

## ESTechnical Toaster Oven Reflow Controller Kit

### Reflow Controller hardware v4

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Thank you for your purchase of ESTechnical products. If you have any questions or comments please let us know, we are always keen to hear feedback about our products.

#### Instructions for fitting ESTechnical Toaster Oven Reflow Controller Kit to a Toaster Oven

[Packing List](#)

[What you will need \(not supplied\)](#)

[Toaster Oven Reflow Controller Installation Procedure](#)

#### Warning

**IMPORTANT – mains electrical wiring is involved in the installation of this controller, but no mains voltages are connected directly to the controller. If you are in any doubt please consult a qualified electrician.**

#### Auto Reset Jumper

The ESTechnical reflow controller v4 PCB and onwards has a jumper for enabling or disabling the auto-reset behaviour of the MCU. With the jumper connecting the two pins it is possible to easily upload new firmware to the controller via USB to serial connection from a computer. With the jumper open, the MCU will not automatically reset when the serial port is opened by a computer - this is more convenient in normal operation and we suggest that you operate the controller with the jumper open.



Auto reset jumper, disable auto reset by disconnecting the jumper

1. Ensure the toaster oven to be converted is unplugged from the power.
2. Remove the screws that fasten the oven cover, set these aside. Remove the cover.
3. Take a moment to familiarise yourself with the wiring that is present. You need to be able to identify each of these cables in order to proceed with the installation:
  - Heater supply cables
  - Fan supply cables
  - Mains power into the oven – it is particularly helpful if this can be connected to a reusable terminal block (not supplied) as several connections need to be made to the live and neutral terminals
  - Earthing of the oven
4. Confirm that the oven has a sound earth connection to the metal case.
5. Disconnect all the wiring from the controls of the oven. Optionally remove the controls.
6. Multiple options are available for mounting the ESTechnical Reflow Controller:

- **Option A:** Make a suitable mounting pattern for the ESTechnical Reflow Controller and keypad. See diagram 1. This will require marking out the pattern, drilling the required mounting holes and cutting out the opening for the display. The keypad cable slot can be made by drilling a row of overlapping holes and then filing the edges until the correct shape. The keypad ribbon cable may be harmed by sharp edges so make sure the edges are well finished.

