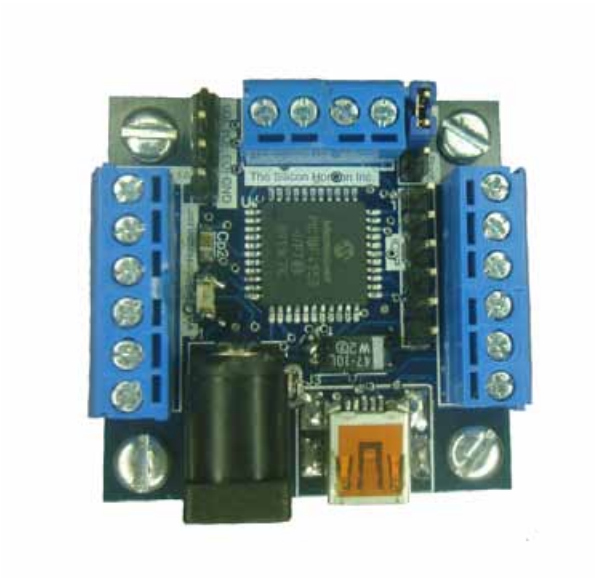
techFX Reflow 3.0 controller and techFX reflow tools

Visit our webpage for tech support and forums

http://www.TheSiliconHorizon.com/



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Warning and user agreement of liability

This product, techFX reflow controller and techFX reflow tools is designed to interface to a USER's method of interfacing to a toaster oven or other such device. Therefore, it is YOU the user that is liable for any such failures, misuse of said target device (for other than such designed ie: cooking food) injury, death, and fire that may result.

By using our product, you agree not to hold The Silicon Horizon responsible for liability from the application of your interface method, or any mishaps that may happen as a result of the interfacing to an oven or other device.

This manual recommends several methods to guide the individual for safety reasons and should only be used as a guide.

Toaster oven wiring and house current WILL KILL you! If you do not know what you are doing, or have no experience with these items or with electronics, then do not use this device. Learn safety procedures for handling and routing AC wires and wiring outlets prior to doing this project.

System requirements:

Operating system

You must have NET 2.0 framework distribution installed to run this software. You can do a web search for "dotnetfx.exe" or use the following link:

http://www.microsoft.com/downloads/details.aspx?FamilyID=0856eacb-4362-4b0d-8edd-aab15c5e04f5&displaylang=en

TechFX tools has been tested to work in Microsoft Windows XP SP2 and Windows Vista. To run the software in Vista with UAC on, you must run the program in Administrator rights mode. You also must right click the program, and run it in “windows XP SP2 compatibility mode”. You should also go to the control panel and find the “PIC 18f4550 family device” driver and go to the power management tab, and disable the power management feature of Vista for that device driver.

You should also disable power management feature in the driver properties in Windows XP (control panel / other devices / pic18f4550 family / properties / power management)

Cables and power supply

You will need a free USB 2.0 port, mini-USB cable and an AC/DC wall adapter with 6-9v DC output, 2.1 mm jack Center positive, regulated output. The board will not run on USB power alone. You must have the wall adapter plugged in to operate the controller.

TechFX reflow controller overview

Hardware features:

- small 1.5"x1.5" size on High Tg PCB 4 layers
- upto 500 deg Celsius temp control!
- AD597 K-type thermocouple amplifier
- 256K I2C serial eeprom for storing profiles and settings
- I2C interface for matrix orbital LK204-25 LCD and keypad with supported firmware and software
- serial port for low cost LCD solution for users wishing to develop their own LCD interface
- USB fullspeed 2.0 communications
- 5 volt 800 mA LDO voltage regulator will power your LCD
- 12 bit A2D
- 12 MIPS 48 MHz Microchip 18f4553 MCU
- USB bootloader for firmware updates
- ICSP port for ICD2 or Pickit2 programmers
- all screw terminals
- 2.1mm CP power jack takes 6-9 volts DC
- 5 IO pins for user expansion which can be used for switches etc (1 INT pin)

Software features:

techFX reflow tools:

- setup any keypad on LK204-25 matrix orbital LCD
- change PID gains as needed
- load and program ramp profiles to/from controller, up to 15 of them, can be used standalone also
- use excel spreadsheets for profiles when controlling from computer
- view, print, save reflow graphs in real-time
- monitor oven output while operating from keypad
- use boot loader to update firmware to add new features
- Create profiles from a few minutes in length to two days in length!!! (intended for drying functions of some components, and curing of composite materials and other such applications.

Required equipment to use this controller

- K type thermocouple from Omega Engineering Inc. www.Omega.com (see thermocouple page for recommended parameters)
- power toggle switch rated at wall adapter voltage (6-9 Vdc, and de-bouncing is accounted for in firmware)
- solid state relay (should be about 20-25 amps) or other interface circuit to switch the oven, 2nd relay needed if you are using the Fan option
- AC/DC power adapter 2.1mm CP jack, 6-9 v DC regulated (no AC transients, switching adapter is preferred—we carry switched adapters!)
- some type of enclosure for safety to shield all the wiring DO NOT mount in or to oven
- power cord and plug to handle up to 15 amps (or more depending on your choice of oven)
- strongly recommend a breaker-type wall outlet for safety (15-20 amps) or ground circuit interrupter that you can mount in the case.
- donor toaster oven (Infrared preferred such as the Black and Decker Infrawave)

Optional equipment for your project

Supported LCD and Keypad I2C interface

- Matrix Orbital LCD p/n LK204-25 with I2C interface www.matrixorbital.com (make sure you get the breadboard cable from them also, it has a connector on one end and 4 wires on other end)
- Keypad to use with LCD (connect to LCD above) can be found on the same website. Other keypads may be used but must have a 0-9, +, - keys.
- This LCD and keypad option is already coded for in our firmware and windows GUI. You can setup the keypad through the GUI and program profiles to run on standalone control.

User supported LCD via Serial interface

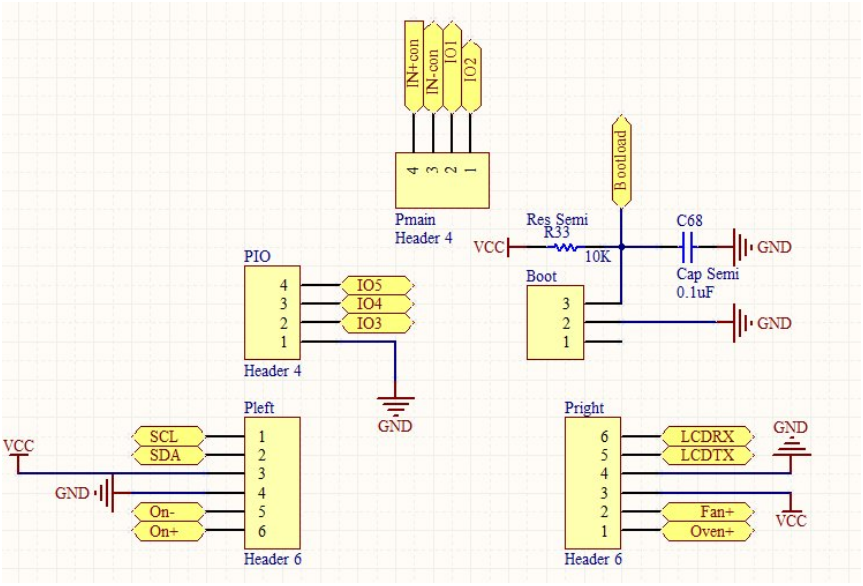
- Any cheap serial LCD that runs on 5 v. You must generate your own code to output to this LCD.

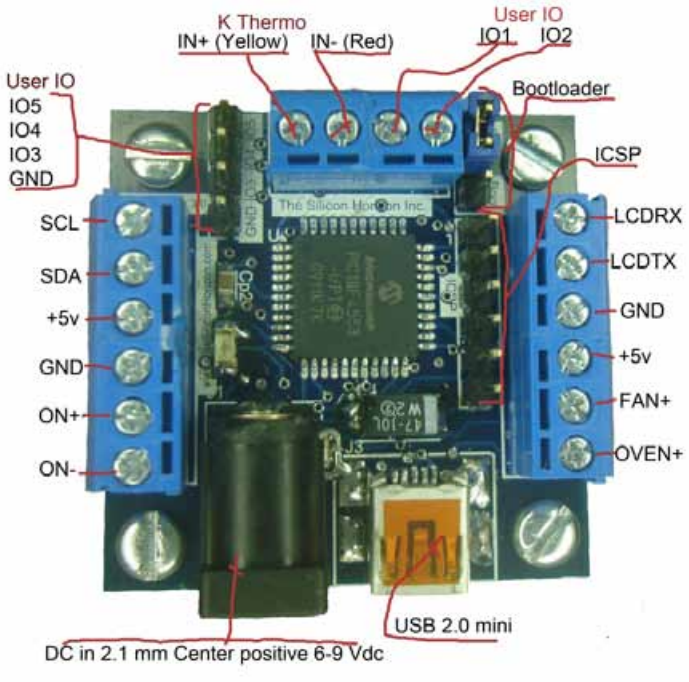
Other miscellaneous (if needed)

- DC panel mount power jack from www.action-electronics.com (2.1 mm CP)

- heat sink for SSR allows firm and safe mounting position and heat dissipation (minimal generated in this application)
- Mini-USB 2.0 panel mount jack
- Fan SSR or other relay for driving the system down and cooldown stages

Reflow controller diagram





IO lines and hookups

On switch+ and – terminals (REQUIRED – WILL NOT OPERATE WITHOUT IT)

These terminals allow the hookup of a toggle or pushbutton switch. De-bouncing is handled in software, so the user does not need to handle that or buy a special switch. Cheap panel mount toggle switches can be purchased from RadioShack. The switch should be SPST (single pole- single throw). Simply hook up the 2 leads to the power switch terminals, they can be connected in any order. The switch should be rated for the wall adapter output voltage (6-9 Vdc) operation.

Oven relay+

This is the output from the PID algorithm, and is used to switch the oven on and off. This output will go to your interface circuitry; although most people would use a solid state relay for simplicity and safety. Other interfacing options can be a triac with a standard relay, but that is left up to the user. Use this output along with the GND terminal to interface to your USER circuitry or SSR.

I2C terminals

The SDA, SCL, +5v, GND terminals are the pins you need to connect to your Matrix Orbital LK204-25 LCD unit (with I2C interface). The I2C interface works at the default speed setting of the LK204-25 which is 100 KHz. Your keypad then plugs into the LCD.

Thermocouple IN+, IN-

This terminal is the + and – of your thermocouple that you purchased from www.omega.com . The yellow lead is + and the red lead is – (please refer to your thermocouple data sheet to verify polarity and colors of leads). You can use any K-type thermocouple, but it is suggested that you use a quality one with an insulated sheath. Yellow is +, Red is minus for K type thermocouples.

Fan relay+

This terminal provides the control output for driving the system down and also when the system is in the cooldown mode. A fan to bring in cool air, or take out hot air (thus sucking cool air in) can be used. Do not connect a fan directly to the pin as it can only sink 25 mA, you must use a relay and depending on the Fan current draw you might be able to use the +5v line as long as the current consumption does not exceed 600 mA for the fan.

Serial RX and Serial TX

These are the serial lines for User-code supported LCD's and other serial devices. The TX terminal connects to the RX pin on the MCU, and the RX Terminal connects to the TX line on the MCU—therefore, no switching is required between these pins and the device. These lines operate on 3.3 volt digital TTL but

ICSP port

The ICSP port allows users to program the device using an ICD2 or Pickit2 programmer. Note pin 1 is denoted on the controller. Bootloader jumper may cease to function if you overwrite the bootloader program in the boot block of the device. To fix this, you may reprogram the device with the bootloader using the ICSP port.

User IO lines (IO1 through IO5)

These lines allow a user to add switches, buttons or LEDs to their project.

The IO pins are mapped to the MCU pins as follows:

IO line	MCU pin	Type of pin configurable
1	PORT A1	Analog input 1, Digital input / output
2	PORT A2	Analog input 2, Digital input / output
3	PORT A3	Analog input 3, Digital input / output
4	PORT A5	Analog input 4, Digital input / output
5	PORT B2	Analog input 8, Digital input / output, Interrupt pin 2

Bootload jumper

The bootload jumper allows you to use the software bootloader instead of the ICSP programming port to upload a new firmware to the controller. Set this to OFF (text is “boot”) to enable normal operating mode. If you use the ICSP port to program a new program, you may overwrite the bootloader accidentally if programming steps are not followed. Set this to ON (“ON” text) and power cycle the board to enter bootloader mode.

Choosing a thermocouple to use

We recommend you use an ungrounded thermocouple. This is handled on the controller. If you are using long thermocouple leads (36 inches or more) you may need to put a 1K resistor between ground and Negative thermocouple lead to handle bias generated in the lead do to excessive length.

You should use an open element thermocouple as the open element ones have a lower time coefficient. The time coefficient is the time it takes to absorb the temperature in the element and thus we want this to be as short as possible in our application.

Wire diameter also plays a role in time coefficient and having one too thick will hurt your absorption times.

Lead length should not be too excessive, however It can be compensated for with the 1K resistor and also there is an ADC software “middle” filter to handle noise generated in the leads due to unknown sources.

