and STM32CubeIDE. The STM32 will handle the complete control of the Oven. However there are some important things you should know.

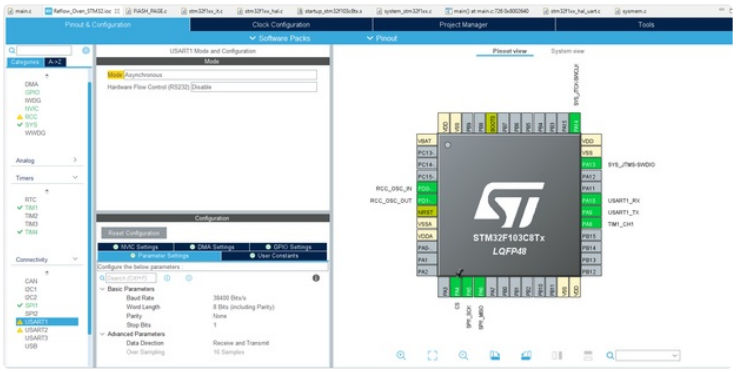
The GPIO Pin for the Relay

To adjust the Output Power of the Heater I have used a Solid State Relay. While working with SSR Relays, you should know that they are often build with Triacs as switching Unit. This means that the SSR can only switch off when the Current is zero. The Heater is Controlled by 230 V 50 Hz Main Voltage so I have to switch way slower than 50 Hz for an better power control. So have set the PWM Frequecy on Pin PA9 to 1 Hz. That way, I could simply adjust the power by the dutycycle on Pin PA9.

The PID Controller

For the PID-Controller I have used the PID Implementation from the ARM CMSIS Package. You can find the documentation here

Write of the parameters to the Flash Memory



To store the parameters permanently to the STM32, the parameters will be automatically stored to the Flash Memory of the STM32. Here I have used the Flash library from Controllers Tech

##

Flash the STM32

Because it much more complicated to set up the STM32CUBEIde and include all the libraries compared to the Arduino IDE, I have precompiled the C-Code as a .bin file. So all you have to do is to flash the .bin file with the ST-Link-Utility to the STM32. For flashing the STM32 you will need a ST-Link Programmer

You can download all the Source Files below:

Or download them from Google Drive

Download

https://www.instructables.com/ORIG/F01/FRHQ/KM7QNCCF/F01FRHQKM7QNCCF.rar

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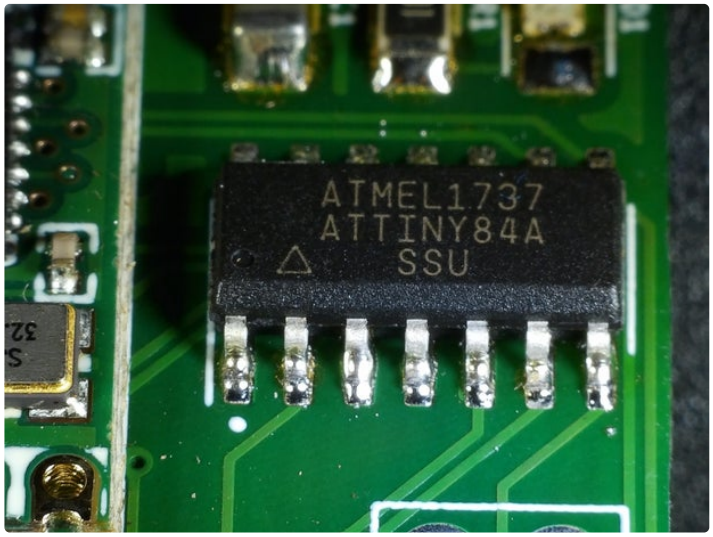
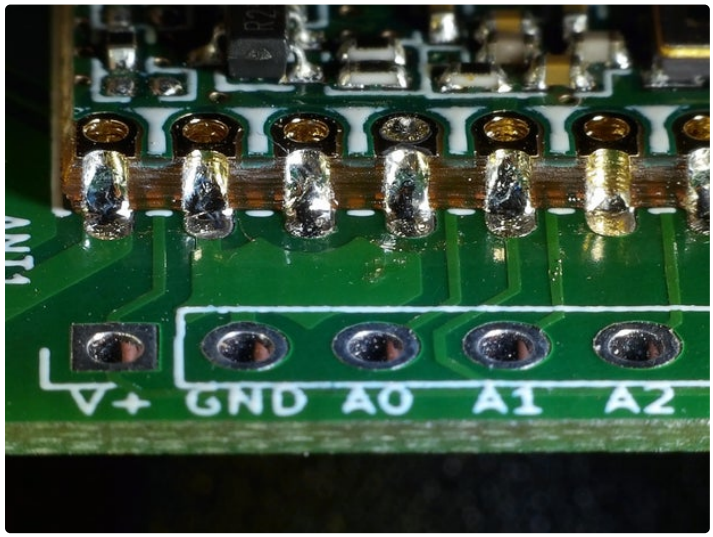
Step 10: Pictures From Soldering

