

# MetroPro Reference Guide

**version 9.0**

**OMP-0347M**

**zygo**<sup>®</sup>

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## MANUAL REVISION INFORMATION

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 Note provides helpful information.

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11/2002

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# MetroPro Basics

## Section

# 1

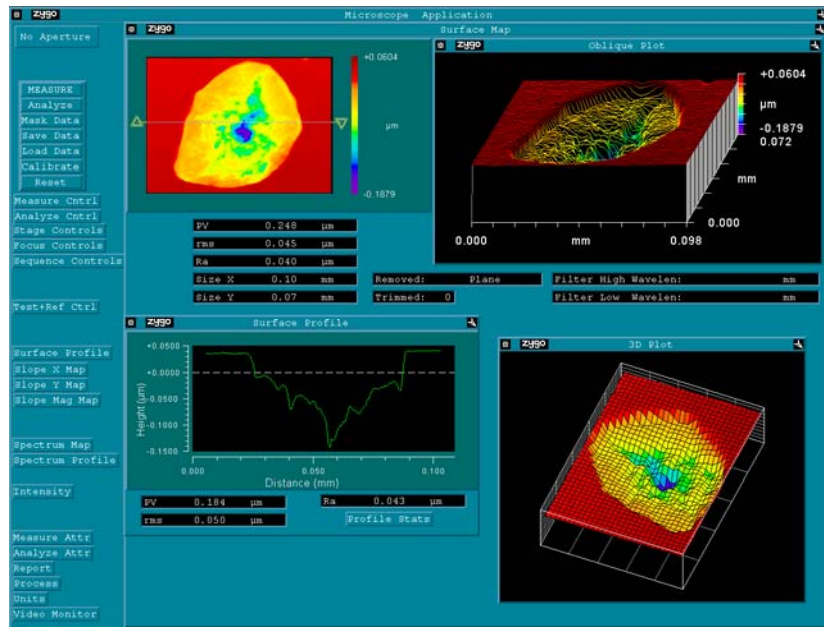
To effectively use MetroPro, you'll need to know some basic terminology, and how to work with menus, boxes, windows, and files.

## MetroPro Manuals

<i>MetroPro Quick-Start Guide OMP-0469</i>	Starting, licensing, and updating MetroPro software. Supplied in Adobe Acrobat Reader (PDF) format in <i>Manuals on CD</i> .
<i>MetroPro Reference Guide OMP-0347</i>	The resource for information on MetroPro. Explains controls, results, windows, and other features of the software. Supplied in PDF in <i>Manuals on CD</i> .
<i>MetroPro Application Booklets (various OMP's)</i>	Details on MetroPro applications specific to your instrument. All application booklets are supplied in PDF in <i>Manuals on CD</i> .
<i>MetroScript Programming Language OMP-0399</i>	A guide to using MetroScript, MetroPro's scripting language. MetroScript is used to automate and customize MetroPro. Supplied in PDF in <i>Manuals on CD</i> .

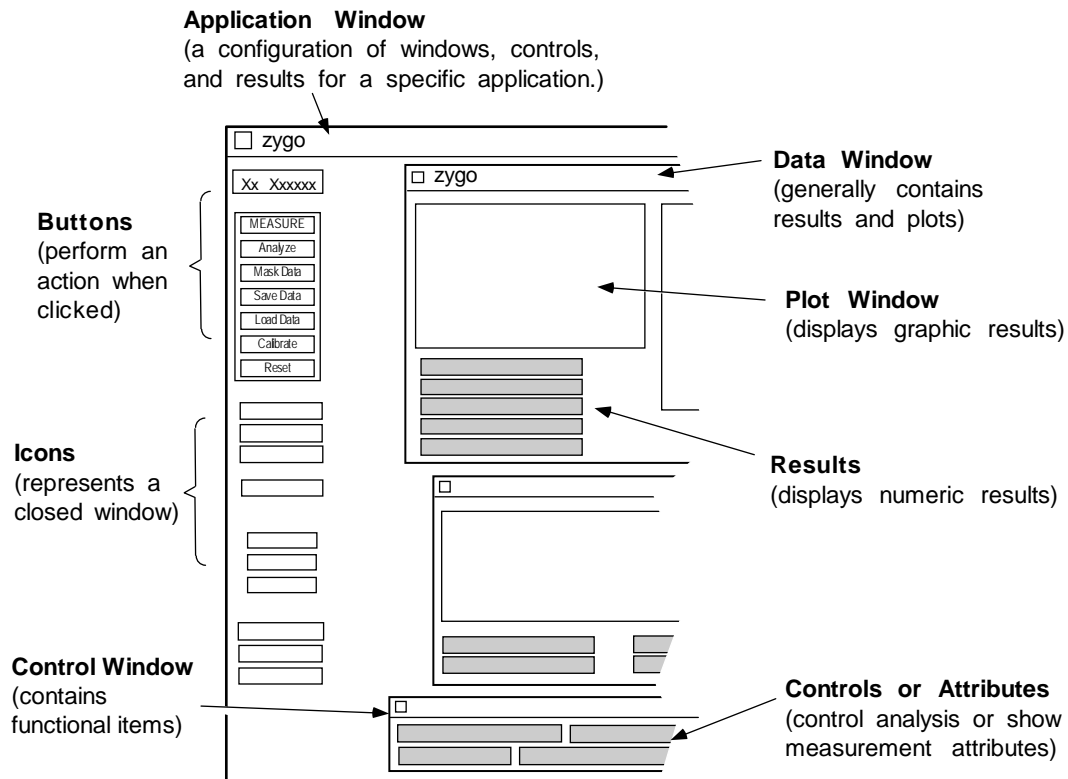
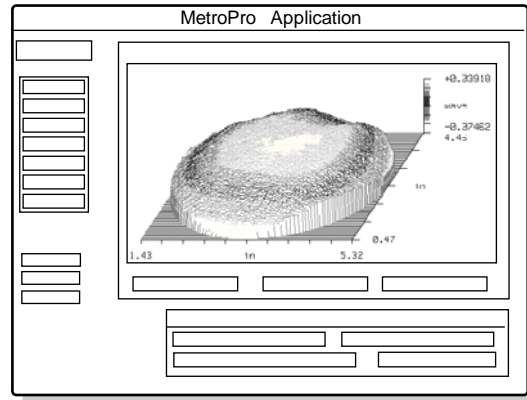
## MetroPro Software

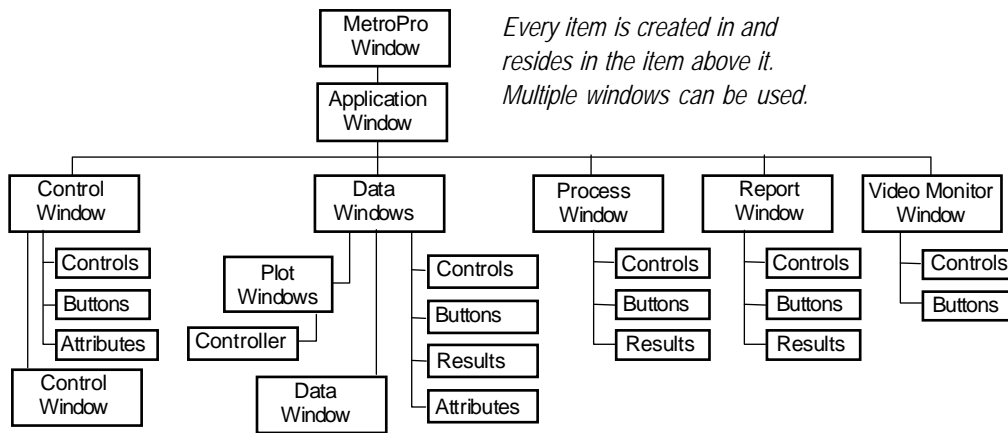
MetroPro software is for use with Zygo Corporation's metrology systems, such as the NewView and GPI instruments. With MetroPro, you get a full-featured, precision measurement program that includes standard applications to get you started quickly, and the tools to make your own special application to fit your needs.



## The Structure of MetroPro

MetroPro displays items in hierarchical or “nested” windows. The controls, buttons, results, plots, and other features within a particular window vary depending on the window. Each item, whether a window, control, result, or button, has its own associated menu. The menu varies depending on the item.

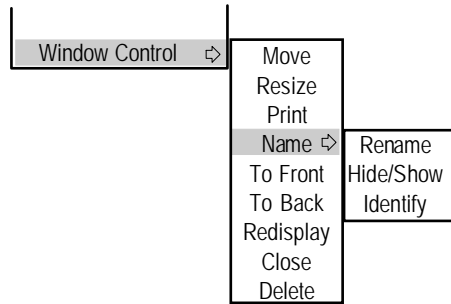




<i>Item</i>	<i>Description</i>
<i>MetroPro Window</i>	The screen displayed when the program starts, it may contain multiple Application windows or icons.
<i>Application Window</i>	Represents one application or use of the instrument; it may contain Control, Data and other windows or icons.
<i>Control Window</i>	Used to control the measurement; it may contain buttons, controls, and attributes, or another Control window.
<i>Data Windows</i>	Used to view the data; it may contain Plot windows, controls, results, attributes, and buttons. There are two basic forms - map (a three dimensional data matrix) and profile (a two dimensional data grid).
<i>Plot Windows</i>	Show graphic representations of measurement data. The most common three dimensional plot is the Filled Plot. A two dimensional plot is called a Profile Plot. A device called a "Controller" is used to control each plot display.
<i>Process Window</i>	Used to gather results from multiple measurements; and for controlling statistical processing analysis; it may contain controls, buttons, and copies of boxes.
<i>Report Window</i>	Used to compose measurement results and information for saving to a file, logging to a file, or for printing; it may contain controls, buttons, and copies of boxes.
<i>Video Monitor Window</i>	Used to place measurement results and information on the Video Monitor screen; it may contain controls, buttons, and copies of boxes.
<i>Controls</i>	Software controls used to manage the acquisition or analysis of data.
<i>Buttons</i>	On-screen push buttons that are activated with the mouse to perform general system functions or open other special windows.
<i>Results</i>	Display numeric measurement results.
<i>Attributes</i>	Status boxes that show information about the current measurement.
<i>Icon</i>	A window in its minimized state; it appears similar to a button.

## Finding Out What an Item Is

Knowing the original software name can help you find out more about an item in question. Use the original name when looking for information in this manual.

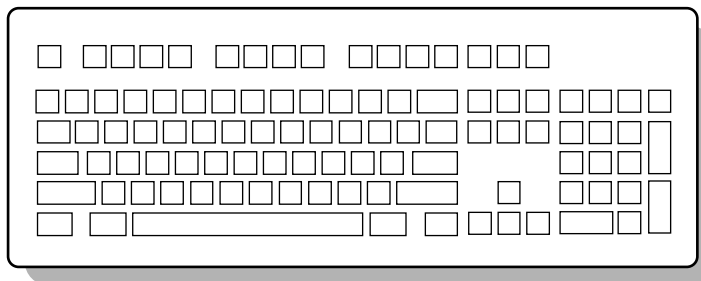


The Identify command provides information about the item under the mouse pointer when the command is selected. The Identify command is useful when the names of windows, boxes, and buttons have been changed in the application or when the window title bar is hidden. For windows, the Identify command is accessed with the Window Control → Name → command. For controls, results, attributes, and buttons, the Identify command is accessed with the Name → command. The Identify command is not available for icons

When the Identify command is selected, a Message box appears with information dealing with the item. Click the OK button to clear the Message.

## Using The Keyboard

The keyboard in MetroPro is used for text entry, when using controls, when saving and loading files, and to substitute for mouse clicks.



### Entering Text and Numbers

Text and numbers are entered with the keyboard. You must enter text when you select a menu item that needs information to carry out the command. For example, text is entered when renaming an item, saving a file, inputting a limit, and entering a numeric value.

At the start of an entry, the entire field is highlighted. If you start typing text, the previous entry is completely replaced by the new entry. To edit or modify the current text, click on any point in the text. These keys move you through an entry: left and right arrow, Home, and End. These keys edit the entry: Insert, Delete, and Backspace. To end text entry press [Enter] or click the *left* mouse button. To cancel a text entry, press [Esc] or the *right* mouse button.

## Special Keys

<i>Key</i>	<i>Function</i>
Esc	Aborts processing, cancels text entry, alternate for NO in a Dialog box.
Ctrl	Modify key used when deleting slices.
Shift	Modify key when moving cursors, slices, and deleting.
Enter	Completes text entry, alternate for YES or OK in a Dialog box.
Backspace	Moves cursor left one space does not delete characters.
Insert	Toggles insert mode; when on characters are added at cursor.
Delete	Removes characters in front of cursor one at a time.
←	Moves cursor left one space, move slices left.
→	Moves cursor right one space, move slices right.
↑ ↓	Moves slices up or down.
Page Down	Same as clicking Next in the File Handler.
Page Up	Same as clicking Prev in the File Handler.

## Key Combinations

<i>Key Combo</i>	<i>Function</i>
Ctrl C	Cancels text entry.
Shift ←	Move cursor to beginning of text field, move slices left in larger increment than ←.
Shift →	Move cursor to end of text field, move slices right in larger increment than →.
Shift ↑	Move slices up in larger increment than ↑.
Shift ↓	Move slices down in larger increment than ↓.
Shift Backspace	Delete character to left of cursor.
Ctrl Alt Delete	Quit MetroPro and all processing, return to Login screen.

## Function Keys

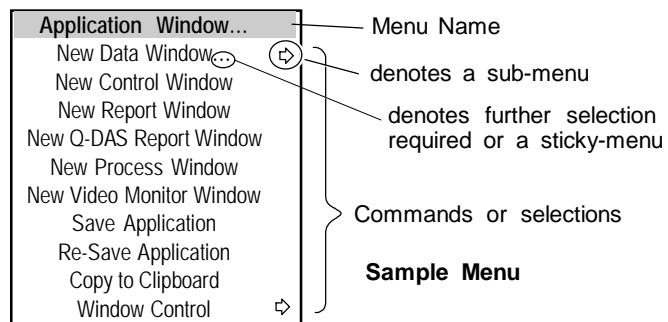
<i>Key</i>	<i>Function</i>
F1	Same as clicking MEASURE button.
F2	Same as clicking Analyze button.
F4	Opens Light Level window.
F5	Automatically adjusts light level.
F8	Closes application window.
F9	Open live video window.

## Light Level Keys

<i>Key</i>	<i>Function</i>
F4	Opens Light Level window.
F5	Automatically adjusts light level.
* /	Coarse up and down light adjust.
+ -	Fine up and down light adjust.
Tab	Toggle between last two light level settings.
Number keys	Adjust light level in 10% increments, 1=10%, 2=20%, etc.

## Working With Menus

Menus are used to control all aspects of MetroPro operation. Like a menu in a restaurant, MetroPro menus allow you to select a command or function from a list of choices.

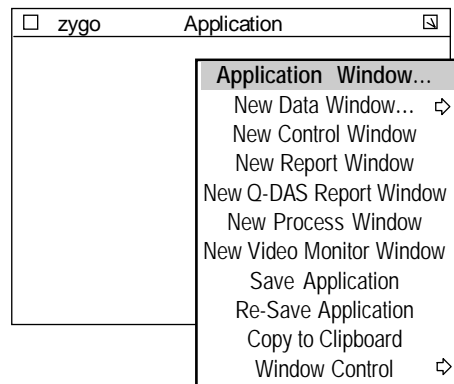


## Accessing a Menu

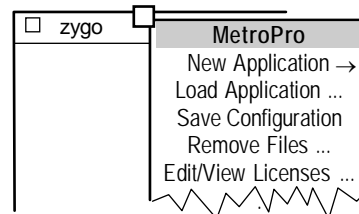
To access a menu position the mouse pointer on an item and press the *right* mouse button. A menu appears on the screen wherever the mouse pointer is, and remains visible as long as you hold the button down. The items listed on the menu pertain to the particular window, box, or button that the pointer was on when you pressed the mouse button.

### To access a menu -

Position the mouse pointer on a window, box, or button and press the *right* mouse button.

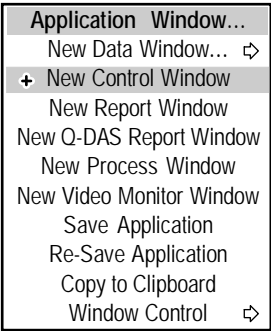


To access the main MetroPro window menu, right click on the topmost MetroPro title bar.



**Selecting a Command**

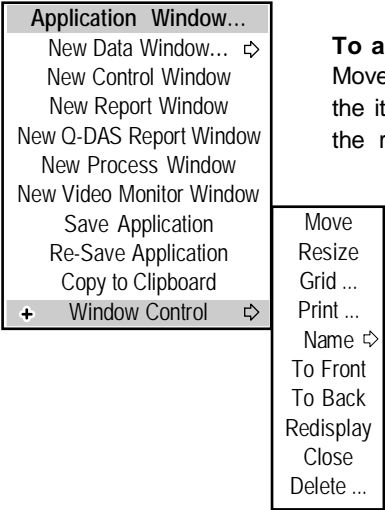
To select an item from a menu, you first access the menu, drag the mouse pointer down the list until the item that you want is highlighted; then release the mouse button. In the menu shown here, the New Control Window command is highlighted.



**To select an item -** Release the mouse button when the desired item is highlighted.

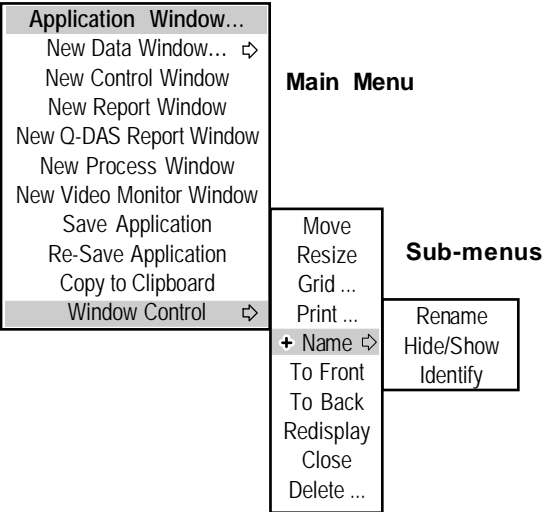
**Selecting a Sub-menu**

If a menu item has a right-pointing arrow next to it, that item itself is not a command; rather, it is used only to access a sub-menu. Instead of releasing the mouse button on an item with an arrow, drag the cursor onto the arrow; a sub-menu appears to the right of the existing menu.

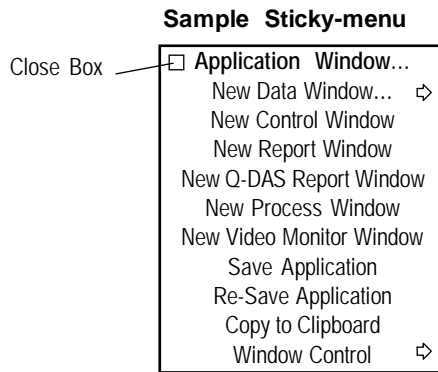


**To access a sub-menu -** Move the cursor onto the arrow next to the item. The sub-menu appears to the right.

To select certain items, you may have to access two or three sub-menus before arriving at the one that has the item you're looking for.



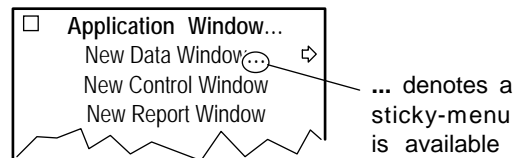
## Using Sticky-menus



Menu choices with “...” (dot-dot-dot) can be posted on the screen; this allows you to select commands without having to access the menu each time. We call this type of menu a “sticky-menu”. Sticky-menus work a little different from the other menus; you use the left mouse button to select commands instead of the right.

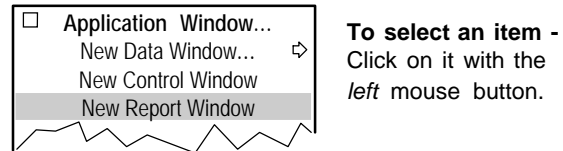
### Creating A Sticky-Menu

To create a sticky-menu, access the menu and choose a “...” menu selection. An outline of the menu appears; press a mouse button, and move the mouse to position the outline on the screen. Release the mouse button and the sticky-menu appears.



### Selecting a Sticky-menu Command

To select an item from a sticky-menu, point to the item with the cursor and click the *left* mouse button. If the selection has a sub-menu, press the *left* mouse button to select other options.



### Moving a Sticky-menu

To move a sticky-menu, position the cursor anywhere on the menu and press the *middle* mouse button, or position the cursor on the title of the menu and press the *left* mouse button. Drag the mouse to relocate the menu and release the mouse button.

### Removing a Sticky-menu

To remove or delete a sticky-menu from the screen display, click its close box with any mouse button or close the window from which the menu was accessed.



**Typical Menus**

**MetroPro Window Menu**

- MetroPro
- New Application →
- Load Application ...
- Save Configuration
- Remove Files ...
- Edit/View Licenses ...
- Print ...
- Redisplay
- Show Program Info
- Show Disk Usage
- View Log File ... →
- Script →
- Quit ...