Pick a sheathing type such as glass bead as they are pretty cheap and durable. Don’t rub the thermocouple against bare metal as it is likely to cut the sheathing and cause shorts between the two lines.

This link will assist you in learning about thermocouples.

http://www.omega.com/thermocouples.html

This link is the 5TC series and comes in a package of 5 thermocouples. This is what we use on our reflow ovens.

http://www.omega.com/ppt/pptsc.asp?ref=5TC&Nav=tema02

Choosing an oven

Choosing the right oven can save you a lot of trouble. The test setup for this controller was done using a Black and Decker Infrawave toaster oven. This oven is ideal since it is easy to hack, and provides us with a quick heating response using the infrared elements.

Some questions to ask yourself when purchasing an oven are:

1) How easy is it to hack the safety door open shutoff switch
2) How easy is it to rewire so elements are on all the time
3) How easy to drill hole in oven chamber

The wattage of the oven determines the amount of amps you will be running through it. Divide the wattage by the voltage and that is your maximum amperage. This is what you need to design for in your circuit breakers, and the power cords you use. Try to find the highest wattage you can get for the cheapest money. Remember if you are doing Lead-free solder paste work, then you need to hit a higher temp than Lead based products. Also more wattage will give you faster rise times at higher temps while low wattage ovens may struggle. Chamber size and ambient temperatures all play a factor in that.

Hacking the oven

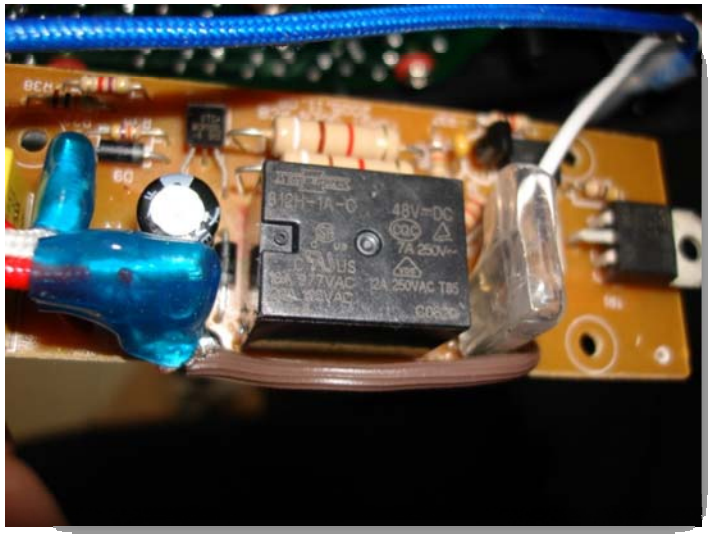
Warning! House current will kill you! You will assume all liability for anything bad happening as a result of your inexperience and/or accidents that may occur. You will not hold us responsible for your implementation of this project as it is your project.

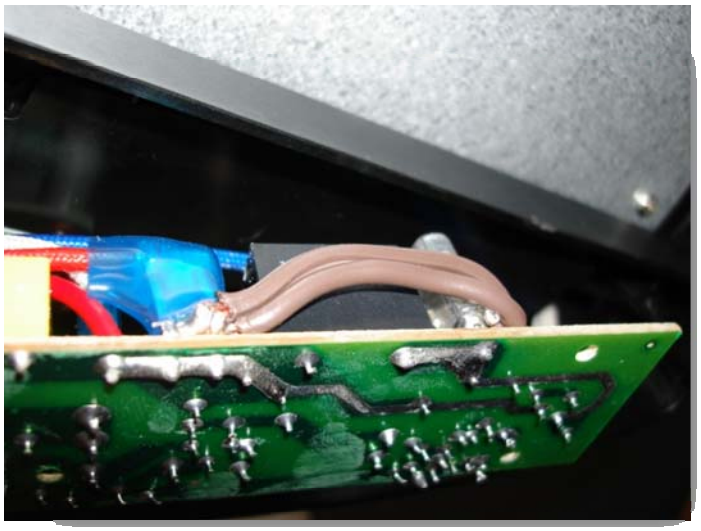
Basically all we have to do to a toaster oven is make the elements work all the time it is plugged in, and disable the door open cutoff switch.

Using our Black and Decker Infrawave, we used a machine screw to take care of the door open switch.

Next, we drill a hole in the back of the oven for our K-type thermocouple to protrude through, it is recommended you use some type of fitting so the edges will not wear out the protected sheathing of the thermocouple.

Next, we modify the circuit board to allow our elements to run all the time the plug is plugged in. On the Infrawave, this is done by bypassing the relays for both the top and bottom elements which can be seen by looking at the circuit board. You can solder in a wire to bypass it, or you can permanently make the relay go on by providing a ground to the ground pin. We chose the bypass method since we had plenty of 16 gauge zip cord, we used 2 pieces just for good current flow. Note that you should use protected heat shielding on any wires you add in here as they do heat up. High temp solder is also a good idea.





Note the above pictures only show the top element relay bypassing. The bottom relay is marked “bottom” and is on the other side.

That’s it for oven hacking! If you drill straight through the back, then you really don’t even have to take this oven apart at all. That’s what makes it a good donor oven.

Once again, whatever oven you choose, be careful! This amperage will kill you no questions asked. If you don’t know what you are doing, then please get someone who does know. There is no tolerance for mistakes in working with house current.

Make sure the oven is unplugged when working on it or whenever any panels are off, or wires are not protected. Make sure you use common sense.

Hooking up the Matrix Orbital LK204-25 LCD and keypad

The I2C LCD and keypad option currently for this controller is the LK204-25 LCD with any keypad (8 or 10 pin) that has a 0-9,+,- keys on it.

When you get the LCD, you may have to remove two solder bridges (or SMD zero ohm resistors) to change the configuration from serial RS-232 to I2C mode for this model LCD. Please refer to matrix orbital's documentation on where to find them and how to do it.

The LCD otherwise should come with a default I2C baud rate 100 KHz. Just leave that setting and others alone! All you need to modify is the I2C hardware mode of operation described above.

You will also need the board connection wire that they sell on their website, it has a 4 pin connector on one end, and 4 wires on the other.

To connect the wires to the reflow controller, connect SCL, SDA, +5 volts, and ground to the appropriate terminals and screw them down tightly.

You may use any keypad 8 or 10 pin as the LK204-25 allows since our software techFX reflow tools allows you to setup the codes for each key prior to using it. It then stores that setup information in the controller. That being said, you could hookup the keypad connector upside down and just do a new setup in techFX reflow tools, it will read and program the different values accordingly.

Matrix orbital also sells the keypad and the breadboard cable that you will need to split up the 4 pin connector to its respective wires.

Using the boot mode feature

The controller has the feature to upload a new program to the chip through the USB port. No special programmer or other device is needed. You may use the software techFX tools to upload your new program to the board if you are writing you own firmware or have found one on the web.

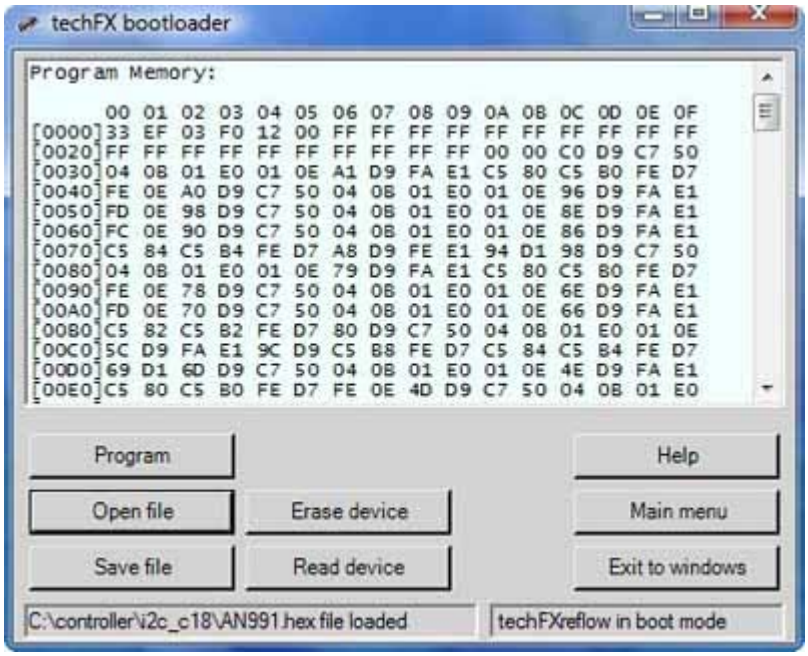
To put the controller into boot mode, locate the jumper marked “boot”. Move the jumper to the “on” position (to the inside of the board) and cycle the power switch. Once the controller restarts, it is now in boot loader mode and awaiting a new program to be uploaded to it.

Now you must use techFX tools to upload that firmware into the controller.

Once that is complete, move the jumper to the “off” boot position and then cycle the power switch. Note that once you cycle the power switch, your newly uploaded firmware will start to run.

TechFX Reflow Tools

Use of the boot loader



Programming a firmware hex file into the controller

Note: make sure the status bar shows your controller in "boot mode" as above.

1. Open file

Click open file to load a Hex file into the program. The screen is updated with the contents of the hex file. If it is invalid an error message is displayed.

2. Connect controller in boot load mode

Connect the controller to a USB port. Make sure you set the boot load jumper to the on position and cycle the power switch. The status bar indicates "techFXreflow in boot load" if it is in boot load mode. If the status bar indicates "techFXreflow in normal mode" then you must set the boot load jumper to on and reset.

3. Program controller

Once a controller is connected and in boot mode, then the program button will become enabled. Press the button and the controller will be programmed. Do not disconnect or reset the device until the status says "write completed". If it fails, then reset controller and try again (cycle power switch). Once complete, move the boot load jumper to off position and cycle the power switch. Then it will be in normal mode.

Other options

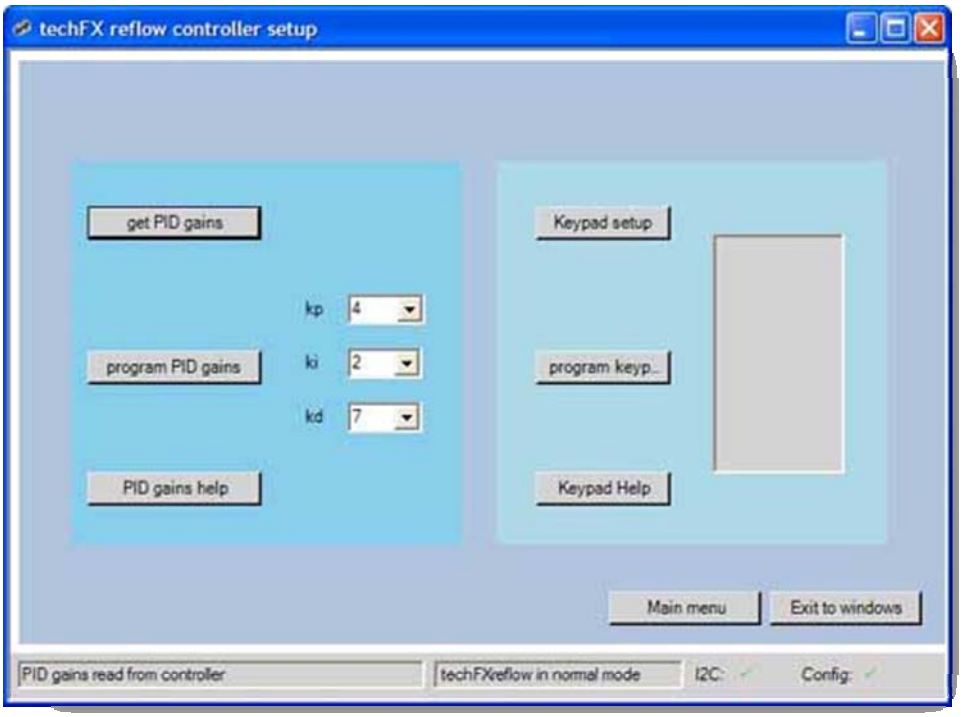
Erase device

Erase device allows you to erase the program space before programming. It is recommended but not necessary before programming a new firmware to the controller to do this.

Read device

Read device reads the contents of the controller into the current display window, thus allowing you to save it to a file for backup purposes.

Using the board setup screen



Note: make sure the statusbar shows your controller in "normal mode". You should have a green checkmark next to I2C and Config.

Setting up PID gains

A PID algorithm uses proportional, integral, and derivative gains to adjust the output of the system. Our modified PID algorithm adapts this to a slow responding toaster oven for maximum control and accuracy.

The proportional term is the gain multiplied by the current error. Ie: kp * (targettemp-currenttemp)

The integral term is the accumulated errors added up multiplied by the integral gain term ki.

The derivative term is the slope multiplied by the derivative gain.

As you can see, the gains determine how much of a factor each element contributes to the system since the output is determined by:

Output= proportional + integral +derivative

A proportional only system will have big overshoots and slow time to target temperature. And may oscillate when the gain is set to high.

A proportional – integral system is better, but may have oscillations when the accumulated error maxes out (as it may in slow responding systems).

A PID system is the best of all, as it achieves the target temp in the quickest amount of time and with the least amount of error.

