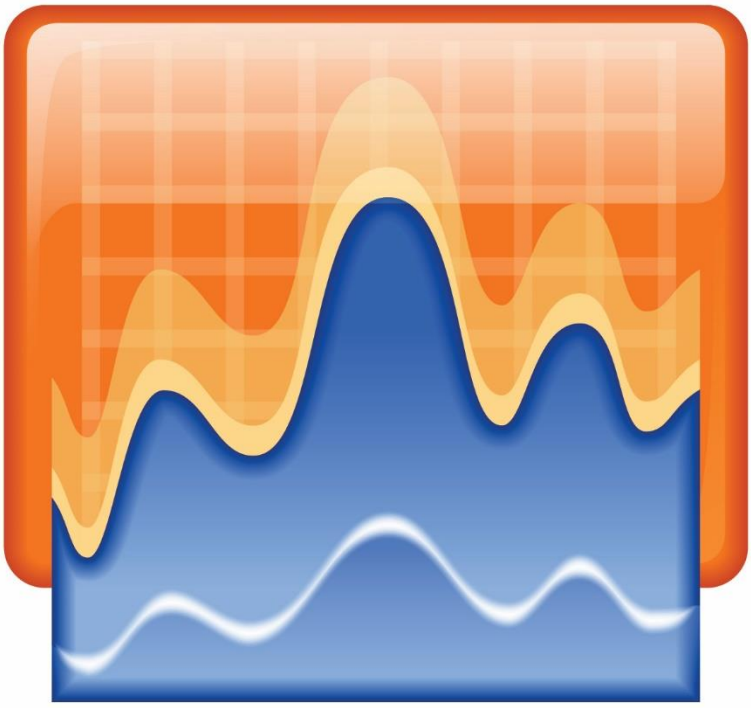
akrometrix

Thermal Profiler



User Manual

Akrometrix Proprietary Information

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Contents

1 Introduction 4
1.1 Overview 4
1.1 Warnings and Precautions 4
1.2 Technical Support 4
2 Thermal Profiler 6
2.1 Overview 6
2.2 Graphical User Interface Layout and Description 6
2.3 File Menu Bar 11
2.4 Changing Thermal Source 12
2.5 Profile Setup 13
2.6 Manual Temperature Profiling 17
2.7 AXP 2.0 Profile Setup 18
2.8 DFP/DIC Modes 19
2.9 Part Tracking Mode 20
Appendix A - Miscellaneous Information 21
A.1 File Formats 21
A.2 Keyboard Shortcuts 21

1 Introduction

1.1 Overview

As part of the Akrometrix Studio software platform, Thermal Profiler is designed as the automated temperature control and data acquisition package for any Akrometrix hardware utilizing the shadow moiré, fringe projection, or DIC techniques. It features a 4 screen interface where all relevant profile and data information can be displayed and compared on screen at one time. This manual is intended for use with Akrometrix Studio 8.2.

This manual describes the interface and functions of the Thermal Profiler software. Manual data acquisition is described in the Surface Measurement User Manual and analysis is described in the Surface Analysis User Manual. Thermal Profiler requires system hardware to operate and, thus, will only be installed on computers attached to Akrometrix measurement equipment. Surface Analysis may reside on the measurement equipment computer and/or on a remote computer.

A user unfamiliar with shadow moiré, fringe projection, and DIC and their application in Akrometrix measurement systems is advised to first read **Akrometrix Optical Techniques and Analyses 101**.

Section 2 describes the Thermal Profiler application. **Appendix A** describes software file formats and keyboard shortcuts.

1.1 Warnings and Precautions

1.1.1 Warnings and Notes in this Manual

Warnings and Notes are marked throughout the manual with these icons:

Figure 1.1 Warning Icon

Figure 1.2 Note Icon

Warnings are specific health hazards for the operator or potential sources of system damage. Notes highlight system limitations or automatic responses that may require corrective action by the operator for successful operation.

1.2 Technical Support

For technical support, contact Akrometrix:

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Building B, Suite 500
Atlanta, GA 30345

404-486-0880
404-486-0890 (fax)

support@akrometrix.com
http://www.akrometrix.com

When contacting Akrometrix, please provide the system serial number, the version numbers of the Akrometrix software being used, a description of the problem or question, and contact information for reply. If the question concerns a particular measurement or analysis, please provide electronic copies of the phase images, reference images, and final results and a description of data acquisition and/or analysis conditions. If the problem concerns changes or failure in general system operation, please describe any events or system modifications that occurred immediately before the problem arose.

2 Thermal Profiler

2.1 Overview

TherMoiré systems are designed to automatically make surface measurements on the sample at specified points during a user-defined thermal profile. Temperature profiles are created using the **Profile Generator** application as xml documents with the extension *.akx_profile. These files can also be created and edited in any text or xml editing program. For more details on how these files are constructed see the **Profile Generator User Manual**.

Profile steps occur at a constant time interval, which is set at run-time using the Time Per Step parameter in the Profile Setup dialog (see **Figure 2.20**). Although a data acquisition instruction is placed at a discrete step, it may take more than one step to execute. This is due to the fact that the time to acquire data is dependent on the delay per step, the camera shutter time, and the motor speed. These factors can lengthen the time per data acquisition. This is especially true for DFP and, to a lesser extent, shadow moiré measurements. In general, DFP will require the most time, due to the number of images captured during each acquisition. Shadow moiré acquisition takes less time, and DIC is the fastest, as it is limited solely by the camera shutter speed. The Thermal Profiler application takes all of these variables into account when the profile is loaded and adds rows to the profile accordingly.

The Control Criteria allows measurement points to be taken against time or temperature and is selected by the user at run-time. In time-based execution, automatic data acquisition is triggered when a specific time is reached, regardless of the actual sample temperature. With temperature-based profiling, automatic data acquisition is triggered only when the target temperature is reached, independent of the amount of time that has elapsed. The actual measurement temperature depends on the value of the Error Band, which defines the allowable deviation from the setpoint temperature to initiate a data acquisition.

A Pause feature allows the profile to be halted at any point during the profile execution. This is useful during the time-based control if sample temperature is lagging behind. While the profile is paused, sample temperature is continuously recorded to both the table and graph. With temperature-based control, the profile is Auto-Paused before the phase measurement step of the profile is executed. The program can remain in Auto-Pause mode for at most 30 minutes.