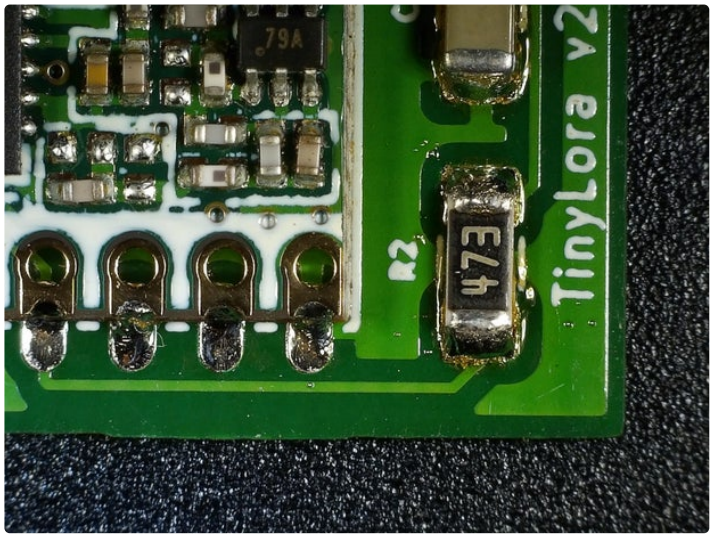
Here you will see some results from soldering. As you can see the soldering is quite nice :-)

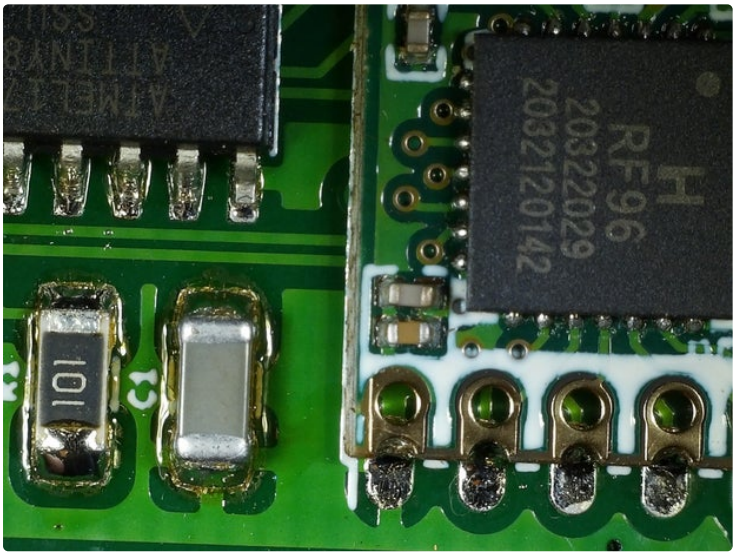
I have used Sn63Pb37 Solder Paste for this PCB. In the future I will update this step with some more PCBs which I have soldered. Also take a look at my Instagram for more pictures.

If you have any questions, feel free to contact me









My oven is almost done. Can you provide font, or font name which do you use in the menu, please? I'm trying to modify a bit HMI file and add some reflow profiles with save functionality. awesome project!

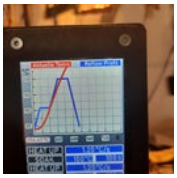
Hi, the font name is called "Bahnschrift". I have added the Inkscape SVG File for all screens to step 8, maybe this will save you a lot of work :-)

Please keep us updated with your version of the oven!

Thank you, I was trying to edit png in gimp.
BTW. What do you think about writing reflow profile variables to flash memory? Frequent changes in Parameters menu will have decreasing life of the flash memory. It's better to use eeprom module?
Kind Regards

I think the flash memory will work fine. The Flash on STM32 has an endurance of min 10K cycles. And because you will only write to flash when you change the parameters, it will work fine for this porpose.