Generally you should start with all gains equal to 1. Then add proportional gain until the system oscillates in the steady state, then back off until good again. Note that there is an inherent error associated with toaster oven control that is about +/- 5 degrees Celsius on our test oven and may vary depending on the oven you use.

You should add derivative next, as you should note that you will now achieve a close value to your desired target temperature with less overshoot.

Keep your integral value low, (preferably to one) because integral windup is a problem in slow responding systems such as this.

Derivate gain may generally be as much as 5 times the proportional gain, however is very much dependent on the oven response and the oven you are using.

You may find that a low proportional gain works best for you, as this controller is pretty fast and scales the values really quickly.

You have to keep experimenting on the SAME reflow curve with different PID values to find the ones that best fits your needs.

Pressing the program button will set the gains to the controller. The controller will automatically load these values every time it starts up.

Pressing the load button will show you what is currently in the controller.

NOTE: in the newer techFX tools version (2.0 and above), all of these functions are available in the pull down menu.

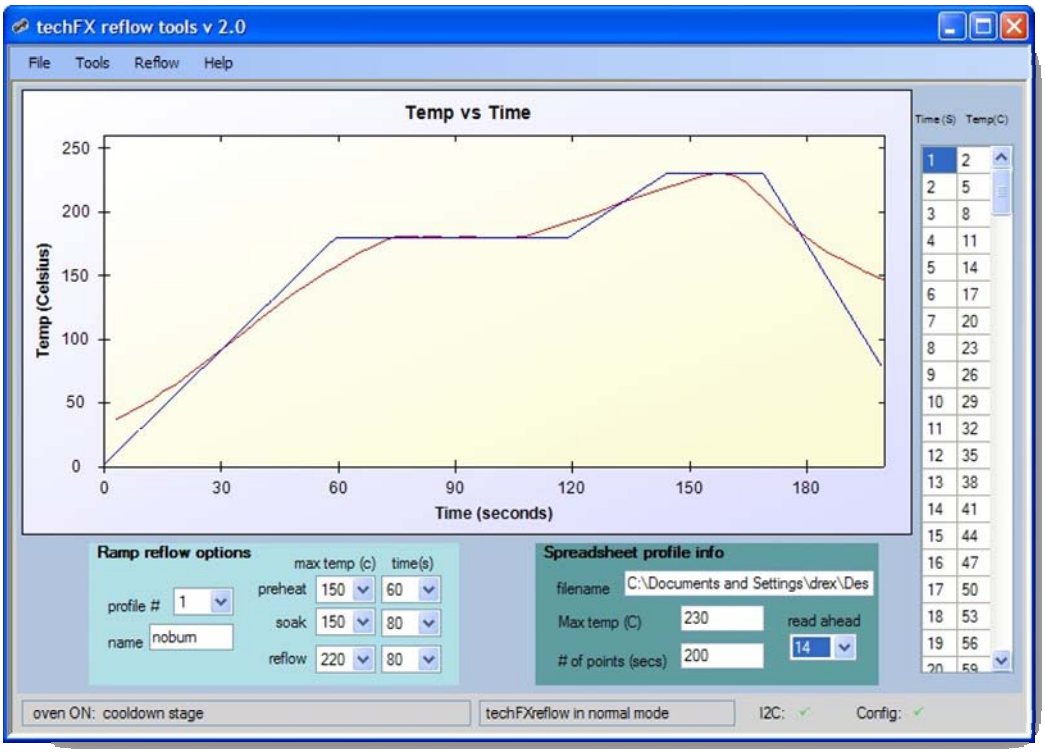
Setting up the keypad (only with LK204-25 Matrix Orbital LCD)

Pressing the “setup keypad” key (or menu item depending on version) will bring you through the process of setting up the keypad. You must only press the button it tells you to one time and it will show the corresponding ASCII value in the box. If it displays error, then most likely the key was not pressed hard enough. If an error happened, you must go through the whole setup again until no error occurs. Only then will you be able to program the keypad.

On programming the keypad values to the controller, the controller resets, and the controller is now capable of standalone operation from the keypad and LCD.

See LCD section for what types of keypad you may use.

Using the reflow oven screen



Note: make sure the statusbar shows your controller in "normal mode" You should have a green checkmark next to I2C and Config.

Setting up a Ramp profile

You should try to emulate the profile for your solder paste or component as closely as possible. This may be found in the documentation for it on their website.

Ramp profiles are composed of the following stages:

1) Preheat
2) Soak
3) Reflow
4) Cooldown

The preheat stage brings the oven up to the desired soak temp.

The soak stage brings the part up to temperature and removes any moisture, etc.

The reflow stage is the most important, it brings the solder paste to the required temperature for the required amount of time to cause reflow.

The cooldown stage is of the manual variety, you simply open the oven door and a natural cooldown curve begins. The LCD will display cooldown until it reaches approx 60 deg Celsius.

You may specify the desired maximum temperatures in Celsius for the given stage in the combo boxes pictured above. You may also specify the maximum time allowed for that stage. If the oven fails to achieve that temperature in that time period, it will go onto the next stage and try to achieve the next desired temperature.

NEW in version 4.0!!

Now you may select whether the units displayed in the pulldown boxes are seconds or minutes. This allows you to create extended profiles of upto 2 days in length when using minutes as your update interval.

Note that the refresh rate box also uses this selection method, and that is the interval for each data point on the graph.

Programming a profile

After selecting all of the maximum stage values for time and temperature, we then select a profile number from 1 to 15.

We can then type in an alphanumeric name in the name box up to 8 characters long (this name will be displayed on the LCD if you have an LCD connected).

Pressing the program button, the profile is programmed into the according profile number slot, and a confirmation message appears on the status bar indicating success or failure.

Newer techFX tools version 2.0 and above:

All of these functions are available in the pull down menus.

Additionally, you may load all of the profiles # 1-15 from the controller to techFX tools at once or program all of the ramp profiles #1-15 from techFX tools to the controller at once.

NEW in version 4.0!!

Now you may select whether the units displayed in the pulldown boxes are seconds or minutes. This allows you to create extended profiles of upto 2 days in length when using minutes as your update interval.

Note that the refresh rate box also uses this selection method, and that is the interval for each data point on the graph.

Loading a profile

First you must select a profile number, then you can press the load button to load it from the controller. The confirmation is then displayed in the status bar indicating success or failure.

Excel profiles

Loading an Excel *.XLS profile

Selecting the “Load spreadsheet” menu item will bring up the open file dialog box. Please then select a *.XLS excel file to open. Note that XML *.XLSX files are not supported at this time.

The graph is updated with your excel file values and the data is displayed in the box at the right. If you have your controller connected, then you may now select “Start spreadsheet profile reflow session” from the pull down menu.

If your spreadsheet produce an error, please use our example spreadsheet on the CDROM as a guide in producing your own spreadsheet and follow the following rules:

1. The 1st column starts at A,0 and goes down using integers (1,2,3,4,5,6,7,8,9,10 etc) and each number stands for 1 second. You may not put any other data in these boxes, just number integers. Please number sequentially for your entire reflow profile; ie: if it is 300 seconds then you should have in column 1 starting at A,0 1,2…..299,300.
2. The 2nd column will contain the temperature (in Celsius) from 1 to 460 deg C. the Row corresponds to the time in seconds you want that temperature to be in your profile. Therefore, if we have 20 next to a “1” in A,0 then that means we wanted 20 deg Celsius at time=1 second.
3. No other data or strings can be present on the spreadsheet. All other cells must be blank. Do not use special formatting or fonts.

Please see the example on the CDROM or in the image distribution which can be downloaded from the forums section of our website.

Note:

Excel spreadsheet time values are unit-less. You choose whether the time value is seconds or minutes AFTER loading the spreadsheet in techFX tools.

Starting a reflow session

To start a reflow session, first you must connect your controller, and it will appear in the status bar as “techFXreflow in normal mode” with two green checkmarks indicating a good status.

If we are doing a ramp reflow session, then we must either select new values for the maximum temps and times, or load a profile from the controller.

If the data displayed for the stage times and temp are satisfactory, we then press the “start ramp profile reflow” menu item to proceed.

If we are doing an excel spreadsheet reflow session, we have first loaded our excel file and it is displayed in the graph in blue. We can then goto the menu item “start spreadsheet reflow session” from the pull down menu and it will then begin. Before you begin the spreadsheet reflow session it is a good idea to select a value for “read ahead” in the spreadsheet box. This value will be tailored for your particular oven and will drastically improve the response of your oven to the XLS spreadsheet file.

The graph will now update and the oven will turn on. The graph updates in real time approximately once every 3 seconds and the data is displayed as a red line.

The current reflow stage will appear in the status bar on the bottom of the screen.

When the cooldown stage hits, you should open the door of the oven to aid in cooling. Note that the cooling stage will stop when the temp hits 60 degrees Celsius. WARNING! The parts and oven is still very hot! The reason this setting was set to 60 C is that the ovens retain a residual heat for a very long time, and we set this value a little higher for people who wanted to conduct multiple batches repeatedly. You should wait an additional amount of time until it cools so you don’t burn yourself.

The current maximum time limit for all stages together is about 10 minutes. This can be changed through a custom firmware, please email tech support if you need a greater length of time. This is done for safety reasons.

After cooldown is complete, you may right click on the graph to save or print out the graphed response of the oven.

When doing a computer initiated reflow session, the LCD will display “computer” on it.

Monitoring oven function

The “monitor oven” function is used when you are using the keypad to initiate a reflow session. This will give you a better idea of the response of the oven that the LCD can tell you. It can graph up to 10 minutes in length and has many of the same features as the “start reflow” function.

Using the controller standalone with Matrix Orbital LK204-25 LCD and keypad

The controller may be used standalone with ramp profiles only, and an “on the fly” parameter entry. Excel profiles are not supported when not connected to a computer. The current firmware support the Matrix Orbital LCD and Keypad option only. All other LCD’s must use user-modified firmware to work properly.

After you setup the correct PID values for your target oven, setup your keypad, and program some profiles into the controller; then you are ready to run in standalone mode without a computer.

It is strongly recommended that you test all profiles out on the computer first to visually verify the correct response needed for the solder paste or part you are using. Only then is it suggested that you use the controller in standalone mode from a stored profile. This method will keep you from wasting parts.

The main menu appears as follows:

The Main menu allows you to choose a custom reflow session (entering values from the keypad) or choosing a stored profile programmed from the computer using techFX reflow tools.

Custom menu function

Choosing the “custom” function will bring you into the parameter entry screens where you will enter the values for the maximum temperatures and times for each of the 3 stages (pre-heat, soak, and reflow). The fourth stage (cooling) is done by opening up the oven door and monitoring the temperature.

When asked for a value, you must enter a 3 number value.

IE: 80 seconds would be “080”

And 80 degrees Celsius would be “080”

To cancel out of this parameter entry, press the minus key.

Then after being prompted to press minus key to begin, the stages are displayed as follows, showing current time (in seconds) in that stage, and temperature in celsius.

When cooldown is complete, the controller resets and brings you back to the main menu.

Profile menu option

Choosing the Profile menu option will allow you to choose a preprogrammed profile from techFX reflow tools.

You may press the + and – keys to scroll through the 15 ramp profile slots on the controller. The profile name is displayed. To use that profile, press the corresponding numeric key next to that profile name. It will then prompt you to press the minus key to begin, and then the reflow session will start as in the custom menu function.

Monitoring a keypad reflow session

You can use the “monitor oven” function of techFX reflow tools to monitor a keypad initiated reflow session.

Device characteristics

It is strongly suggested that you use a switching regulated power supply. They cost about the same money, but it will keep out any unwanted AC signals and noise from the controller. !!

The controller only works with a AC/DC adapter plugged into it, it will not work on USB power alone since it draws too much current for that task.

Max current consumption: 800 mA

DC input voltage: 6-9 volts

Max mA per IO pin: 25 mA

Total mA for all IO: 200 mA

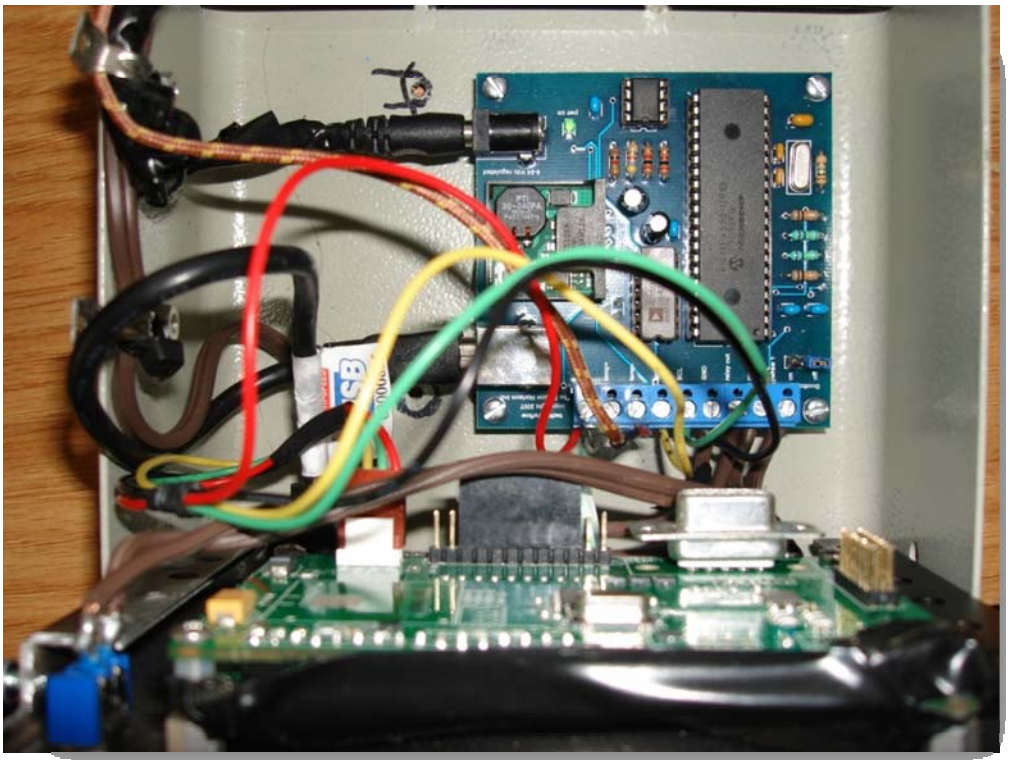
For other specifications, please refer to Microchip's PIC 18f4550 datasheet.