2.2 Graphical User Interface Layout and Description

The Thermal Profiler GUI (see **Figure 2.1**) consists of 4 main window panes where all pertinent profile information can be seen at one time.

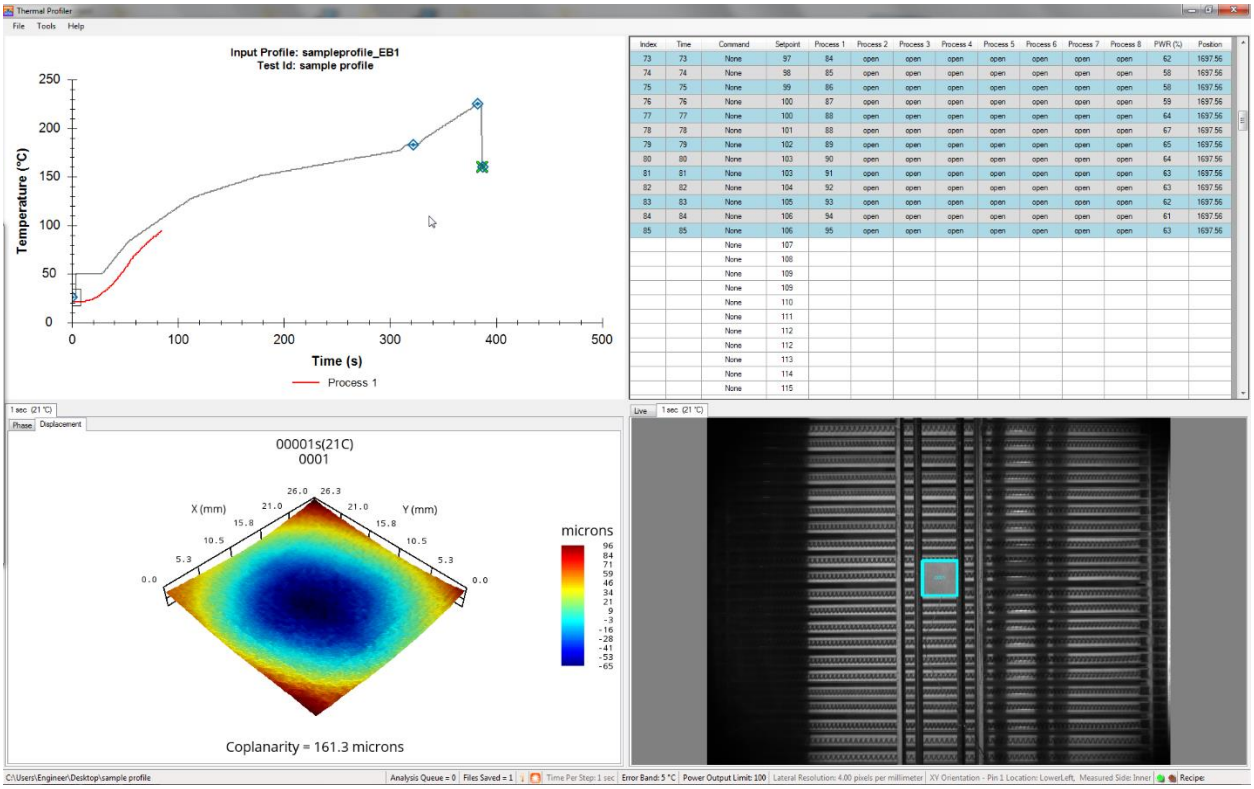


Figure 2.1 Thermal Profiler GUI

2.2.1 Profile Graph Pane

The top left pane shows the profile graph view. Right-clicking anywhere in this pane will bring up a context menu, similar to that in **Figure 2.2**. Note that although all three possible context menus are shown in **Figure 2.2**, this is not possible in the actual software. They are shown for illustration purposes only.

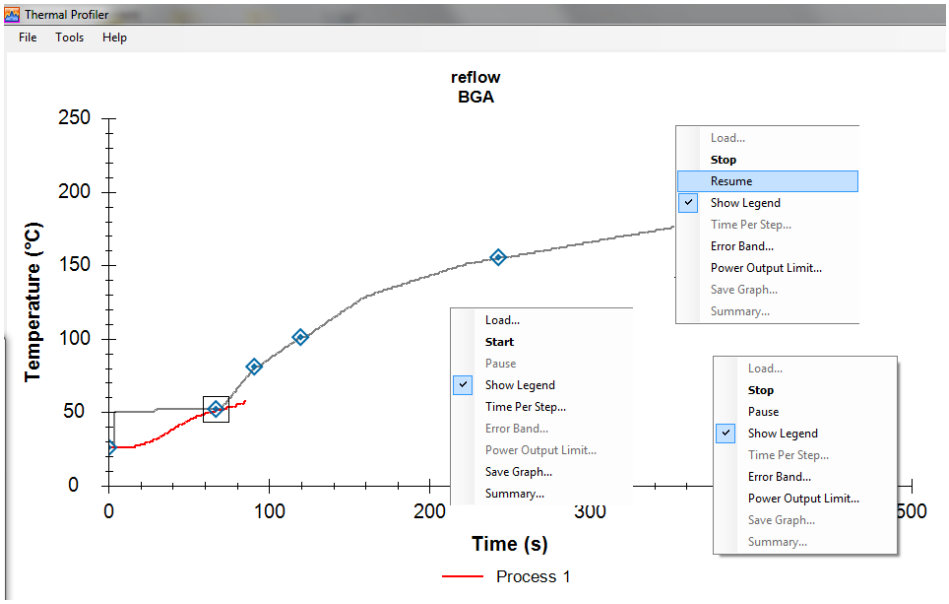


Figure 2.2 Graph Pane

The context menu options and a brief description of each are listed below:

1. Load: Brings up a file select dialog where the user can point to an input profile and load it into the Thermal Profiler application.

2. Start/Stop: If Start is available, it means there is no profile actively running. Selecting this option will bring up the Profile Setup Window (see **Figure 2.20**). If Stop is available, it means there is an actively running profile. Selecting Stop will stop the profile and prompt the user to save the text and graphical outputs of the profile.

3. Pause/Resume: Pauses the profile. Rows in the Table Pane will show up as yellow to indicate that the profile was paused.