## ESTechnical Reflow Controller Mounting pattern Copyright Ed Simmons 2014

4x 3mm  $\varnothing$  mounting holes  
LCD display cutout 80 x 29 mm

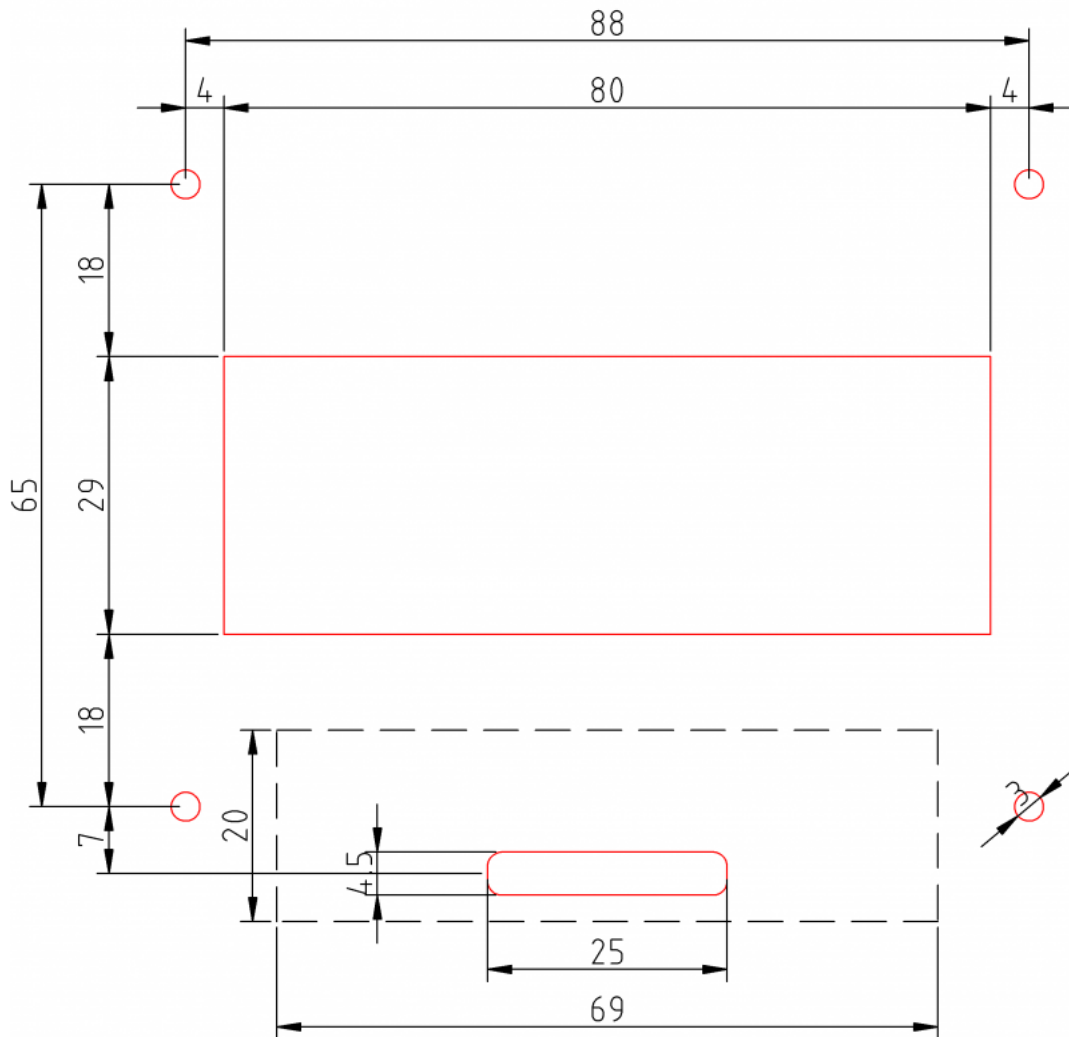


Diagram 1 - Controller and keypad mounting dimensions

- **Option B:** Using the Mounting Plate for ESTechnical Reflow Controller (available separately [🔧 Fix Me!](#)). The mounting plate requires a single square cutout in the panel and 4 screw/bolt/rivet holes.
  - **Option C:** Using the 3d Printed Pod for ESTechnical Reflow Controller (available separately [🔧 Fix Me!](#)). The pod requires one cable access hole and four screw holes.
7. Mount the two solid state relays and 9v transformer onto a flat metal surface inside the oven, somewhere that will remain cool during operation of the oven and within easy reach of the cables inside the oven. Front or rear metal panels of the oven are good locations.
    - Once you have chosen a location for each item to be fitted, mark the location of the required drill holes with the marker pen and check against the item to be mounted (be sure that nothing will obstruct the terminals once mounted).
    - When you are certain the marks are correct, make a punch mark on each pen mark to aid the drill starting in the right place.
    - Secure the Solid State Relays and 9v transformer using the supplied M4 bolts.
  8. Assemble the supplied stand off posts onto the four corners of the Reflow Controller, fasten these with the supplied M3 nuts.
  9. Mount the controller onto the inside of your chosen mounting method using the M3 bolts provided.
  10. Mount the keypad onto the panel by removing the cover on the self adhesive back, then carefully threading the connector through the hole in the panel and firmly press the keypad into place on the panel.

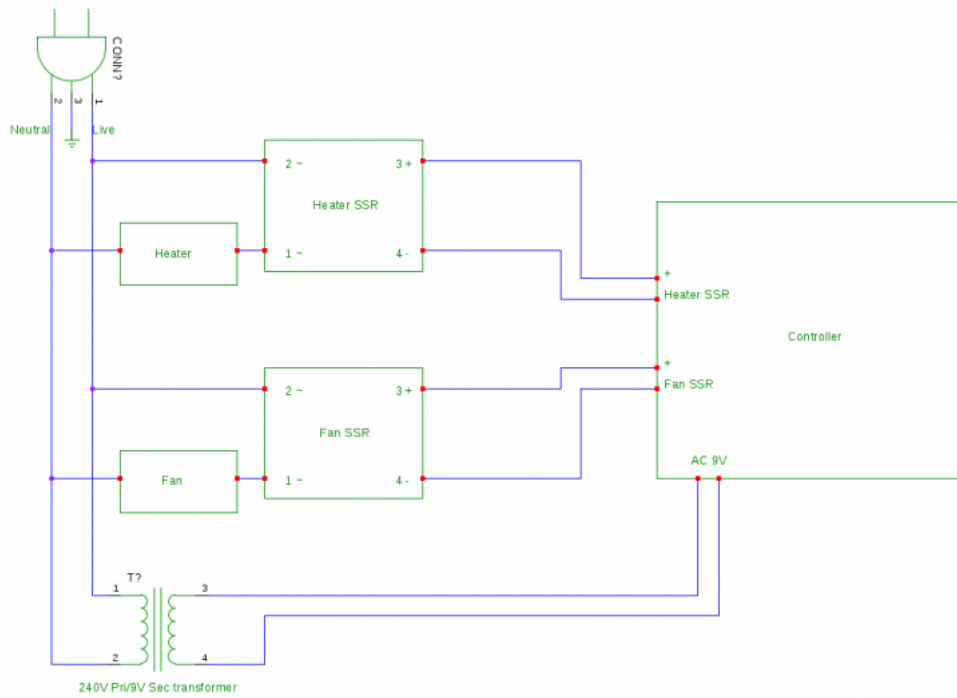


Diagram 3 - Mains wiring overview

11. Referring to diagram 3, connect the primary winding of the mains transformer to the mains supply of the oven. For 110/115V mains (USA), connect both primary windings in parallel. For 220/230V mains, use both primary windings connected in series. The terminals are labeled on the transformer. Insulate the terminals with heat shrink sleeve.
12. Connect one of the heater supply wires to the neutral terminal of the incoming mains power.
13. Decide which solid state relay is going to control the heater and label it to prevent mistakes.
14. Connect the remaining heater supply wire to one of the mains terminals (labeled ~) on the heater solid state relay.
15. Connect the remaining terminal of the heater solid state relay to the live terminal of the mains supply. Use wire of a suitable current and temperature rating, ideally recycle as much of the existing wiring of the oven as possible. Do not use cable that is thinner than the existing heater wiring for any part of the heater connections.
16. Connect one of the supply cables for the fan to the neutral terminal of the mains supply to the oven.
17. Connect the other fan supply wire to one of the mains terminals (labeled ~) of the fan solid state relay.
18. Connect the remaining terminal of the fan solid state relay to the live of the mains supply to the oven.
19. Now the heater and fan mains wiring should be completed. Check the connections made so far. The original controls of the oven should no longer be connected to any of the oven wiring.