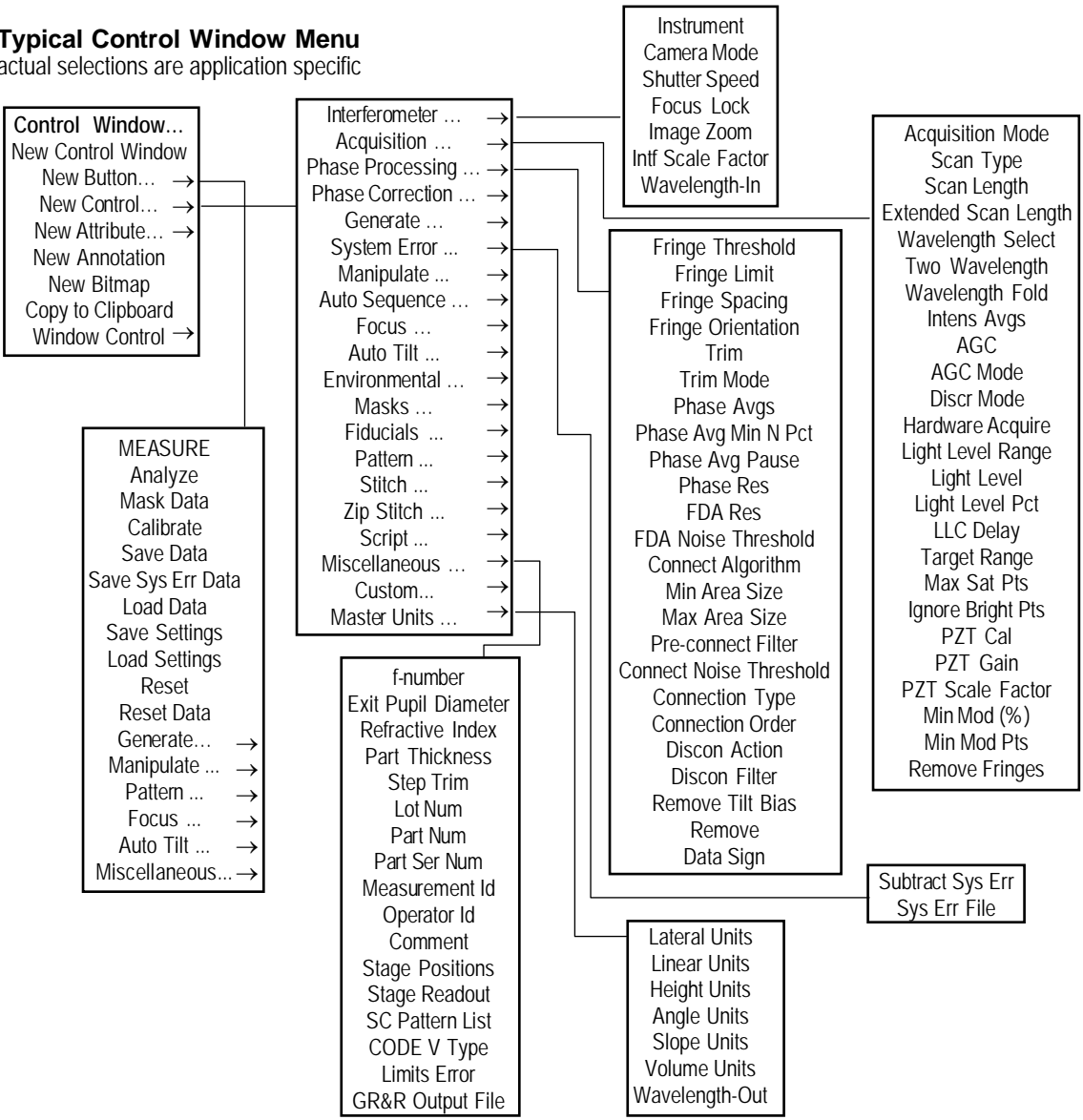
**Application Window Menu**

- Application Window...
  - New Data Window... →
  - New Control Window
  - New Q-DAS Report Window
  - New Report Window
  - New Process Window
  - New Video Monitor Window
  - Save Application
  - Re-save Application
  - Copt to Clipboard
  - Window Control →
- Move
  - Resize
  - Grid ...
  - Print ...
  - Name →
  - To Front
  - To Back
  - Redisplay
  - Close
  - Delete ...
- data window choices specific to application

  - Rename
  - Hide / Show
  - Identify

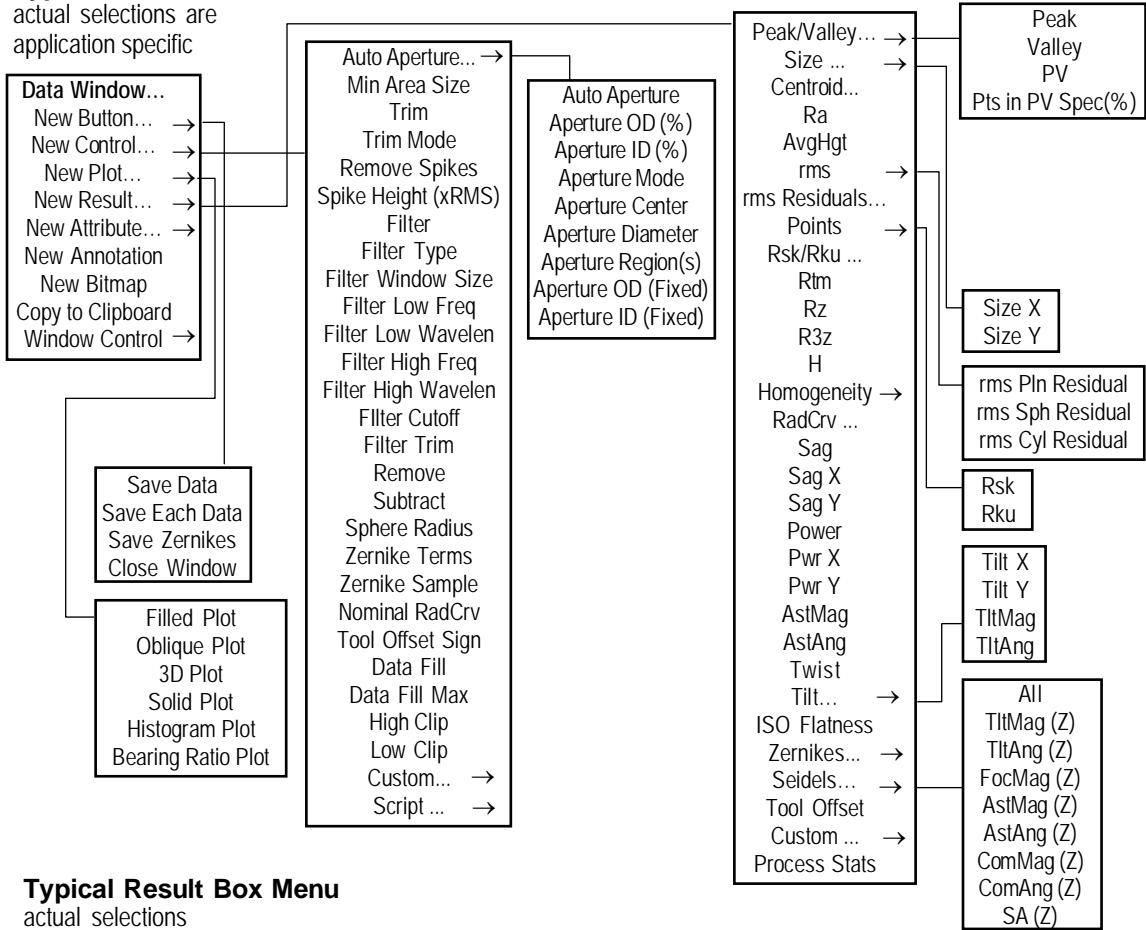
**Typical Control Window Menu**

actual selections are application specific



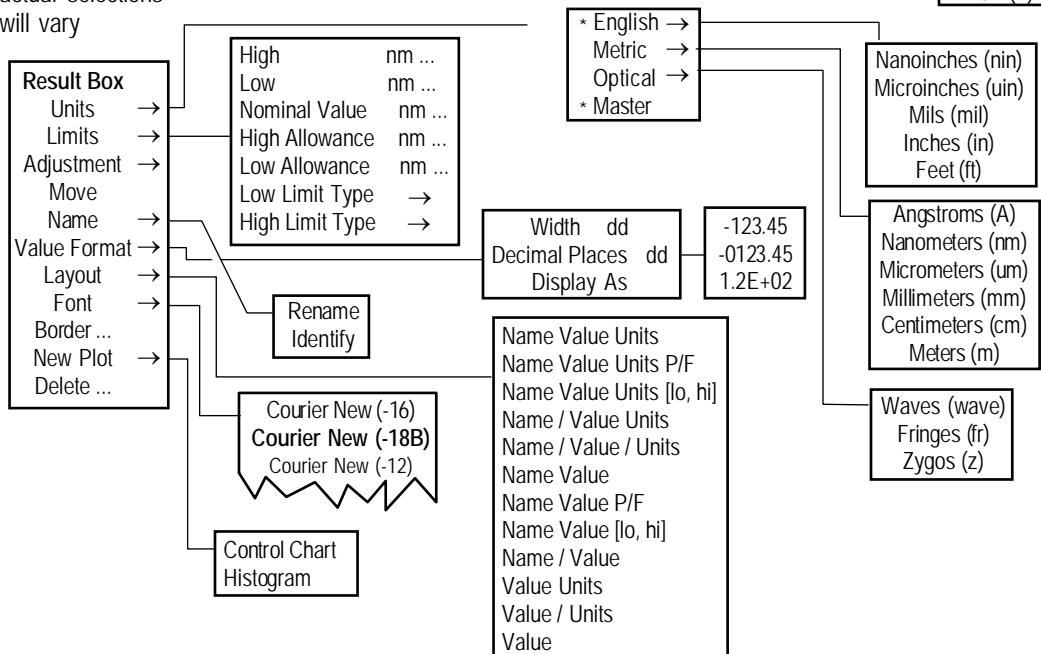
**Typical Data Window Menu**

actual selections are application specific



**Typical Result Box Menu**

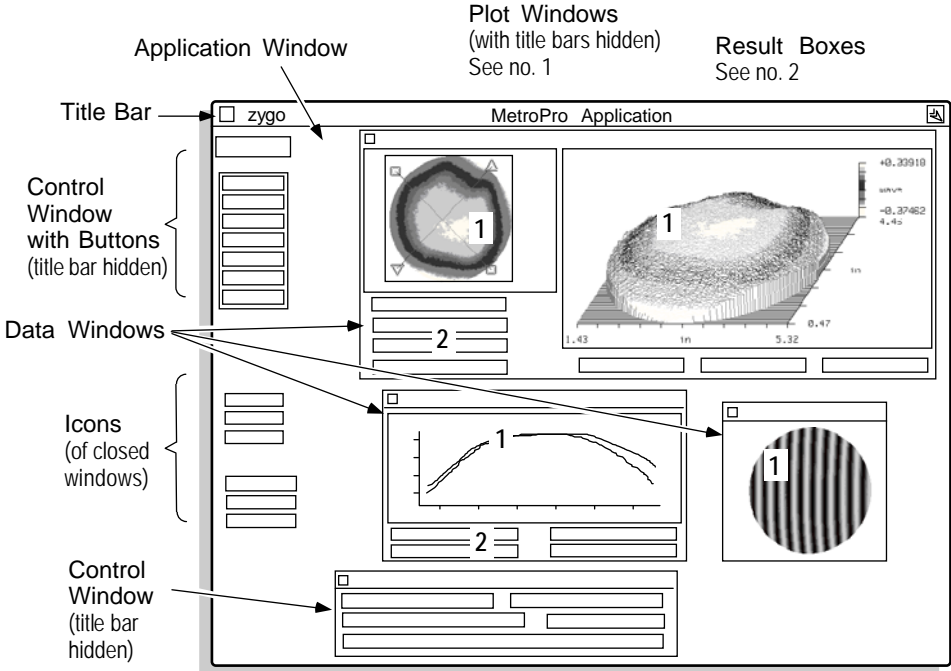
actual selections will vary



# Working With Windows

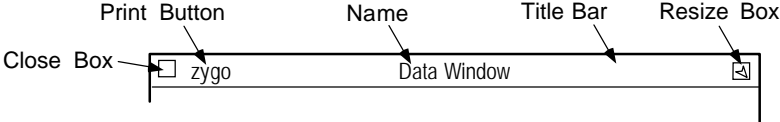
All MetroPro displays and controls appear within “windows”. A window is a rectangular outline on the screen that defines an area where related things are displayed. MetroPro uses “nested” windows; some windows must be created and used within a parent window.

The Application window is the main or parent window of an application. The Application window may contain Data windows and Control windows. Data windows may contain Plot windows, buttons, and boxes. Control windows may contain only buttons and boxes. Any windows, boxes, or buttons created within a parent window always remain inside the parent window boundaries.



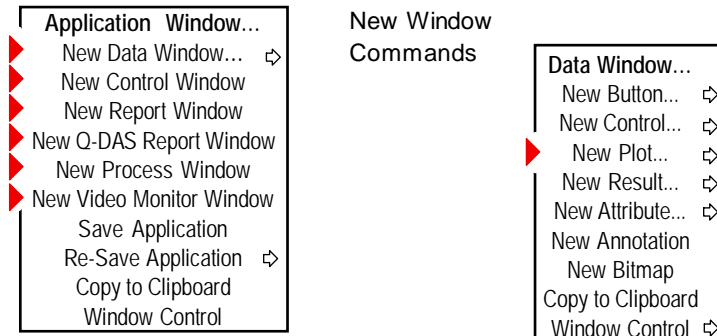
## Parts of a Window

A window usually has a title bar at the top containing a name, a Resize box, a Close box, and a “zygo” Print button. The title bar itself also serves as a place to grab the window to move it.



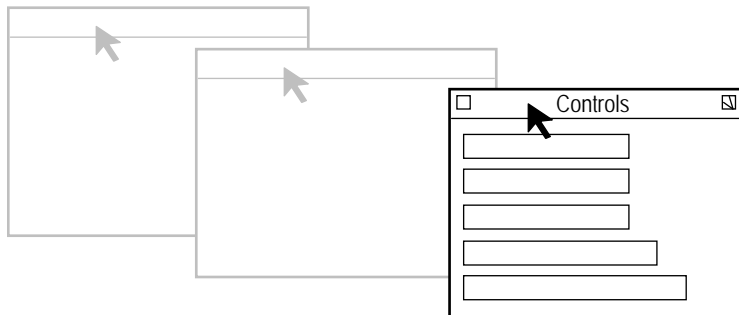
## Creating a New Window

To create a window, select a relevant command from the parent window menu; an outline of the window appears; move the mouse to position the outline. For the window to appear, *click* any mouse button. Alternatively, to resize the window before it appears, *press* any mouse button and drag the mouse to size the window; then, release the mouse button.



## Moving a Window

To move any window, except a Plot window, position the cursor on the window and press the *middle* mouse button. Or, for all windows, position the cursor on the window title bar and press the *left* mouse. Then, drag the mouse to relocate the window and release the mouse button.

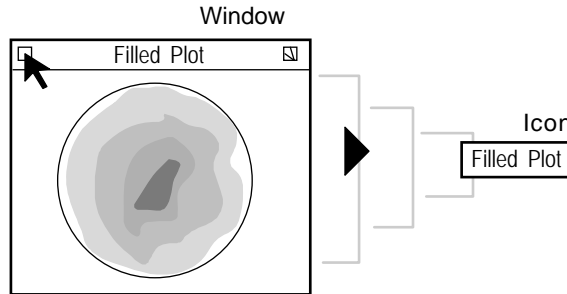


Press the middle mouse button on the window, drag to relocate window, then release the mouse button.

Remember, a window cannot be moved outside the boundaries of its parent window. For example, in the previous illustration, the Control window must remain within the Application window.

## Closing a Window

Click the *left* mouse button on the window Close box to close the window into an “icon”. An icon represents a closed window. The entire window and anything inside of it are preserved in the icon.



## Closing a Window for the First Time

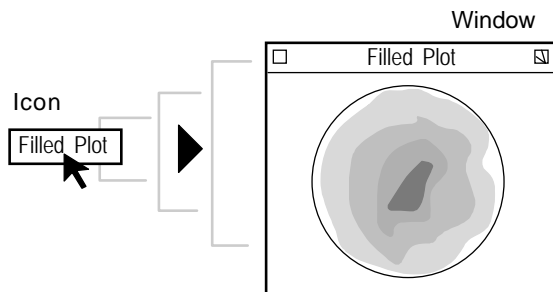
The first time you close a window you have to position the icon. When you click the window Close box, the window closes down to an icon outline. Press and hold any mouse button; move the mouse to locate the icon and release the mouse button. The icon appears where you placed it.

Closing a window to an icon conserves room on the screen without discarding any measurement data. The window reappears full size, with all data intact, when you click on the icon with the *left* mouse button.

## Opening a Window

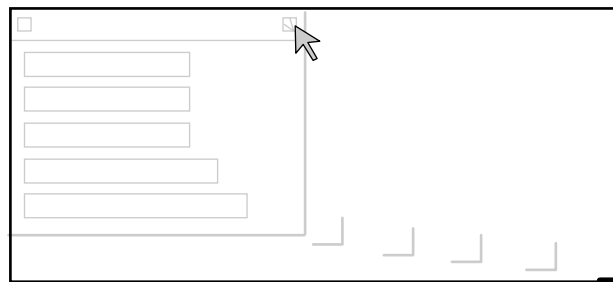
To open a window, in icon form, position the cursor over the icon and click the *left* mouse button.

Note that only three application windows can be opened at a time.



## Resizing a Window

Press any mouse button on the window Resize box to change the size of the window. A window outline appears with a reverse “L” shape bracket at the lower right corner of the window. The window is resized from the “L” bracket. Drag the mouse to change the size of the window and release the button when the window is the size you want.

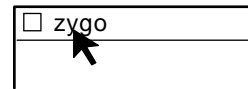


Press the left mouse button on the Resize box, drag "L" bracket to size window, then release the mouse button.

If you reduce the size of the window too much, items inside the window can be hidden or cut off. Remember, you can't enlarge a window beyond the boundaries of its parent window.

## Printing a Window

To print the contents of a window, click the left mouse button on the **zygo** Print button in the title bar.



A Print Panel opens which is used to send the image to a printer or a file. The screen is printed exactly as it is displayed, except that all type is printed black and the blue background is ignored. Printing is discussed in a later chapter.

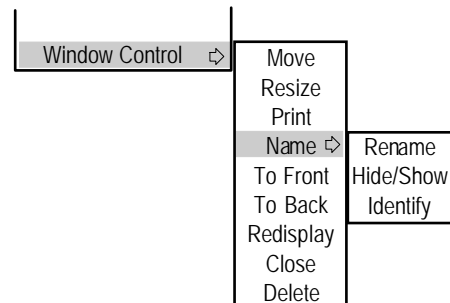
## Layering Windows

Windows and icons may overlap or cover one another. All opened items, even if they are not the front most item, are active.

To bring a window to the front, click the *middle* mouse button inside the window, or click the *left* mouse button on the window title bar.

## Using the Window Control Command

Most of the techniques described in this section can also be performed with the Window Control → menu command. These commands are especially useful if the title bar of a window is hidden.

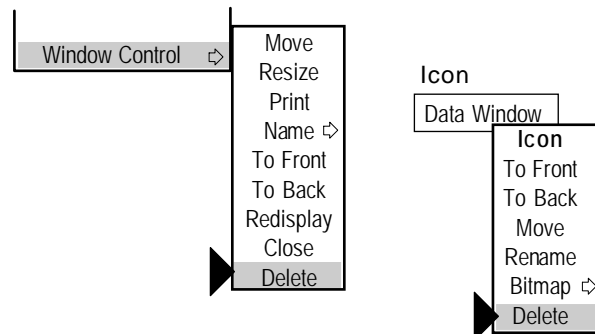


Take note of the Name → Identify command. Select this command if you want to get information on a window.

It is useful when window names have been changed and you want to know the original name.

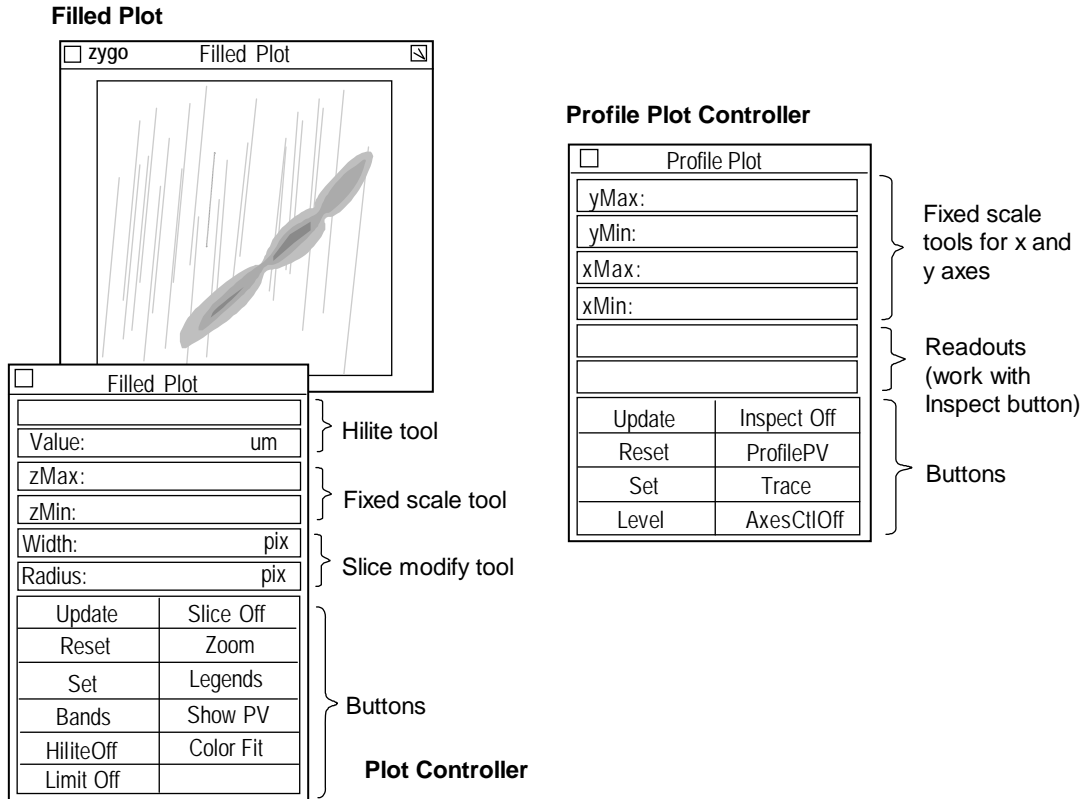
## Deleting a Window

To remove a window from the screen, select Window Control → Delete from the window you want to delete. If the window is in icon form, select Delete from the Icon menu.



## Working With Plots

Plots are unique types of windows. The display within the plot window is modified by a plot controller. Each plot has its own controller. There are different controllers for each of the plot types. Controllers use buttons and other tools to control the plotting of data. An example of two plot controllers is shown below.



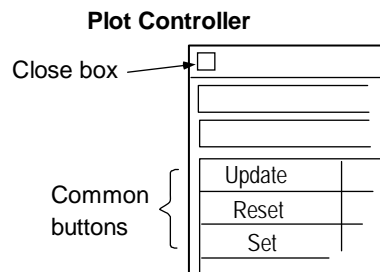
To access a plot controller, click on the plot window with the *middle* mouse button; or position the cursor over the plot, click the *right* mouse button and select the Show Controller command. When it is opened for the first time, an outline of the Controller appears; drag the mouse to position the Controller and then release the mouse button.

All plot Controllers have three common buttons: Update, Set, and Reset, plus a close box.

Update redraws the plot to the latest changes. Set makes the current settings the default. Reset changes the plot display to match the default settings.

Other buttons in the Controllers function as activators (to cause something to happen), switches (to turn something off and on), or selectors (to cycle through a series of choices). Most buttons are activated with the *left* mouse button.

More details on using plot controllers can be found in later sections of this manual.



## Working with Boxes and Buttons

### What is a Box?

A box is a small rectangular view of information on the screen. A box may show results or be used as a software control device. There are four categories of boxes: Control, Attribute, Result, and Annotation.

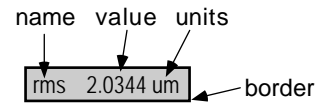
<i>Category</i>	<i>Description</i>	<i>Sample</i>	<i>Color</i>
<b>Control</b>	Specify and adjust measurement parameters.	Trim 2	blue
<b>Attribute</b>	Show status information about the current data.	Trimmed: 2	black
<b>Result</b>	Display numeric measurement results.	rms 2.0344 um	black
<b>Annotation</b>	Allow user-input text.	zygo corporation	black

You can differentiate boxes by their color; Control boxes are blue, the rest are black. An Attribute box is distinguished from a Control box having the same name by its color. Also, some Attribute boxes have the past tense of the word in the Control box. For example, if the Control box says Remove, the corresponding Attribute box says Removed.

When working with MetroPro, a message may be displayed on the screen. These messages are presented within boxes called Dialog boxes.

### Parts of a Box

Most boxes have similar parts. Each box is identified with a name and usually has a border; it also displays other information, such as values or current selections.





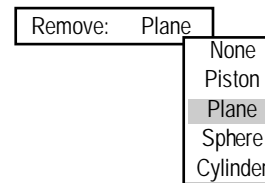
## Using Boxes

Result and Attribute boxes only display information. Control boxes, on the other hand, are devices used to specify analysis or to control the measurement.

To use a Control box, click on it with the *left* mouse button. For text entry controls, enter text in the text frame. For controls with selections, the selection either toggles to an alternate choice, or select the setting from the drop-down list and release the mouse button.

The Annotation box is used for adding comments; text is entered by clicking on the box and typing with the keyboard.

Example of a Control Box Drop-Down List



## Creating a New Box

Boxes may be created in Data, Control, Report, Process, and Video Monitor windows. To create a box, choose the appropriate command from the window menu and use sub-menus to specify the exact box.