4. Show Legend: Check to show the Graph Pane legend. Uncheck to hide.

5. Time Per Step: Before the profile has been executed, the user can click this option to open a dialog where the profile Time Per Step can be set.

6. Error Band: While the profile is running the user can select this option to bring up a dialog where the Error Band can be set. The Error Band only comes into play when the profile is running in Temperature Base and defines the allowable deviation from the target temperature, while autopausing, to initiate a data acquisition.

7. Power Output Limit: Allows the user to set the heater bank output percentage to control the heat transmitted to the sample.

8. Save Graph: Allows the user to save the profile graph as an image file (.jpg, .bmp, etc.)

9. Summary: Displays the Maximum, Minimum, and Measurement Points for both Profile Input and Output (see **Figure 2.3** and **Figure 2.4**)

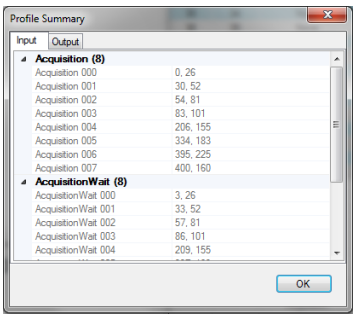


Figure 2.3 Profile Summary Input

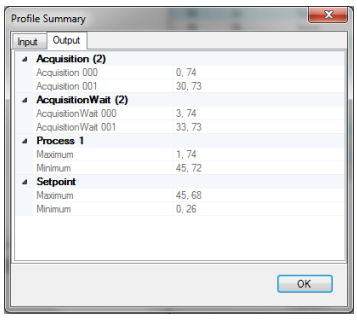
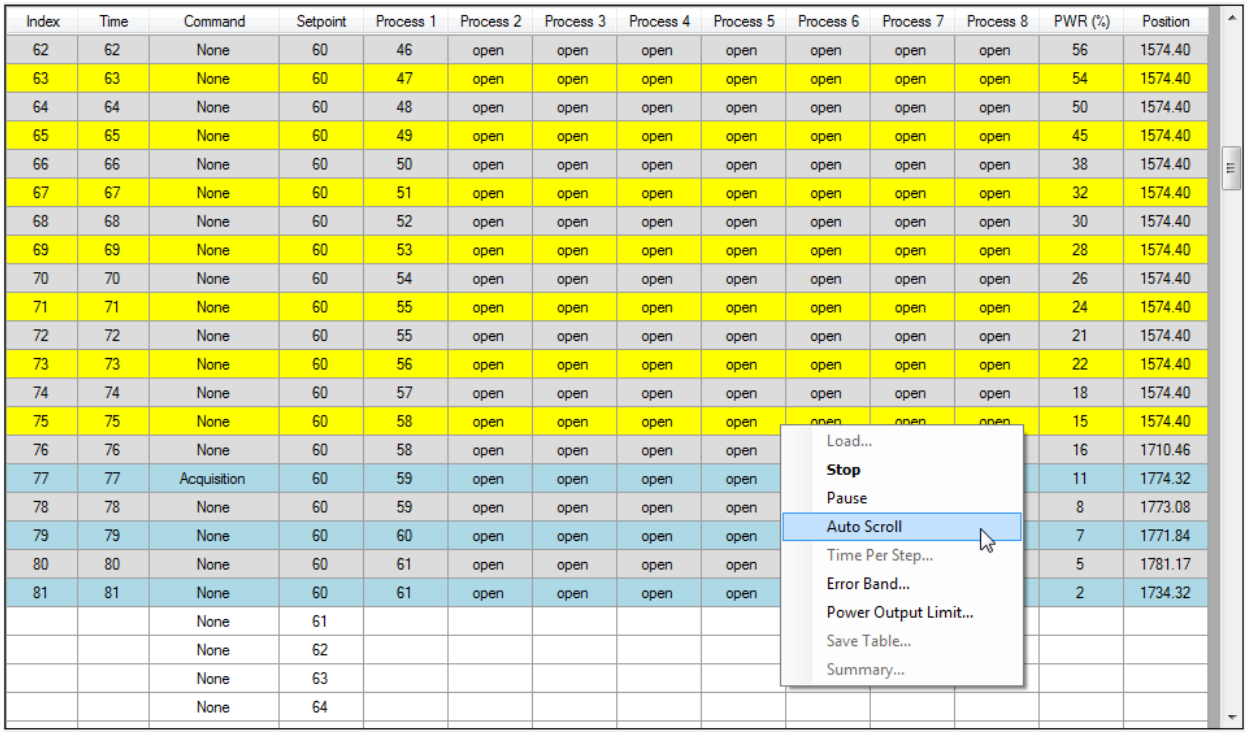


Figure 2.4 Profile Summary Output

2.2.2 Profile Table Pane

The top right pane shows the profile table view, which consists of individual temperature points and instructions for when to take measurements, turn on system

blowers, etc. Yellow highlighting of a row indicates that it has been inserted automatically by the software either because of autopausing while in Temperature Base Control or a manual pause initiated by the user.



Index	Time	Command	Setpoint	Process 1	Process 2	Process 3	Process 4	Process 5	Process 6	Process 7	Process 8	PWR (%)	Position
62	62	None	60	46	open	open	open	open	open	open	open	56	1574.40
63	63	None	60	47	open	open	open	open	open	open	open	54	1574.40
64	64	None	60	48	open	open	open	open	open	open	open	50	1574.40
65	65	None	60	49	open	open	open	open	open	open	open	45	1574.40
66	66	None	60	50	open	open	open	open	open	open	open	38	1574.40
67	67	None	60	51	open	open	open	open	open	open	open	32	1574.40
68	68	None	60	52	open	open	open	open	open	open	open	30	1574.40
69	69	None	60	53	open	open	open	open	open	open	open	28	1574.40
70	70	None	60	54	open	open	open	open	open	open	open	26	1574.40
71	71	None	60	55	open	open	open	open	open	open	open	24	1574.40
72	72	None	60	55	open	open	open	open	open	open	open	21	1574.40
73	73	None	60	56	open	open	open	open	open	open	open	22	1574.40
74	74	None	60	57	open	open	open	open	open	open	open	18	1574.40
75	75	None	60	58	open	open	open	open	open	open	open	15	1574.40
76	76	None	60	58	open	open	open	open	open	open	open	16	1710.46
77	77	Acquisition	60	59	open	open	open	open	open	open	open	11	1774.32
78	78	None	60	59	open	open	open	open	open	open	open	8	1773.08
79	79	None	60	60	open	open	open	open	open	open	open	7	1771.84
80	80	None	60	61	open	open	open	open	open	open	open	5	1781.17
81	81	None	60	61	open	open	open	open	open	open	open	2	1734.32
		None	61										
		None	62										
		None	63										
		None	64										

Figure 2.5 Table Pane

Right-clicking on the Table Pane will bring up a context menu (see **Figure 2.5**) which is very similar to that of the Graph Pane. The only difference is the substitution of a toggle to turn the table's Auto Scroll behavior on or off instead of the Show Legend toggle.