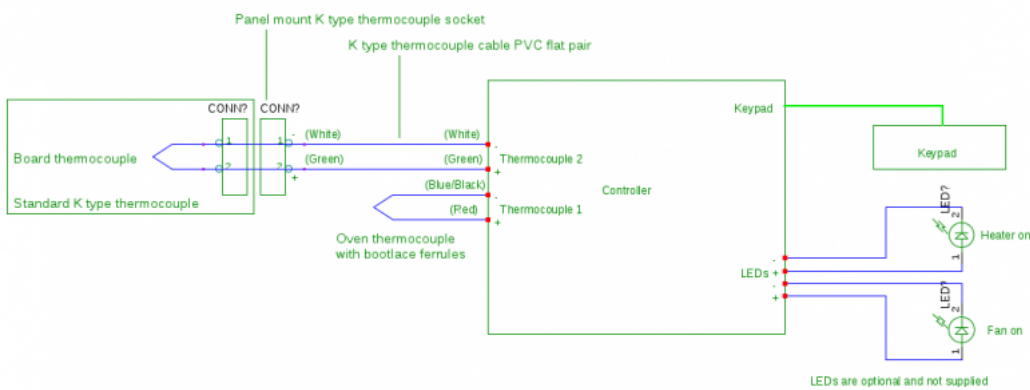


Diagram 4 - Thermocouple, keypad and LEDs wiring diagram

20. Mount the oven thermocouple (this has bootlace ferrules, the other thermocouple has a plug) into the oven by drilling a hole in the oven casing at a suitable location for the cable to enter. Feed in enough cable so that the thermocouple is placed close to the surface of the board to be reflowed. The tip of the thermocouple should be about 15mm above the board to be reflowed. Secure the thermocouples in place using kapton tape. Also apply tape to cover the hole where the cable enters the oven.
21. Connect the oven thermocouple to the A input on the controller board paying attention to the polarity of the thermocouples. The thermocouple cables are colour coded, the red wire from the thermocouple should go to the + (positive) terminal of the thermocouple input.
22. Connect the supplied small signal cables to the control inputs of the solid state relays.
23. Plug in the other end of these cables to the controller outputs, these are labeled 'heater' and 'fan' on the board. Pay attention to the polarity of these connections (shown in diagram 4).
24. If you wish, you can connect panel mounted LEDs (not supplied) to indicate the operation of the heater and fan to the LED connector on the PCB, this connector is next to the solid state relay outputs.
25. Connect the low voltage secondary winding of the mains transformer to the AC input of the ESTechnical reflow controller board. The transformer provides two sets of 9V AC output, connect just one pair of terminals and insulate the connections with heat-shrink tube.
26. The controller and keypad should be mounted onto a panel to suit your oven.
27. Plug the keypad into the controller board.
28. At this point there should be no remaining cables to connect. There should also be no cables remaining on the original controls of the oven. Check all the connections, particularly verify polarity of the solid state relay control signals and thermocouples.
29. Reassemble the oven using the original housing and screws.
30. Now the oven is ready for testing. Plug in the power and switch on the oven, the display should illuminate and the controller will display the main item of the menu. (If the display does not illuminate, switch off the power immediately and go back and check connections.)
31. Check the small (optional) cooling fan is running, if not, go back and check the connections.
32. Press OK to start a reflow cycle, the main fan should begin to gently idle and the heater should begin to heat up. Press the back/stop key to stop the cycle. The controller will go into cool-down mode. The fan will stop when the oven returns to room temperature. The cooling down display can be interrupted without interrupting the cooling of the oven to get to the menu, just press the back/stop key again. If the fan does not start or heater does not start to heat up, switch off the oven immediately to prevent any possible damage and go back and check all connections.

Caution

**ESTechnical accept no responsibility or liability for personal injury or damage to property – it is the user's responsibility to correctly carry out installation and confirm the correct operation of the oven once installed.**

Precautions

**ESTechnical accept no responsibility or liability for personal injury or damage to property – Perform testing on waste boards until you are confident the settings are correct for your oven, boards and parts density etc.**

Place the reflow oven on a hard, level and heat resistant surface. Do not cover any holes in the oven housing – the airflow is necessary, damage to the oven and/or your PCBs will result if airflow is impeded.

Always allow the oven to cool to below 50 degrees (as reported on the display) before stopping the cycle or attempting to remove the boards from the drawer. Do not stop a reflow cycle and begin another without first allowing the oven to cool to near ambient air temperature.

Never start a reflow cycle with hot PCB(s) - allow to cool first.

Ensure adequate ventilation in the work area, air extraction is essential if working in a confined space.

Place boards to be soldered centrally in the drawer of the oven. If a small board is being soldered, it is best to position this below the thermocouple towards the front of the oven. This will provide the most accurate temperature control. Always ensure there is PCB below the oven thermocouple.