After you choose a specific box on the sub-menu, an outline of the box appears on the screen. Press the *left* mouse button and drag the mouse to locate the box. Release the mouse button and the box appears

Commands That Create New Boxes



## Modifying a Box

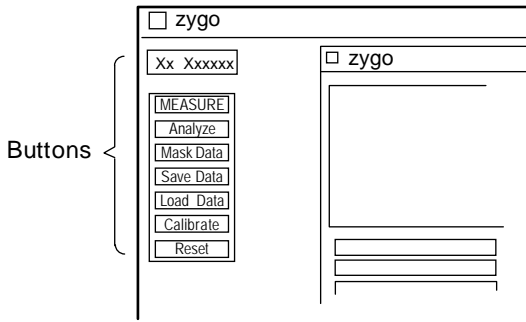
You can move a box by pressing the *middle* mouse button on the box, dragging it to a new location, and releasing the button. Using the box's menu, you can rename it; delete it; or change its display format, border width, and type style. Unlike windows, boxes cannot be resized, closed, or printed by themselves. Typical box menus are shown below.

Result Box	
Selects measurement units...	Units ⇄
Specifies upper and/or lower limits for results...	Limits ⇄
Scales result values...	Adjustment ⇄
Lets you move the box...	Move
Changes the name of the box...	Name ⇄
Specifies the format of information in the box...	Value Format ⇄
Selects the "look" of the box...	Layout ⇄
Selects the type style...	Font ⇄
Selects the pixel width of the border...	Border
Creates a control chart of the result...	Plots ⇄
Erases the box...	Delete

Control Box
Move
Name ⇄
Width
Layout ⇄
Font ⇄
Border
Delete

Selecting a menu command or clicking a box may open a text entry field.

## What is a Button?



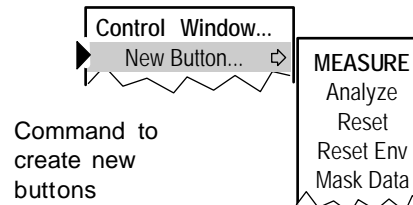
Buttons are on-screen switches that perform an action.

To activate a button, click the *left* mouse button when the cursor is over the button.

To cancel a button selection, move the cursor off the button before releasing the mouse button.

## Creating a New Button

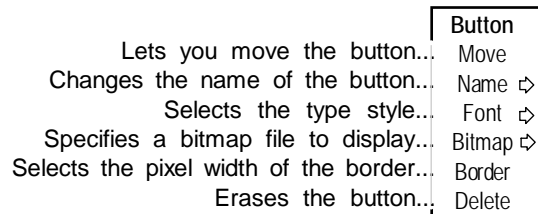
Buttons may be created in Data, Control, Report, Process, and Video Monitor windows. To create a button, choose the appropriate command from the window menu and use sub-menus to specify the exact button.



After you choose a specific button on the sub-menu, an outline of the button appears on the screen. Press the *left* mouse button and drag the mouse to locate the button. Release the mouse button and the button appears.

## Modifying a Button

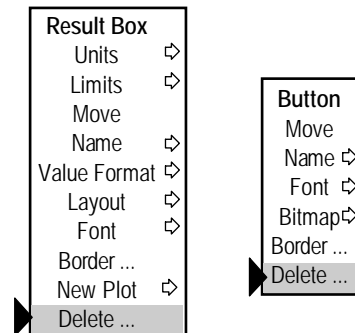
Just like a box, a button can be moved with the *middle* mouse button. By using the button menu you can rename it, delete it, alter its type style, and change its border width. A typical button menu is shown.



Take note of the Name → Identify command. Select this command if you want to get information on a box or button. It is useful when names have been changed and you want to know the original name.

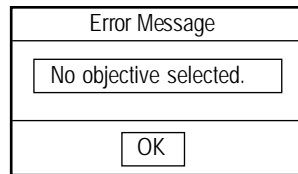
## Deleting a Box or Button

To remove a box or button from the screen, select Delete from the item's menu. When a Control box is deleted, it is only deleted from the screen; the last setting of the box is used for subsequent measurements.

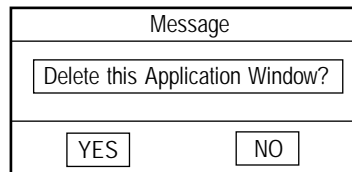


## ***What is a Dialog Box?***

A dialog box is a box that contains a message, often requesting more information from you or a requesting you to confirm an action. It is not related to any of the other boxes described earlier in this section.



Sample Dialog Boxes



## ***Responding to a Dialog Box***

To confirm an action or respond to the message, click on the appropriate button in the box with any mouse button.

Dialog boxes with an OK button also accept any keystroke as the response. Dialog boxes with YES or NO buttons also accept a [Enter] key for a “yes” response or the [Esc] key for a “no” response.

## Working With MetroPro Files

There are several different file types in MetroPro. Each is saved and loaded independently of the other. The most commonly used file type is the data file.

<i>File Type</i>	<i>Extension</i>	<i>Description</i>
<b>Application</b>	.app	A file containing the look and placement of windows and boxes, plus all control settings.
<b>Data</b>	.dat	A file containing measurement data. A data file contains multiple numerical arrays representing the part under test, plus measurement parameters.
<b>Fiducials</b>	.fid	A file containing fiducial information. For a detailed discussion of fiducials, refer to Section 5.
<b>Mask</b>	.mas	A file containing information that defines the way a measurement is taken or analyzed. For a detailed discussion of masks, refer to Section 5.
<b>Pattern</b>	.pat	A file containing programmable stage data.
<b>Report</b>	.rep	A text file containing user-selected measurement results and attributes. For a detailed discussion of making and using a Report file, refer to Section 11.
<b>Script</b>	.scr	A MetroScript file.
<b>Settings</b>	.set	A file containing control setting information.
<b>Template</b>	.geo	A file containing the geometric description of templates used for test part analysis.
<b>Zernikes</b>	.zfr	A text file containing Zernike terms in CODE V format. For a detailed discussion of exporting a Zernike file, refer to Section 12.

### Using the File Handler



MetroPro 9.0 uses standard Windows dialogs for saving and loading files. Previous versions of MetroPro used the save/load file dialogs described below. To use the older version, use the following command line option:  
-nowindowsDialog

File Handler is the general name given to the dialog box that is used to save, load, and remove files. All files are all managed in a similar fashion using a File Handler. A File Handler is invoked when you click a save or load button, or select a save or load menu command.

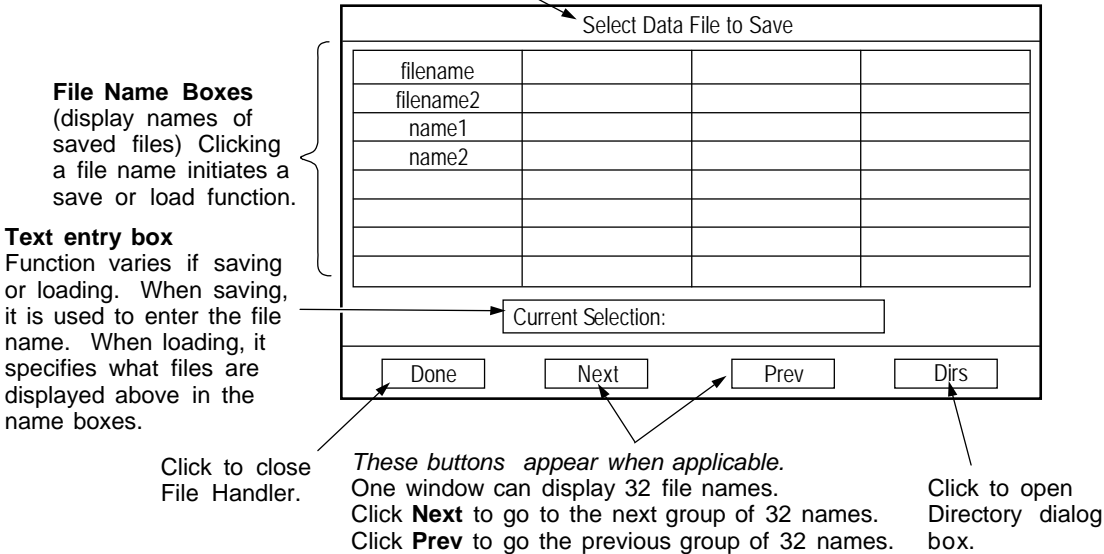
The specific File Handler shown will vary depending on the file type and the selected action.



If the -windowsDialog command line option is used, MetroPro saves and loads files using the standard Windows dialog box in place of those shown here.

### A Look at a File Handler

Identifies the action being performed.



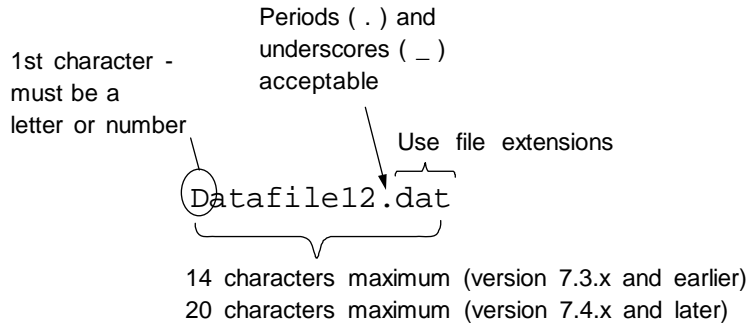
### Naming Files

When naming files, keep these guidelines in mind:

- The first character must be a letter or number.
- Subsequent characters can be letters, numbers, underscores ( \_ ) and periods.  
Names are limited to:

14 characters (MetroPro version 7.3.x and earlier)  
 20 characters (MetroPro version 7.4.x and later)

- Spaces and special characters are not accepted.
- Use file extensions to simplify file organization.



MetroPro uses a default name when a file is saved for the first time. It is a good idea to use file extensions along with each name, as they make it easier to locate file types and perform backup functions. The default names and recommended file name extensions are shown in the following table.

<i>File Type</i>	<i>Default Name</i>	<i>Recommended Extension</i>
Application	MyApp.app	.app
Data	MyData.dat	.dat
Fiducial	MyFid.fid	.fid
Mask	MyMasks.mas	.mas
Pattern	MyPattern.pat	.pat
Report	MyReport.rep	.rep
Script	MyScript.scr	.scr
Settings	MySettings.set	.set
Template	MyGeom.geo	.geo
Zernike	MyZernikes.zfr	.zfr

### ***Saving Files***

A File Handler appears when *saving* files, such as: selecting the Save Application command, or clicking on the Save Data button, Save Report button, Save Template button, or the Save button in the Mask Editor.

1. To open a File Handler, click the appropriate **Save** button or select the **Save Application** command.
2. Click on "Current Selection" with the left mouse button, type in a file name and press [Enter].
3. Click Done to close the File Handler.

Select Data File to Save			
filename			
filename2			
name1			
name2			

Current Selection:

**Re-saving an existing file**

*Substitute this for step 2:*  
Click on the file name box you want to resave and respond "Yes" to the Warning Message.

Note - the Directory feature is disabled when saving applications.

**Loading Files**

A File Handler appears when *loading* files, such as: selecting the Load Application command, or clicking on the Load Data button, or the Load button in the Mask Editor.

1. To open a File Handler, click the appropriate **Load** button or select the **Load Application** command.
2. Click on the file name box you want to load with the *left* mouse button.
3. Click Done to close the File Handler.

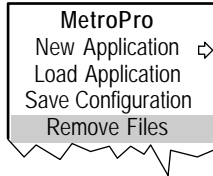
Select Data File to Load			
filename			
filename2			
name1			
name2			

Template: \*.xxx

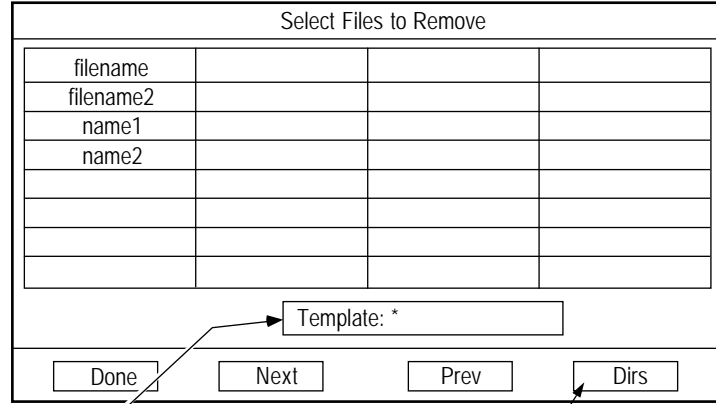
## Removing Files

A File Handler appears when removing or erasing files -- selecting the Remove Files command from the MetroPro Window menu.

1. Select the **Remove Files** to open the File Handler.



2. Click on the file name you want to erase with the *left* mouse button.
3. Respond "Yes" to the screen message to confirm your action.
4. Click Done to close the Handler.



*Use the template entry box to determine the listed files.*  
A \* (star) will list all files.  
\*.app lists applications, \*.dat lists data files, etc.

Click to open Directory Dialog box, which is used to access other directories.



### Using the File Handler Directory Function

A directory is an organizational structure into which files are stored and retrieved. After you've used your system for a while, you may accumulate a large number of files. With the help of directories, you can organize your files into manageable, related groups.

### The Directory Dialog Box

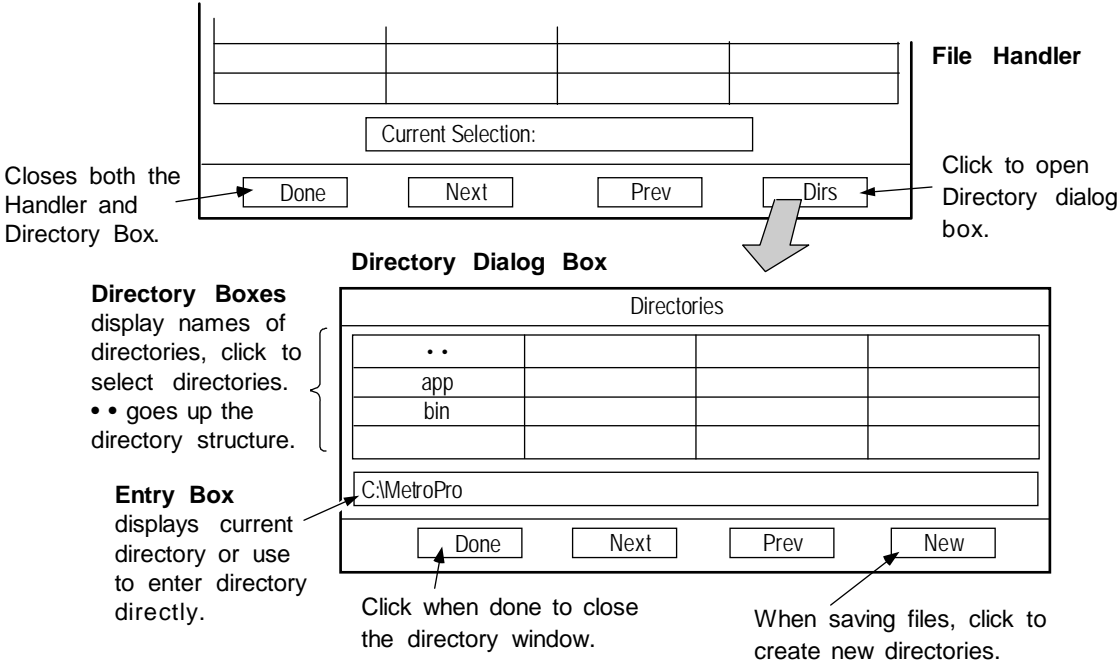
The Directory Dialog box appears when you click the File Handler's Dirs button with the left mouse button. Each File Handler is linked to one Directory Dialog box.



The Directory Dialog box allows you to access other directories and to also create directories when saving files. The Directory Dialog does not allow you to manage directories. Use the Microsoft Windows File Manager to rename, delete, or to manage directories.

More than one File Handler (such as the Save Data handler and the Remove Files handler) and Directory Dialog box can be opened at the same time. If you choose to do this, exercise care, as you might accidentally confuse which directory goes with which File Handler.

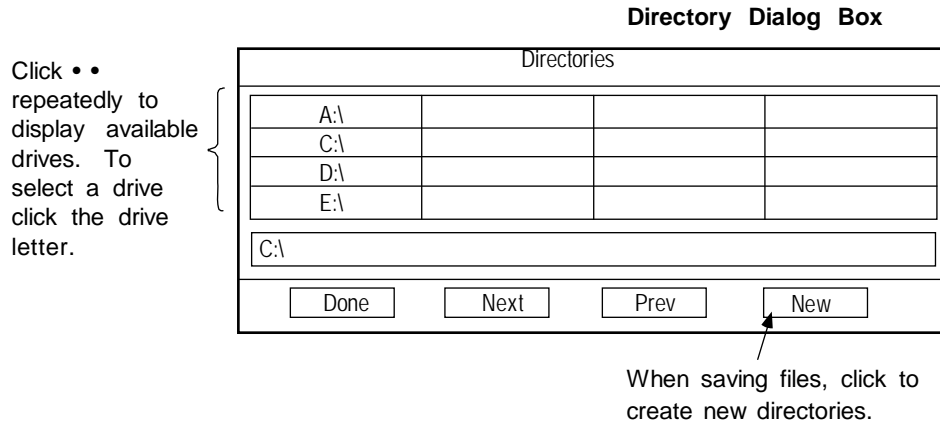
The Directory Dialog box is linked to the File Handler in which it is accessed. Both handler and directory may be closed simultaneously by clicking on the Done button in the File Handler. If you close the directory and handler this way, the next time the File Handler is opened the Directory box also opens. Use the Done button in the Directory box to independently close the Directory box.



(continued)

## Selecting Drives

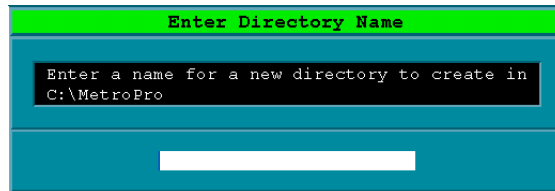
Click •• (dot-dot) repeatedly until the topmost directory is displayed. Select the drive by clicking on it.



## Creating New Directories

This feature is available when saving files other than application files.

1. Using the directory buttons, navigate to the location where you want to create the directory.
2. Click the Directory Dialog Box New button.
3. In the dialog box, type in the name of the new directory and press [Enter]. To cancel press Esc.



## Working With Directories

Directories are renamed, deleted, and managed using the Microsoft Windows Explorer. The degree of control provided depends on the user account privileges set with the Windows Control Panel in Users and Passwords.

For information on the administrator's role refer to Microsoft documentation and on-line help files.

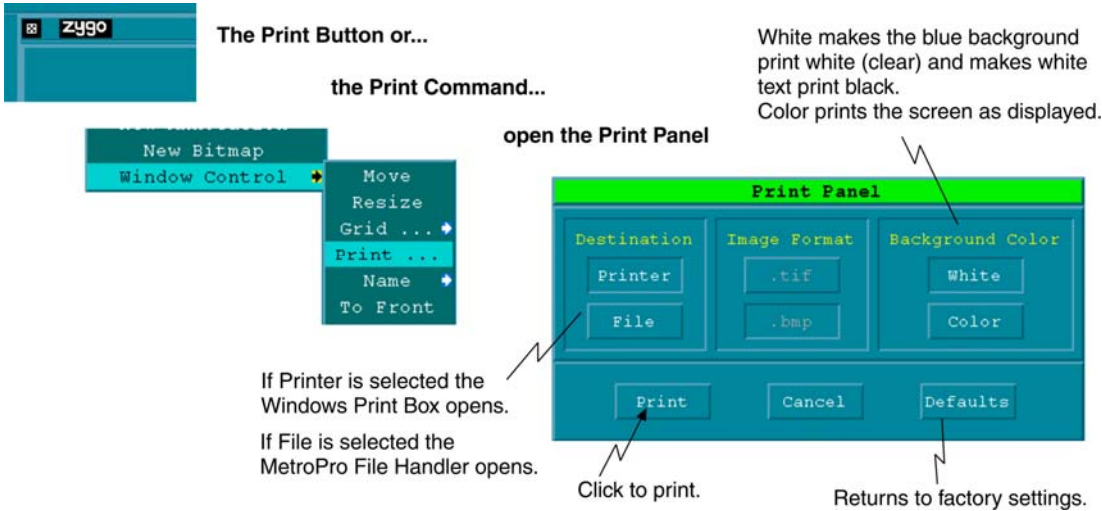
# Printing Results

## Output Options

- Print screens to hard-copy printer.
- Print screens to disk in graphic formats.
- Print measurement data as text.

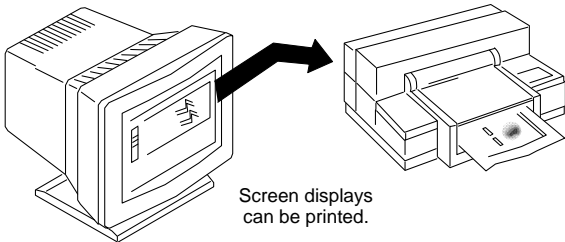
## The Print Panel

When the “zygo” Print button or the Print command is selected, a Print Panel opens. The Print Panel can send an image to the printer or save a file to the hard drive for later export to other software programs. The particular Print Panel invoked is dependent on the window. The basic Print Panel is shown below.



## Printing Screens to a Printer

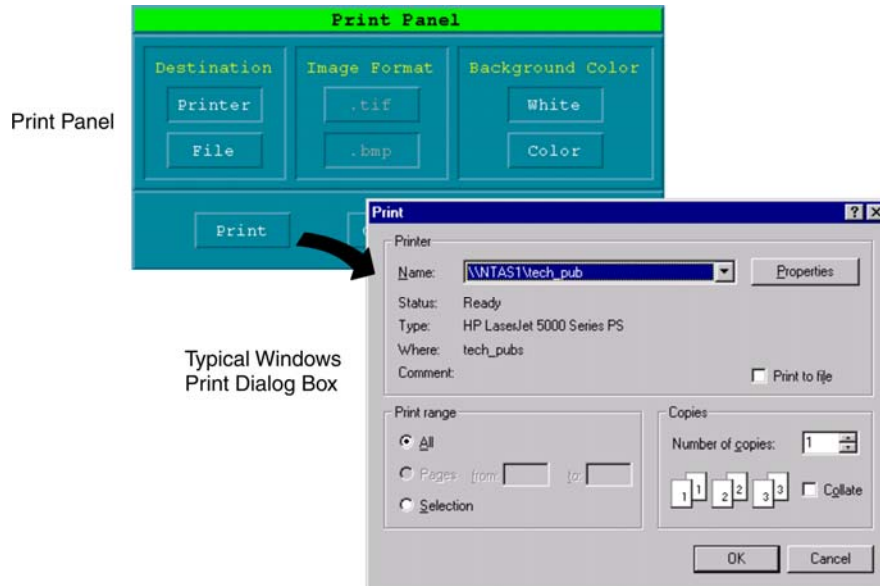
Your measurement results can be printed to any printer configured and operational under Windows. For best reproducibility of screens and graphic results, you may want to print to a color printer, such as an HP DeskJet printer.



## Printing the Contents of a Window

Everything inside the window where you access the print command is printed. This can include anything from the entire application screen to a single plot.

1. Click the “zygo” Print button or select the Window Control → Print command.
2. In the Print Panel, click Printer as the destination, then click Print.
3. In the Windows Print dialog box, select the printer and click OK.



## Printing Screens to Disk in Graphic Formats

Measurement screens can be saved to disk as tagged image file format (tif) or a bitmapped image (bmp).

1. Click the “zygo” Print button or select the Window Control → Print command.
2. In the Print Panel, click File as the destination, select .tif or .bmp as the image format, then click Print. (If the print panel has a Source selection it must be Image.)
3. In the File Handler, type a name for the file, with the correct extension, and press [Enter].

## Printing Measurement Data as Text

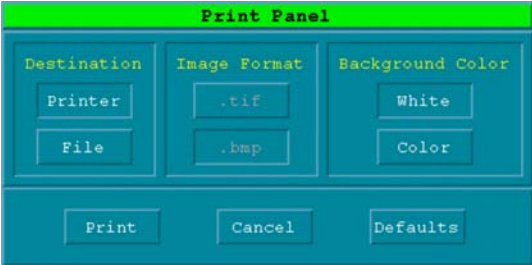
Measurement data from Profile Plots, Control Charts, and Process Stats, can be saved to disk or printed as text.