2.2.3 Displacement Data and Phase Data Pane

The bottom left pane shows both phase and displacement data in a tabbed window format. The top row of tabs displays the time and temperature at which a data acquisition has occurred. Below this, for each acquisition, there is a Displacement and a Phase tab. **Figure 2.6** shows the displacement data while **Figure 2.7** shows the phase data view. The top row of tabs is also linked to the Profile Graph Pane so that the currently selected acquisition point is highlighted on the profile graph by a black square outline.

Both of these panes will show data for the currently selected ROI if there are multiple ROIs. The user can change the active ROI by clicking on a different one in the camera window pane (see **Section 2.2.4**).

At the very bottom of this window the current Output Path is listed. This is the directory where all the displayed results are stored. It can be changed at the start of a profile in the Profile Setup Window (see **Figure 2.20**).

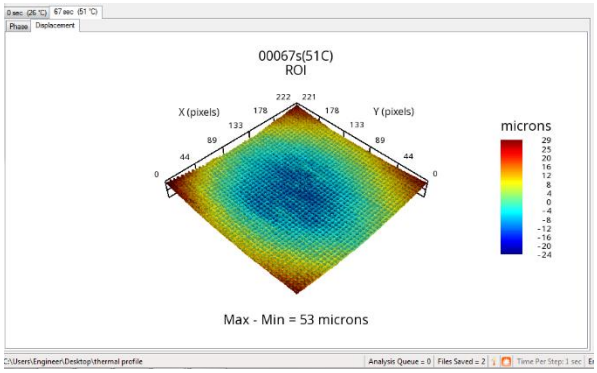


Figure 2.6 Displacement Data

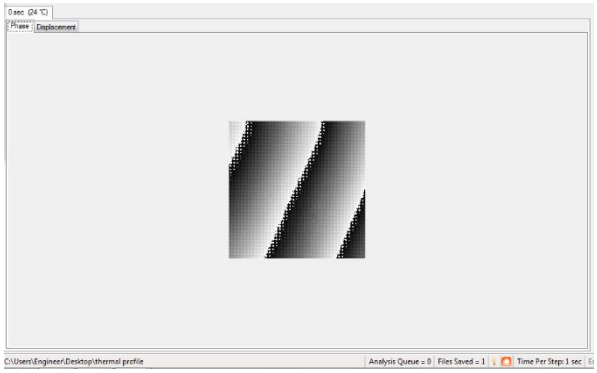


Figure 2.7 Phase Data

2.2.4 Camera Window Pane

The bottom right pane shows the live camera view and the locations of all current ROIs. The camera view can be zoomed to any individual ROI right-clicking anywhere in the Camera pane and selecting **Zoom To Selected ROI**, or zoomed to show all ROIs by selecting **Zoom To Extents** (see **Figure 2.8**).

All ROIs will be shown here with blue outlines, with a thicker outline on the currently selected ROI. To change the selected ROI, click on any of the other ROIs. Whichever ROI is selected will have its phase and displacement data displayed in the data pane.

Figure 2.8 Camera Window Pane

At the bottom of the camera window pane there is an information bar which tells the user about the current state of various settings.

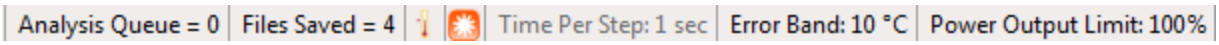


Figure 2.9 Information Bar 1

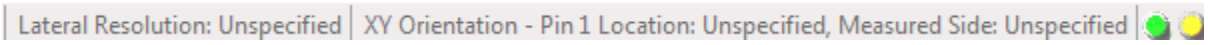


Figure 2.10 Information Bar 2

The leftmost section describes how many files are in queue to be saved (Analysis queue) and already saved. The Time/Temperature Base indicator tells whether the current profile (or last run profile) is in Time or Temperature base mode (see **Figure 2.11**). To the right of this icon is the Radiant/Convective Mode Indicator Icon (see **Figure 2.12**). The thermal source can be changed by clicking on this icon to bring up the Select Thermal Source dialog shown in **Figure 2.17**. Current Time Per Step and Error Band settings are shown in the Information Bar as well. The Error Band section can be clicked to bring up a dialog where the Error Band can be changed while a profile is running. The current heater output percentage is shown and can be clicked to bring up a dialog to change its value.

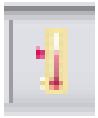


Figure 2.11 Time/Temperature Base Indicator

Figure 2.12 Radiant/Convective Mode Indicator

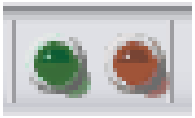


Figure 2.13 Profile Status Indicator Lights

Currently input XY orientation settings and measured side are shown in the information bar as well. Lastly, the indicator lights shown in **Figure 2.13** tell the user what state the profile is in using the conditions shown in **Table 2.1**.