Hi, any idea where to look first ? My oven heats and heats



Hi,
what are your PID-Parameters? Do you have installed the V1.1 Firmware? In Firmware 1.0 was a bug...

I think the problem is, that you never reach the temperature, you have set in your reflow profil. Because of that, the PID-Controller will always give out a dutycycle of 100%. Try to decrease the HEATUP times to 0.4-0.6 °C/s. I think this should solve your problem.

best regards

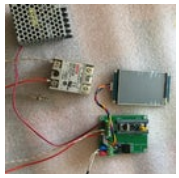
Thanx for the fast reply,
-installed Reflow_Oven_STM32_V1_1.bin
-decreasing Heatup time to 0.5 °C/s brings no success
P=45
I=0.2
D=0
hmmm...

Hmm. Then try to set the I-Term to 0. And set the temperature to 50°C for a long time Soak (300s/50°C). At this temperature, try to tune your P-Term.
Does your LED on the SSR starts blinking? Can you notice a change in the frequency of the blinking?

Yeah, i made some progress by decreasing I to zero.
Now i have to get the charts congruent

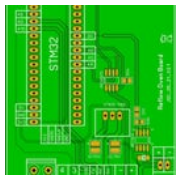
I think the SSR will not switch off. Do you use 3.3V or 5V for the SSR ?

Very good project! Because I want to build my own furnace, I would have a question about the fan. I would need the fan to start after the top is completed and to expel the warm air. Would it be difficult to modify the firmware? I'm not a programming expert. I mean assign pin STM32 and switch fan after peak completion.
Thanks for the reply and sorry for the bad English.



Do you have made a PCB for mount all the Parts on it ?

Yes, I designed the record



Hello, do you not have Problems with the Voltage Levels on the A9 and A10 Pins ? (blue Pill use 3.3V and Display needs 5V) ??

No need, it's useless !!! It works so well.

OK, thank you for explanation

Hello, do you share the GERBER Files or can i pay for the GERBER ???
I also will make such a PCB, it looks nice !!
regards Triton

https://uloz.to/tamhle/WdFt8wySS3DK/name/Nahrano-18-6-2021-v-17-33-34#!ZJL0AmR2ZwWxAmAyLGEwMzH2AwpjARgRZ1AspxZ3DIMWZTH1Lj==

Hello, thank you very much, I am excited

Hi,
no it won't be that difficult as you said. You just need to switch the I/O pin when the display shows "finished" . If you want I can do that for you. You can contact me by Email " info @ vulcaman.de"

BTW... Nice PCB!

Just finished the project for a T-shirt press. If it is worth doing, it is worth overdoing :-)

It would be nice if there was an option tot select different profiles.

It took a little longer than expected, but today our group of ham radio operators (DM5AF, DL8AS, DL1LK and myself) managed to finish the build. While building our own oven based on Vulcaman's design we found out that the solid-state relais does not work reliably when using 3.3V as its input voltage (though it claims to switch states from 3V upwards...). We ended up using an unused pin of our level shifter to run the relais with 5V, which finally did the trick.

DM5AF also made a custom PCB to add all the components to, after we had some issues with attaching the DYI PCBs to the custom-made front plate. These PCBs have a tendency to break into little pieces once you start drilling holes into them for screwing the onto the aluminium front plate.

We also came up with additional ideas after finishing the project (of course... why do ideas not materialize during the build phase?!), which we consider adding in the near future: add a buzzer to alarm us once the cool-down phase starts (so we can open the door to help the PCBs cool down faster), and we also want to add a USB breakout cable to the build so that we can re-flash the BluePill without opening the oven.

To get an idea about the assembly process, I added some photos of the final steps and the first "smoke test" (where the oven literally emitted puffs of smoke when it was switched on and heated up for the very first time, mainly due to all the grease and stuff used by the manufacturer of the oven. It was far less "smoky" during the second heat-up).

aye how much for da hoe?????

Well, got the oven all assembled. All working ok except for the solder profile. The temperature doesn't turn off the heating elements at soak temperature until about 30° to 40°degrees above. Sometimes, the heating elements do not turn off until 20 degrees above reflow temperature, skipping the soak. Playing with the PID values doesn't help much.
I need some help and suggestions. Thank you.