1. From the applicable window, click the “zygo” Print button or select the Window Control → Print command.
2. In the Print Panel, select Data as the source, next select the destination for the data, and select the data format, then click Print.
3. To print the data, use the Windows Print dialog box to select the printer and click OK.
4. To save the data to disk, use the File Handler to type a name for the file, and press [Enter].

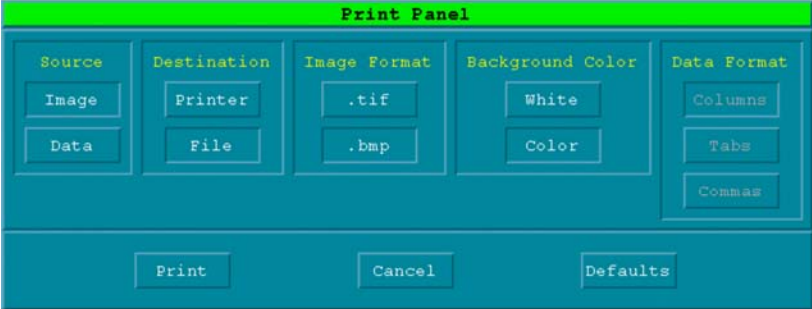
**Print Panel Options**



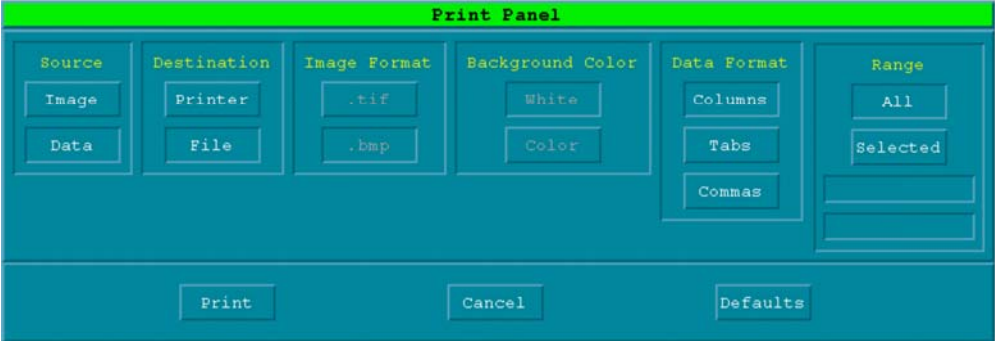
Buttons that appear grayed indicate that the option is not applicable to the type of data being printed.



General Print Panel



Print Panel from Profile Plots and Control Charts

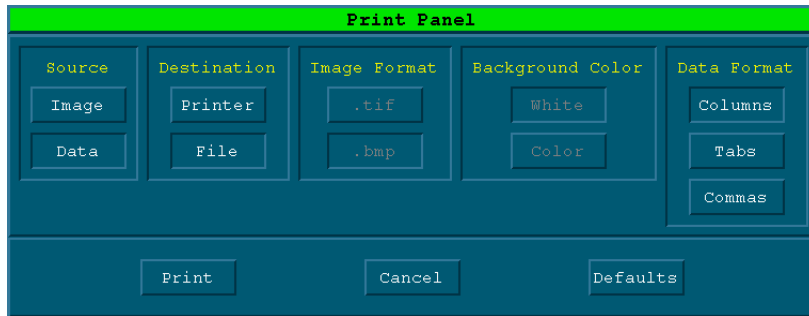
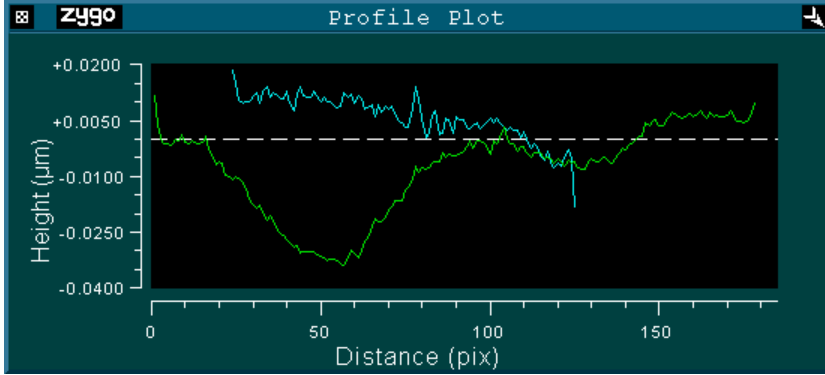


Print Panel from Process Stats

Source	Destination	Image Format	Background Color	Data Format	Range
<p><b>Image</b> Use screen image.</p> <p><b>Data</b> Use data points in image.</p>	<p><b>Printer</b> Send image or data to printer.</p> <p><b>File</b> Save image or data as a file.</p>	<p><b>.tif</b> Tagged Image File Format is a standard, bitmapped graphics format.</p> <p><b>.bmp</b> A bitmapped file format is common graphics format.</p>	<p><b>White</b> Makes the blue background print white (clear) and makes white text print black.</p> <p><b>Color</b> Prints the screen as displayed.</p>	<p><b>Columns</b> Vertical rows of data used for viewing.</p> <p><b>Tabs</b> Tab separated values for export to other programs.</p> <p><b>Commas</b> Comma separated values for export to other programs.</p>	<p><b>All</b> Output all data.</p> <p><b>Selected</b> Output the data rows specified in the First and Last controls (not shown above).</p>

**Printing Example- Profile Data**

This example shows printing profile data to a file. In this case, the Print command must be selected from the menu accessed from the plot itself. When the Print Panel appears, click Data as the Source, File as the Destination, and then selected the Data Format option.



Note that with profile data, only the active slice is saved. The active slice in the Filled Plot appears as the slice with triangles at each end, in the Profile Plot it is the green colored slice.

The saved data will look like this:

```
Surface Profile
Profile Plot Data
  Distance (pix)           Height (µm)
      43.0                 0.02348
      44.0                 0.02202
      45.0                 0.01784
      46.0                 0.01197
      47.0                 0.00680
      48.0                 0.01004
      49.0                 0.01259
      50.0                 0.01120
      51.0                 0.00641
      52.0                 0.00765
      53.0                 0.01120
etc
```

## Exporting Information from MetroPro

<i>Function</i>	<i>Use MetroPro feature...</i>	<i>Refer to...</i>
Export numeric results as text	Report Window	Section 11
Export results and information as Q-DAS compatible format	Q-DAS Report Window	Section 11
Print the contents of a window to a printer or a file	Print Button or Print Command to access Print Panel	Section 1
Copy the selected window to the clipboard as a bitmap graphic	Copy to Clipboard Command	-
Print the fringe pattern	Print the Video Monitor window or use the File menu for the Live Display	Section 4
Export MetroPro data in other data formats	Format converters for ACSII, bmp, CODE V, ZEMAX, SDF, XYZ, or OSLO data	Section 12





# Working With Applications

## Section

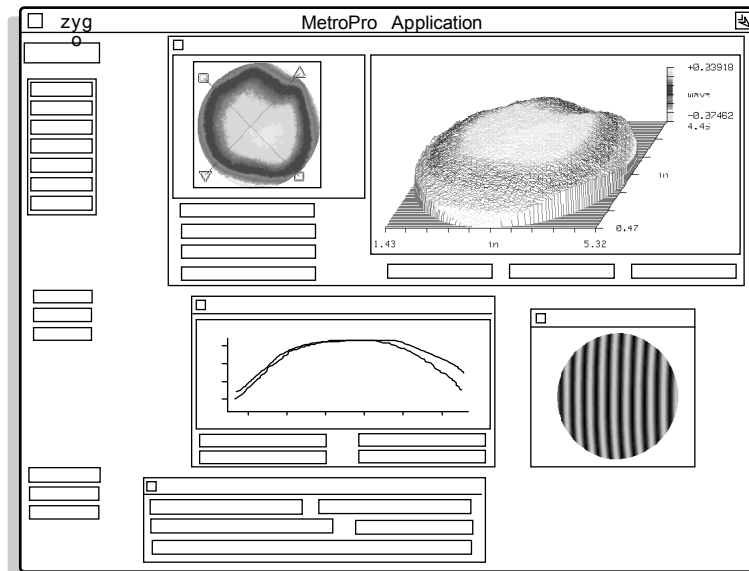
# 2

*Applications are the key to using MetroPro. You can create your own or use the ones included with MetroPro.*

## What is an Application?

An application is an arrangement of windows, controls, plots, and numeric results configured to acquire, analyze, and display data. An application is independent of the measurement data; it is the way the data is acquired, analyzed, and displayed; it is not the data itself. Once an application is loaded and opened, you may acquire and examine new data, or load and examine previously stored data.

An Application is an assembly of windows, controls, buttons, and results that are used to measure and analyze a test part.



## Why Are Applications Useful?

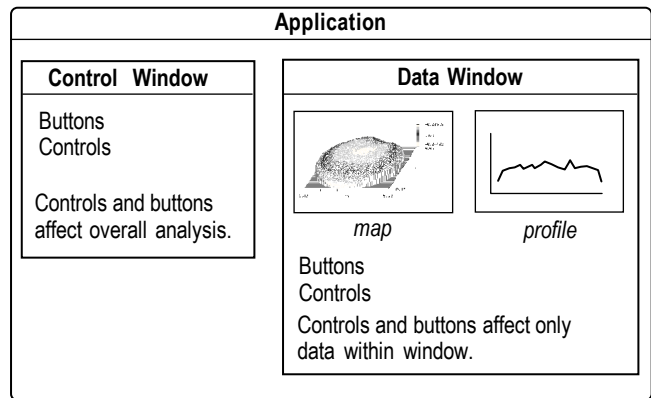
MetroPro applications are designed to fit most customers' requirements. All controls, graphic plots, and results are already in place so you can start making measurements immediately. Applications can also be custom-designed to fit a specific measurement need. You select the controls and displays you need, arrange them on the screen the way you like to see them, configure them to perform the functions you want, and save them as an application.

Multiple applications can be created and stored to provide you with a storehouse of testing tools. In day-to-day operation, you just load and open the application that suits the type of testing you are doing. An existing application can be modified slightly or extensively, and renamed to become a new application of the future.

## Understanding Applications

The most basic elements of any MetroPro application are control windows and data windows.

The control window contains controls for the application. Some are specialized for the particular application, but the large majority are similar from application to application. Controls determine how data is obtained and how it is analyzed.



A data window is a look at the data somewhere along the analysis path. There are numerous varieties of data windows. Data windows are named such that they indicate what data is displayed within. There are two general types of data windows, map and profile. A map data window shows three dimensional data; a profile data window shows two dimensional data, based on a slice through the three dimensional data. The controls, results, and plots available in each data window vary. Controls within data windows affect only the data within that window.

### Learning to Use Applications

The easiest way to learn about an application is to “jump right in”. Open the application by clicking on its icon with the *left* mouse button. Position a test part and click the MEASURE button; then try experimenting with the displays.

## Types of MetroPro Applications

MetroPro comes with several applications. Most applications are described separately in booklet form for easy reference. All applications are available in the “MetroPro\app” directory.

Some applications are “standard”, that is, they are included with, and licensed with MetroPro. Other applications are “optional”, they are sold separately, usually require individual licensing, and sometimes special hardware as well. If you have specific questions regarding your applications contact your Zygo Corporation representative.

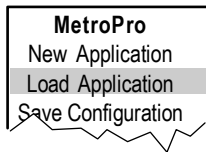


The applications in the MetroPro\app directory are write-protected to most users, except the administrator. These applications should not be changed, even by the administrator. Run the MetroPro User Setup program to create a working directory for user accounts.

## Loading Applications

When you first start MetroPro, all the applications that are applicable to your display and instrument usually load unto the MetroPro window in the form of icons. If an application icon is not displayed on the MetroPro window, you can load an existing application by selecting Load Application from the MetroPro menu. This opens the File Handler; instructions on using the File Handler are shown in the illustration below. Multiple application icons may be loaded onto the the MetroPro window.

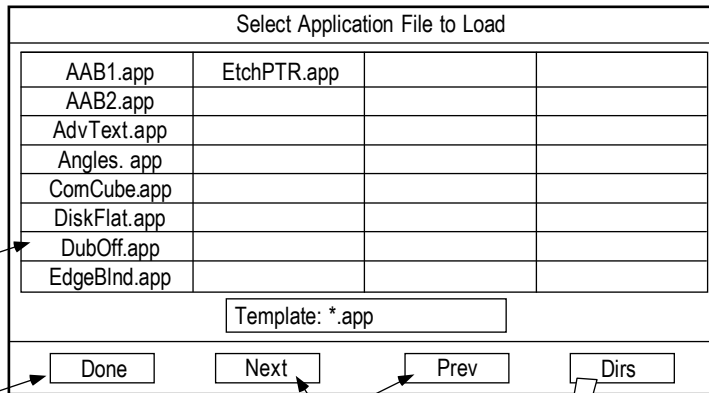
1. From the MetroPro Window, press and hold the right mouse button, choose Load Application to open the File Handler.



2. Click on the name of application you want to load with the left mouse button.

3. Click the Done to close the File Handler.

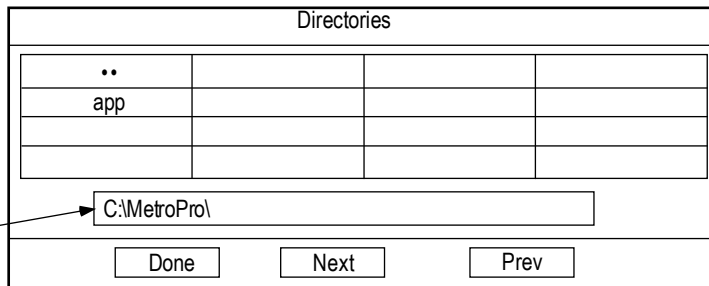
**File Handler**



Goto next or previous group of files.

Click to select directory.

**Directory Dialog Box**



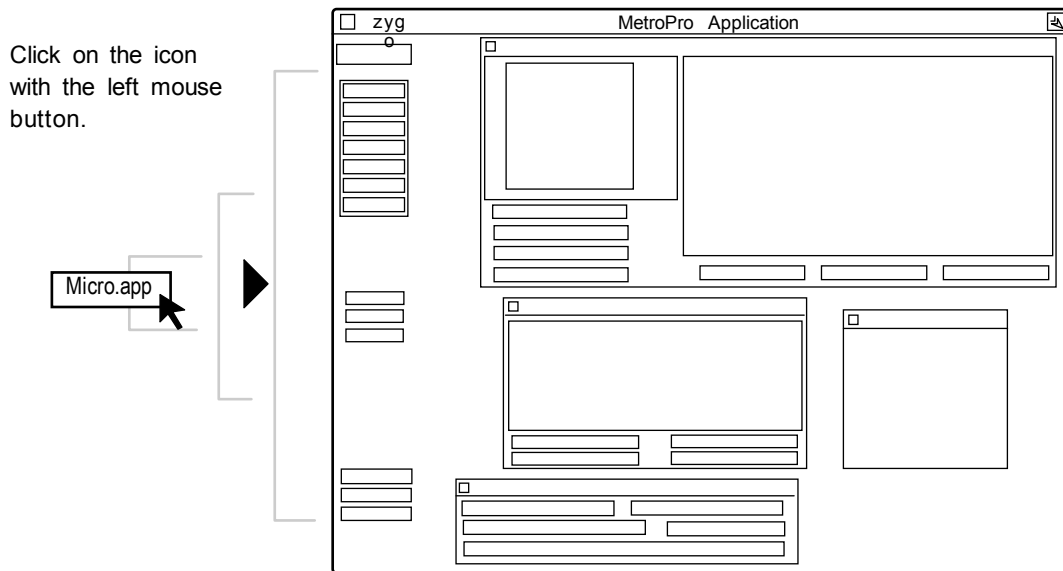
**Directory Names**  
Click to select directory. Click .. to go up the directory tree.

Shows current directory.

## Opening Applications

Applications are opened by clicking once on the application icon with the *left* mouse button. Only three applications may be *open* at any given time. When you first open an application, the plot windows are blank and the result boxes have no numeric values in them. Even though the application is open and operational, it doesn't have any measurement data to display yet.

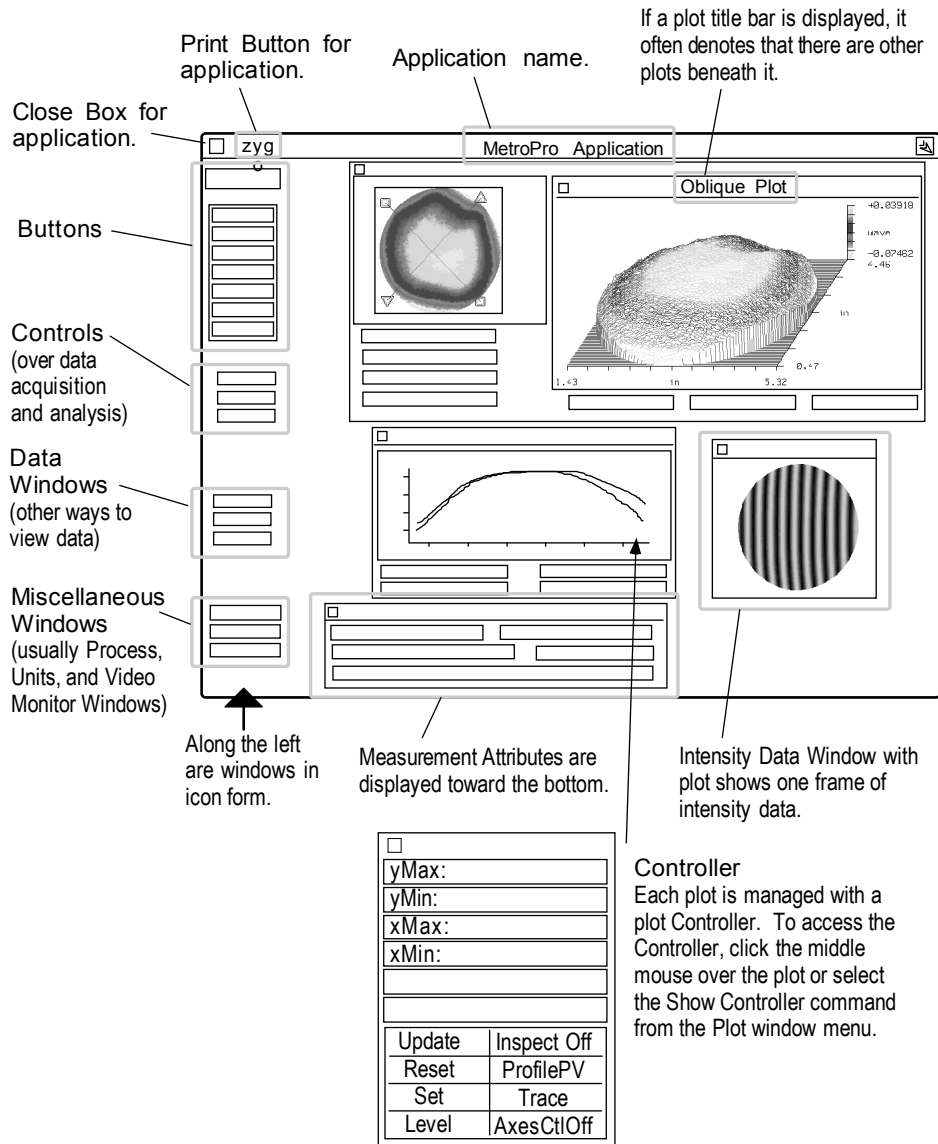
Assuming that you have connected the instrument to the computer, configured a test setup, and focused on the test part, you may acquire data by clicking the MEASURE button. Measurement data is automatically analyzed and displayed in the Result boxes and Plot windows.



## The Common Parts of Applications

All applications share a similar design and layout. Becoming familiar with these “common threads” will make it easier to understand and use MetroPro applications.

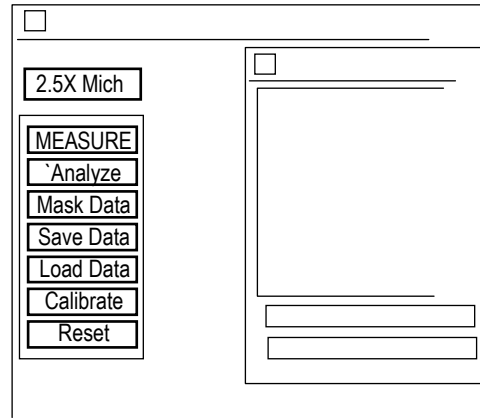
If you can't take measurements, be sure that you have licensed MetroPro and the applications you plan to use, as described in the *MetroPro Quick-Start Guide*.



Parts shown are typical of Zygo applications, actual layout and components will vary.

## Buttons

Below is a brief explanation of the most common buttons that appear in the upper left corner of ZYGO applications. Some applications have additional buttons.



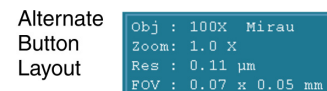
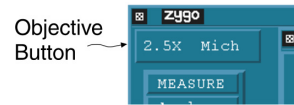
<i>Button</i>	<i>Function</i>
<b>Objective or Aperture</b>	Specifies which microscope objective you are using, or Configures the GPI for small or large aperture.
<b>MEASURE</b>	Initiates the acquisition, analysis, and display of measurement data.
<b>Analyze</b>	Re-analyzes measurement data after changing analysis parameters.
<b>Mask Data</b>	Opens the Mask Editor, which specifies measurement areas.
<b>Save Data</b>	Opens the File Handler, which saves unanalyzed measurement data.
<b>Load Data</b>	Open the File Handler, which loads saved measurement data.
<b>Calibrate</b>	Open the Calibrate window, which calibrates the instrument for lateral measurements.
<b>Reset</b>	Reloads the current application.

### Objective Button (Microscope Applications Only)

To select the objective in use, click the Objective button with the left mouse button.

To display the current instrument settings, choose the Layout → Obj/Zoom/Res/FOV command from the Button's menu.

- Obj** is the current objective  
(with motorized turret this automatically updates).
- Zoom** is the image zoom setting  
(with encoded zoom this automatically updates).
- Res** is the objective lateral resolution.
- FOV** is the objective field of view (horizontal x vertical).



## Controls and Attributes

All Zygo applications include controls. Here is an overview of the windows where you'll encounter these controls:

### Measure Cntrl

These Control boxes select parameters that control the measurement and are used to enter descriptive text. Information entered in the first three boxes are displayed in the Measure Attributes window shown below.

#### Measurement Controls

*Microscope Application Shown*

### Analyze Cntrl

These Control boxes are used to select data analysis parameters. Click the Analyze button to update results after changing these controls.

#### Analyze Controls

*GPI Application Shown*

### Measure Attr

These Attribute boxes display information about the measurement and settings of controls when the measurement was made.

#### Measure Attributes

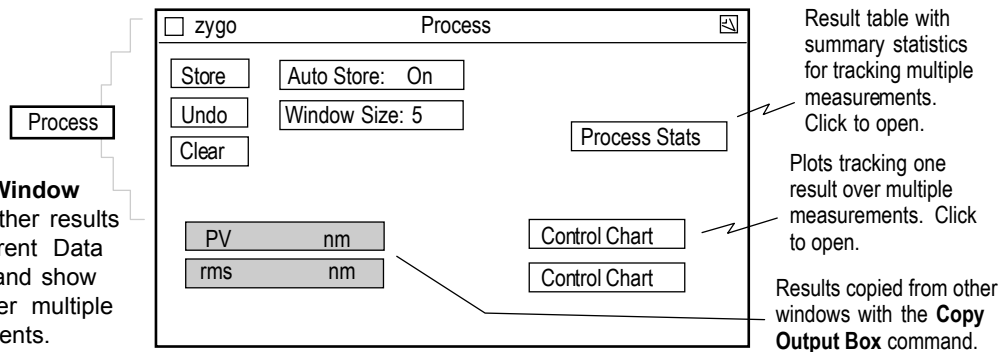
*Microscope Application Shown*

## Miscellaneous Windows

Most Zygo applications include Process, Video Monitor, Units Systems, and Report Windows. The purpose of these windows is highlighted below.