**Reflow Controller Installation Troubleshooting**

Issue	Cause	Solution
Controller does not power on when oven is switched on	Incorrect connection of low voltage AC supply to controller	Check connection of low voltage AC power supply to the ESTechnical Reflow Controller.
	Mains power is not supplied to the 9V transformer	Check the primary winding of the 9V transformer is connected between the switched live feed of the oven and the neutral terminal
Fan or heater does not work during a reflow cycle	Incorrect connection of signal cable between Reflow Controller and SSR	Check the polarity of the connection and correct if necessary, the polarity is marked on the controller and the SSR terminals
	Incorrect mains power or SSR connections	Check the connections between the mains power, SSRs and loads (heater and fan) are made as per the instructions
DC cooling fan does not start	Incorrect connection of the DC cooling fan to the ESTechnical Reflow Controller	Check (and possibly reverse) the connection on the controller to the DC cooling fan, the wiring colours used by the original oven manufacturer are inconsistent and can be misleading
LED indicators do not light during a reflow cycle	Incorrect polarity connection of the LEDs to the ESTechnical Reflow Controller	Check (and possibly reverse) the connection on the controller to the LEDs, the wiring colours used by the original oven manufacturer are inconsistent and can be misleading
When a reflow cycle is started the temperature reported on the display drops instead of rising	Thermocouple connection is reversed	Correct the reversed thermocouple connection
Controller displays "Thermocouple input open circuit"	Incorrect connection of the thermocouple to input A of the ESTechnical Reflow Controller, or broken thermocouple	Disconnect the thermocouple from input A and measure the resistance of the thermocouple, it should measure less than 10 ohms. If the thermocouple is open circuit, replace the thermocouple.
Controller displays "Temperature following error during heating"	Thermocouple is incorrectly placed	Confirm the placement of the thermocouple is as per the installation instructions and adjust if necessary

Issue	Cause	Solution
	There is no PCB in the oven drawer	The temperature following error can occur when the oven drawer is empty and a cycle is run, test with a PCB below the oven thermocouple
	The Fan Idle Speed is set too high	Ensure the Fan Idle Speed is set to the correct value as suggested in the installation instructions
	The Ramp up Rate is set too high for the PCB(s) currently in the oven	Reduce the Ramp up Rate setting slightly and test again

## ESTechnical Reflow Oven Controller Operating Instructions

Caution

**ESTechnical accept no responsibility or liability for personal injury or damage to property – it is the user's responsibility to correctly carry out installation and confirm the correct operation of the oven once installed.**

### Initial Set Up

- Place the Reflow Oven on a hard, level, heat resistant surface
- Attach the power cable to the reflow oven and plug in to a power outlet
- Ensure none of the grilles on any panel are covered

### Overview of Operation

#### Initial Set Up for new PCB designs

- Prepare one or more test PCBs with a thermocouple attached
- Load the default profile settings
- Perform a test reflow cycle and observe the board temperature
- Adjust the cycle settings in small increments and repeat the test cycle (with oven and PCB starting from near ambient temperature for every test) until the profile meets the needs of the solder paste and components used on your PCB(s)
- Save these profile settings and make a note of the profile number in your project documentation for the PCB

#### Production of PCBs

Once you have set up a reflow profile for your PCB design:

- Prepare PCBs with solder paste and components
- Select the correct profile for the board design
- Place PCB(s) in the reflow oven drawer
- Run the cycle
- Remove soldered PCB(s) once the oven has cooled
- Repeat as needed

#### Menu Layout & navigation

Navigate the menu using the keypad keys < & > to move through the menu items, press Ok to select a menu item. Pressing Back will return you to the previous level of the menu.

The menu is organised as follows:

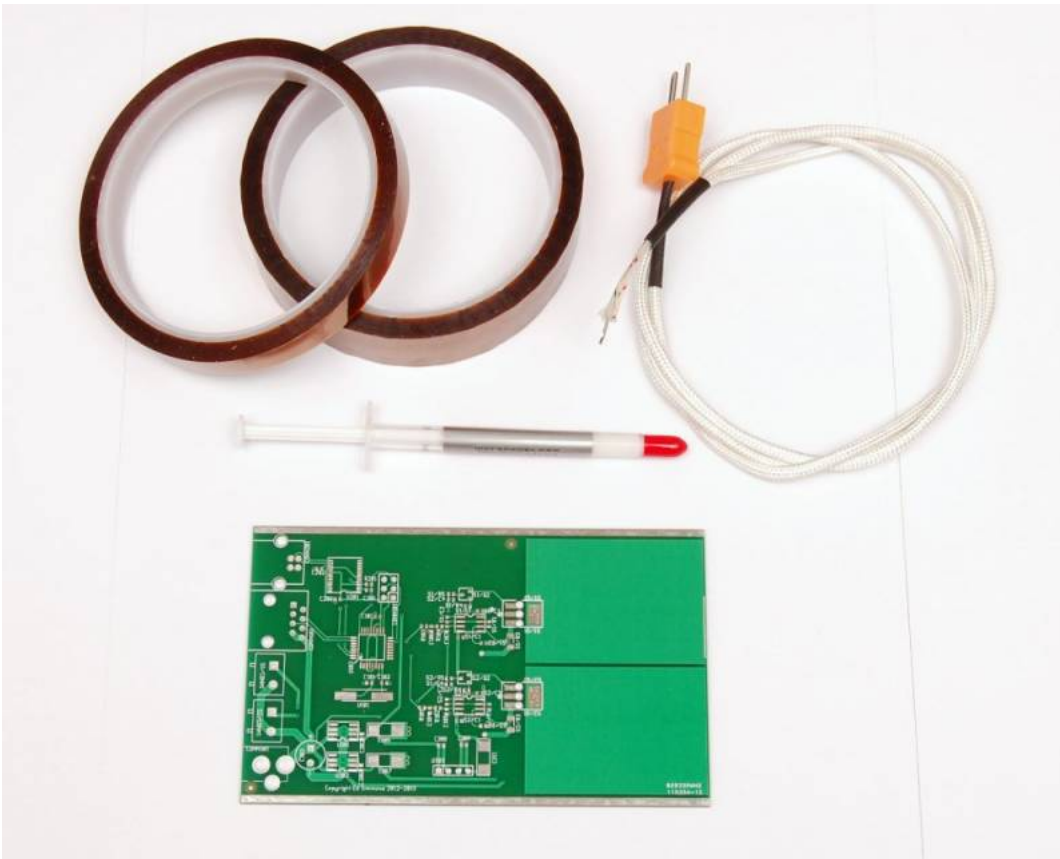
Menu layout
<ul style="list-style-type: none"> <li>• Start Cycle</li> <li>• Edit Profile <ul style="list-style-type: none"> <li>• Ramp up rate</li> <li>• Soak temp</li> <li>• Soak time</li> <li>• Peak temp</li> <li>• Peak time</li> <li>• Ramp down rate</li> </ul> </li> <li>• Load Profile <ul style="list-style-type: none"> <li>• Choose profile number</li> </ul> </li> <li>• Save Profile <ul style="list-style-type: none"> <li>• Choose profile number</li> </ul> </li> <li>• Fan Settings <ul style="list-style-type: none"> <li>• Idle speed</li> <li>• Save</li> </ul> </li> <li>• Factory Reset</li> </ul>

#### Reflow Profile Testing

The ESTechnical Reflow Oven Controller is equipped to make setting up reflow profiles easy – it is essential to carry out this testing correctly to ensure correct profile settings are used for your board(s).

Profile testing should be carried out for each design of board to be soldered.

To carry out profile testing, you will require a test PCB, kapton tape and heatsink compound.

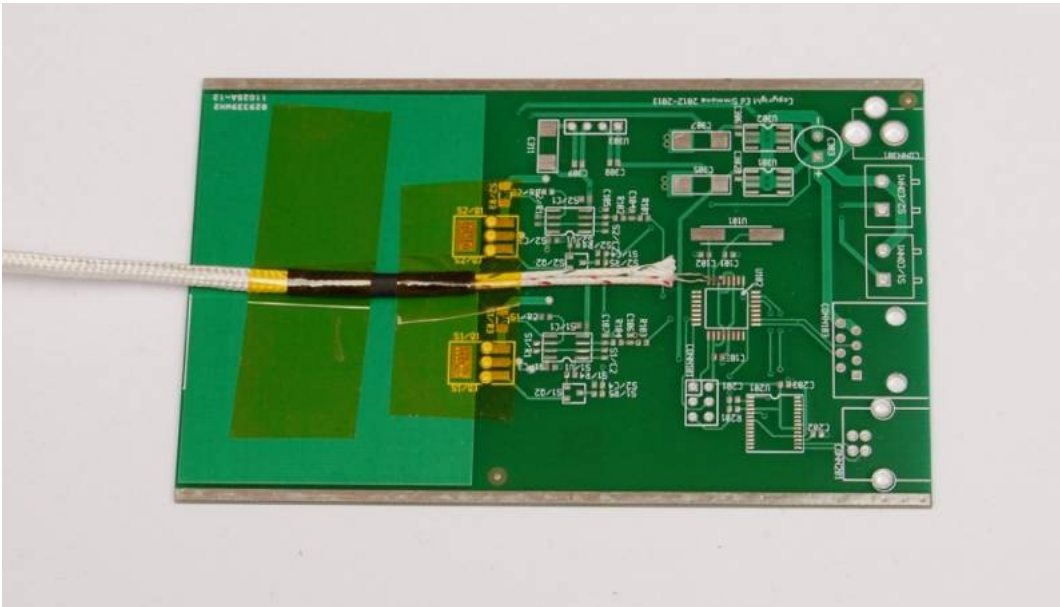


Test PCB, kapton tape, heatsink paste and thermocouple

Decide where to place the thermocouple. Where you place the thermocouple on the PCB depends largely on the design. Densely populated areas or areas with large copper fills are a good choice for initial testing. Other areas of the board (for example, the top of tall parts) should also be measured once a suitable reflow profile has been set up to ensure the peak temperature is not exceeding the manufacturer's stated limits.

Small boards with few parts are often easy to profile correctly with no parts present, as the parts comprise a very small amount of the overall mass of the board. More densely populated boards may require further adjustments to the profile to adequately reflow all solder joints. Further testing is advised to ensure safe margins are kept from the maximum temperature specified for the most sensitive parts.