Pictures of our test setup

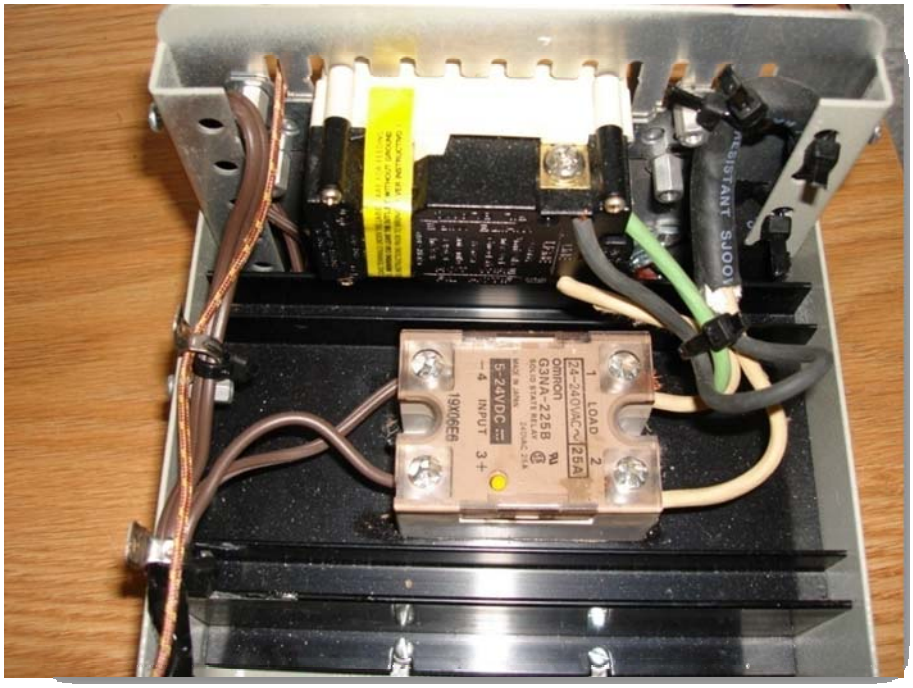
These pics were taken with our techFX reflow 1.0 controller test setup.

Make sure you use a big enough enclosure! Had to trim the keypad up a little to make everything fit. Don't mind the electrical tape, we need to employ a metal worker ☺

This is right behind the faceplate. You see the back of the LK204-25 LCD unit with the keypad connector in the bottom of it. The yellow, red, green, and black wires run from the LCD to the controller. You can see the power switch was hooked up using 16 gauge zip cord. The USB connector is from www.datacorp.net (reflow 2.0 controller needs a mini-USB connector). The DC power runs to a DC panel mount power jack on the back plate. Make sure the controller is screwed down good. You don't want any shorts.



Here is the business part of things, The Omron SSR and the breaker type wall outlet. All we do is break 1 wire to the relay. Note that we have the ground hooked up on the wall outlet for safety. This wall outlet has a 15 amp breaker in it, and will turn off the power in case something goes wrong. The outlet should have a metal box around it, consider this a non-example of how to do it safely. Make sure you mount the SSR really firmly. The heat sink is more for a good mounting point than for heat. Not much heat is generated in this application.

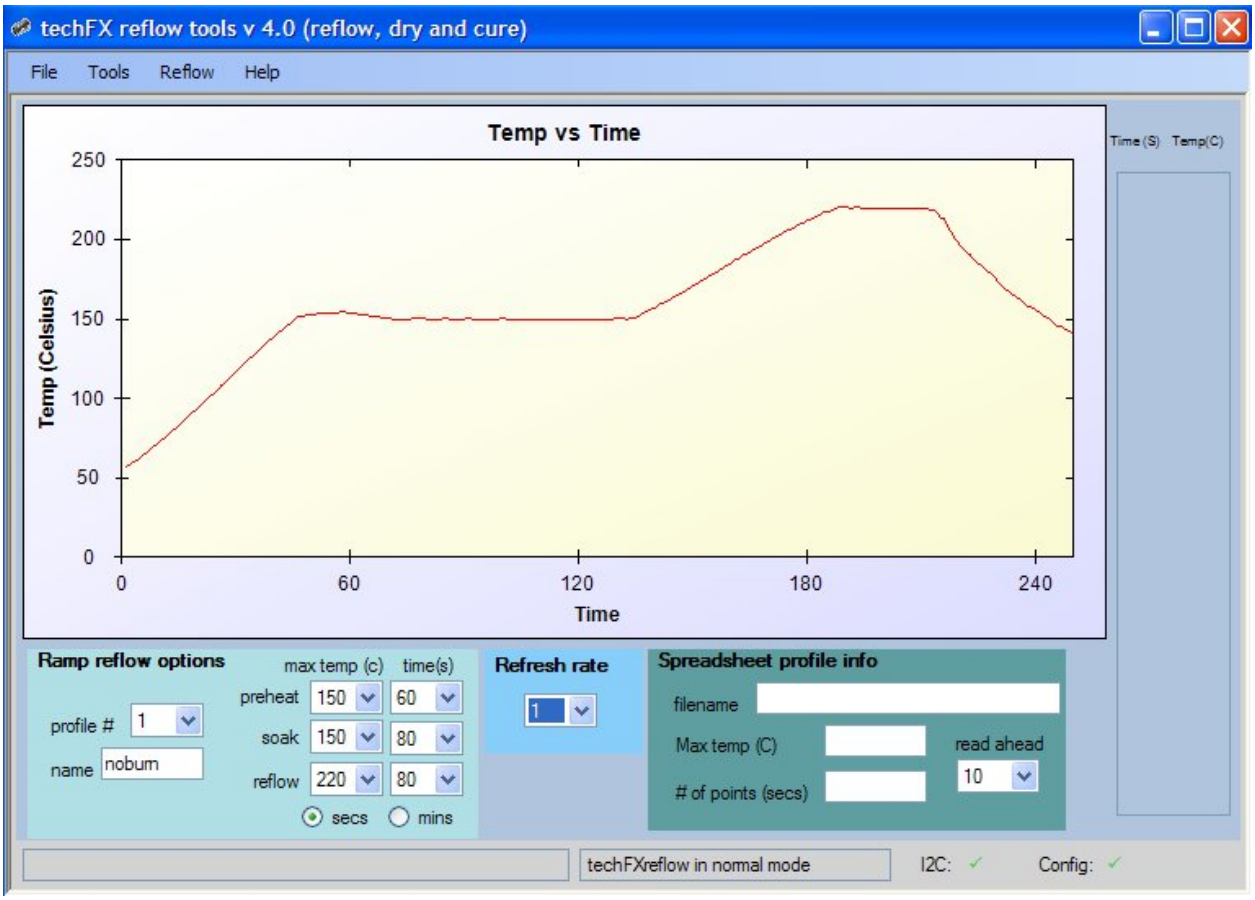


This is the back-end of our example. The outlet has a breaker in it to shutoff the current if something goes wrong, it is a really good idea for safety. The wire on the left is our thermocouple, you must use the thermocouple all the way to the controller, you cannot solder other wires to it!

Example profiles and settings for techFX reflow 3.0 controller all using Custom PID firmware

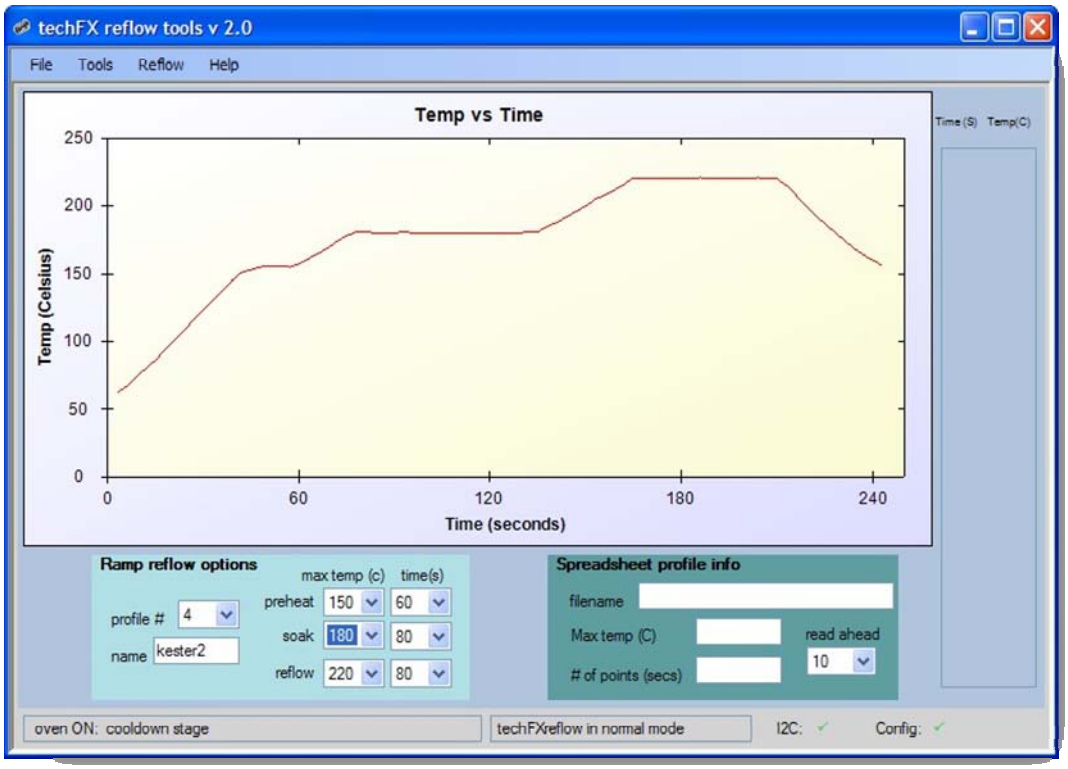
Shenmao water-soluble www.SMTsolderpaste.com profile kp=1, ki=0, kd=3 (techFX tools v 4.0 and techFX reflow 3.0 controller) for Pb (2.5 mS period)

The Shenmao (Manncorp) at www.SMTsolderpaste.com is a low cost alternative to Kester products. This reflow profile is what we use most often on Pb paste. It's a short time length profile compared to traditional Kester profiles results in the infamous "noburn" profile which you will find on your controller initially. This profile is well tested on the water-soluble Pb version solder pastes (as Pb solder paste has a lower reflow stage temperature)



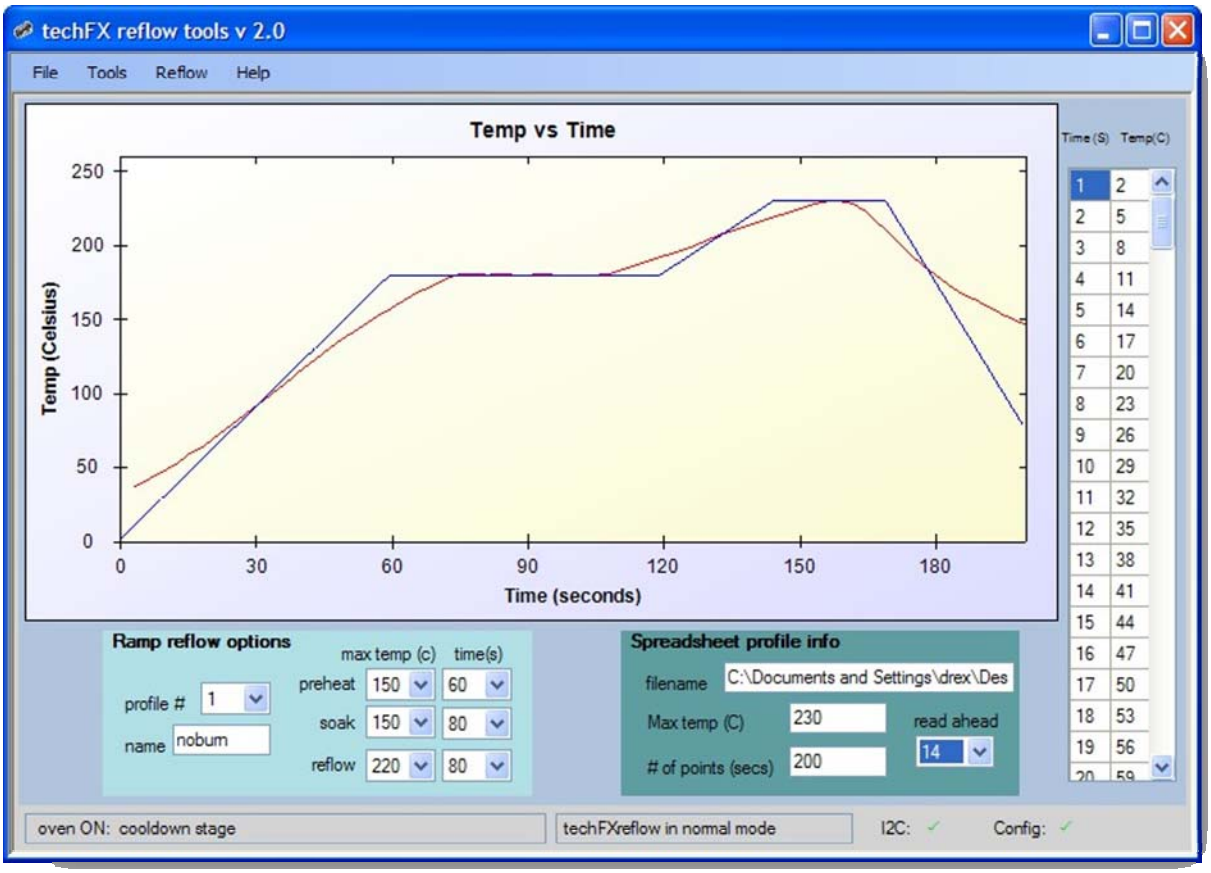
Kester solder paste profile (using maximum periods) kp=1, ki=0, kd=3 (techFX tools v2 and techFX reflow 2.0 controller) for Pb

Kester profiles can vary a lot! This profile has a normal reflow stage time. This is intended for Pb applications as we do not go above 220.