Hi, nice to hear that everything works :-)
The problem comes from the arm_Math PID Controller that I have used, because there is no integral windup correction implemented. If you only use the P-Term and no I Term, it should worked better.

I will try to fix that, I think I will update an updated code in the next week :-)

Do you have any pictures from the oven? :-)

best regards
Vulcaman

Wow, setting Integral to 0 sure fixed the issue. Thank you. I was pulling my hair out. See attached picture. It was the first run are the fix.

I have fixed the Problem with the Integral Wind-Up. Now you can use a small value for the I-Term, to compensate the last few degrees...

You can find the source files on google drive or here on instructables. I have also Updated the temp draw function, so it will draw the complete blue reflow curve.

I would be really thankful, if you could give me a feedback, if everything works. And it would be awesome, if you could post your oven here under "I made it" :-)

P-TERM = 45
I-TERM = 0.2
D-TERM = 0.0

I installed the new version software(Reflow_Oven_STM32_V1_1). It works great.
See attached picture.

What are your PID-Parameters?

Great project. I really like that Vulcaman responses to the comments and really fast. The reflow oven works very good.

I noticed on the PID controller, you don't have a value for Derivative. Are you using Derivative? Are you running the fan?

The fan is always on

The Derivative is not necessary, because the thermal progress is so slow...

This looks like a fantastic project to work on, but an actual electrical schematic with a Mouser/Digikey parts list would be amazing. For instance, where is the switch wired in to the actual circuit? Is the fan wired in to the SSR or the switch and did you include a fusible link?

Don't get me wrong, I feel comfortable in sorting out where it would go, but not everyone may be as confident which is where a full schematic helps.

Like I wrote in a Email I want to use the reflow oven for beekeeping. Well, there are other temperatures (only up to 42 degrees), but longer times (1 hour). Therefore I have to change some settings in program and display...

The project looks very nice and the time to learn stm32 programming is well done.

Nice screen interface. I would build this as my 3rd DIY reflow oven.
In my experience, an integrated fan is *essential* to getting good, consistent results with a variety of boards and components, and getting multiple boards to melt all at once.

Unfortunately, most DIY reflow oven designs use cheaper toaster ovens with no fan, and that's a mistake. Maybe because convection models with fans are not as common, at least in some parts of the world. If you search around though, they can be found even in the smallest sizes.

Nice job.
Envious.

Thank you! A reflow oven is on my list.
Now your next instructable can be "Using A Reflow Oven/Howto".

Ralph

Dear Vulcaman, thank you for sharing such detailed project!

Excellent project! By any chance, can you modify the GUI for a 2.8 Nextion LCD? I have one around and I think would be nice to gave it a chance to do something usefull in my lab! Thanks, Adrian

An adaption to a 2.8 Nextion is not planned yet but you can do that by your own. All you have to do is to modify the pictures in the HMI file and update the draw functions inside the STM32.

Awesome reflow oven!! Agree this is the best reflow oven project I have seen! Great GUI! Would suggest changing the control architecture away from PWM PID at 1hz with a triac to simple on/off with the triac to follow the curve better. The PWM won't help you and looks like the PID settings are hurting more than helping. Perhaps some optimization of the PID settings would get a better profile following (or maybe it is simply the limitations of the hardware and/or sensor)

A simple on/off will result in a big overshoot, because the oven has a big dead time. Yes the PID Parameters needs to be tuned, but these Parameters I have used worked for me. I could live with that overshoot.

Very good project details and execution! I am going to make one of these following your template here. I have been contemplating buying a flow oven, but like you say "they are very expensive to buy one". Have your reflows worked out for you since completing this unit? I was wondering about the glass door and heat escaping through the glass.. Have you had any issues on the front side? The insulation on the sides, back and bottom is genius..
Thanks!
mrstan

Yes, so far my reflows came out great. However I get this oven finished since one week now and I run out of PCBs ;-) . I have some plans for some upcoming projects, where I will include more custom PCBs, but as you might know I takes some time to order all the electronic components.

The insulation at the front is not a big deal. The fan will homogenise the temperature inside the Oven.

A very interesting project and well documented.
Until now, I was manually adjusting the temperature of the oven, but I think I will try this project.

Did you also make a pizza profile? ;)

Yes this is very well done and written up. I would definately enter it into a contest!

Very well executed. Nice job.

This is by far the nicest DIY reflow oven I have yet seen on here. Well done and documneted.