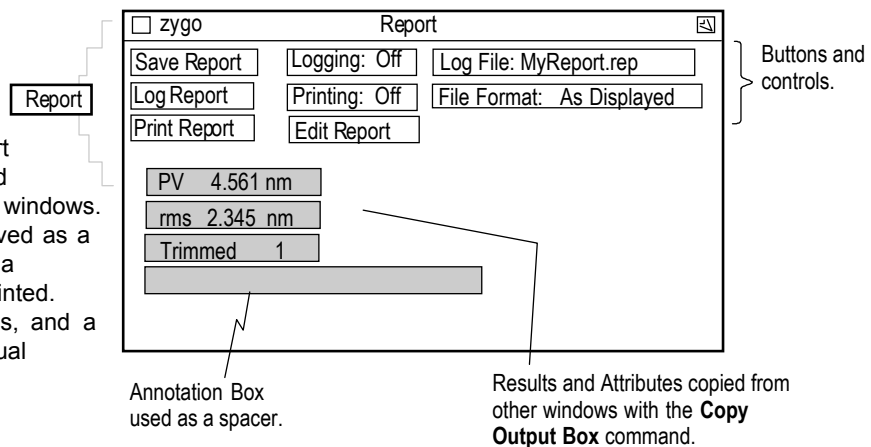
### Process Window

Use to gather results from different Data Windows and show results over multiple measurements.



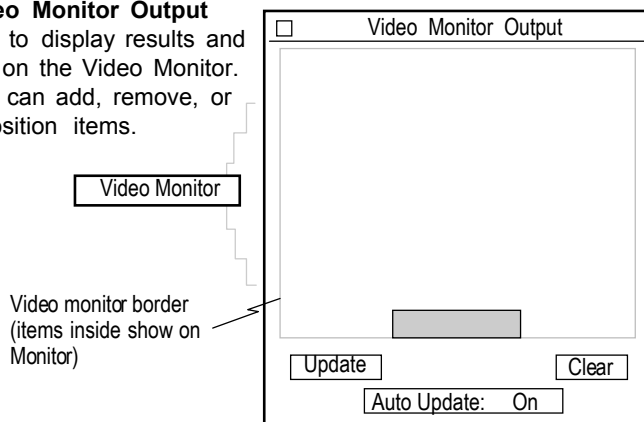
### Report Window

Use to create a report containing results and attributes from other windows. The report can be saved as a single file, logged as a continuous file, or printed. Only results, attributes, and a title make up the actual report.



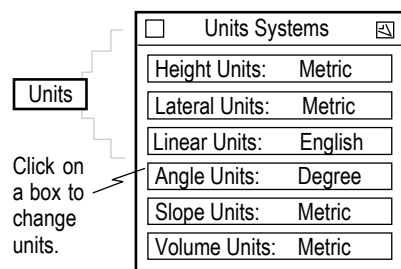
### Video Monitor Output

Use to display results and text on the Video Monitor. You can add, remove, or reposition items.



### Units Systems

Selects measurement unit systems for plots and results.



Parts shown are typical of Zygo applications, actual layout and components will vary.



## Making New Applications

There are two techniques to make a new application: build your own application from scratch, or modify an existing application and resave it. It is usually easier to modify an existing application for your needs.



The applications in the MetroPro\app directory are write-protected to most users, except the administrator. These applications should not be changed, even by the administrator. Run the MetroPro User Setup program to create a working directory for user accounts.

### ***Building an Application***

To build an application, select New Application → from the MetroPro menu and then choose one of the applications listed in the sub-menu. Next, create Data and Control windows in the Application window. In the Data windows create the plots and results you need. In the Control window, create the Control boxes and buttons required. Then add other windows as needed.

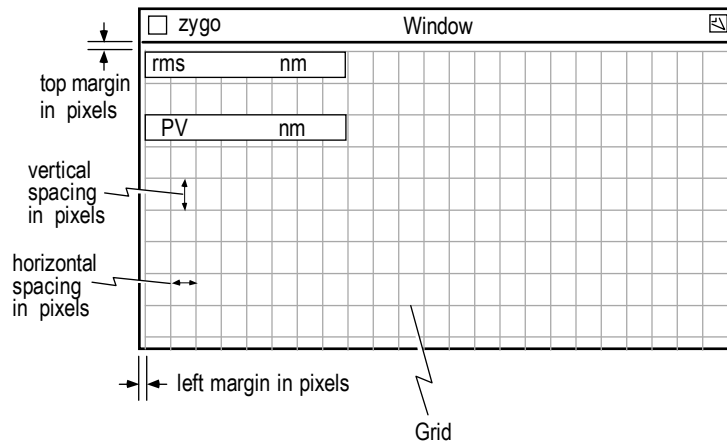
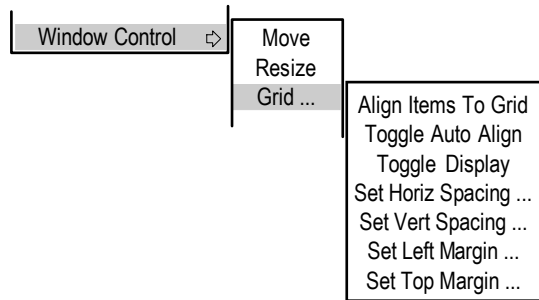
### ***Modifying an Existing Application***

1. Start by opening an application that is similar to the one you have in mind to create. Clear out any existing data by clicking the Reset button.
2. Modify existing windows, boxes, or buttons. You can delete, move, and rename items. Add new plots and boxes. Arrange items into the arrangement you want.
3. Modify plots with the plot Controller for each plot. To ensure that your plot settings are preserved, click the plot Controller Set button.
4. The first time you save the application, select the Save Application command from the Application Window menu. Select a unique name.
5. Regularly save the application during the creation process with the Re-save Application command from the Application Window menu.
6. Select the Save Configuration command from the MetroPro Window menu, if you want to preset MetroPro to load and open your applications.

## Using the Grid Controls

The grid controls are used when building or modifying applications or windows to automate the spacing and alignment of items inside the window.

The controls are accessed through the window's Window Control → Grid command.



<b><i>Control</i></b>	<b><i>Function</i></b>
<i>Align Items To Grid</i>	Select to immediately realign all items to the grid.
<i>Toggle Auto Align</i>	Select to turn automatic align on/off. When on, items snap to grid positions when created or moved.
<i>Toggle Display</i>	Select to display/hide grid lines in the window.
<i>Set Horiz Spacing</i>	Specifies the horizontal spacing of the alignment grid in pixels.
<i>Set Vert Spacing</i>	Specifies the vertical spacing of the alignment grid in pixels.
<i>Set Left Margin</i>	Specifies the left side margin from the edge of the window to the alignment grid.
<i>Set Top Margin</i>	Specifies the top side margin from the edge of the window to the alignment grid.

## Saving Applications

If you have created an application or modified a standard application, you may save it on the hard drive, with a name of your choosing. If you make changes to a standard application, the only way to preserve your changes is to save the application under a new name.

To save an application, position the mouse pointer on the Application window, press the *right* mouse button to access the Application menu, and select the **Save Application** command. Then use the File Handler as shown below.

1. From the Application Window, press and hold the right mouse button, choose Save Application to open the File Handler.



2. Click on "Current Selection" with the left mouse button, type in a file name and press [Enter].

**File Handler**

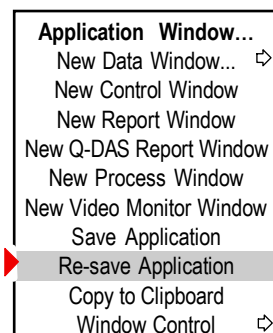
A screenshot of the 'File Handler' dialog box. The title bar reads 'Select Application File to Save'. The main area contains a table with 4 columns and 8 rows. Below the table is a text input field labeled 'Current Selection:'. At the bottom of the dialog are three buttons: 'Done', 'Next', and 'Prev'. Arrows from the text instructions point to the 'Current Selection' field and the 'Done' button.

3. Click the Done to close the File Handler.

File names must start with a letter or a number and may contain underscores ( `_` ) and periods. However, names may not contain spaces or special characters, or be longer than 20 characters. Use “.app” for a file extension. You could incorporate your company name, like “AcmeCorp.app”.

## Re-Saving Applications

To bypass the File Handler and save the application under its current name and settings, select the **Re-save Application** command from the Application menu. This replaces the existing application file.

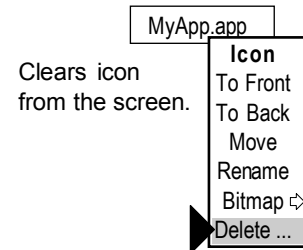
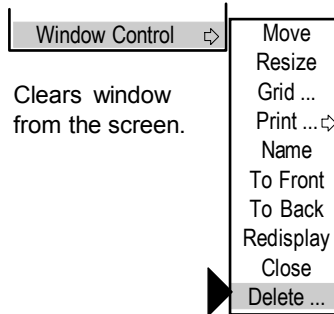


## Updating Old Applications

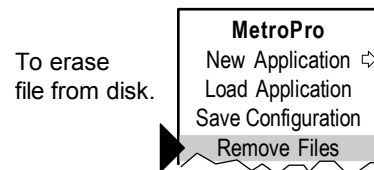
Whenever there is a major update in MetroPro, your existing applications may require conversion to run in the latest MetroPro version. Refer to the *MetroPro Quick-Start Guide*.

## Deleting an Application

To clear an application window from the screen, select Window Control → Delete. If the application is in icon form, select Delete from the Icon menu to clear the icon from the MetroPro window.



To erase a saved application from disk choose the Remove Files command or use the Windows File Manager.



## Saving Application Configurations

To save the current configuration of the opened application select the Save Configuration command from the MetroPro window menu. The next time MetroPro is started, the application will automatically load and open.

A configuration file, named “MetroPro.cfg”, is saved that tells MetroPro what applications to load and open, and their position on the screen. Note that many applications can be loaded onto the MetroPro window, but only two applications can be opened at a time. The configuration of the windows and boxes within the application itself is saved with the Save Application command.

## Using Settings Files

When an application is saved, it includes both the look and placement of windows, controls, and buttons, as well as the actual settings of controls. However, control settings can be saved separately, as a settings (.set) file, without the look and placement of screen items. Use settings files to reset control settings to known values, to load specific settings for a particular part without creating a separate application, or to support scripting functions.

To save a settings file, click the Save Settings button, which can be created in a Control window with the New Button → command. Then use the File Handler as previously described. To load a settings file, click the Load Settings button.

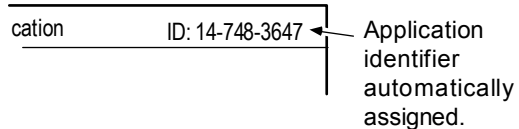
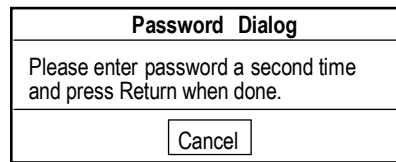
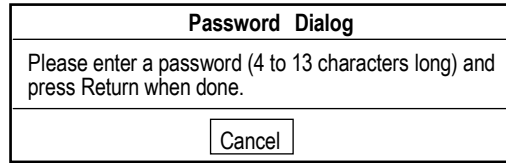
**Information Preserved in Application and Settings Files**

<i>Type of Information</i>	<i>Preserved in App Files</i>	<i>Preserved in Settings Files</i>
Control values	Yes	Yes
Numeric result box limits, adjustments, Q-DAS values	Yes	Yes
Plot Controller values, including slice settings	Yes	No
Appearance	Yes	No

## Locking An Application

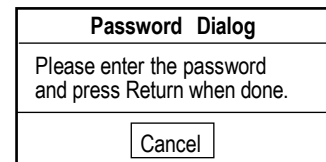
Applications may be locked so controls or windows can't be changed. When an application is locked, there are no menus, icons can't be opened, and items can't be moved. Even if MetroPro is restarted, locked settings are preserved. However, controls and buttons work if they are visible, and the application can be opened and closed.

1. Configure the application in the condition you wish to lock it.
2. Press CTRL-shift-L. A message box asks "Lock Application?"  
If you click YES, a password dialog box appears; continue with steps 3 and 4.  
If you click NO, the application is locked without a password.
3. Using the keyboard, enter a password.  
After the password is entered once, another dialog box appears.  
Legal characters are letters and numbers; *not* allowed are special characters (i.e. dashes, underlines, spaces, and periods). Select a password that you can remember.
4. Enter the password a second time. When the application is locked, it is given a unique ID number. This number is displayed on the right side of the application title bar. The number helps to distinguish between multiple locked applications.

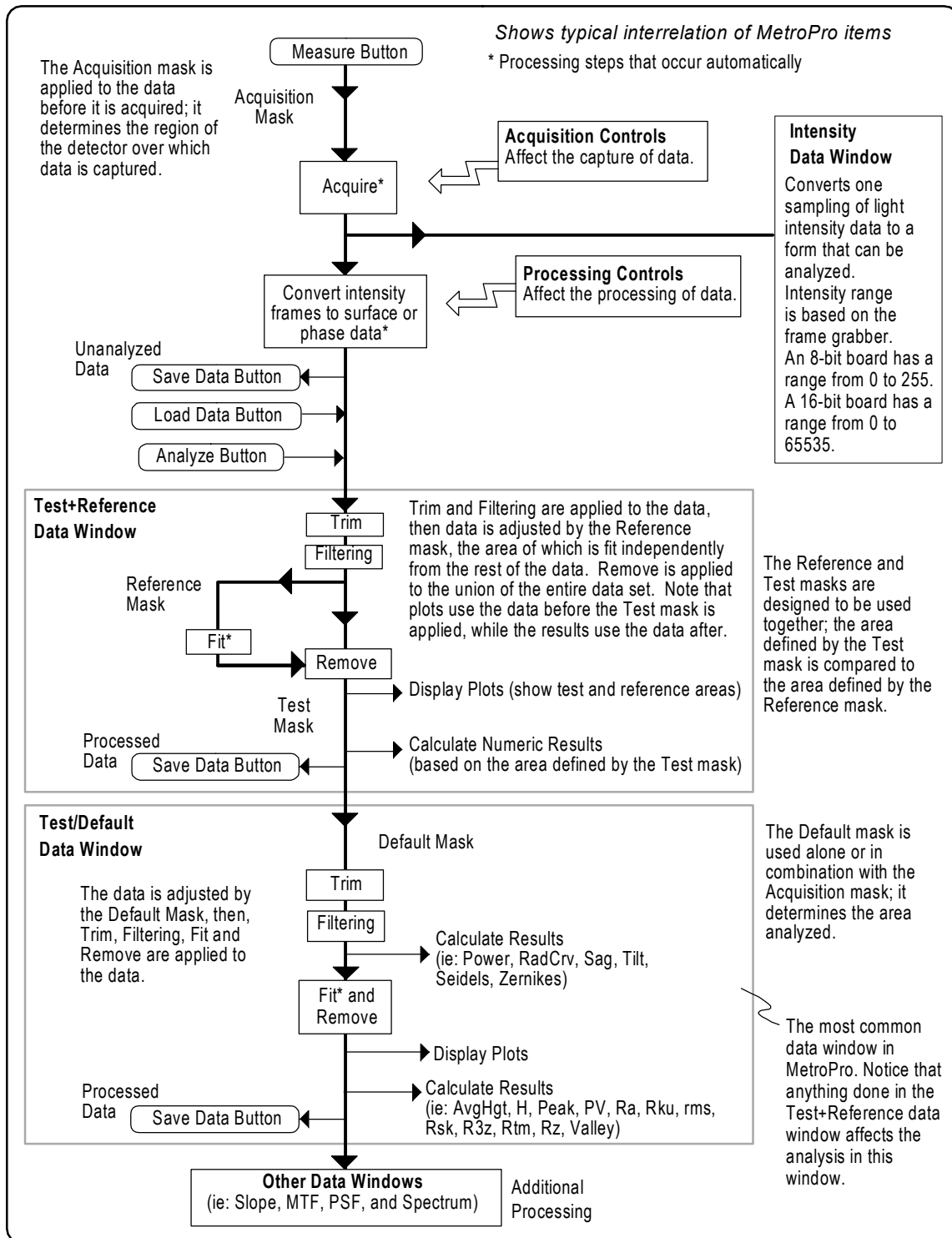


## Unlocking an Application

1. Press CTRL-shift-L. A message box asks "Unlock Application?" Press [Enter] for YES. A password dialog box appears.
2. Enter your password or nothing if you did not use a password. The application is unlocked and the ID number disappears.



# MetroPro Processing Flow

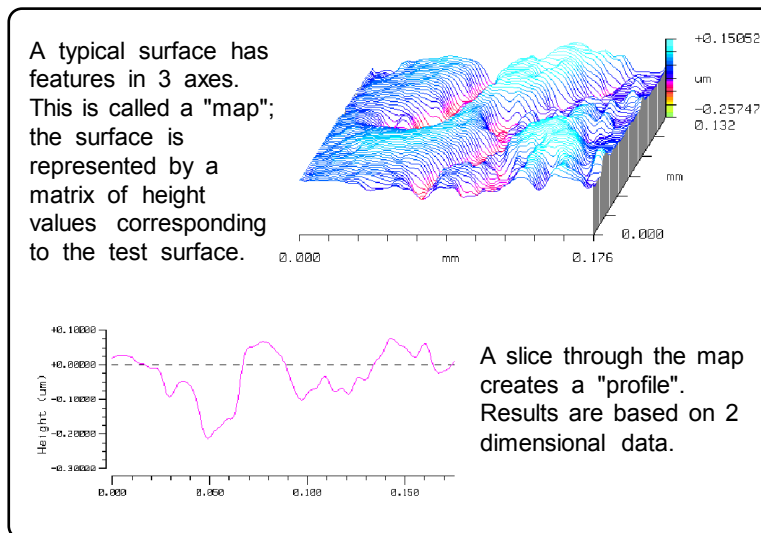


## Understanding Data Windows

A data window is a view of the test part at a specific stage of the analysis. The analyses performed on the test part are determined by what data windows are opened. When new plots and results are added into a data window, they are immediately calculated and displayed. Most applications have data windows that are labeled to depict their function.

Data windows are created with the New Data Window command, which is accessed through the Application Window menu. Before creating a data window, clear the screen displays of measurement data by clicking the Reset button.

Many data windows can exist in two forms: map and profile. A *map* is an area of data; a map data window displays plots and results based on three dimensions. A *profile* is a line of data; a profile data window displays plots and results based on two dimensions. Profile data windows are vector data subsets of the parent data window map.

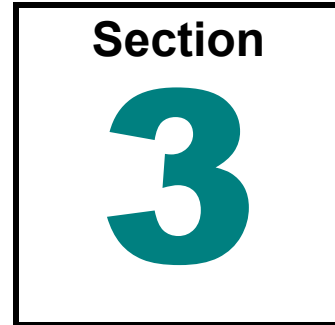


One special data window of interest is the Test+Reference data window. It is used with test and reference masks for relational type measurements where one area of the part (test) is compared in relation to another area on the same part (reference). It shows the results of acquiring, converting, and connecting the measurement data, and then manipulating a test region and a reference region. The test and reference regions are specified by masks; these areas may be disjointed, overlap, or be the same area.

Plots in data windows using test and reference areas use the data points in the union of the reference and test regions. Results are calculated on the points in the test region. However, results with the suffix "All", are calculated on the points in both test and reference regions. If the Remove control is set to any setting other None, a fit is performed on the reference region, and remove is performed on the union of the reference and test regions.



# Controls and Buttons



*Use the controls and buttons described in this section to acquire and analyze data in MetroPro according to your measurement needs. The buttons and controls are listed in alphabetical order.*

This section provides an alphabetical listing of MetroPro controls and buttons that are common to most applications. Details for selecting and changing control settings are provided. Refer to the button or control of interest by name in this section. All entries for buttons have the word “button” in them.



Application specific controls are described in separate application booklets and are not listed in this section. However, you can use the index to locate the correct manual.

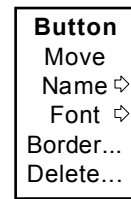
## Buttons

A button is a small on-screen box that causes some action when you click on it with the left mouse button. To create buttons use the New Button command.

Buttons that are located in the Mask Editor, Calibrator, plot Controllers, and other specialized software items are explained under the item in which it resides.

*Use the Button's menu to modify the button.*

- Move** relocate the button.
- Name** change the button name or get information.
- Font** select the button's type style.
- Border** change the line width of the surrounding box.
- Delete** erases the button from the screen.



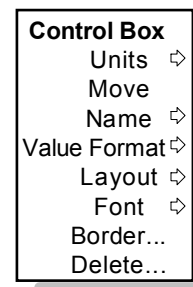
## Controls

Controls are used to adjust settings that affect the measurement and the analysis of measurement data, or to enter user or test part information. Most controls within control windows serve as global controls affecting all measurements. Controls within other windows are used to control the analysis only within that particular window. Controls are blue and are created with the New Control command.

To enter text or a number in a control, click on the box with the left mouse button, type entries with the keyboard, and then press [Enter]. To change a selection, click on the box with the left mouse button.

Controls that are part of a unique function, such as those in the Mask Editor, Calibrator, and other items are explained under the item in which it resides.

- Use the Control's menu to modify the box.*
- Units** select measurement unit.
  - Move** relocate the button.
  - Name** change the control name or get information.
  - Value Format** select the way numbers are displayed.  
For example, one selection makes it possible to have numeric values left-padded with zeroes instead of spaces.
  - Layout** change the way the box looks.
  - Font** select the control's font type and size.
  - Border** change the line width of the surrounding box.
  - Delete** erase the control from the screen.



*actual menus will vary*

Most controls are also available as attributes. Attributes normally reflect the setting of a corresponding control at the time the measurement was taken. Attributes display status information of the current data set and appear as black boxes. An attribute may appear to look just like the control, except for its color. Unique attributes are listed under "Results" in *Section 9* of this guide.

### Organizing Controls

Typically, most controls are accessed through the Control window, which in most supplied applications have been renamed. To provide for grouping and organizing controls, Control windows can contain other Controls windows. To create a Control window within a Control window, access the Control window's menu and select New Control Window.

## ***Saving Control Settings***

Normally, the settings of controls return to factory default settings when an application is closed and reopened. You can however, save the present configuration of control settings and later load these; this quickly sets all controls to your predetermined settings.

In a Control Window, select the New Button command and create the Save Settings button and Load Settings button.

- To *save* your control settings click the Save Settings button. In the File Handler, click the “Current Selection” box, enter a name for the settings file, ending with “.set”, and then press [Enter]. Click the Done button to close the File Handler.
- To *load* your control settings click the Load Settings button. In the File Handler, click on the box with the name of the file you want to load. Click the Done button to close the File Handler.

## ***Control Settings and Their Interaction***

The settings of certain MetroPro controls are interrelated. This means that changing the value of one control can change the selections available in other controls. The following controls fall into this category:

- Acquisition Mode
- Camera Mode
- FDA Res
- Scan Length
- Scan Type

These controls have a hierarchical interaction. Changing the value of a control *higher* in the list can change the selections available lower in the list. Changing a control *lower* in the list has no effect on the selections available in controls higher in the list. Wherever possible, MetroPro tries to preserve the user’s settings.

However, it is important to remember that changing one setting for a control can impact other control settings that have a common functionality.

## Acquisition Mode

Selects the way data is obtained by the instrument. Settings may be Phase, Scan, Fringe, Intens, or FlashPhase\*. The selections available are linked to the instrument.