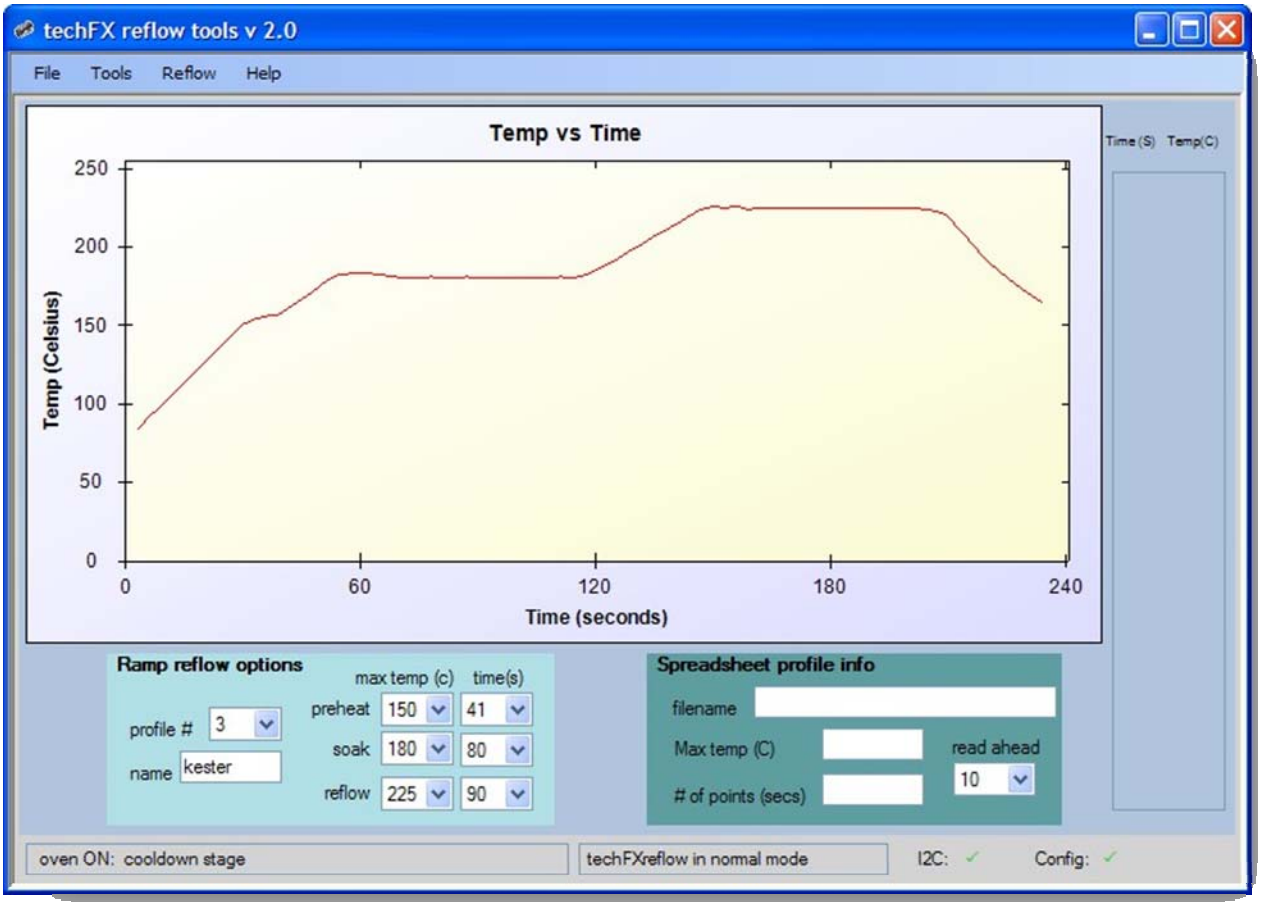
Shenmao water-soluble solder paste profile (kp=1,ki=0,kd=3) (techFX tools v 2.0 and techFX reflow 2.0 controller) spreadsheet profile for Pb

Excel spreadsheet profiles allow us to modify the rate of climb, however it will only max out at the oven's heat transfer function which will differ over different temperatures. The read ahead value gives us another derivative term to see future changes and account for them in software.



Kester derivative profile (kp=1,ki=0,kd=3) (techFX reflow tools v 2.0 and techFX reflow 2.0 controller) intended for Pb-free solderpaste

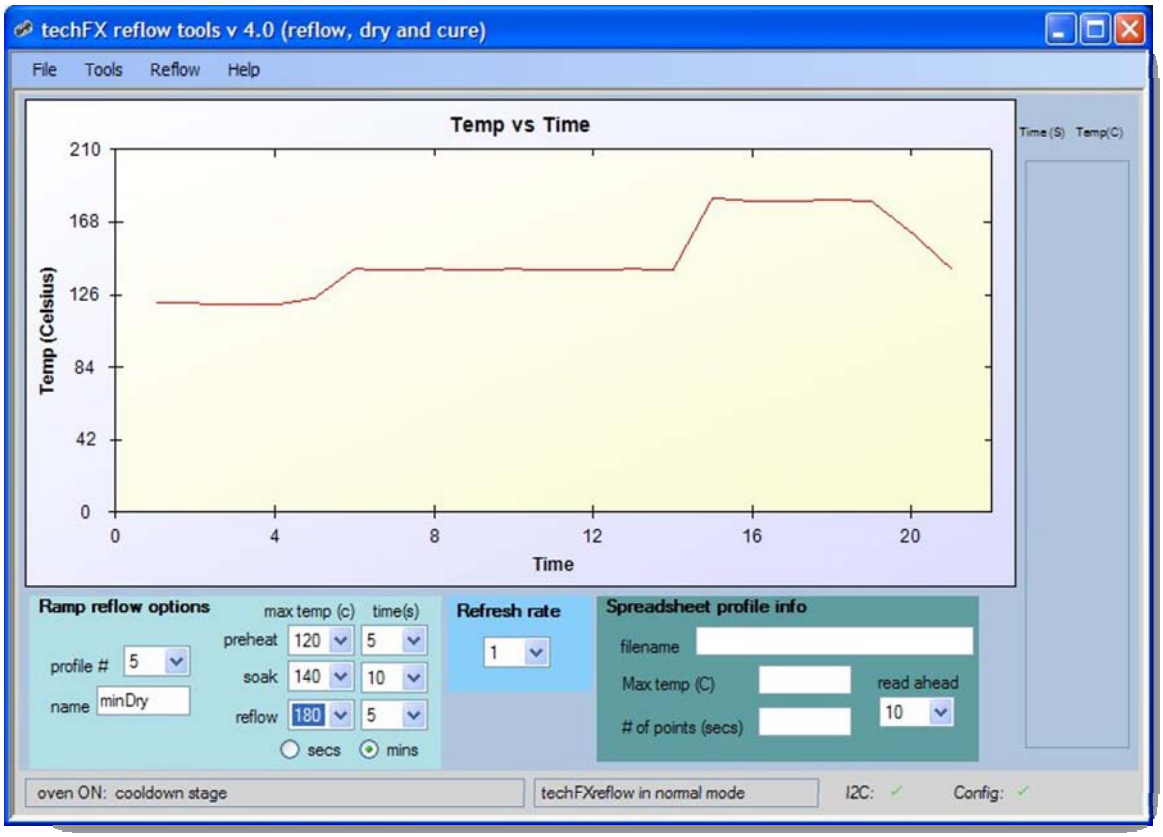
This is just a kester derivative with a longer than normal reflow stage with a higher peak temperature. When using a higher peak temperature, you may want to decrease the soak stage so you do not burn any boards. Consult your solder paste datasheet for your Pb-free reflow stage parameters.



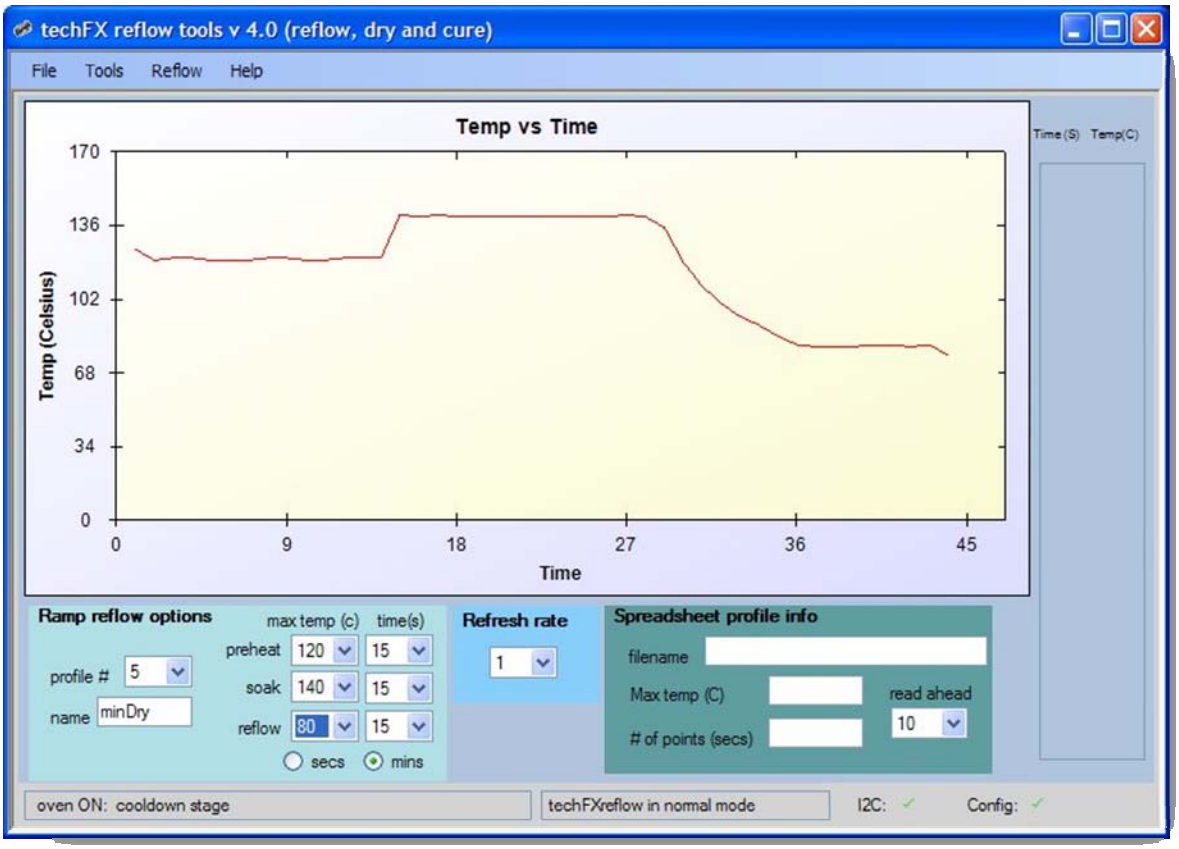
Example extended length profiles

20 minute drying example using 3 stages (no fan)