Table 2.1 Profile Status Indicator Light Conditions

Light Condition	Profile Status
Solid Green	Running
Blinking Green	Auto-pause
Solid Green & Blinking Yellow	Manual Pause

2.3 File Menu Bar

At the top of the Thermal Profiler application window there is a standard Windows File Menu bar (see). It contains the following menu categories:

- File
- Tools
- Help

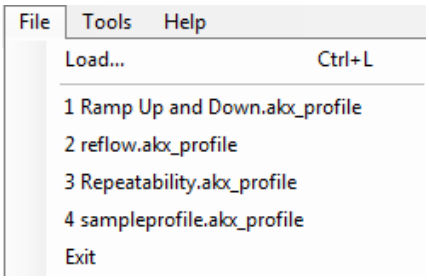


Figure 2.14 File Menu

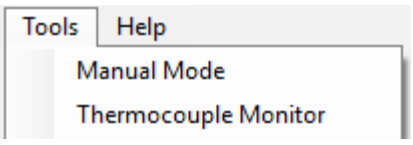


Figure 2.15 Tools Menu

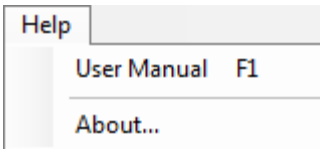


Figure 2.16 Help Menu

2.3.1 File

This menu category is where the user can open thermal profiles (*.akx_profile). It also shows the last 4 recently opened profiles.

2.3.2 Tools

This menu contains two options: Manual Mode and Thermocouple Monitor. Manual mode allows manual temperature control and data acquisition, and is detailed in **Section 2.6**. Thermocouple Monitor allows the user to quickly see all thermocouple temperatures for setup purposes. This tool can also be opened from the Monitor… button in the Profile Setup dialog (see **Figure 2.20**).

2.3.3 Help

This menu item contains a link to the Thermal Profiler User Manual as well as an About command for determining program version information.

2.4 Changing Thermal Source

The Thermal Profiler application can control either the built in TherMoiré IR heater source or an optional add-on called the Convective Module. In order to switch to Convective mode the user must tell the software to use the Convective Module controller. In order to do so the user clicks on the Radiant/Convective Mode Indicator (see **Figure 2.12**) icon at the bottom of the Camera Window Pane. A dialog (see **Figure 2.17**) pops up asking the user to select either Radiant or Convective sources.

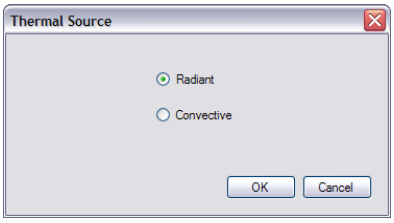


Figure 2.17 Select Thermal Source Dialog

Note: In order to change from Radiant to Convective mode the Convective Module must be turned on and hooked up as described in the Convective Module User Manual.

When changing between thermal sources, dialogs will pop-up (see **Figure 2.18** and **Figure 2.19**) reminding the user what actions should be taken in order to use the desired thermal mode.

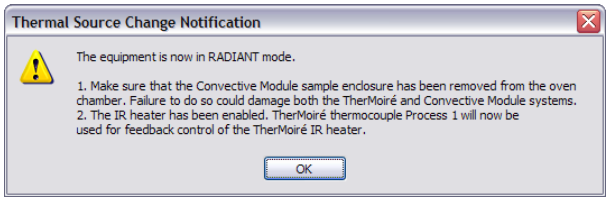


Figure 2.18 Radiant Mode Notification

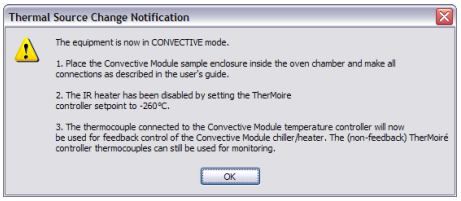


Figure 2.19 Convective Mode Notification

Thermal Profiler operation is exactly the same whether in Radiant or Convective mode. The only thing that changes is the hardware used.

2.5 Profile Setup

The Profile Setup dialog is accessed by right-clicking on either the Profile Graph (**Figure 2.2**) or Table Panes (**Figure 2.5**) and choosing **Start**. This dialog is shown in **Figure 2.20**, and with it the user can set up the parameters for a profile run. This dialog has four major sections: Execution, XY Settings, Output Settings, and Active Thermocouples.

Execution contains options for editing profile control.

- **Time Per Step** – Defined as the number of seconds that each step represents in the input profile. This is almost always set to 1 second per step. Overall profile length can be changed by altering this parameter.
- **Control Criteria** – must be set to either Temperature or Time based, and an Initial Error Band selected if Temperature base is chosen.
- **Initial Error Band** – Defines the offset from the desired temperature that an acquisition can occur within. For example, if the setpoint is 100C and the error band is 5C, acquisitions that aren't reached in the profile's specified time can happen anywhere from 95C to 105C. If the profile is not within this error band when the acquisition is supposed to occur, the profile will autopause (inserting rows into the profile) until the temperature is within the error band. This parameter can also be changed by clicking on the Error Band section of the Information Bar once the profile is running.
- **Power Output Limit** – an overall percentage of oven power to be used in heating.

Note: This item is replaced by a list of more complex temperature settings in the TherMoiré AXP 2.0. See **Section 2.7** for details.

- **Lower Sample During Profile** – Activating this toggle causes the program to lower the sample by a set distance during heating and cooling. This will typically reduce the chance of outgassing products from the samples under test condensing on the grating. It also has the potential to improve temperature uniformity and heating/cooling rates by reducing the heat sink effect of the

grating. The distance that the sample is lowered can be set here, with typical values falling in the 100-400 mil range. Larger distances can be entered, but will take longer to execute, affecting profile timing and acquisition temperature.

Note: The temperature reading of an acquisition will be recorded at the end of the motor move motion. As a result, for longer move times or closer sample/grating distances, the temperature can be offset by several degrees from the setpoint (± error band) temperature.

In **XY Settings** the user can specify XY Orientation to be used with Interface Analysis or Automated Reporting. If Lateral Resolution has been specified in Surface Measurement, the user can enable it during the thermal profile.

Note: Both of these settings are deselected the next time a profile is run to force the user to make sure that they are still correct from run to run.