*Phase* converts multiple frames of intensity data into phase data. This setting is used for the GPI, MicroLUPI, and VeriFire interferometers, plus phase microscopes. *Scan* converts multiple frames of intensity data into surface data. This setting is for white light scanning microscopes, such as the NewView. *Fringe* analyzes one frame of intensity data, such as with the Static Fringe application, to produce crude phase data. This setting is for large aperture interferometers without phase modulation. *Intens* analyzes one frame of intensity data but does not produce any height data. *FlashPhase* uses the intensity acquisition process to capture a single frame of data that is expected to have 30 fringes oriented at 45 degrees. MetroPro then uses carrier fringe analysis to convert the single intensity frame to height data.

\*FlashPhase is no longer available as a data acquisition method. Information is provided for reference purposes and backwards compatibility.

## Add Data button

Opens a text entry box, which is used to specify the name of an existing data file in the current directory. The specified data file is added to the current data. The summed data map becomes the current data set. Bad pixel locations in either data map remain bad pixels. If data sets don't intersect in space, there is no data. To cancel the action, press the right mouse button or the ESC key. Adding one data set to another may be used to view the effects of combining aberrations.

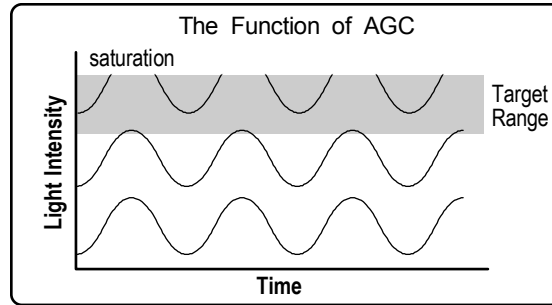
The manipulated data set must exist in the current directory. You can change directories by clicking the Save Data button or Load Data button, and specifying the directory with the File Handler.

## AGC

Selects if AGC (Automatic Gain Control) is used to automatically adjust for the optimum light level during the measurement. AGC is a system level control feedback loop that samples the camera output while adjusting the instrument variable light level controller for the best signal from the camera for the specific part under test. The AGC function maximizes the signal-to-noise of the camera data by raising the light level to a point just below where any pixels become saturated. Refer to the following graph.

For most conditions AGC should be On, as it compensates for different test part reflectivity and varying laser output. In addition, AGC adjusts for the optimum light level of the test part defined by an optional Acquisition mask. When AGC is Off, the variable light level controller is set to either the setting specified by the Light Level control or the last setting used with AGC on.

This graph illustrates the function of AGC. The sine wave represents alternating light and dark fringes. AGC adjusts the light intensity output from the instrument as high as possible without saturation. The Target Range control defines an acceptance band before saturation.



## AGC Mode

Selects the mode of operation for the light level automatic gain control of the instrument. Settings are Normal Reflectivity or High Reflectivity. The AGC Mode does not affect the acquisition of data; it only affects the AGC function.

*Normal Reflectivity* adjusts the light intensity output from the instrument as high as possible without saturation; this setting is used for most test parts. *High Reflectivity* readjusts the threshold level of the AGC function to help prevent camera saturation. Use this setting when the test part has a reflectivity greater than 90% and the video monitor screen is very bright.

## Align Pattern button

The Align Pattern button initiates a pattern alignment procedure for systems with programmable stages. This function aligns the positions on the pattern to the axes of the motorized stage and compensates for parts (or trays of parts) that are not exactly aligned to the x and y axes of the stage. Once the rotation or skew values are determined, they are factored into the pattern during the Run Pattern operation.

## Align Pattern Operation

Selects what is done at each position during a pattern alignment procedure. Settings are None, Measure, or Run Script. When set to None, nothing extra is done. Measure takes a measurement. Run Script executes the script specified by the Align Pattern Script File control. Only applicable to instruments with programmable stages.

## Align Pattern Script File

This control is used in conjunction with the Run Align Pattern Script control and the Align Pattern button. This control specifies the name of the pattern script file that should be run at each pattern alignment site after the Align Pattern button is clicked. Applicable only to systems with a programmable stage option.

## Align View button

Brings up a live display camera window that displays positions during a pattern alignment procedure. Use [ESC] to close. Only applicable to instruments with programmable stages.

## Align/View Mode button

This button selects the operational mode of the GPI or VeriFire instrument. The mode can be switched between Align Mode and View Mode. This is the same as pressing the applicable button on the instrument's remote control.

## Alignment

Selects the type of alignment done when subtracting data with fiducials. Settings are Fiducials or None. Click it to select Fiducials.

## Alignment Scaling

Selects how fiducials are aligned. Settings are Isomorphic or Anamorphic. Isomorphic scales both axes equally. Anamorphic scales to the best fit.

## Alignment Tol

Specifies the pixel tolerance allowed when aligning fiducials. Enter a numeric value. This control is used in conjunction with the Alignment Scaling control.

## Amendment Status

A Q-DAS Report window text entry control for the date and time of the last change to the part drawing.

## Amplitude

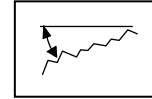
Sets the peak-to-peak voltage output by the Tegam Arbitrary Waveform Generator (AWG) hardware. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Driver menu.

## Analyze button

Recalculates measurement data using the present control settings; it does not acquire new data. Click the Analyze button to recalculate data after changing control settings, such as Remove or Trim. Pressing F2 is the same as clicking the Analyze button.

## Angle Units

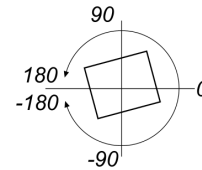
Selects the master unit system for all angle based results; settings are Degree or Radian. It applies to results such as TltAng, TltMag, Tilt X, Tilt Y, and Seidels.



For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or  $\mu\text{m}$ .

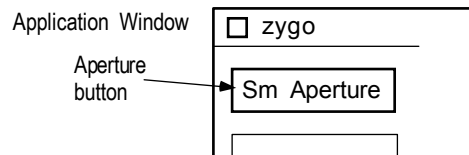
## Aperture Angle

Specifies a rotation angle value from the x-axis, which is applied to an automatic aperture rectangular mask. The value may be between  $-180$  and  $+180$ . The rectangle aperture mask will rotate about the center defined with the Aperture Center control. The Auto Aperture control must be set to On, and the Aperture Shape control must be set to Rectangle.



## Aperture button

Selects the interferometer aperture in use. This button is part of the interferometer applications. It is permanent; it cannot be moved or deleted. Selections are Sm Aperture or Lg Aperture.



Sm Aperture is for a 4-inch or 6-inch aperture or when you are using the smaller channel of a large aperture system. In this setting, the PMR attached to the instrument is selected and its driving circuitry is activated.

Lg Aperture is for systems with a 12-inch or 18-inch aperture. In this setting, the instrument's PMR is turned off and a remote PMR is activated.

## Aperture Center

Selects the center of the automatic aperture mask when the Auto Aperture control is On. The selections are: Min Encl Rectangle (default), Min Encl Circle, Data Centroid, Filled Data Centroid, Inner Radius, Outer Radius, or Fixed.

**Min Encl Rectangle** is the center of a minimum enclosing rectangle.

**Min Encl Circle** is the center of a minimum enclosing circle.

**Data Centroid** is the center of all valid data points.

**Filled Data Centroid** is the center of all valid filled data points.

**Inner Radius** is the center of the best fit circle to the inner radius, when the Aperture Regions control is set to Largest; this setting requires an area of invalid data points within the center of data set.

**Outer Radius** is the center of the best fit circle to the outer radius, when the Aperture Regions control is set to Largest.

**Fixed** uses the values entered in the Aperture Ctr X and Aperture Ctr Y controls for the location of the mask center.

## Aperture Ctr X

Specifies the x coordinate value for the center of the automatic aperture mask. Only applies when the Aperture Center control is set to Fixed. Refer to Aperture Shape for an illustration.

## Aperture Ctr Y

Specifies the y coordinate value for the center of the automatic aperture mask. Only applies when the Aperture Center control is set to Fixed. Refer to Aperture Shape for an illustration.

## Aperture Dimensions

Specifies how the circular or rectangular auto aperture mask size is calculated. The choices are Percent or Fixed.

Percent sizes the mask as a percentage of the data set and uses OD and ID (%) controls for a circular aperture, and OW, OH, IW and IH (%) controls for a rectangular aperture. Fixed sizes the mask by the values entered in OD and ID (Fixed) controls for a circular aperture, and OW, OH, IW and IH (Fixed) controls for a rectangular aperture.



## Aperture ID (%)

Specifies the inner diameter of an automatic round aperture mask. The size is specified as a percentage of the data set. Data inside this mask is excluded from the analysis. The Auto Aperture control must be On, and the Aperture Dimension(s) control must be set to Percent.

## Aperture ID (Fixed)

Specifies the inner diameter of an automatic round aperture mask; data inside this diameter is excluded. The Auto Aperture control must be On, and the Aperture Dimension(s) control must be set to Fixed.

## Aperture IH (%)

Specifies the inner height value for an automatic rectangular aperture mask. The size is specified as a percentage of the height of the data set. Data *inside* this mask is excluded from the analysis. The Auto Aperture control must be set to On, and the Aperture Shape control must be set to Rectangle. Refer to Aperture Shape for an illustration.

## Aperture IH (Fixed)

Specifies the inner height of an automatic rectangular aperture mask. The size is specified as pixels or real units. Data *inside* this mask is excluded from the analysis. The Auto Aperture control must be set to On, and the Aperture Shape control must be set to Rectangle. Refer to Aperture Shape for an illustration.

## Aperture IW (%)

Specifies the inner width value for an automatic rectangular aperture mask. The size is specified as a percentage of the width of the data set. Data *inside* this mask is excluded from the analysis. The Auto Aperture control must be set to On, and the Aperture Shape control must be set to Rectangle. Refer to Aperture Shape for an illustration.

## Aperture IW (Fixed)

Specifies the inner width of an automatic rectangular aperture mask. The size is specified as pixels or real units. Data *inside* this mask is excluded from the analysis. The Auto Aperture control must be set to On, and the Aperture Shape control must be set to Rectangle. Refer to Aperture Shape for an illustration.

## Aperture Mode

Selects how MetroPro defines the auto aperture mask when the Auto Aperture control is On. *Mask Editor Controlled* creates the circular mask within the Mask Editor; this mode automatically creates a Default mask and is compatible with an Acquisition mask. Any existing default mask is cleared before the measurement is made. *Test Window Controlled* defines the circular mask independent of the Mask Editor; this mode is compatible with Default, Acquisition, and Test/Reference masks.

## Aperture OD (%)

Specifies the outer diameter of an automatic round aperture mask. The size is specified as a percentage of the data set. Data outside this mask is excluded from the analysis. The Auto Aperture control must be On, and the Aperture Dimension(s) control must be set to Percent.

## Aperture OD (Fixed)

Specifies the outer diameter of an automatic round aperture mask; data outside this diameter is excluded. The Auto Aperture control must be On, and the Aperture Dimension(s) control must be set to Fixed.

## Aperture OH (%)

Specifies the outer height value for an automatic rectangular mask. The size is specified as a percentage of the height of the data set. Data *outside* the mask is excluded from the analysis. The Auto Aperture control must be set to On, and the Aperture Shape control must be set to Rectangle. Refer to Aperture Shape for an illustration.

## Aperture OH (Fixed)

Specifies the outer height of an automatic rectangular aperture mask. The size is specified as pixels or real units. Data outside this mask is excluded from the analysis. The Auto Aperture control must be set to On, and the Aperture Shape control must be set to Rectangle. Refer to Aperture Shape for an illustration.

## Aperture OW (%)

Specifies the outer width of an automatic rectangular aperture mask. The size is specified as a percentage of the width of the data set. Data *outside* of the mask is excluded from analysis. The Auto Aperture control must be set to On, and the Aperture Shape control must be set to Rectangle. Refer to Aperture Shape for an illustration.

## Aperture OW (Fixed)

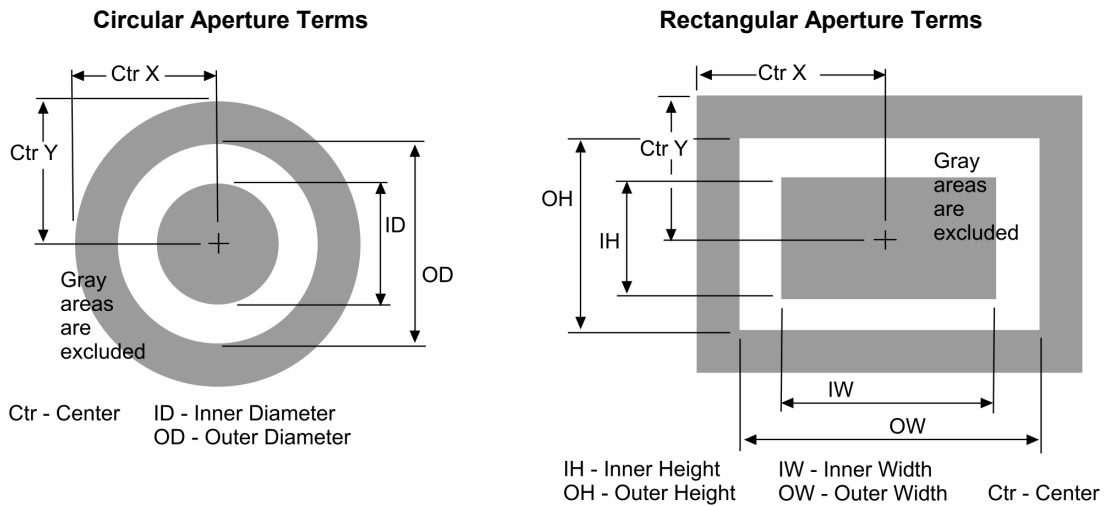
Specifies the outer width of an automatic rectangular aperture mask. The size is specified as pixels or real units. Data *outside* this mask is excluded from the analysis. The Auto Aperture control must be set to On, and the Aperture Shape control must be set to Rectangle. Refer to Aperture Shape for an illustration.

## Aperture Region(s)

Selects which data points are used to calculate the mask center when the Auto Aperture control is On. *All* uses all data points. *Largest* uses the largest contiguous region.

## Aperture Shape

Selects the shape of an automatic aperture mask as either Circle (default) or Rectangle. The Auto Aperture control must be set to On.



## Auto Aperture

When set to On, an automatic aperture mask functions is active. The center, the shape, and the size of this mask are defined other Aperture controls. Results are only calculated on the region enclosed by the aperture mask.

## Auto Load Cal Markers

Selections are On or Off. When On, each time the application is opened, the file specified by the Cal Markers File and Cal Markers Dir controls will be loaded into the Cal Markers Editor.

VeriFire MST Applications only.

## Auto Load Fiducials

Activates automatic loading of a fiducials file specified with the Fiducials File Control box.

## Auto Load Masks

Activates automatic loading of a mask file specified with the Masks File Control box.

## Auto Load Masks on Acquire

Selects if the mask file is loaded before acquiring data. Settings are On and Off. When set to On, the mask file specified with the Masks File control is loaded. It is available in a Control window with the New Control → Masks menu.

## Auto Load Pattern

Activates automatic loading of a pattern file specified with the Pattern File Control box.

## Auto Null

This control selects if the auto null function is performed at the start of a measurement. Settings are On or Off. This control is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## Auto Null at Catseye

Selects if Auto Null is performed on a radius of curvature measurement at the catseye position. Settings are On or Off. The Auto Null control must be set to On.

When On, the Auto Null function is enabled for the catseye position. When Off, the Auto Null function is not performed at the catseye position. This control is available in a Control window with the New Control → Auto Null menu.

## Auto Null at Confocal

Selects if Auto Null is performed on a radius of curvature measurement at the confocal position. Settings are On or Off. The Auto Null control must be set to On.

When On, the Auto Null function is enabled for the confocal position. When Off, the Auto Null function is not performed at the confocal position. This control is available in a Control window with the New Control → Auto Null menu.

## **Auto Null button**

Click to make the instrument perform an auto null adjustment based on the current settings of the auto null controls. This button is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## **Auto Null Calibrate button**

Click to initiate the auto null calibration routine. This function establishes the lateral measurement resolution of each camera pixel in the instrument for the x, y, and z axes. This should be performed before using the auto null function. This button is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## **Auto Null Calibrate X Step**

Specifies the distance to move along the x-axis between measurements when calibrating the system for auto null. This control is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## **Auto Null Calibrate Y Step**

Specifies the distance to move along the y-axis between measurements when calibrating the system for auto null. This control is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## **Auto Null Calibrate Z Step**

Specifies the distance to move along the z-axis between measurements when calibrating the system for auto null. This control is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## **Auto Null Catseye Calibrate button**

Click to initiate the auto null catseye calibration routine. This function establishes the lateral measurement resolution of each camera pixel in the instrument for the z axis. Calibration should be performed before using the auto null function during radius of curvature measurements. This button is only applicable to instruments measuring spherical parts with the appropriate programmable motorized stage.

## Auto Null Catseye Focus Cal Factor

Specifies a calibration factor, based on FocMag ( $Z$ ) in  $\mu\text{m}/\text{wave}$ , that the auto null function uses when nulling the part along the z-axis during a radius of curvature catseye measurement. This value is usually established by auto null catseye calibration. This control is only applicable to instruments measuring spherical parts with the appropriate z-axis programmable motorized stage.

## Auto Null Catseye Power Cal Factor

Specifies a calibration factor, based on Power in  $\mu\text{m}/\text{wave}$ , that the auto null function uses when nulling the part along the z-axis during a radius of curvature catseye measurement. This value is usually established by auto null catseye calibration. This control is only applicable to instruments measuring spherical parts with the appropriate z-axis programmable motorized stage.

## Auto Null Filter

Activates the auto null data filtering options. Filtering is used to highlight the roughness (high frequency components) or waviness (low frequency components) of a test part. Settings are Off, Low Pass, High Pass, Band Pass, and Band Reject. The affect of filtering varies based on the settings of the Filter Type and Filter Window Size controls. Off disables data filtering, all other filter controls are ignored.

## Auto Null Filter Cutoff

This control is activated when the Auto Null Filter Type control is set to FFT Auto or FFT Fixed. There are two selections: Sinusoid and Gaussian. These settings represent two methods of attenuating the frequency components.

## Auto Null Filter High Freq

Specifies the frequency of the higher cutoff point between roughness and high frequency data when the Auto Null Filter Type control is set to FFT Fixed and the Auto Null Filter control is set to Low Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is displayed in the Auto Null Filter High Wavelen control.

## Auto Null Filter High Wavelen

Specifies the wavelength of the higher cutoff point between roughness and high frequency data when the Auto Null Filter Type control is set to FFT Fixed and the Auto Null Filter control is set to Low Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is displayed in the Auto Null Filter High Freq control.

## Auto Null Filter Low Freq

Specifies the frequency of the lower cutoff point between waviness and roughness data when the Auto Null Filter Type control is set to FFT Fixed and the Auto Null Filter control is set to High Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is displayed in the Auto Null Filter Low Wavelen control.

## Auto Null Filter Low Wavelen

Specifies the wavelength of the lower cutoff point between waviness and roughness data when the Auto Null Filter Type control is set to FFT Fixed and the Auto Null Filter control is set to High Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is output in the Auto Null Low Filter Freq control.

## Auto Null Filter Trim

Controls the preservation of data edges during the filtering processing when filtering is activated with the Auto Null Filter control. When On, filtering performs normally and some edge data is lost. When Off, edge data is preserved that is usually lost due to filtering. Set to On if you notice “ringing” effects at the edges of the data.

## Auto Null Filter Type

Selects the filtering algorithm when the Auto Null Filter control is activated. Filtering separates data into waviness, roughness, and high frequency components. The choices are: Average, Median, 2 Sigma, FFT Auto, or FFT Fixed. Use filtering with caution, as filtering can help to isolate frequencies, but it modifies the entire data set, and may not work uniformly on edge data.

*Average* uses all valid data points in each filter window (as determined by the Filter Window Size control) and averages them. The averaged value is then used to replace the data point at the center of the window. These averaged values are used to generate a new data array. It is the fastest of the filtering types. When used, the Auto Null Filter High/Low Wavelen (or Freq) controls are ignored.

*Median* selects the middle or median value of all the valid data points in each filter window. The median is the value of the middle point when the points are sorted from smallest to largest. The median value is then used to replace the data point at the center of the window. These median values are used to generate a new data array. Median filtering preserves edge detail better than the average algorithm. When used, the Auto Null Filter High/Low Wavelen (or Freq) controls are ignored.

*2 Sigma* uses data points that are within two times the rms value in each filter window and disregards data values that are out of this range. Points within the 2 sigma range are averaged. The averaged value is then used to replace the data point at the center of the window. These averaged values are used to generate a new data array. When used, the Auto Null Filter High/Low Wavelen (or Freq) controls are ignored.

FFT Auto and FFT Fixed use a Fast Fourier Transform algorithm; and the Filter Window Size control is ignored. FFT Auto automatically selects filter cutoff points based on the test data; it should be used as a starting point only. FFT Fixed sets filter cutoffs based on the entries in the Auto Null Filter High/Low Wavelen (or Freq) controls. If FFT filtering is used, the instrument must be calibrated.

## **Auto Null Filter Window Size**

Selects the number of data points used to generate a new filtered data point when the Auto Null Filter Type control is set to Average, Median, or 2 Sigma. As the window size is increased, the effects of filtering are increased.

## **Auto Null Focus Cal Factor**

Specifies the  $\mu\text{m}/\text{wave}$  factor that the auto null function uses when nulling the part along the z-axis based on FocMag (Z). This value is usually established by auto null calibration. This control is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## **Auto Null Focus Pass Limit**

Specifies the minimum FocMag (Z) value that auto null should achieve before considering the part nulled. Required entry for auto null. This control is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## **Auto Null Iterations**

Identifies the number of attempts the auto null function should attempt when correcting the part's position for null. This control is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## **Auto Null Lateral Correct Limit**

Specifies the maximum lateral (x or y) move allowable during the Auto Null routine.



## Auto Null Min Area Size

Auto Null Minimum Area Size specifies the smallest acceptable number of contiguous data points in a valid region of data for the Auto Null function. Settings: 7 to 9999999, default is 0. Decrease to allow smaller areas. Increase to accept larger areas and reject smaller. It is useful for eliminating the effect of isolated data areas that are not meant to be included in the auto null function, without the need of defining a mask.

## Auto Null Mode

Selects how the auto null routine is performed. Settings are: Tilt, Focus, Power, Tilt & Focus, or Tilt & Power. In overview, auto null uses the z calibration factors and the Auto Null Tilt Pass Limit values to adjust part positioning. The z-axis is moved to find optimum location for fringes and power; the x and y axes are moved to minimize the number of tilt fringes. This control is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

*Tilt* nulls the part based on TiltMag (Z). *Focus* nulls the part based on FocMag (Z). *Power* nulls the part based on Power. *Tilt & Focus* nulls the part based on both TiltMag (Z) and FocMag (Z). *Tilt & Power* nulls the part based on both TiltMag (Z) and Power.

## Auto Null Power Cal Factor

Specifies the  $\mu\text{m}$  factor that the auto null function uses when nulling the part along the z-axis based on Power. This value is usually set by auto null calibration. This control is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## Auto Null Power Pass Limit

Specifies the minimum Power values that auto null should achieve before considering the part nulled. Required entry for auto null. This control is only applicable to instruments measuring spherical parts with the appropriate X, Y, and Z programmable motorized stages.

## Auto Null Remove Spikes

Determines if spikes are removed from the data for the auto null function. When On, RMS is calculated for the entire surface and then each point is tested to determine if its height differs by at least that global amount from the average height of points in its averaging window.

When Off, spikes are not removed.

## Auto Null Spike Height (xRMS)

Auto Null Spike Height is used to remove spurious spikes in the data for the auto null function. An indication of data spikes is a single color and extremely flat Oblique plot. The entry specifies a multiplier applied to the RMS whose resultant specifies a height above which all points are deleted.