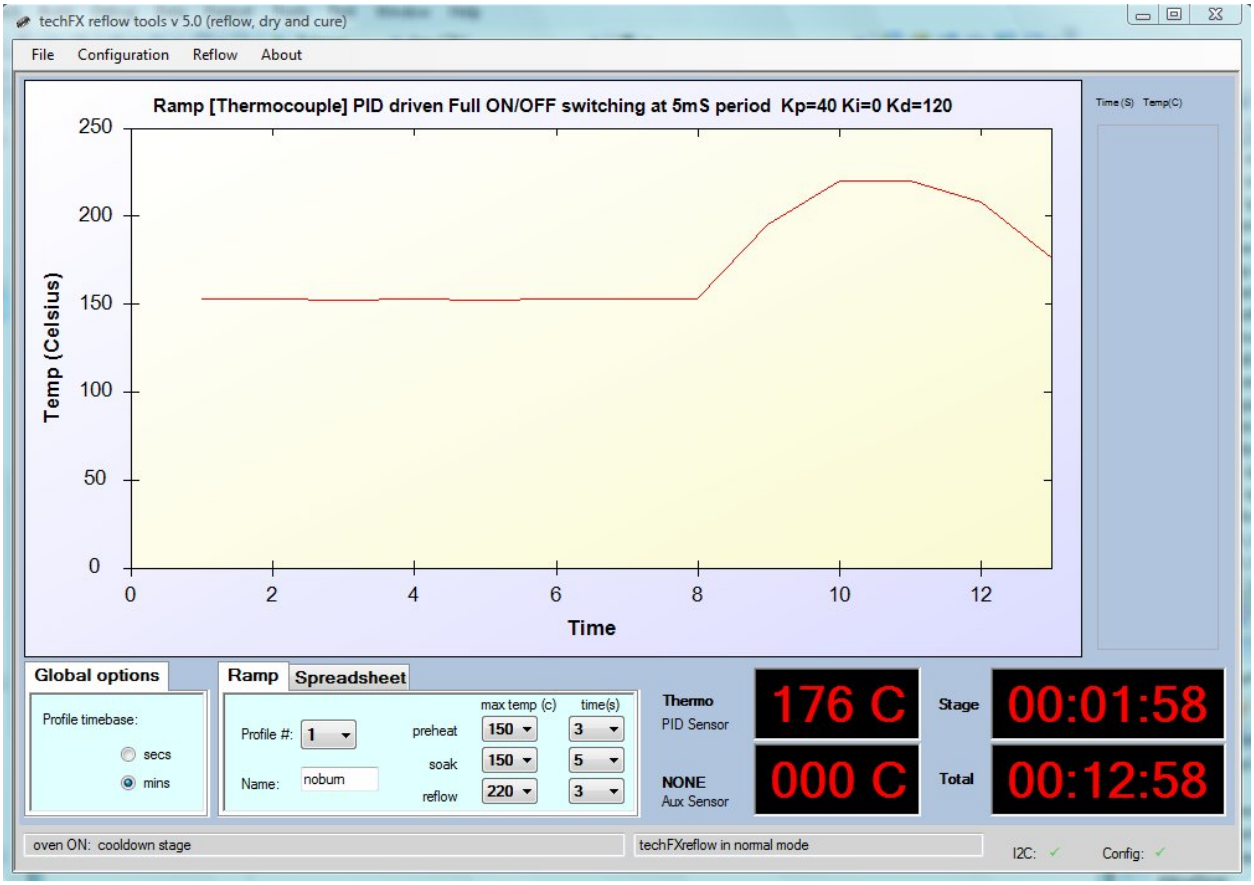
This example uses 3 stages (same reflow stages) to dry a component. Note the selection of the minutes radio button, and the units on the graph are now in Minutes instead of seconds.

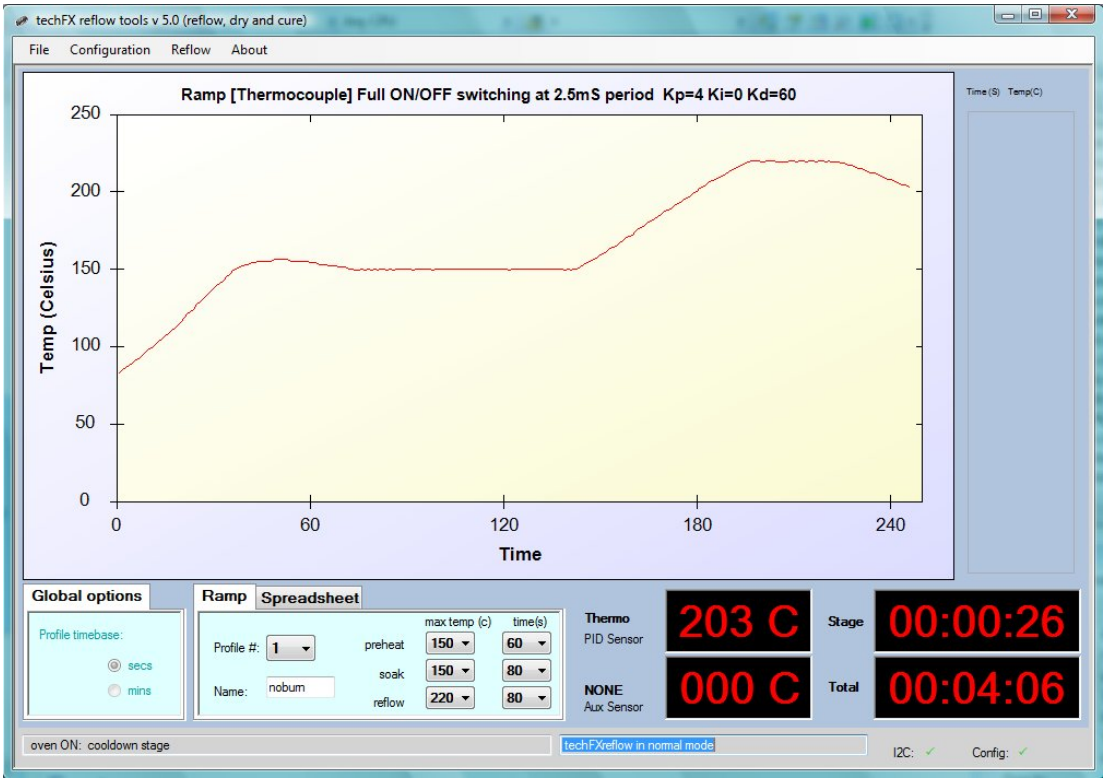


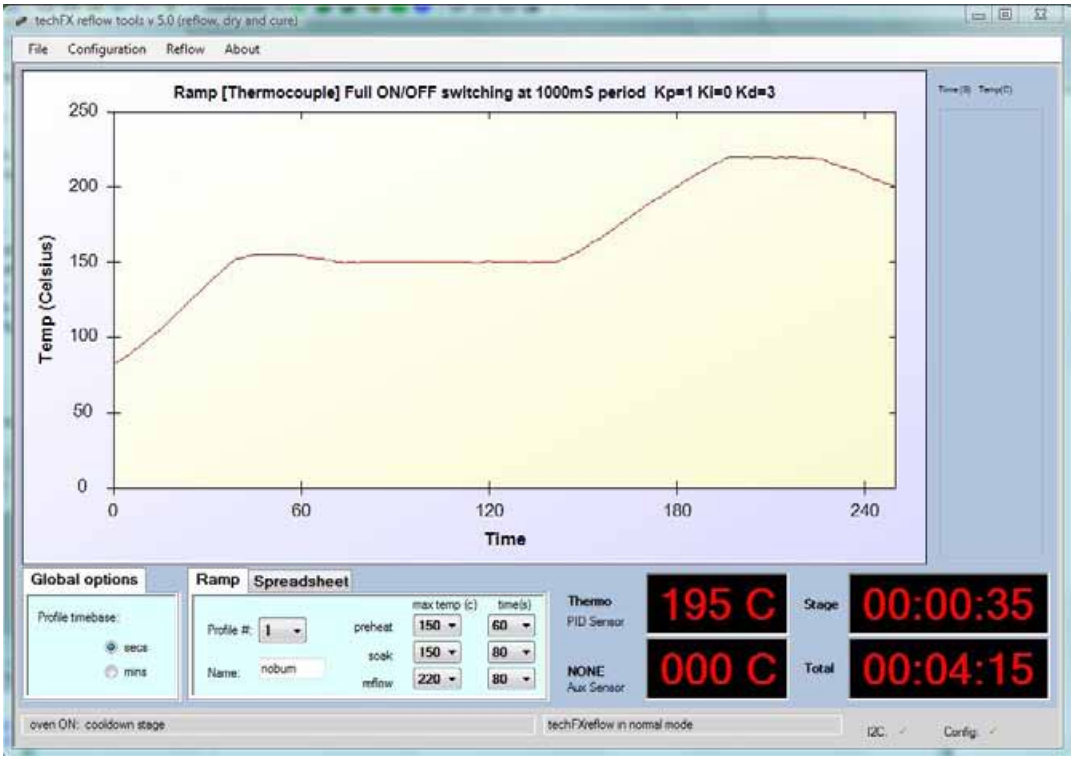
45 minute drying example using 3 stages (no fan)

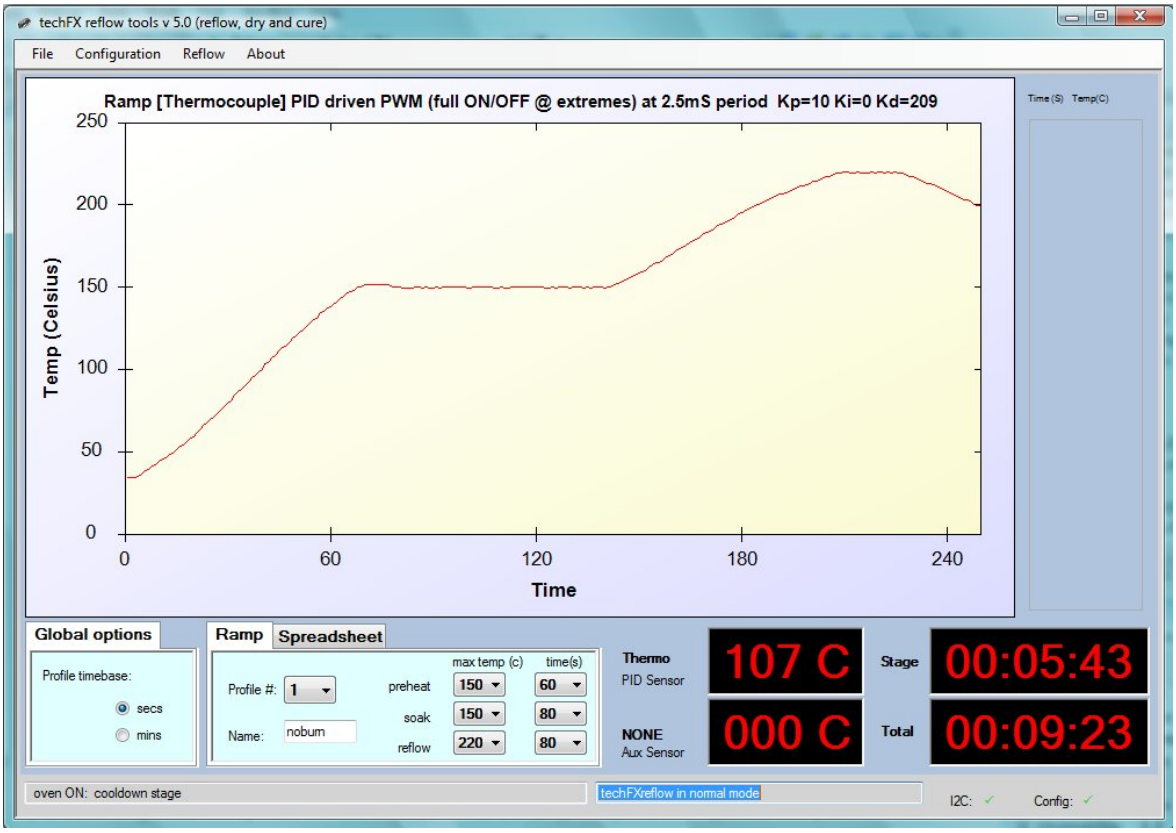


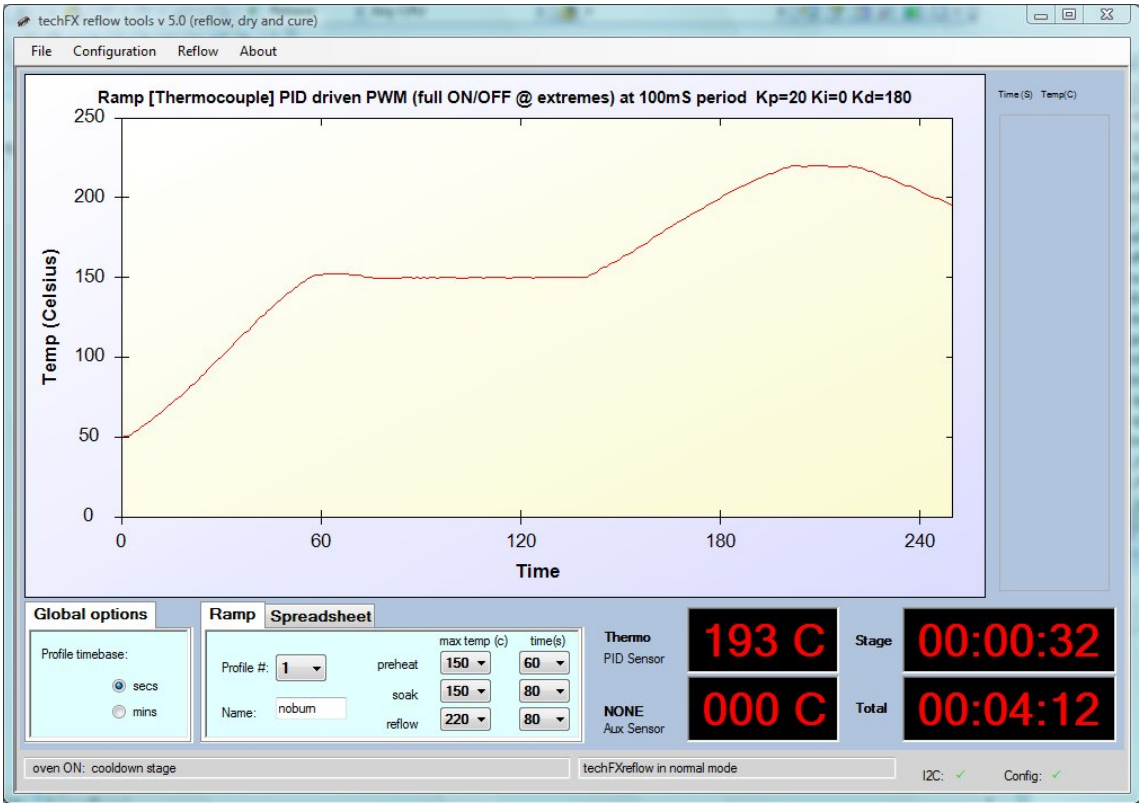
TechFX Reflow Tools 5.0 Example graphs (details in graph titles)