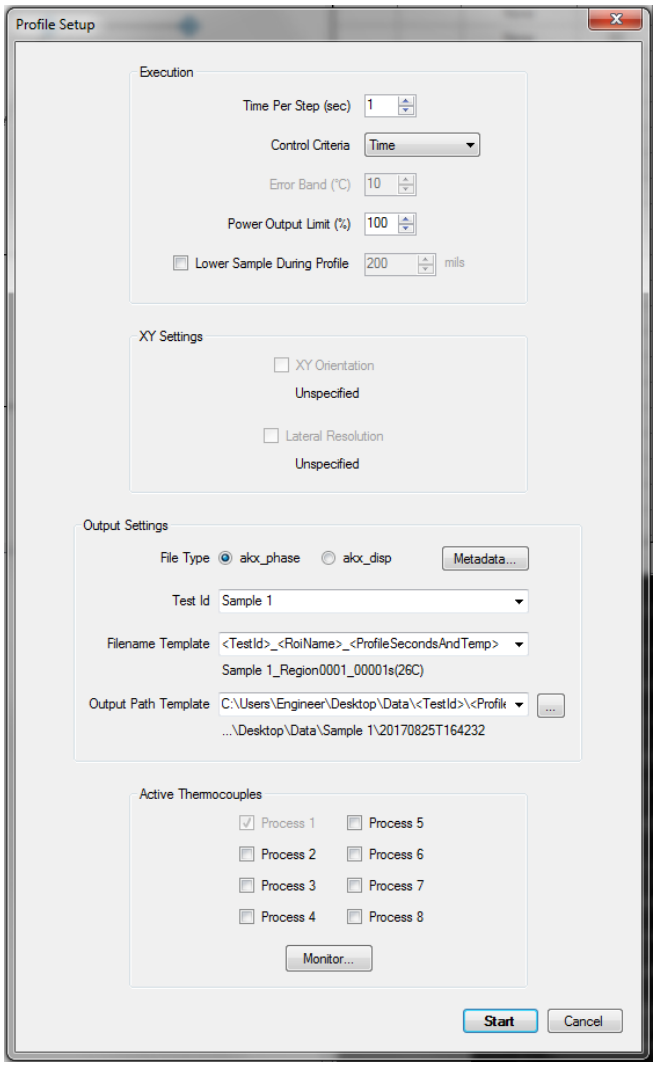


Figure 2.20 Profile Setup Dialog

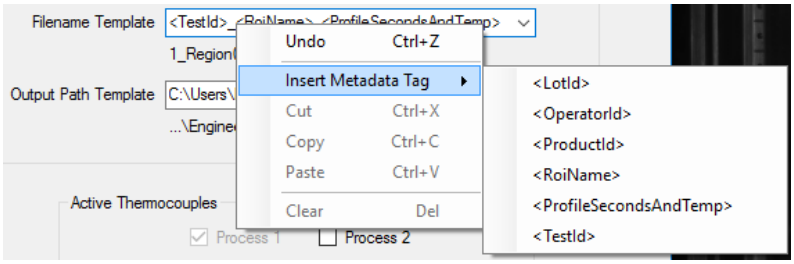


Figure 2.21 Filename Template Metadata Tags

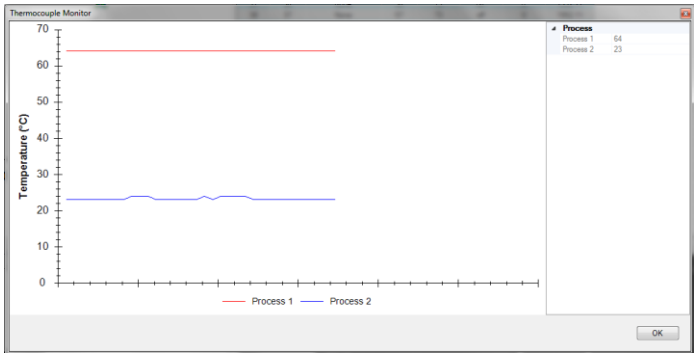


Figure 2.22 Thermocouple Monitor

Output Settings allows the user to determine where the data files will be saved, and what naming pattern will be used. It has five options.

- **File Type** – Allows the user to choose between saving data as phase or displacement. Phase (*.akx_phase) is preferable in most cases.
- **Metadata…** – Allows the user to set metadata for the run such as Product ID, Lot ID, and Operator ID.
- **TestID** – This is a piece of metadata that labels a specific run. The program remembers the last 8 TestIDs used. They can be recalled by clicking on the TestID box and pressing the down arrow key until the desired previous ID appears, or by clicking on the arrow on the right of the box and selecting from the resulting list.
- **Filename Template** – Allows the user to create a standard name for files created by the profile. This usually consists of a list of metadata tags associated with the run, plus the ROI name and temperature for a given reading. See **Appendix A.1.1** for available Metadata fields. The specific tags used and their

order can be changed by the user. As **Figure 2.21** shows, this box has a list of standard metadata tags in its context menu that the user can select from instead of typing them in manually. The arrow at the end of the box allows the user to select from a few default tag options:

- **<Default>**: All results will go in the chosen output path.
- **<Default: Organize By Roi>**: Results will go in subfolders in the output path, one for each ROI.
- **<Default: Organize By Temperature>**: Results will go in subfolders in the output path, one for each temperature in the profile.

Note: When any of these default tag options are chosen, the text in the filename template will change to the appropriate tags required to perform the action.

A sample filename created by the tags is listed just below the entry box.

- **Output Path Template** – Allows the user to choose a folder in which to save the profile results. The user can either select an existing folder with the '…' button or use a similar metadata tagging system to the Filename Template to create new folders tagged with metadata labels. The arrow at the end of the template entry box allows the user to select from a list of recent file paths. The current full file path is listed below the template entry box.

Note: If the output path template contains tags, the path is generated dynamically at the start of the profile and then remains static thereafter. Because ROI Name can vary within a profile, it is unsupported in this box. If the user wishes files to go in different folders, the subfolder tags should be placed in the filename template a la the default **Organize By…** examples above.

The Active Thermocouples section is used to turn thermocouples on and off depending on which ones are actually attached and measuring a sample. Below thermocouple selection is the Monitor… button, which brings up the Thermocouple Monitor (see **Figure 2.22**). This window allows the user to see, in real time, what the thermocouples are reading.

Once all these parameters have been set up, the user can press Start. The profile will run automatically, regulating temperature via the temperature controller and capturing data using the system camera. The user can stop the profile at any time by right-clicking on the profile graph or table and selecting Stop. Pressing the system E-Stop button will also end the profile.

Regardless of how the profile is stopped, at the conclusion of the profile, the application will prompt the user to save both the graph and table view data. These files will use the same tags as the Filename Template, minus <RoiName> and <Profile Seconds and Temp>, since those are specific to the different acquisitions.