The Auto Null Remove Spikes control must be set to On. RMS is calculated for the entire surface and then each point is tested to determine if its height differs by at least that global amount from the average height of points in its averaging window. In other words, single data points higher than the spike heights are removed.

## Auto Null Tilt Pass Limit

Specifies the minimum TiltMag (Z) value that auto null should achieve before considering the part nulled. Required entry for auto null. This control is only applicable to instruments measuring spherical parts with the appropriate X, Y, and Z programmable motorized stages.

## Auto Null Tilt X Cal Factor

Specifies the  $\mu\text{m}/\text{wave}$  factor that the auto null function uses when nulling the part along the x-axis. This value is usually set by auto null calibration. This control is only applicable to instruments measuring spherical parts with the appropriate X, Y, and Z programmable motorized stages.

## Auto Null Tilt Y Cal Factor

Specifies the  $\mu\text{m}/\text{wave}$  factor that the auto null function uses when nulling the part along the y-axis. This value is usually set by auto null calibration. This control is only applicable to instruments measuring spherical parts with the appropriate X, Y, and Z programmable motorized stages.

## Auto Null Trim

Specifies the number of pixel layers removed from edges and around isolated obscurations for the auto null function. It is useful for removing bad data points from the measurement, such as those caused by diffraction at edges. From one to ten pixel layers can be removed. The action of the Auto Null Trim control is controlled by the Auto Null Trim Mode control.

## Auto Null Trim Mode

Selects how data is trimmed for the auto null function. The Auto Null Trim Mode control works in union with the Auto Null Trim control. Settings are All or Outside. *All* trims pixel layers at the edges of all data including outside edges and edges around internal holes or obscurations. *Outside* trims pixel layers at the outside edges only and not around internal holes. This is useful for removing diffraction edge effects without trimming holes in the data due to dropouts from poor modulation or nonfunctional camera pixels.

## Auto Null Use Catseye Cal Factor

Selects if the auto null catseye calibration factors are used during an auto null routine. Settings are On or Off. When On, the Auto Null Catseye Focus Cal Factor or Power Cal Factor is used. This control is only applicable to instruments measuring spherical parts with the appropriate z-axis programmable motorized stage.

## Auto Null Z Correct Limit

Specifies the maximum Z move allowable during the Auto Null routine.

## Auto Pattern Retry

When turned on, this control will automatically re-measure sites within the pattern that have the status selected. Settings are Off, Remeasure ?, Remeasure O, Remeasure F, and Remeasure ? O F. When set to Off (default), no sites are remeasured. Remeasure ? remeasures sites that could not be measured the first time. Remeasure O and Remeasure F remeasure only those sites that have a status of O (out of limit) or F (failed) respectively. Remeasure ? O F remeasures all of the sites that could not be measured, were out of limit, or failed. Only applicable to instruments with programmable stages.

## Auto Run Script

When On, the script file specified by the Script File control, is automatically run when the application is opened. Off is the default setting.

## Auto Save Data

Auto Save Data activates the automatic saving of a data file after the measurement. Its settings are On or Off. When Auto Save Data is On, data is saved every time the Measure button or the Run Pattern button is clicked. The names of the data files are determined by the Auto Save Data File control.

## Auto Save Data Dir

This control allows you to specify a directory path in which to automatically save data files. The directory may have any number of levels. When the data is being auto-saved, the directory path will be created automatically if it does not already exist. It is possible for the directory path to be automatically generated using a combination of control values such as Lot Number, Part Number, Part Serial Number, and Pattern File. See Section 11 and “Special Codes for Controls” for additional information.

## Auto Save Data File

Specifies the name of the data file to automatically save and how the name changes with subsequent measurements. To enter a file name, click on the box with the left mouse button, type a name, ending with “.dat” and press [Enter]. The file name must be 20 characters or less. The default auto save data file name is “MyData000.dat”. The Auto Save Data control must be On. It is possible to have additional information, such as Lot Number, Part Number, Part Serial Number, and Pattern File Name, appear in the data file name. See Section 11 and “Special Codes for Controls” for additional information.

The mode of operation of the Auto Save Data File control is selected with the Mode command from the control’s menu. The current mode of operation is indicated by an asterisk (\*). Modes are Normal, Prompt, or Auto-Increment.

When the Mode is *Normal*, the data is saved under the specified name after the measurement is complete. If additional measurements are made, the file is overwritten with new data. When the Mode is *Prompt*, the software asks you to enter the file name after each measurement.

When the Mode is *Auto-Increment*, the file name is incremented by one and a new data file is created after the measurement is complete. This lets you create a series of data file names without typing a file name after each measurement. For example, “MyData000.dat” becomes “MyData001.dat”. One digit in the name provides for ten increments, two digits for 100 increments, and three digits for 1000. When the maximum increment is reached, digits roll over and 999 become 000.

## Auto Save Data Sag Width

This control is operational only if MetroPro was started with the –windowsDialog command line option. This control specifies the sag width for saving data when taking measurements with the Auto Save Data Type control set to ZEMAX.

## Auto Save Data Type

This control is operational only if MetroPro was started with the `-windowsDialog` command line option. It provides a selection of data file types with which to save files when taking measurements. The Auto Save Data control must be set to On. File Format selections include: Binary, ASCII, CODE V, OSLO, ZEMAX, and SDF.

## Auto Save Seq

Activates the automatic saving of a sequence file. When On, the sequence file named by the Seq File control is saved to file.

## Auto Seq Buckets button

When the Acquisition Mode control is set to Phase, the instrument acquires multiple "buckets" of intensity data for the phase algorithm. The Auto Seq Buckets button displays the complete sequence of intensity data in the plots in the Intensity Data window. It is primarily used as a diagnostic tool.

## Auto Seq button

Activates an auto sequence function. The auto sequence function can automatically make multiple measurements and save the data. Various events are controllable: the number of measurements, time delays before and between sequences, and the automatic saving of data files.

## Auto Seq Delay

Auto Seq Delay (Auto Sequence Delay) specifies a time delay in hours, minutes, and seconds before an auto sequence is started.

## Auto Seq Interval

Auto Seq Interval (Auto Sequence Interval) specifies a time delay in hours, minutes, and seconds between measurements or auto sequences.

## Auto Seq Max Count

Auto Seq Max Count (Auto Sequence Maximum Count) specifies the number of auto sequences to perform, from 0 to 9999.

## Auto Seq Operation

Auto Seq Operation (Auto Sequence Operation) selects the auto sequence mode. *None* means that auto sequencing is disabled. *Measure* means that the instrument is set to take a series of measurements. *Run Pattern* means that the programmable stage option is set to run the current pattern file. *Run Script* means that the MetroScript file specified in the Auto Seq Script File control will be run.

## Auto Seq Script File

Specifies the script file to be run during an auto sequence when the Auto Seq Operation control is set to Run Script.

## Auto Store

The Auto Store control, in the Process window, activates the automatic storing of measurement values in temporary memory for Control Charts and Process Stats. Settings are On, Off, and On Load.

When set to On, values are stored. When set to Off, values are not stored. The On Load setting is used in conjunction with the Avg LoadData button when working with multiple data sets. When multiple data files are loaded, On Load stores the averaged results of multiple data sets in the Process Stats window. It does not store the individual results of each loaded file.

## Auto Tilt

This control enables or disables tilt removal at the start of a measurement. Settings are On or Off. This control applies only to instruments with programmable tip and tilt (or roll and pitch) stages.

Stitching Application. Selects how to use auto tilt in the stitch sequence. Settings are Off, First Measurement Only. First Measurement Only uses auto tilt only on the first measurement of the stitching sequence.

## Auto Tilt Adapt

This control enables the optimization of tilt adjustments during a stage control pattern in order to reduce the overall time. Values are Off, During Pattern and Pattern On Bar. The optimization involves making use of the measured tilt at the current pattern position to predict the tilt at the next pattern position. This control applies only to instruments with programmable pitch and roll stages.

## Auto Tilt button

Click to make the microscope stage perform an auto tilt adjustment based on the current settings of the auto tilt controls. This button applies only to instruments with programmable tip and tilt stages.

## Auto Tilt Domain

Specifies an area or range of degrees of usable fringes. This control applies only to instruments with programmable tip and tilt stages when the Acquisition Mode control is set to Scan.

## Auto Tilt Iterations

Specifies how many times to perform the auto tilt operation. On some instruments, repetition allows the auto tilt operation to converge and obtain a more accurate adjustment. A value of 2 causes the operation to be performed initially and then repeated. A value of 3 is the highest setting that should be required. This control applies only to instruments with programmable tip and tilt stages.

## Auto Tilt Max Adjust

This control is used for any auto tilt function. Specifies the maximum adjustment allowed from the starting pitch (motion about the x-axis) and roll (motion about the y-axis) positions. This control applies only to instruments with programmable tip and tilt stages.

## Auto Tilt Min Contrast

Specifies the minimum tilt fringe contrast in percent. Contrast is based on values from 0-100, with 100 being the highest contrast. Fringes with lower contrast than the entered value are considered unacceptable. This control applies only to instruments with programmable tip and tilt stages when the Acquisition Mode control is set to Phase.

## Auto Tilt Min Mod %

This is the minimum modulation (in percentage) necessary to obtain a valid height data point for use in the auto tilt calculation. A lower value includes weakly modulating points. A higher value includes only strongly modulating points. The value is usually a low number, as low as 1. This control applies only to instruments with programmable tip and tilt stages.

## Auto Tilt Mode

This control, in conjunction with the Acquisition Mode control, determines the technique used to remove tilt. Settings are Software (default), Hardware, or Scan. Hardware applies only to instruments with applicable hardware. This control applies only to instruments with programmable tip and tilt stages.

## Auto Tilt Pitch Backlash

Specifies an amount of tilt the programmable stage is adjusted in motions about the x-axis (pitch) to minimize the affect of mechanical backlash. This control applies only to instruments with programmable tip and tilt stages.

## Auto Tilt Pitch Offset

Used for any auto tilt function. The value entered in degrees is added to the stage pitch position calculated for null tilt. Pitch is motion about the x-axis; it is also referred to as tilt. This control applies only to instruments with programmable tip and tilt stages.

## Auto Tilt Pitch Tol

Specifies how fine to adjust the pitch of the part; it is a tolerance value in degrees for the pitch axis. The calculated pitch angle is compared to this value. If the absolute stage pitch value is less than the respective tolerance, no adjustment is performed. Pitch is motion about the x-axis; it is also referred to as tilt. This control applies only to instruments with programmable tip and tilt stages.

## Auto Tilt Roll Backlash

Specifies an amount of tilt the programmable stage is adjusted in motions about the y-axis (roll) to minimize the affect of mechanical backlash. This control applies only to instruments with programmable tip and tilt stages.

## Auto Tilt Roll Offset

Used for any auto tilt function. The value entered in degrees is added to the stage roll position calculated for null tilt. Roll is motion about the y-axis; it is also referred to as tip. This control applies only to instruments with programmable tip and tilt stages.



## Auto Tilt Roll Tol

Specifies how fine to adjust the roll of the part, it is a tolerance value in degrees for the roll axis. The calculated roll angle is compared to this value. If the absolute stage roll value is less than the respective tolerance, no adjustment is performed. Roll is motion about the y-axis; it is also referred to as tip. This control applies only to instruments with programmable tip and tilt stages.

## Auto Update

The Auto Update control, in the Video Monitor window, activates the automatic updating of the video monitor screen with the contents of the Video Monitor window after each measurement. When Off, the video monitor screen is not updated with information.

## Average Overlap Regions

Selects if the stitching algorithm averages overlap regions. Settings are On or Off. It is recommended that this control be On. Averaging the overlap regions results in a stitched image with less discontinuity.

## Avg LoadData button

This button loads multiple data files and calculates the average for all loaded files. This function retains pixels even if all data sets do not have data at a particular pixel. For example, if one of the five data sets doesn't have data at a certain pixel, but the other four do, the software averages the four data sets at that pixel. (The Avg Min Accum control must have been set from 1 through 4). MetroPro must be started with the `-windowsDialog` flag; refer to *Appendix C*.

To use the average load function:

1. Be sure the `-windowsDialog` flag is active.
2. Set the Auto Store control to On Load.
3. Create an Avg LoadData button.
4. Create a Process Stats window.
5. Copy results to be displayed to the Process Stats window.
6. Click the Avg LoadData button and select the files to be averaged.

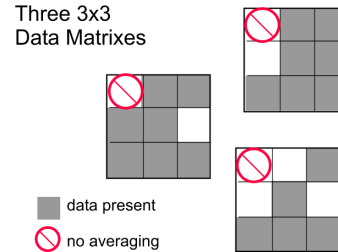


Once the selected files are loaded, the displayed plot represents the *averaged* data. The Process Stats window displays one line showing averaged results. Results for each of the loaded files are not displayed in the Process Stats window. If only one file is loaded, MetroPro loads just the single file and *does not* perform averaging.

## Avg Min Accum

This control establishes the minimum number of valid data points that must be present in the matrix in order for averaging to occur. It is used along with the AvgLoadData button.

For example, if 3 data files are loaded for averaging, and the first location in the data matrix of 1 of the files does not have data, and Avg Min Accum is set to 3, then averaging will not occur at this first position. However, if Avg Min Accum is set to 2 or 1, averaging is performed for the first position and the result is stored.



## AWM Acquire button

This button causes MetroPro to acquire data from an absolute wavelength meter. Use of an AWM is described in the AWM Acquisition Mode control.

VeriFire MST applications only.

## AWM Acquisition Mode

MetroPro supports the addition of an absolute wavelength meter (AWM) to a ZYGO interferometer. The interferometer must be a VeriFire MST type instrument that incorporates a relative wavelength meter. The AWM provides an absolute measurement of the wavelength of the light source in order to increase the accuracy of interferometric measurements.

This control affects the operation of an absolute wavelength meter (AWM). Selections for this control are Manual or Auto. In Auto mode, MetroPro acquires new AWM data immediately before each interferometer measurement. In Manual mode, MetroPro acquires AWM data only when the AWM Acquire button is pressed.

VeriFire MST applications only.

## AWM Show Last Error button

This button shows the last error message associated with an AWM. Use of an AWM is described in the AWM Acquisition Mode control.

VeriFire MST applications only.

## Back button

Loads the previous data file of a MetroPro movie. Used with dynamic stroboscopic measurements. This button is available in a Control window with the New Button → Dynamic menu.

## Batch Number

An alphanumeric entry in the Q-DAS Report window, which identifies the batch number. This entry is saved with the data.

## Bucket

Specifies which bucket of intensity data to use in the plots and results within the intensity data window. Functions only when MetroPro is run in the diagnostic mode.

## Calibrate button

Opens the Calibrator window. See Calibrator for more details on the calibration function.

## Cal Markers Dir

Specifies the name of the directory containing the Cal Markers file to be loaded. Refer to the Auto Load Cal Markers control

VeriFire MST applications only.

## Cal Markers File

Specifies the name of the Cal Marker file to be loaded. Refer to the Auto Load Cal Markers control

VeriFire MST applications only.

## Camera Gain

Selects the camera gain For the Illunis MMV340 camera only. Choices are 1X (default), 2X, 4X, and 8X.

## Camera Mode

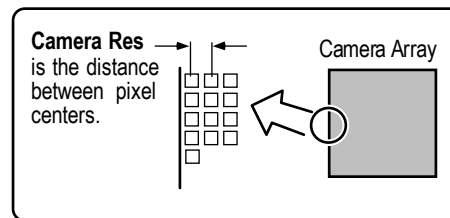
Camera Mode selects the effective camera size for acquiring test data; it defines the measurement resolution in pixels. The selections for this control vary based on the actual camera installed in the instrument. If there is not an active instrument, Camera Mode displays None.

Typical selections for Camera Mode include: 160x120, 320x240, and 640x480. Generally, the selections are the full camera array or aperture. The greater the number of pixels, the finer the resolution, but the longer it takes to process the data. The Camera Mode selections also indicate the speed (in Hz) at which data is collected.

Additional information on specific Camera Mode selections may be found in the applicable instrument manual.

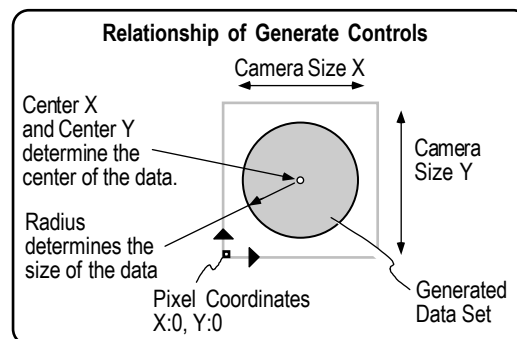
## Camera Res

When generating a data set, this control specifies the distance between camera pixels. Entering a value in the Camera Res control has no affect on measurements, as resolution information is overwritten by a system calibration file.



## Camera Size X

When generating a data set, this control specifies the number of camera pixels in the X dimension. Settings are: 50 to 512.



## Camera Size Y

When generating a data set, this control specifies the number of camera pixels in the y dimension. Settings are: 50 to 480.

## Cavity Number

A numeric entry in the Q-DAS Report window, which specifies either the cavity, nest, or spindle number. This entry is saved with the data.

## Center X

Specifies the x-axis center location in pixels of a generated wavefront. An entry of -1 places the Center X in the middle of the Camera Size X dimension. See Camera Size X.

## Center Y

Specifies the y-axis center location in pixels of a generated wavefront. An entry of -1 places the Center Y in the middle of the Camera Size Y dimension. See Camera Size X.

## Clear button

In general, this button removes all information from the window in which it is located. Some specific functions are detailed below.

Process window; removes all stored measurement values from temporary memory, which also erases all values from Process Stats and Control Charts. Video Monitor window; clears all information from the video monitor display. PHom Application, Three Flat Application, and Two Sphere Application; erases all current measurement information; click when starting a new measurement series.

## Clear Movie button

Unloads the current movie from memory. Note that clicking the Play, Forward, or Back buttons or editing the Jump to Frame control, reloads the movie.

## Clear Report button

A Q-DAS Report window button. When clicked, the file specified by the Log File control is cleared of values.

## Clip Location

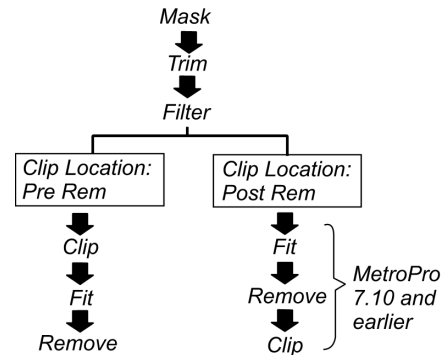
Specifies where clipping is applied. The settings are Pre Rem (default) or Post Rem. Pre Rem applies clipping before the remove. Post Rem applies clipping after the remove.

The illustration shows the difference in the analysis routine between Pre and Post Remove options.



The Post Rem option applies clipping to the data based on the order of operations used in versions 7.10 of MetroPro and earlier. To replicate earlier software versions, also select Fixed in the Low Clip Mode or High Clip Mode control and enter a value the High Clip or Low Clip controls.

**MetroPro Data Flow and Clip Location**



## Clip Surface Fit

Specifies a surface shape to subtract from the data during clip analysis. Options are: None, Piston, Plane, Sphere, and Cylinder. The surface fit is temporary and is not removed from the final data. The surface fit is applied to the data before determining the reference plane for clipping. This control is best used with a Clip Location control setting of Pre Rem. Also refer to High Clip Ref or Low Clip Ref.

## Close App button

Closes the application window in which it resides. This button is useful when using a Touchscreen interface.

## Close Window button

Closes the window in which it resides. This button is useful when using a Touchscreen interface.

## CODE V Type

The type of CODE V data saved when the Save Zernikes button is clicked. Settings are WFR (wavefront) or SUR (surface). This control should be used when saving data as Code V Zernike data as described in Section 12.

## Coef (0 to 36)

This discussion includes 37 Control boxes, from Coef 0 to Coef 36. Settings: positive or negative number. This group of controls is used to enter the coefficients for Zernike Polynomials when generating a Zernike data set. The number of Coef X controls used should match the number of Zernike Terms selected in the same Control window.

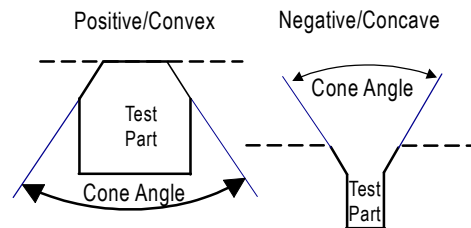
## Comment

Serves as a user entry box for typed remarks. To enter text, click on the box with the left mouse button. An entry field appears, in which you type whatever you want, such as a company name, a part description, or a technician name. When you have completed the entry, press [Enter].

Comment differs from an Annotation in that it is saved with a data set, an Annotation is not. Change the size of the Comment box by using the control's Width command.

## Cone Angle

This control specifies the cone angle to remove from the data during analysis. It is used in conjunction with Fixed Angle Cone and Variable Angle Cone, which are options in the Remove control. An entry is required for Fixed Angle Cone.



The acceptable range is: 5 to 180; -180 to -5. A positive value indicates a convex cone, and a negative value a concave cone. While this control is not required with the Variable Angle Cone option, if a value is entered, the software will use the value as a starting point when determining the best-fit cone. Access this control from the New Control menu. See the Remove control in this section for additional information on Cone Angle.

## Connect Algorithm

Selects which algorithm is used to connect data. Settings are Normal (default) or Noise Tolerant. Noise Tolerant attempts to tolerate some noise in the measured data. When set to Noise Tolerant, enter a value in the Connect Noise Threshold control.

## Connect Data button

Reconnects data using connect and its associated parameters such as Min Area Size and others. Part of a manipulate function.

## Connect Noise Threshold

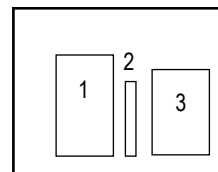
Specifies how much noise in neighboring pixels is tolerated when the Connect Algorithm control is set to Noise Tolerant. The units are in percent of a fringe. A value between 10 and 25 is typical. Lower values allow less noise in the measured data, while a larger value allows more noise.

## Connection Order

Selects how data is connected when the Acquisition Mode control is set to Phase. During the processing of data, regions of data are connected or joined together to form the details of the test sample. Connect is defined as the process of taking wrapped (modulo  $2\pi$ ) phase data and turning it into unwrapped (continuous) phase data.

Settings are Location or Size. *Location* connects data areas by location; it starts with the largest area and connects it to adjacent areas, radiating outward until all areas are connected. *Size* connects consecutive data areas by size; this connects largest data areas first, which provide a more reliable starting point because they have more points.

The box shown here represents a data set; regions 1, 2, and 3 are all in the same plane. The connect algorithm uses a least squares technique to establish the proper offset that must be added to regions 2 and 3 to place them on the same surface as region 1. If Connection Order is Location, areas 1 and 2 are first connected, then region 3 is added. But region 2 may be at the wrong offset and affect the plots. If Connection Order is Size, the greater number of data points in regions 1 and 3 provide a stable platform which to add region 2.



## Connection Type

Specifies what portion of the surface is used in the connect process to join multiple regions when the Acquisition Mode control is set to Phase. Settings are Standard (use all data) or Modal (use dominant surface).

## Cont Pattern button

Click to continue running the current pattern from its present location. Only applicable to systems with programmable stages.

## Convert Movie button

Converts the MetroPro movie as defined by the movie controls to an .avi file. Used with dynamic stroboscopic measurements. This button is available in a Control window with the New Button → Dynamic menu



## Conv Intens To Data button

Takes intensity data and dumps it into the surface/wavefront data window. Sometimes used as a debugging tool. When this action is performed, the only valid measurement units for results and plots are “zygos”, which are internal intensity units.

## Cost Area

A Q-DAS Report window text entry control for entering cost information.

## CSA Reference (%)

This is a percentage value between 0 and 100. Selection of this value is dependent upon the Reference Type chosen.

## CSA Reference Type

Selections are Area and PV.