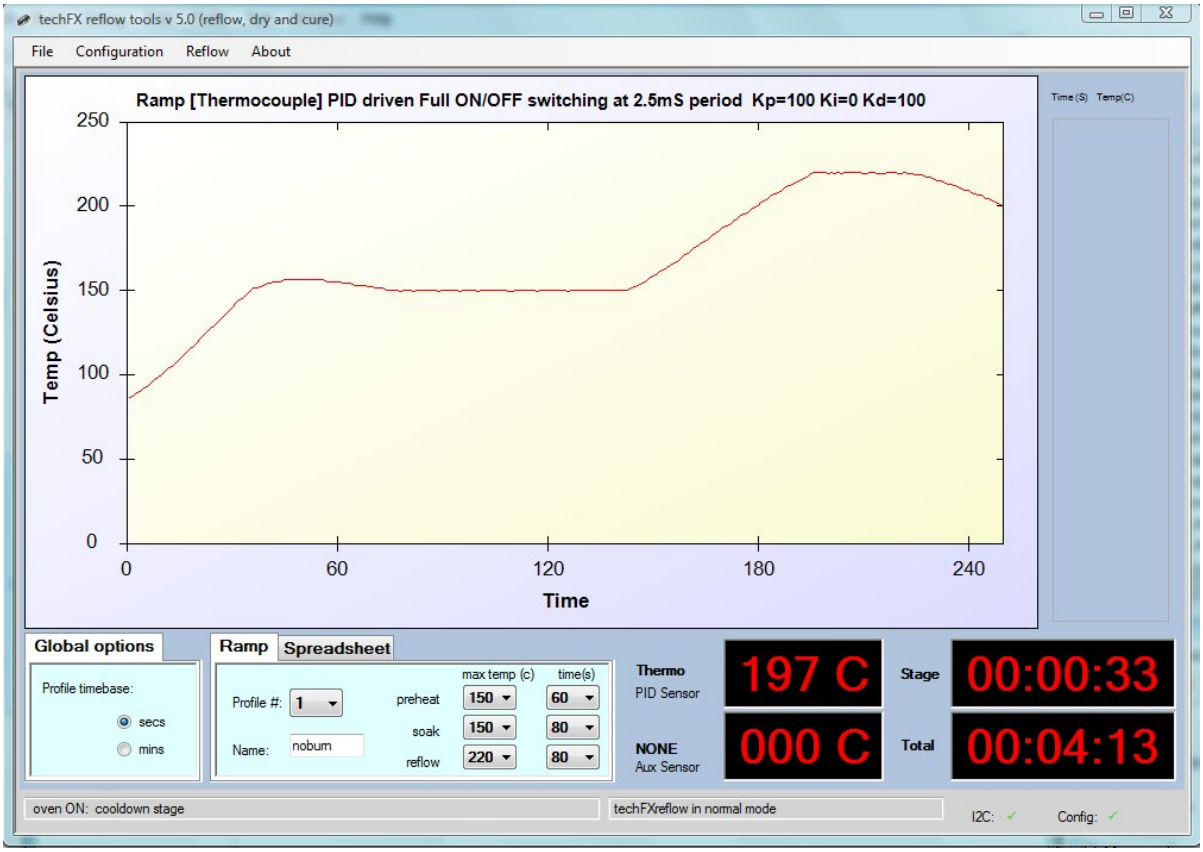


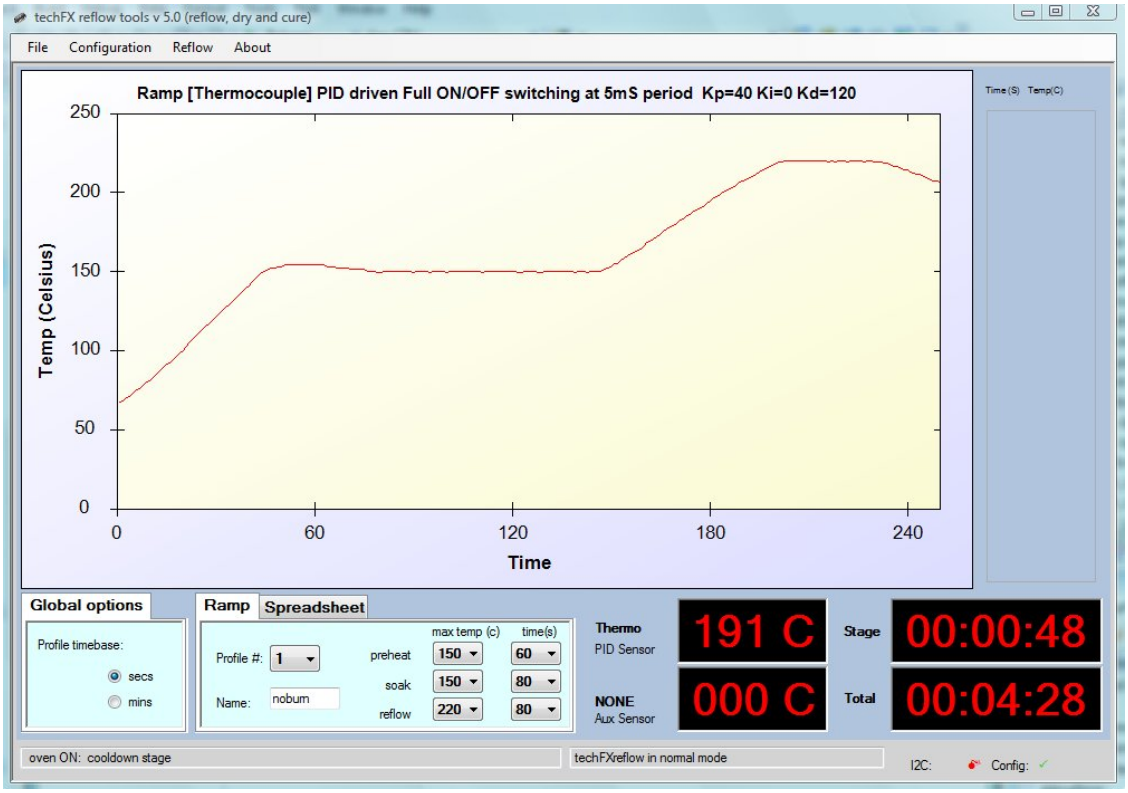

techFX reflow tools v 5.0 (reflow, dry and cure)
File
Configuration
Reflow
About
Ramp [Thermocouple] Full ON/OFF switching at 2.5mS period Kp=4 Ki=0 Kd=60
Temp (Celsius)
Time
Global options
Profile timebase:
secs
mins
Ramp
Spreadsheet
Profile #:
Name:
nobum
max temp (c)
time(s)
preheat
soak
reflow
Thermo
PID Sensor
203 C
NONE
Aux Sensor
000 C
Stage
00:00:26
Total
00:04:06
oven ON: cooldown stage
techFXreflow in normal mode
I2C:
Config:

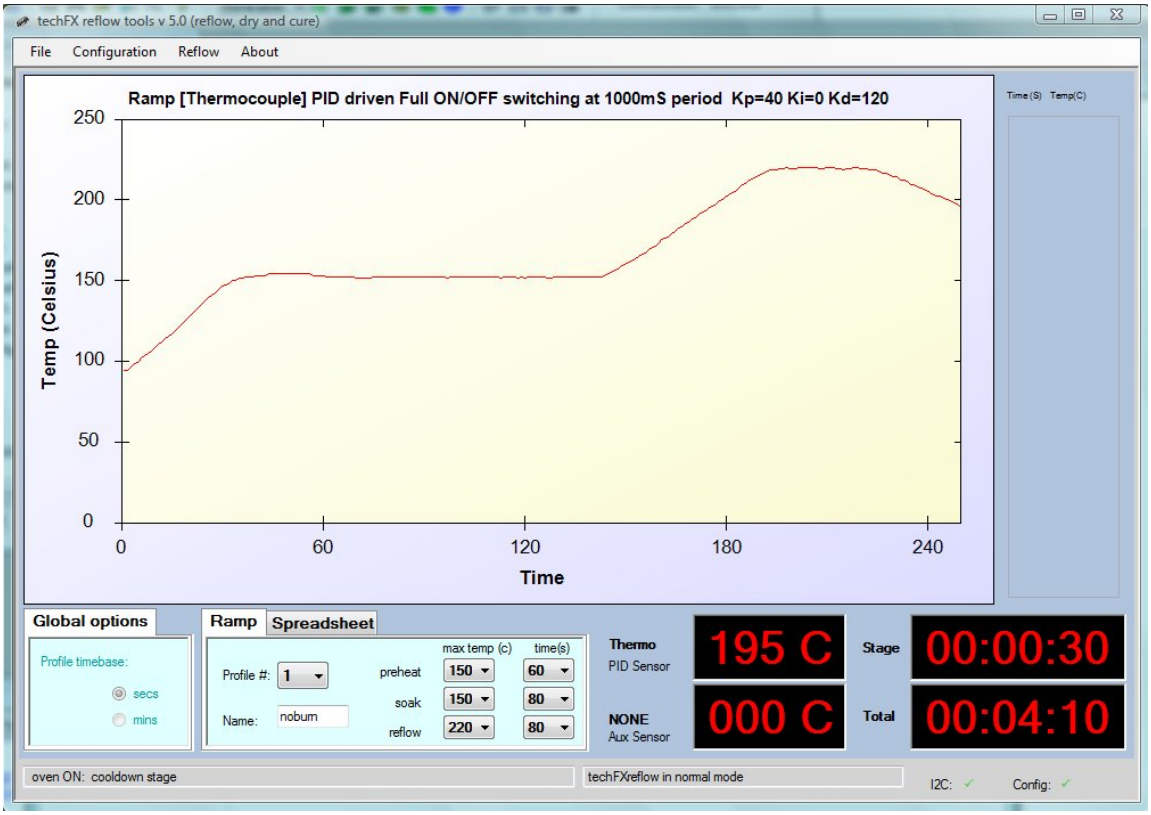

techFX reflow tools v 5.0 (reflow, dry and cure)
File
Configuration
Reflow
About
Ramp [Thermocouple] Full ON/OFF switching at 1000mS period Kp=1 Ki=0 Kd=3
Temp (Celsius)
Time
Global options
Profile timebase:
secs
mins
Ramp
Spreadsheet
Profile #:
Name:
nobum
max temp (c)
time(s)
preheat
soak
reflow
Thermo
PID Sensor
195 C
NONE
Aux Sensor
000 C
Stage
00:00:35
Total
00:04:15
oven ON: cooldown stage
techFXreflow in normal mode
I2C:
Config:

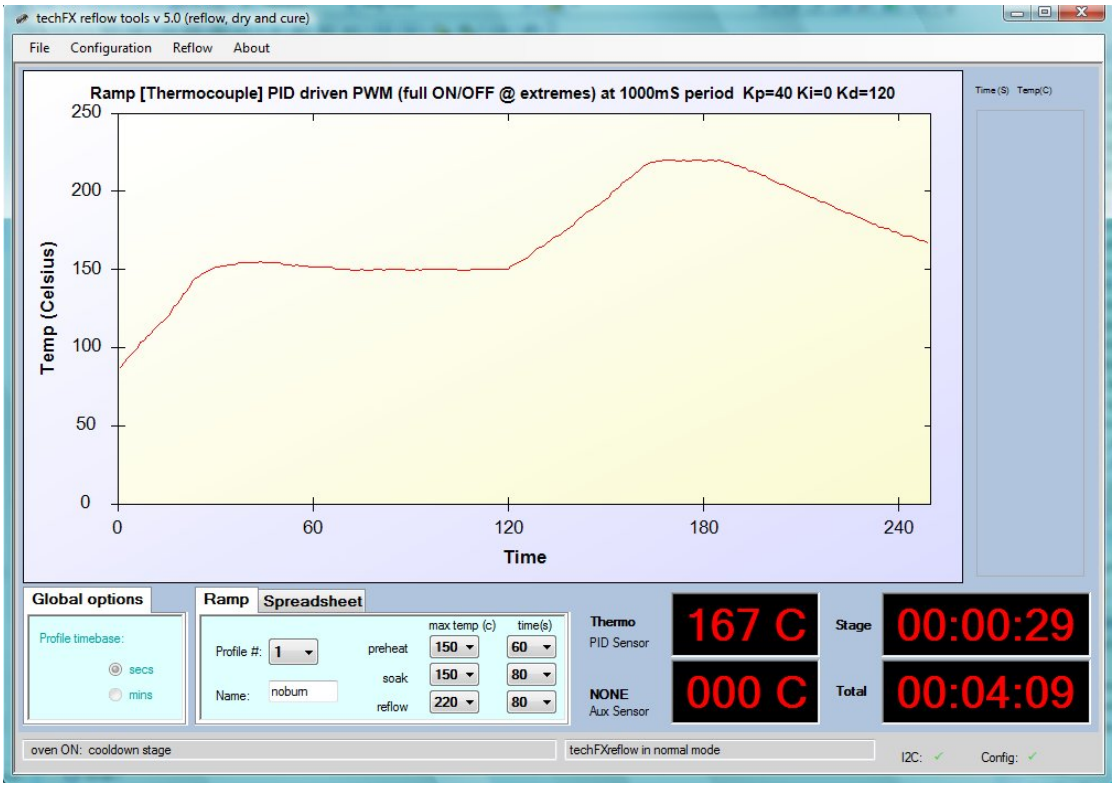

techFX reflow tools v 5.0 (reflow, dry and cure)
File
Configuration
Reflow
About
Ramp [Thermocouple] PID driven PWM (full ON/OFF @ extremes) at 2.5mS period Kp=10 Ki=0 Kd=209
Temp (Celsius)
Time
Time (S) Temp(C)
Global options
Profile timebase:
secs
mins
Ramp
Spreadsheet
Profile #:
Name:
nobum
max temp (c)
time(s)
preheat
soak
reflow
Thermo
PID Sensor
107 C
NONE
Aux Sensor
000 C
Stage
00:05:43
Total
00:09:23
oven ON: cooldown stage
techFXreflow in normal mode
I2C:
Config:

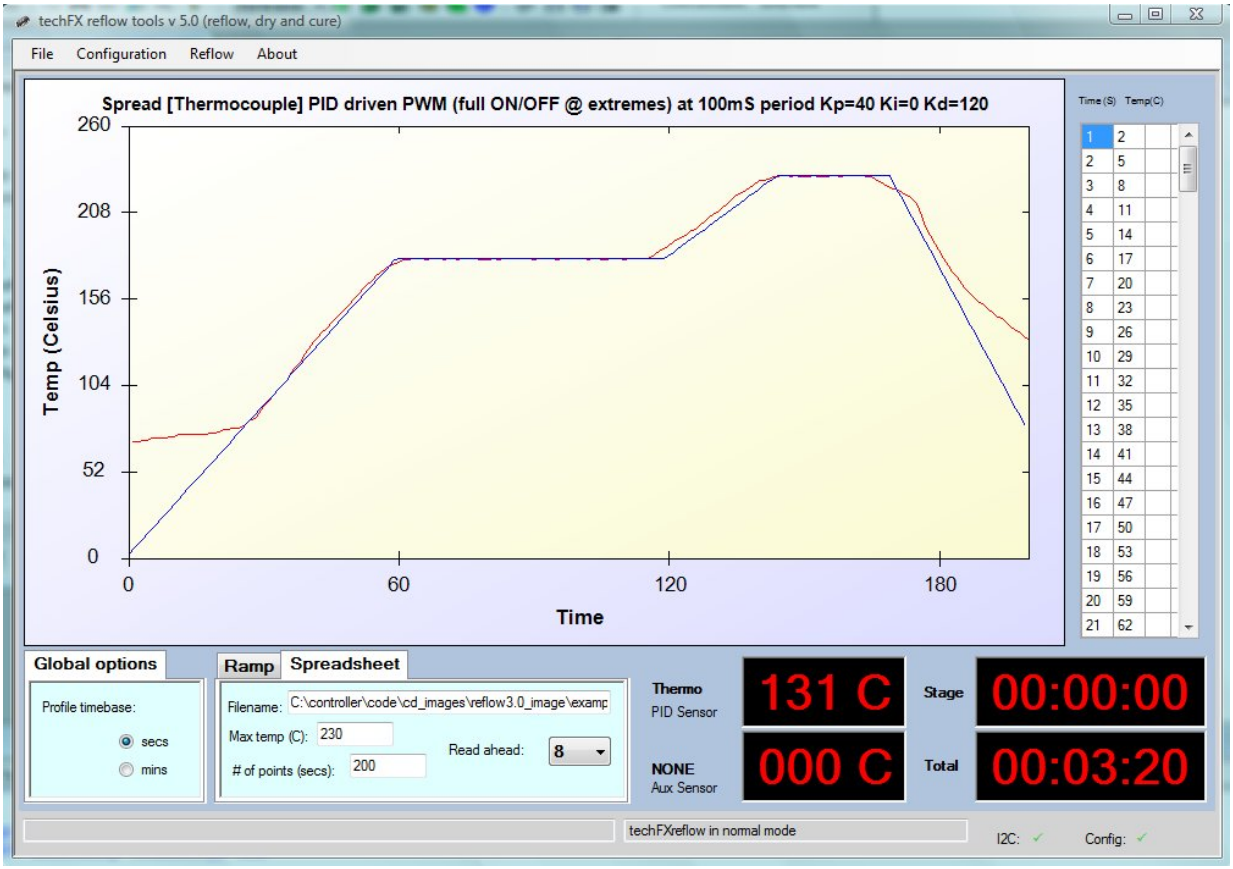

techFX reflow tools v 5.0 (reflow, dry and cure)
File
Configuration
Reflow
About
Ramp [Thermocouple] PID driven PWM (full ON/OFF @ extremes) at 100mS period Kp=20 Ki=0 Kd=180
Temp (Celsius)
Time
Time (S) Temp(C)
Global options
Profile timebase:
secs
mins
Ramp
Spreadsheet
Profile #:
Name:
nobum
max temp (c)
time(s)
preheat
soak
reflow
Thermo
PID Sensor
193 C
NONE
Aux Sensor
000 C
Stage
00:00:32
Total
00:04:12
oven ON: cooldown stage
techFXreflow in normal mode
I2C:
Config:


techFX reflow tools v 5.0 (reflow, dry and cure)
File
Configuration
Reflow
About
Ramp [Thermocouple] PID driven Full ON/OFF switching at 2.5mS period Kp=100 Ki=0 Kd=100
Temp (Celsius)
Time
Time (S) Temp(C)
Global options
Profile timebase:
secs
mins
Ramp
Spreadsheet
Profile #:
Name:
nobum
max temp (c)
time(s)
preheat
soak
reflow
Thermo
PID Sensor
197 C
NONE
Aux Sensor
000 C
Stage
00:00:33
Total
00:04:13
oven ON: cooldown stage
techFXreflow in normal mode
I2C:
Config:


techFX reflow tools v 5.0 (reflow, dry and cure)
File
Configuration
Reflow
About
Ramp [Thermocouple] PID driven Full ON/OFF switching at 5mS period Kp=40 Ki=0 Kd=120
Temp (Celsius)
Time
Time (S) Temp(C)
Global options
Profile timebase:
secs
mins
Ramp
Spreadsheet
Profile #:
Name:
nobum
max temp (c)
time(s)
preheat
soak
reflow
Thermo
PID Sensor
191 C
NONE
Aux Sensor
000 C
Stage
00:00:48
Total
00:04:28
oven ON: cooldown stage
techFXreflow in normal mode
I2C:
Config:


techFX reflow tools v 5.0 (reflow, dry and cure)
File
Configuration
Reflow
About
Ramp [Thermocouple] PID driven Full ON/OFF switching at 1000mS period Kp=40 Ki=0 Kd=120
Temp (Celsius)
Time
0
50
100
150
200
250
0
60
120
180
240
Time (S) Temp(C)
Global options
Profile timebase:
secs
mins
Ramp
Spreadsheet
Profile #: 1
Name: nobum
max temp (c)
time(s)
preheat 150 60
soak 150 80
reflow 220 80
Thermo
PID Sensor
195 C
NONE
Aux Sensor
000 C
Stage
00:00:30
Total
00:04:10
oven ON: cooldown stage
techFXreflow in normal mode
I2C:
Config:


techFX reflow tools v 5.0 (reflow, dry and cure)
File
Configuration
Reflow
About
Ramp [Thermocouple] PID driven PWM (full ON/OFF @ extremes) at 1000mS period Kp=40 Ki=0 Kd=120
Temp (Celsius)
Time
0
50
100
150
200
250
0
60
120
180
240
Time (S) Temp(C)
Global options
Profile timebase:
secs
mins
Ramp
Spreadsheet
Profile #: 1
Name: nobum
max temp (c)
time(s)
preheat 150 60
soak 150 80
reflow 220 80
Thermo
PID Sensor
167 C
NONE
Aux Sensor
000 C
Stage
00:00:29
Total
00:04:09
oven ON: cooldown stage
techFXreflow in normal mode
I2C:
Config:


techFX reflow tools v 5.0 (reflow, dry and cure)
File
Configuration
Reflow
About
Spread [Thermocouple] PID driven PWM (full ON/OFF @ extremes) at 100mS period Kp=40 Ki=0 Kd=120
Temp (Celsius)
260
208
156
104
52
0
0
60
120
180
Time
Time (S) Temp(C)
1 2
2 5
3 8
4 11
5 14
6 17
7 20
8 23
9 26
10 29
11 32
12 35
13 38
14 41
15 44
16 47
17 50
18 53
19 56
20 59
21 62
Global options
Profile timebase:
secs
mins
Ramp
Spreadsheet
Filename:
C:\controller\code\cd_images\reflow3.0_image\examp
Max temp (C):
230
# of points (secs):
200
Read ahead:
8
Thermo
PID Sensor
131 C
NONE
Aux Sensor
000 C
Stage
00:00:00
Total
00:03:20
techFXreflow in normal mode
I2C:
Config:

Tips and suggestions for assembly and operation

- Use a switching regulated power supply! If you don't your voltage may be much higher since the load is pretty low (that is a characteristic of cheap power supplies). You may buy a cheap good switching power supply from us or www.digikeycom for around 10 dollars. Measure the output voltage of your power supply before connecting it.
- If you are using a long thermocouple lead, you can compensate for bias generated in the leads by putting a 1K resistor across Negative lead and ground.
- Use an ungrounded, open head, sheathed thermocouple. Try to make leads as short as possible (under a foot). Try to get one with the lowest time coefficient as possible. Make sure it is K type!
- Buy the highest wattage oven you can find preferably IR.
- Use safety devices like ground fault interrupters and circuit breakers
- Do not mount the controller and electronics in or attached to the oven! You don't want the electronics and controller to heat up.

Troubleshooting

Software issues

TechFX tools doesn't find my device

If you have installed the driver correctly, then this is most likely do to the power savings feature in Windows XP and Windows Vista. To disable this feature, goto Control Panel/System/Hardware devices/Other devices/pic18f4550 family/power savings tab/ and disable that feature). If you are using Windows Vista 32, you must browse to <installdir> which is most likely c:\program files\the silicon horizon inc\ techFX reflow tools\ techFXcontroller.exe and right click on it. Then choose properties. Now select "run in WinXP SP2 compatability mode" and "run as administrator".

Upgrading techFX tools doesn't work!

Did you uninstall the previous version? Goto the control panel / add remove programs and select "techFX reflow tools". If in Windows Vista you will need Admin in UAC mode.

Hardware issues

Erratic readings between a temperature value and zero on graph

This is most likely do to shorted thermocouple wires (did it rub on bare metal and break the sheathing?) or the thermocouple is not mounted good in the terminals. You may also verify that the thermocouple leads are connected correctly.

Noise in output on graph

Noise may be compensated for in longer lead thermocouples by using a 1K resistor between the negative lead and ground. You may also try reseating the thermocouple leads in the terminal blocks, and making sure there is no short in the leads. You should also check for other sources of noise such as devices nearby that may cause interference. You should also make sure you are using a quality switching

power supply. Cheap unregulated power supplies can output AC transients which may saturate the thermocouple amplifier and add noise to your output signal (since it affects the voltage reference signal).

Voltage regulator is running hot

The voltage regulator can handle from 6 to 9 volts DC. Even though your power supply says it is 9 volts DC it may be outputting a much higher value such as 14 or 15 volts. That is why you should purchase a switching DC wall adapter which we sell on our site and on www.digikey.com

Not getting full scale of readings up to 500 deg Celsius

Are you using at least a 6 volt DC power supply? Make sure and measure the output. If you use a 5 volt power supply you will lose some of the top end of the scale and thus will not be able to reach the 500 deg Celsius mark.

Reflow techniques and suggestions

This will be updated shortly.