2.6 Manual Temperature Profiling

In addition to profile-based measurement, Thermal Profiler now allows the user to manually enter temperatures for oven control. In this mode, measurement acquisitions can be made both on demand and once set points are reached. Thermal Profiler will record and graph thermocouple values while the user enters setpoints and acquisition temperatures.

To enter manual mode, select Manual Mode from Tools (see **Figure 2.15**). The menu displayed in **Figure 2.23** will appear. The user will then have the option to choose a set point and to either take an immediate acquisition or tell the program to take one at the setpoint. To run the manual profile, the user must press Start, which brings them to the normal Start menu described in **Section 2.5** and allows them to enter settings such as output path and tracked thermocouples.

Once the manual profile is running, Thermal Profiler will return to the normal interface with two differences. First, the profile will be created as it runs, with the input profile line being a flat line at the setpoint temperature. Second, the manual menu will return to the center of the screen, allowing the user to change the setpoint or take an acquisition at any time. However, the manual menu will now say Stop at the bottom instead of Start.

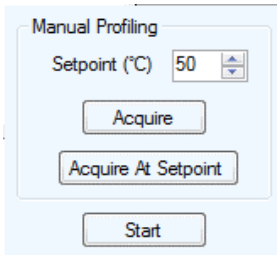


Figure 2.23 Manual Mode Menu

2.7 AXP 2.0 Profile Setup

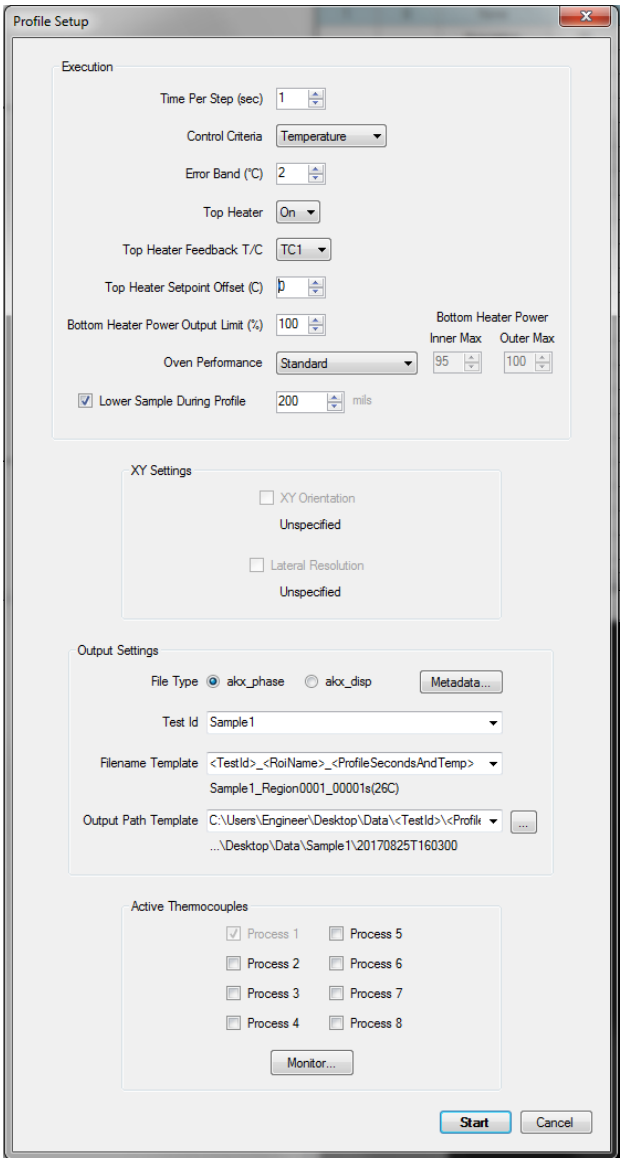


Figure 2.24 AXP 2.0 Profile Setup

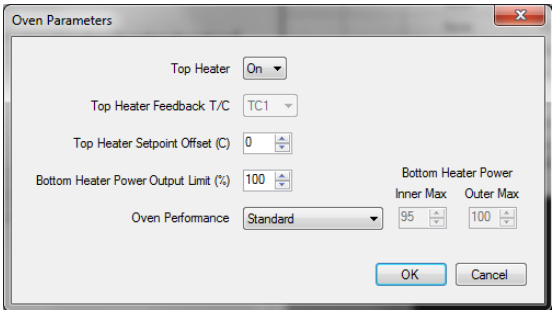


Figure 2.25 AXP 2.0 Oven Parameters

When operating the AXP 2.0, Thermal Profiler has additional options for controlling the Bottom and Top heater elements (**Figure 2.24**). The Top heater can be turned on and off, depending on top/bottom uniformity needs. The Top heater can be controlled by either thermocouple 1 or 2, depending on the setup needs of the current sample. An offset value can be programmed such that the setpoint for the Top heater is either above or below the setpoint for the Bottom heater. The total power percentage available to the Bottom heater can be set, as well as the relative power percentages available to either the inner or outer zones. Several pre-defined modes for inner and outer power percentages come by default, but custom power percentages can also be set. The heater modes are as follows:

- **Standard** – 95% inner, 100% outer, good compromise between heating rate and uniformity for most setups

- **Max Heating** – 100% inner, 100% outer, maximum power for maximum heating
- **Top Bottom Uniformity** – 0% inner, 100% outer, designed to bounce IR energy off of the bottom surface of the top lid glass assembly, which is coated with an IR reflective coating
- **Custom** – allows user to adjust inner and outer zone percentages at will

In addition to setting these oven power parameters at setup, the user can also alter them during a profile by clicking on the Power Output Limit section of the info bar (**Figure 2.9**). All the parameters available at profile start will be available in a pop-up window (**Figure 2.25**) and tracked during the profile as additional columns in the profile table text file.

2.8 DFP/DIC Modes

2.8.1 DFP

When Surface Measurement is in DFP mode, the Thermal Profiler application will also be in DFP mode. However, for all intents and purposes, the user will not notice this change. All program functions will be identical to that of regular shadow moiré measurements.

2.8.2 DIC

There will be some slight changes to Thermal Profiler while in DIC mode. Because there is no DIC analysis built into the Surface Measurement application, no graph will show up when DIC images are captured. Instead, all the user will see is the captured images in a tabbed format (see **Figure 2.26**).