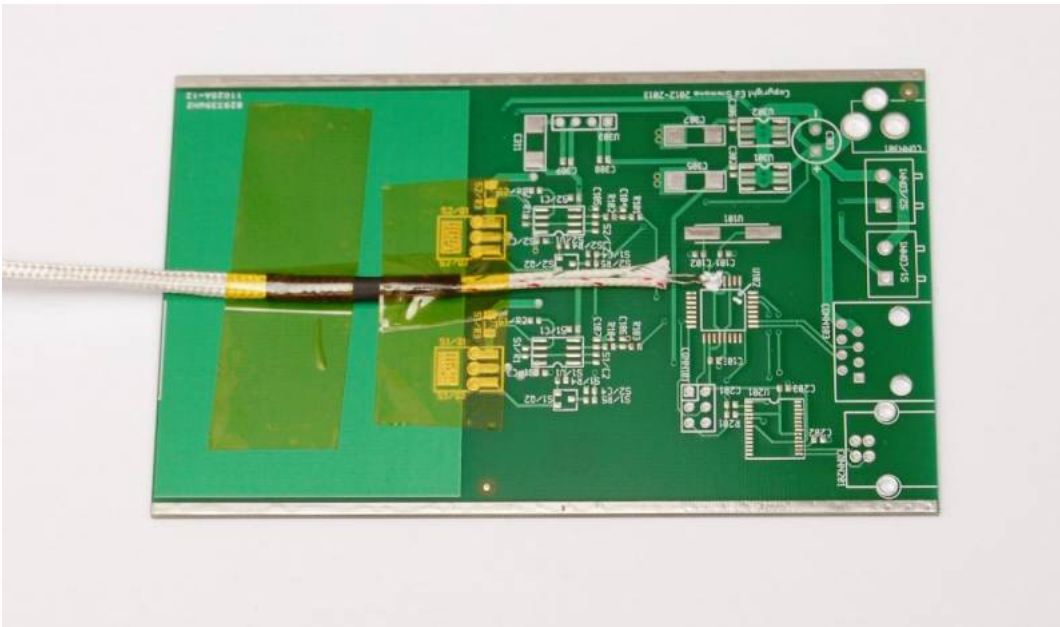
Secure the thermocouple cable with kapton tape while holding the tip in the correct location. Ensure the cable is well stuck down to provide some strain relief to prevent the tip of the thermocouple moving. It can help to strip back some of the outer layer of thermocouple sleeve.




Stick down the thermocouple cable securely with the tip held in the correct location

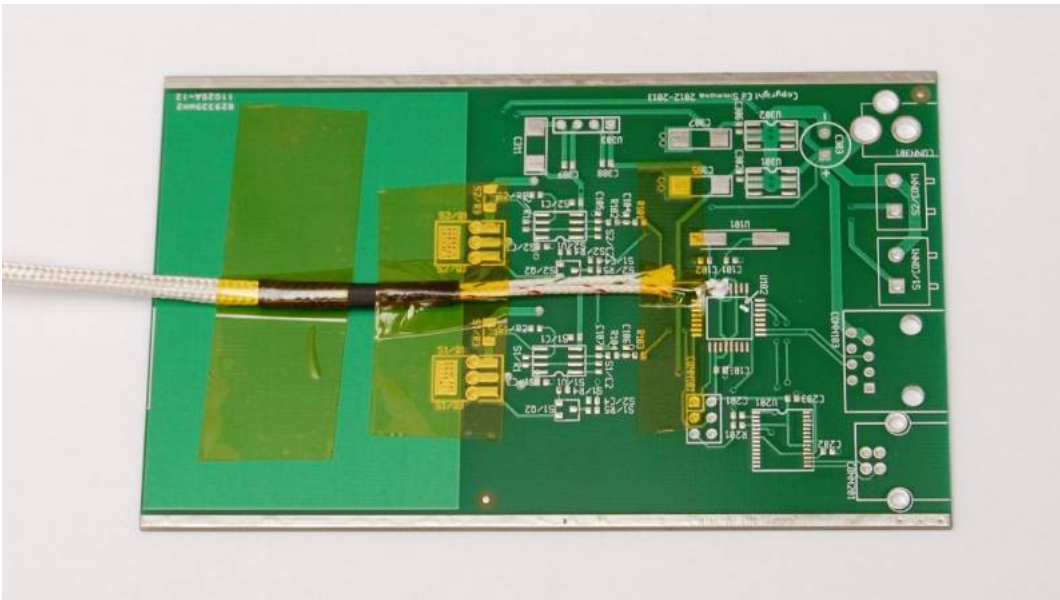
Apply heat sink paste to the tip of the thermocouple. Only apply a very small amount to ensure good thermal coupling between the PCB and the tip.






 Apply heatsink compound to the thermocouple tip

Apply a thin strip of kapton tape over the thermocouple wires, very close to but not touching the tip of the thermocouple. Ensure this is well stuck down and the tip is making good contact with the PCB.



 Apply more kapton tape to ensure good contact between the thermocouple tip and the PCB

Place the prepared PCB in the reflow oven, route the thermocouple cable out of the drawer at one side and fully close the drawer. Ensure the PCB is placed underneath the thermocouple mounted in the front of the oven. Plug the thermocouple into the thermocouple socket on the side of the reflow oven.