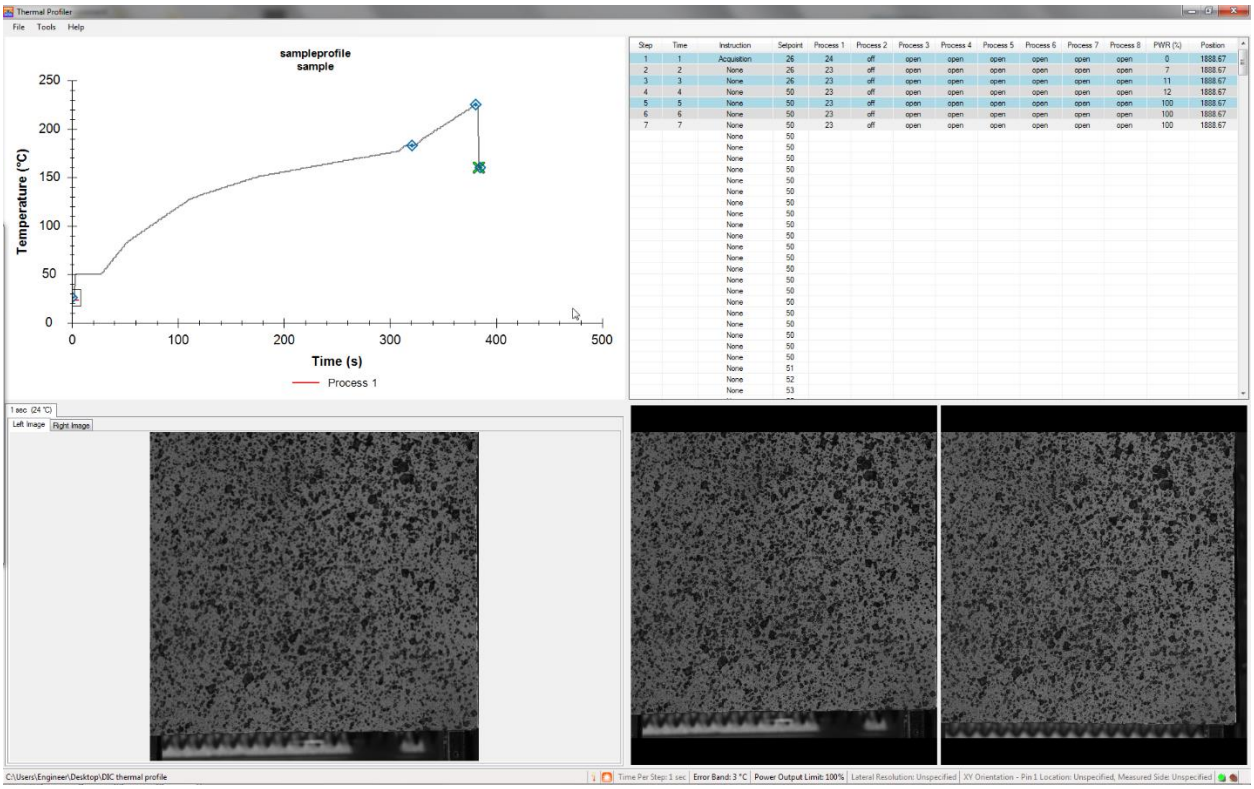


Figure 2.26 Thermal Profiler in DIC mode

2.9 Part Tracking Mode

Before a thermal profile is run with Part Tracking enabled, an initial part track operation is performed to establish a base line for how many parts the software should expect to find. If a part happens to not be found during any subsequent measurements, the remaining parts will still be numbered appropriately. A Baseline Arrangement confirmation dialog (**Figure 2.27**) will pop up stating the number of parts found and asks the user to confirm that this is the desired number of parts. While a profile is running with Part Tracking enabled, parts will be tracked and ROI selection annotations will be placed on the Camera Window Pane over the location where the parts were found.

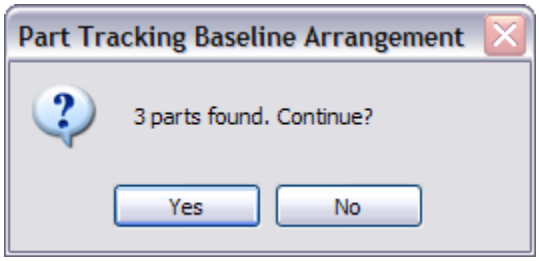


Figure 2.27 Baseline Arrangement Confirmation

Appendix A - Miscellaneous Information

A.1 File Formats

Input files for the Thermal Profiler application consist of only one type, files with the extension .akx_profile. For more information on this file format and its construction please see the Profile Generator User Manual.

Output files consist of *.txt, *.png, *.akx_phase, *.akx_disp, and, while in DIC mode, *.tif files.

A.1.1 Metadata Fields

Metadata fields embedded in *.akx_phase or *.akx_disp objects can be used in building filenames, output paths, and report labels in various places in Akrometrix Studio applications. Some of the more commonly used metadata fields are described below.

<RoiName>	User defined when adding ROIs to the Camera Window. Also defined when partitioning in **Surface Analysis**.
<LotId>	User defined in the Metadata settings dialog (**Figure 2.20**)
<TestId>	User defined in the Metadata settings dialog (**Figure 2.20**)
<OperatorId>	User defined in the Metadata settings dialog (**Figure 2.20**)
<ProductId>	User defined in the Metadata settings dialog (**Figure 2.20**)
<TemperatureNominal>	User defined when creating a profile in **Profiler Generator**
<TemperatureReading>	Any thermocouple data for the acquisition (can include up to 16 temperatures in the case of a CRE measurement). With no suffix, this metadata tag will provide TC1 data, but a two digit numerical suffix, such as “02” will provide the data for the corresponding thermocouple.
<TemperatureSetpoint>	User defined when creating a profile in **Profile Generator**
<ProfileSecondsAndTemp>	Inserts the current time/temperature of the acquisition into the filename

Other metadata fields such as Pin 1 Location, Equipment Model, etc. are available by right clicking on any phase or displacement image and going to **Properties…**. Any entry in this list can be surrounded by “<” “>” symbols to indicate to the application to use that metadata field in populating the corresponding text entry area. In addition, any gauge value can be added in the same way.

A.2 Keyboard Shortcuts

There are currently no keyboard shortcuts in the Thermal Profiler application.