Run a test cycle and observe the temperature profile of the PCB. Make adjustments as necessary to the profile settings after each test profile, repeat until the profile temperature measured on the board is suitable for your parts and solder paste recommendations. Ensure the maximum temperature for the most sensitive part(s) are not exceeded.

Profile testing can be carried out by carefully watching the temperature reported for the PCB thermocouple, or by logging the data via the USB port and using the ESTechnical reflowViewer software (see below). Alternatively it is possible to use an external thermocouple meter to monitor the PCB temperature. Adjustments should be made to the profile settings based on the observed temperature of the PCB.

Ideal Fan idle speed Adjustment  
 If the PCB temperature does not closely follow the profile temperature settings, consider carrying out Fan Idle Speed Adjustment procedure.

#### Data Logging – ReflowViewer Software

ESTechnical provide a simple live data graphing application for use with the reflow oven, this aids adjusting profile settings and helps reduce the number test cycles performed for each design. The software allows easy adjustment of the reflow profile settings stored in the oven controller.

For more information, see <https://github.com/estechanical/reflowViewer> [<https://github.com/estechanical/reflowViewer>]

#### Operating Instructions

##### Starting a reflow cycle

Navigate to Cycle start in the menu and press OK. The controller will perform the cycle using the current cycle settings.

##### Stopping a cycle

Should you need to abort a reflow cycle, press the S key. The oven will move into the Cool down state. Observe the temperature on the display before attempting to open the drawer or remove boards.

#### Saving an edited profile

To save a profile navigate to Save Profile and press OK. Choose a profile number to save (by default all 30 profiles are the same, the user can save to any of these profiles) and then press OK. The profile is now saved in the chosen profile number.

Please note that any previous settings in the profile number you save to will be overwritten with the new settings.

#### Loading a saved reflow profile

Navigate to Load Profile and press OK, using the < and > keys, choose the profile number you wish to load. Press OK, the reflow profile settings will be loaded. When running a reflow cycle, these settings will now be used.

#### Editing the active profile

Navigate to Edit profile and press OK, then navigate to the parameter you wish to edit. The options are Ramp up rate, Soak temperature, Soak duration, Peak temperature, Peak duration and Ramp down rate. Press OK once you have selected the option to edit, the controller will display the value and allow editing using the < and > keys. Press OK to confirm your changes, or to cancel press Back. Repeat these steps to edit each parameter you wish to adjust.

When running a reflow cycle, the controller will use the settings as per your adjustment.

N.B. This process edits the variables stored in RAM and does not save the changes permanently until you save the profile.

#### Fan Idle Speed Adjustment Procedure

The oven's cooling fan is used to provide a small amount of air movement inside the oven, this helps the oven evenly heat the PCBs. The speed of the fan is important, too fast and the oven is being actively cooled while trying to heat up, too slow and the PCB will be heated unevenly.

The fan is run at a fixed 'idle speed' during reflow to provide a small amount of air movement in the oven. The fan should idle very slowly, to adjust the idle speed:

- Navigate to Fan settings in the menu.
- Press OK, Idle Speed will display on the screen.
- Press OK to edit. (The default value for the fan idle speed in T962A is 35, for the T962 the default is 15.)
- Test this idle speed by starting a reflow cycle, the fan should start up easily but not run so fast as to cause the oven to be cooled dramatically during reflow.
- It is very important this value is set high enough for the fan to start every time the cycle is started (at low values, the fan will not be able to start spinning) but it is equally important not to set this speed too high, otherwise the fan forces too much cool air into the oven and reduces the efficiency of reflow soldering.

If the PCB temperature profile does not follow the programmed profile settings closely:

- Set the Fan idle speed to a low value and ensure that the fan starts when a reflow cycle is started.
- Perform a test profile using a PCB with thermocouple and observe the resulting temperature profile of the PCB.
- Increase the Fan idle speed by 5-10 and repeat the test cycle without changing any profile settings.
- When the PCB temperature accurately tracks the programmed profile temperature, note the Fan idle speed value and ensure it is saved.

#### Profile tuning tips

To get the best from your reflow oven, it is advisable to perform a series of tests to determine the settings required to properly reflow each design of board you work with. Boards of different masses will behave differently and may require different soak duration, temperatures etc. to properly reflow all solder joints on the board.

Refer to the data sheets for all the parts you use to determine the allowable reflow profile for the design. Once the peak temperature of the most sensitive part is known, this must not be exceeded anywhere on the board.

The board's temperature lags behind the heat of the heater tubes, the oven controller is not controlling the board temperature directly, but the air temperature inside the oven via the thermocouple mounted above the PCB. However, the surface of the PCB will absorb more energy than the thermocouple directly due to the IR radiation, meaning that it is possible for the PCB temperature to overshoot the air temperature in the oven.

The PCB temperature should always remain below or equal to the profile temperature set using the controller; until cooling begins. If the soak duration is too long or the ramp rate too slow, the board temperature will exceed the soak temperature before the soak stage of the profile is completed. This will cause the temperature of the board to remain above the profile temperature that has been set, resulting in the peak temperature being higher than required.

There is an offset between the air temperature and the board temperature. Often, the peak board temperature is higher than the air temperature measured immediately above the boards. Be aware of this when choosing profile settings as a peak temperature of 220°C can result in a peak board surface temperature of 240-250°C. If the fan speed is set too slow, this offset can be even larger. Performing testing (see Reflow Profile Testing) will allow you to determine the best settings for a given board.

Towards the end of the peak stage of the reflow cycle, the board will reach its own peak temperature. During cooling, the air temperature needs to drop quickly below the melting point of the solder and continue to decrease to adequately cool the board.

#### Ideal Fan idle speed Adjustment

If the PCB temperature does not closely follow the profile temperature settings, consider carrying out Fan Idle Speed Adjustment procedure.

To work out the best profile settings adjust the following, one at a time, in small increments, in this order:

- Soak time
- Soak temperature
- Peak temperature
- Ramp up rate (as a last resort for heavy boards)

Repeat the test cycle to confirm the effect of the adjustment. If the PCB temperature overshoots the soak or peak temperature by more than 2°C, abort the reflow cycle and reduce the soak or peak duration appropriately. When the reflow cycle is aborted the oven will immediately begin cooling, wait for it to reach ambient temperature before beginning another test cycle.

Any of these changes alone can be enough to alter the profile to be suitable for your needs, take small steps to avoid large unexpected changes. A small change to the soak duration can have a large effect! The board temperature profile should not completely level off or begin to drop during soak, it should continue to climb slowly toward the desired soak temperature. If the board temperature exceeds the soak temperature before the end of the soak stage, reduce soak duration.

When viewing and adjusting reflow profiles, there are a few crucial points during the cycle to examine:



- When transitioning from soak to ramping up to the peak temperature, the PCB temperature should have almost equalised with the oven temperature. If the PCB temperature is rising past the programmed soak temperature, the soak duration is too long. If this occurs, the PCB temperature will likely be too high for the remainder of the cycle.
- At the start of the peak stage of the reflow cycle, the oven and board temperature should be a few degrees below the desired peak temperature, if the board temperature is overshooting the desired peak temperature, either increase the fan idle speed slightly or reduce the soak duration.
- When cooling down, the air temperature of the oven needs to drop a lot faster than the desired board cooling temperature to ensure the desired board ramp down rate is met. It takes several seconds for the air temperature in the oven to begin to reduce at the start of the cooling phase. Ensure that the duration of the Time Above Liquidous is appropriate for your solder paste and parts.

#### Care and Maintenance

ESTechnical recommend the following care and maintenance should be carried out at the intervals specified in order to get the best performance and longest useful life-span from your reflow oven.

#### Before every use

- Check that the oven has adequate air flow around it and that no grilles are covered.
- Ensure the drawer is clean and free from dirt, dust or other potential contaminants.
- Start a reflow cycle with no PCB(s) in the drawer, confirm that the main cooling fan starts to idle gently, abort the reflow cycle.

#### After every 50-100 reflow cycles

- Remove the drawer from the oven, clean the drawer and internal surfaces of the oven being careful not to damage the oven thermocouple or heaters. Flux deposits will harm the performance of the reflow oven, remove these with flux thinners or a dedicated reflow oven cleaner such as Electrolube ROC.

#### Packing list

- 1x ESTechnical Reflow Oven Controller PCB with LCD display
- 1x Membrane keypad
- 1x 9v AC transformer – 115/230v primary, 9v secondary
- 4x 12mm M3 standoffs – male to female threads
- 4x M3 Bolts
- 4x M3 nuts
- 2x 25A surface mounting Solid State Relays (SSR)
- 6x M4 x 16mm bolts with self-locking nuts
- 2x 50cm two pole signal cable with 2.54mm pitch header connector to bare ends
- 1x K type thermocouple
- 1x Installation manual
- 1x Operation manual

#### What you will need (not supplied):

- Screwdrivers
- Multi-meter (ideally with 250v insulation resistance test mode)
- Allen keys
- Wire cutters
- Wire strippers
- Crimp pliers
- Small pliers to help grip the nut when fitting the Solid State Relays (SSRs)
- Electric drill
- Various sizes of drill; 2mm and larger suitable for drilling steel
- Sharp pencil for marking panel
- Center punch and hammer (for marking where to drill)
- Metalwork files
- A container for screws
- Soldering iron
- Solder
- Hot glue gun and glue sticks
- Hot air gun or other suitable tool for shrinking heat-shrink sleeve

EC Declaration of Conformity

In accordance with EN ISO 17050-1:2004

We, ESTechnical

of

12 Ormonde Road,  
Folkestone,  
Kent,  
CT20 1PG,  
United Kingdom

in accordance with the following Directive(s):

2004/108/EEC	The Electromagnetic Compatibility Directive
2011/65/EU	ROHS 2

hereby declare that:

Equipment:  
ESTechnical Reflow Oven Controller

when installed and operated as per the supplied instructions the equipment named above complies with all applicable Essential Requirements of the Directives.

Signed by: Ed Simmons



Position: Founder

Carried out at:  
ESTechnical  
12 Ormonde Road,  
Folkestone,  
Kent,  
CT20 1PG,  
United Kingdom

on  
16th September 2013