For Area, the reference will be set at the height that is located at the dataset PV value multiplied by the area percent starting from the lowest data point. For example: if there are 1000 data points and 2% of them are used, the starting point will be established by beginning at the bottom height value and going up 20 points, and then using the height value at that point.

For PV, the reference height will be set to the dataset valley plus the PV percent times the dataset peak-to-valley value.

## Current Part

A Q-DAS Report window control that specifies the number of the part being currently measured in a type 3 manual gage study.

## Custom Waveform

Specifies a custom waveform. When the Driver Waveform control is set to Custom, the custom waveform stored in the Tegam Arbitrary Waveform Generator's (AWG) memory (in the slot indicated by this control) is played back. Used with dynamic stroboscopic measurements. This control is available in the Control window with the New Control → Dynamic → Driver menu.

## Data Fill

Determine if missing data points in plots are filled, based on the setting of the Fill Max control. Settings are Off (default) or On.

## Data Fill Max

Specifies the maximum size in pixels of a data hole that is filled when the Data Fill control is On. It is the total number of pixels in any one data hole.

## Data Sign

Changes the sign of the data. The normal sign of phase data is such that increasing phases correspond to decreasing cavity length and increasing surface heights. The Data Sign control allows you to change the sign, if due to your setup the measurement data appears reversed in the results on screen. Settings: Normal (default) or Inverted.

## Department

A Q-DAS Report window text entry control for entering department information.

## Disable Wand Focus button

Temporarily disables the Remote Control Focus buttons. This ensures that the focus is not inadvertently changed.

## Discon Action

Selects how discontinuities or ambiguous data is handled, when the Acquisition Mode control is set to Phase. A discontinuity occurs when very steep pixel-to-pixel slopes or steps greater than half the wavelength of the light source are found in the data. Missing data in plots may indicate discontinuities. Settings are Filter, Delete Regions, or Ignore.

When **Filter** is selected, discontinuities are deleted based upon the setting of the Discon Filter control. After the connect processing is finished, and if discontinuities are detected, suspected areas are deleted from the phase data and the connect is repeated. (Connect is the process of joining data points together into a map representing the test part.) This process continues until no discontinuities remain in the data. A part may be so rough that none of it is measurable; if this is the case you would receive an error message. If discontinuities are present, it takes additional processing time.

When **Delete Regions** is selected, areas or regions that have discontinuity are removed. Use this option for special cases only. An example where Delete Regions is useful is when the test part has hundreds of separate discontinuous areas of data, in which some of these areas may have discontinuities. In this case, areas with discontinuities are removed and the analysis continues. However, with a typical test part comprised of one area of data with a few discontinuities, the entire area would be eliminated and the connect process would fail.

When **Ignore** is selected, data is checked for discontinuities, but they are not removed. This is primarily for debugging and should not be selected.

## Discon Filter

Specifies the degree to which discontinuities are removed from data. A discontinuity occurs when very steep pixel-to-pixel slopes greater than half the wavelength of the light source are found in the data. The greater the value, the more discontinuities are removed, but the more likely that data is removed as well. Discon Filter is only applicable when the Discon Action Control box is set to Filter. Settings: 0 (none) to 100 (all), default is 60.

When should you change this value? If you are measuring rough parts, and the processing time has increased, you should try raising the filter value. This reduces the number of iterations it takes to remove discontinuities. If you see large areas of data missing where you think there should be data (and you see some screen indication that the discontinuity filter has been at work), then reduce the filter number.

## Discr Mode

The Discr (discriminator) Mode control specifies how camera frames are processed during data acquisition. Settings are Normal (default) or RAM. When set to Normal, acquired data is processed in real-time. When set to RAM, the raw frame data is stored in the computer's RAM and processed later. This setting can reduce the "could not keep up with frame grabber..." error.

## Display Measurements

Selects whether individual measurements are displayed on screen during the stitch sequence. Settings are On or Off.

## Driver Frequency

Sets the output frequency of both the Drive Signal and Sync Pulse from the Tegam Arbitrary Waveform Generator (AWG) hardware. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Driver menu.

## Dynamic\ Driver\ Generator Output

This control is used to enable and disable the waveform generator output. The possible values of the control are Enabled and Disabled. If there is no waveform generator connected to the system, only the disabled value is available.

## Dynamic Light Level

Sets the starting position of the variable light level controller used during dynamic data acquisition when the LLC Mode control is set to Dynamic. The variable light level controller is part of the instrument's automatic gain control feedback loop and is used to provide optimum illumination of the test part. Settings are: 0 (brightest) to 159 (darkest); the default is 80.

## Dynamic Light Level Pct

Specifies the light level (in percentage from 0 to 100) for dynamic measurements when the LLC Mode control is set to Dynamic. When the AGC control is On, it specifies the starting point for the AGC function for dynamic measurements.

## Dynamic LLC Mode

This control is used with the Dynamic Stroboscopic Measurement function and controls the behavior of the light level controller electronics. There are two selections: Fixed Duty Cycle or Fixed Pulse Width.

In Fixed Duty Cycle mode (recommended), the electronics adjust the LED pulse width to maintain a desired duty cycle (as a function of drive frequency) while a sweep is performed. This maintains more uniform illumination and avoids blurring of fringes as the frequency increases.

In Fixed Pulse Width mode, the illumination electronics use a particular pulse width, in time units. This width is held constant during a sweep, and as such is appropriate for phase sweeps only, or those in which the drive frequency is held constant.

This control has no effect if the LLC Mode control is set to Static.

Applicable to microscope instruments only with the appropriate hardware.

## Edit Header button

A Q-DAS Report window button. When clicked, opens a file for editing in a text window. If the Split Data File is Off, the file specified in the Log File control is opened. If the Split Data File is On, the .dfd file is opened.

## Edit Pattern button

Click to open the Pattern Editor window, which is used to define, save, and load pattern files. Applicable only to systems with programmable stages.

## Edit Pattern Pos button

Click to open the Position Editor window. Applicable only to systems with programmable stages.

## Edit Report button

Report window button. Opens a text editing program so the report file may be modified.

A Q-DAS Report window button. When clicked, opens a file for editing in a text window. If the Split Data File is Off, the file specified in the Log File control is opened. If the Split Data File is On, the .dfx file is opened.

## Enable Wand Focus button

Restores operation of the Focus buttons on the Remote control.

## End Frequency

Specifies the ending frequency for a Frequency or Frequency & Phase sweep measurement. It is not used for Phase only sweep measurements. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Sweep menu.

## End Phase Delay

Specifies the ending Phase Delay for a Phase or Frequency & Phase sweep measurement. Enter a value between 0 and 360 degrees. It is not used for Frequency only sweep measurements. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Sweep menu.

## Event

A numeric entry for entering event codes in the Q-DAS Report window. Enter a list of numbers in the range of 0 to 255, separated by spaces. This entry is saved with the data.

## Exit Pupil Diam

Specifies the actual exit pupil diameter of an afocal wavefront for the MTF analysis. An entry is required to calculate the Cutoff Freq (afocal) result.

## Extended Scan Length

For a scanning microscope with an extended scan option only. Specifies the length of the scan. The Scan Length control must be set to Extended. The value entered should be the vertical range of detail in the part plus 10%.

## Failure Action

Selects the action to take if there is an error during a stitch sequence. Settings are Abort, Retry, or Continue. Abort will stop the stitching sequence. Retry repeats the measurement and aborts the sequence if it fails again. Continue ignores the error and goes to the next location.

## FDA Noise Threshold

Specifies how much noise in neighboring pixels is tolerated when the FDA Res control is set to High 2G. The units are in percent of a fringe.

A recommended starting setting is between 10 and 15. Lower the percent if too many points drop out, but keep the value as high as possible. Higher values allow more points to pass through the FDA algorithm, but may result in errors resolving  $2\pi$  ambiguity. Lower values decrease the chance of processing problems, but more pixels are removed.

## FDA Prefilter Mode

FDA Prefilter Mode is used *only* with the FDA Res control when it is set for High2G analysis. To access the FDA Prefilter Mode control, select a Control Window and then select the New Control → Phase Processing menu.

The three settings for this control are 3x3 (default setting), 5x5, and 7x7. During High2G analysis, the selected mode controls the amount of filtering used to resolve the  $2\pi$  phase ambiguity associated with single-wavelength, phase-shift interferometry. The filtering is internal and does not affect the final height data. The 5x5 or 7x7 mode makes High2G more effective when there is a particular range of high-frequency slopes present (e.g. ground steel surfaces that may contain large spikes or steps which are obvious artifacts of the metrology). Begin with 5x5 and then try 7x7. The 3x3 mode represents standard High2G processing and should be used whenever possible. This is the correct setting for smooth surfaces.

## FDA Res

Scanning Microscopes. FDA is a mathematical method for processing complex interferograms in terms of phases and spatial frequencies. FDA transforms data to the frequency domain, where it is analyzed to calculate surface height.

The objective is mechanically scanned to generate a sequence of interferograms, which are transformed to get phase information. Fourier analysis is used to extract a range of phases for each color or wavelength in the spectrum of the white-light source. The source spectrum together with the corresponding phases is a frequency domain representation of an interferogram. The particular combination of phases found by FDA uniquely defines the surface height map.

In traditional, single-wavelength, phase-shift interferometry, the interference pattern is transformed into a matrix of phase values with an algorithm, such as the “five-bucket” method. With FDA, it is as if the five-bucket algorithm is applied for every one of the wavelengths in the source spectrum. The resulting phase measurements would be different for each wavelength. Having this type of data resolves the slope  $2\pi$  ambiguity problem common to single-wavelength, phase-shift interferometry.

The essential idea behind FDA is that it examines interference phase, not the original intensity data measured by the detector. To change intensity data to the frequency domain, the data is transformed using a Fast Fourier Transform. Distance is calculated using multiple phase values found within the source spectrum. Using multiple phase values allows the removal of  $2\pi$  ambiguities found during traditional, single-wavelength, phase-shift interferometry. There are different methods, resulting in different resolutions, of using the multiple phase values to generate the final height.

The settings of the FDA Res control determine the method, and thus the resolution, of the analysis as shown in the following table. The selections available in the FDA Res control are affected by the Scan Type control setting. Refer to the entry for Scan Type later in this section.

## FDA Res Control - Summary of Selections

<i>FDA Res</i>	<i>Technique</i>	<i>Vert. Res.</i>	<i>Conditions of use</i>
<i>High</i>	Equivalent to phase shifting interferometry with $2\pi$ phase ambiguity resolution. Uses FFT analysis of the source spectrum.	~0.1 nm	Maximum vertical resolution.
<i>Normal</i>	Equivalent centroid detection of envelope peak with FFT.	~3 nm	Rough surfaces, typically > 75 nm Ra
<i>High2G</i>	Next generation High selection. Has better processing on surfaces with phase departures.	~0.1 nm	Maximum vertical resolution.
<i>Low</i>	Fast centroid detection of envelope peak, without FFT.	~20 nm	Extended scan option, Scan Length control set to Extended.
<i>Phase 1</i>	Hybrid approach, combines vertical scanning interferometry and phase shifting interferometry techniques in a single measurement. Data is acquired at optimal focus.	~0.1 nm	NewView 5022/5032 only, <80 nm bandwidth filter required, general purpose for scans <150 nm. The Scan Type control must be set to Phase.
<i>Phase 2</i>	This method is almost the same as Phase 1 above, while allowing surface structure with greater phase value than $\pi/2$ .	~0.1 nm	NewView 5022/5032 only, <80 nm bandwidth filter required, for step heights from 0 – 5 $\mu\text{m}$ and low magnification objectives. The Scan Type control must be set to Phase.
<i>Films</i>	This method allows for High2G quality measurements in the presence of transparent films greater than 1.5 $\mu\text{m}$ in optical thickness.		Using FDA Res Films requires that Films Mode is also selected.

## FDA Use All Bins

Selections are On or Off. This control affects the Frequency Domain Analysis (FDA) that is applied during a scan measurement. Setting this control to On causes the analysis to use more of the frequency spectrum. It can improve data quality when using certain objectives having greater dispersion, such as the 100X. Note that when this control is On, processing time is increased.

Microscope Applications only.



## Fiducials Dir

Specifies where fiducial files are located. If no directory is specified, then the current working directory is used. It is available in a Control window with the New Control → Fiducials menu.

## Fiducials File

Specifies the name of a fiducials file to load automatically when the Auto Load Fiducials control is On. The fiducials files must exist prior to entering its name in the Fiducials File control. The file name should end with “.fid”.

## Field Flattening Dir

Identifies the directory in which the IDR and ISE files are located.

## Field Flattening IDR File

Identifies the name of the Intensity Dark Reference (IDR) file to apply to field flattening. The file has a .dat extension. To create an IDR file, a specified number of measurements of intensity images (no fringes) are made and averaged with the light off. Turn the light off by setting the Light Level Pct control to zero (0). Also set AGC (Automatic Gain Control) to Off.

## Field Flattening ISE

Identifies the name of the Intensity System Error file (ISE) to apply to field flattening. The file has a .dat extension. This file is made by measuring and averaging a specified number of intensity images from an SiC flat. The Remove Fringes control must be set to On.

## Field Location Prompt

This On/Off control specifies if the operator is prompted to adjust the stage position before measuring each field on the part. Only applicable to instruments with programmable stages.

## File Format

Selects the format of a report file or a Q-DAS report file. The report file is a text file containing user-specified measurement information and results.

For a Report window, the settings are As Displayed, Comma Separated, or Tab Separated. The *As Displayed* format makes an exact copy of the Report window and puts it into the Log File. It includes any spaces you have put between results. The As Displayed format is generally used when outputting the contents of the Report window to a printer. *Comma Separated* format places double quotations around text items, separates all fields with commas, and removes any spaces between items. The Comma Separated format is used when the report file is transferred to a spreadsheet program for further processing. *Tab Separated* format is identical to the comma separated format, except fields are separated by tabs instead of commas.

For a Q-DAS Report window, the settings are: Sample Analysis, Gage-Type 1, or Gage-Type 3. *Sample Analysis* is a standard test measurement. *Gage-Type 1* is a gage study using one operator measuring a known reference standard a number of times. *Gage-Type 3* is a gage study using one operator measuring a number of parts in a series of measurement trials.

## Film Fringe Removal %

This value is a percentage of the distance between two film surfaces. This control affects how the software calculates intensity map data when the Remove Fringes control is On.

Microscope applications only.

## Films High2G Processing

Selections are On or Off. The default is On, and it should not be changed. In very limited measurement cases, such as surfaces composed of dissimilar materials, it may be necessary to turn off Films High2G Processing. See the “FDA Res Control.”

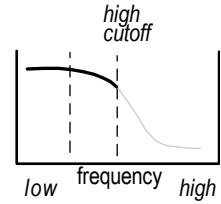
Microscope applications only.

## Filter

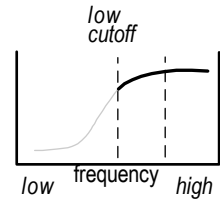
Activates data filtering options. Filtering is used to highlight the roughness (high frequency components) or waviness (low frequency components) of a test part. Filtering controls are available in both "map" and "profile" data windows. Settings are Off, Low Pass, High Pass, Band Pass, and Band Reject. The affect of filtering varies based on the settings of the Filter Type and Filter Window Size controls. Off disables data filtering, all other filter controls are ignored. Filter controls are available in the Surface/Wavefront Map (T&R) window as well as the Test window.

Refer to the following description of the Filter control settings.

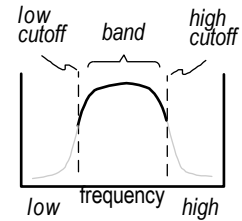
**Low Pass** allows the low spatial frequency components to pass through the filter; roughness is removed. Its affect is determined by the Filter Type control. When FFT Fixed filtering is selected, the cutoff is specified by the Filter High Wavelen or Filter High Freq control.



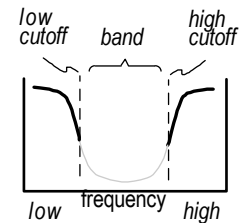
**High Pass** allows the high spatial frequency components to pass through the filter; waviness is removed. Its affect is determined by the Filter Type control. When FFT Fixed filtering is selected, the cutoff is specified by the Filter Low Wavelen or Filter Low Freq control.



**Band Pass** passes the spatial frequency components that are in-between two cutoff values; the Filter Type must be set to FFT Auto or FFT Fixed. When FFT Fixed filtering is selected, the lower cutoff is specified by the Filter Low Wavelen (or Freq) control and the higher cutoff is specified by the Filter High Wavelen (or Freq) control.



**Band Reject** removes the spatial frequency components that are in-between two cutoff values; the Filter Type must be set to FFT Auto or FFT Fixed. When FFT Fixed filtering is selected, the lower cutoff is specified by the Filter Low Wavelen (or Freq) control and the higher cutoff is specified by the Filter High Wavelen (or Freq) control.



Also refer to Section 11.

## Filter Cutoff

This control is activated when the Filter Type control is set to FFT Auto or FFT Fixed. There are two selections: Sinusoid and Gaussian. These settings represent two methods of attenuating the frequency components. Also available in the Surface/Wavefront Map (T&R) window.

## Filter High Freq

Specifies the frequency of the higher cutoff point between roughness and high frequency data when the Filter Type control is set to FFT Fixed, and the Filter control is set to Low Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is displayed in the Filter High Wavelen control. Also available in the Surface/Wavefront Map (T&R) window.

## Filter High Wavelen

Specifies the wavelength of the higher cutoff point between roughness and high frequency data when the Filter Type control is set to FFT Fixed, and the Filter control is set to Low Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is displayed in the Filter High Freq control. Also available in the Surface/Wavefront Map (T&R) window.

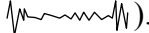
## Filter Low Freq

Specifies the frequency of the lower cutoff point between waviness and roughness data when the Filter Type control is set to FFT Fixed, and the Filter control is set to High Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is displayed in the Filter Low Wavelen control. Also available in the Surface/Wavefront Map (T&R) window.

## Filter Low Wavelen

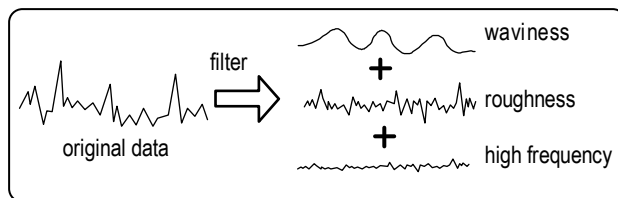
Specifies the wavelength of the lower cutoff point between waviness and roughness data when the Filter Type control is set to FFT Fixed, and the Filter control is set to High Pass, Band Pass, or Band Reject. When a value is entered, a corresponding value is output in the Low Filter Freq control. Also available in the Surface/Wavefront Map (T&R) window.

## Filter Trim

Controls the preservation of data edges during the filtering processing when filtering is activated with the Filter control. When On, filtering performs normally and some edge data is lost. When Off, edge data is preserved that is usually lost due to filtering. Set to On, if you notice “ringing” affects at the data edges (for example: .

## Filter Type

Selects the filtering algorithm when the Filter control is activated. Filtering separates data into waviness, roughness, and high frequency components.



The choices are: Average, Median, 2 Sigma, FFT Auto, FFT Fixed, Gauss Spline, Gauss Spline Auto, Robust Gauss Spline, and Robust Gauss Spline Auto. Use filtering with caution, as filtering can help to isolate frequencies, but it modifies the entire data set, and may not work uniformly on edge data. See Filter.

**Average** uses all valid data points in each filter window (as determined by the Filter Window Size control) and averages them. The averaged value is then used to replace the data point at the center of the window. These averaged values are used to generate a new data array. It is the fastest of the filtering types. When used, the Filter High/Low Waven (or Freq) controls are ignored.

**Median** selects the middle or median value of all the valid data points in each filter window. The median is the value of the middle point when the points are sorted from smallest to largest. The median value is then used to replace the data point at the center of the window. These median values are used to generate a new data array. Median filtering preserves edge detail better than the average algorithm. When used, the Filter High/Low Waven (or Freq) controls are ignored.

**2 Sigma** uses data points that are within two times the rms value in each filter window and disregards data values that are out of this range. Points within the 2 sigma range are averaged. The averaged value is then used to replace the data point at the center of the window. These averaged values are used to generate a new data array. When used, the Filter High/Low Waven (or Freq) controls are ignored.

**FFT Auto and FFT Fixed** use a Fast Fourier Transform algorithm; and the Filter Window Size control is ignored. FFT Auto automatically selects filter cutoff points based on the test data; it should be used as a starting point only. FFT Fixed sets filter cutoffs based on the entries in the Filter High/Low Waven (or Freq) controls. If FFT filtering is used, the instrument must be calibrated.

**Gauss Spline and Robust Gaussian Splines**—often defects can have different wavelengths. The Gaussian Spline filters enhance the ability to separate wavelengths and look at them independently. These filters retain the detail of the original fit of the data resulting in much less distortion. They make it possible to maintain the integrity of the peak to valley distortion while eliminating extreme distortions. The Robust Gaussian Spline filter handles end regions better and eliminates outliers. In general, both spline filters are faster than traditional FFT calculation.

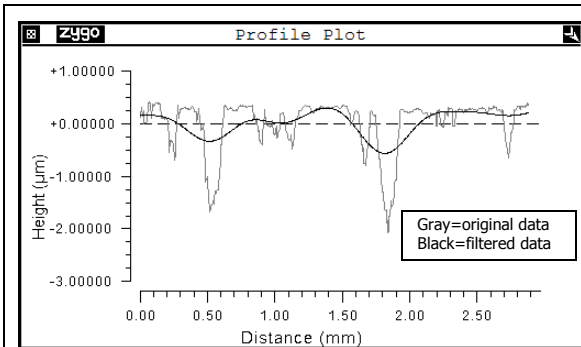
For the “spline” filters to function properly, the Filter control must be set to Low Pass, High Pass, or Bandpass, and the Filter Waven or Filter Freq controls must have low and/or high values entered where appropriate. The Spline Beaton Coeff and Spline Tension controls have default settings that should not be changed when using the spline filters.

**Gauss Spline Auto and Robust Gauss Spline Auto**—the software arbitrarily sets the cutoff as a starting point.

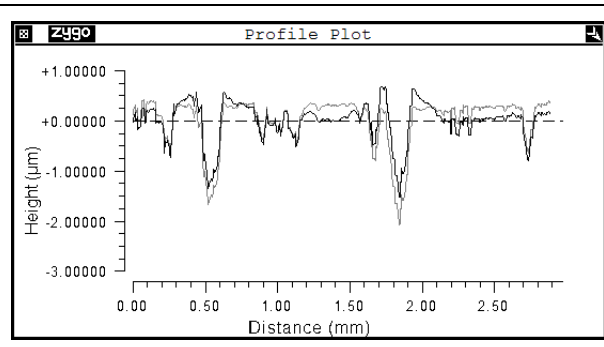
### Sample Data Sets Showing the Robust Gaussian Spline Filter

The sample data sets shown below represent a measurement of a part with two different filters applied. The interaction of filtering controls can have an impact on the post-filtered data; therefore, be sure to use the filters carefully.

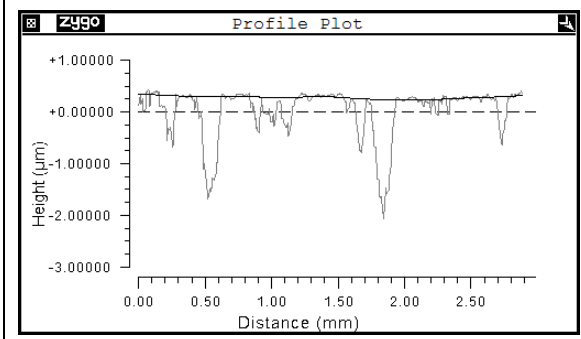
Note that the color configuration for the profile plots in MetroPro is: original data displays as gray; filtered data as green. For easier differentiation in print, these plots have been highlighted with black and gray to best show both lines.



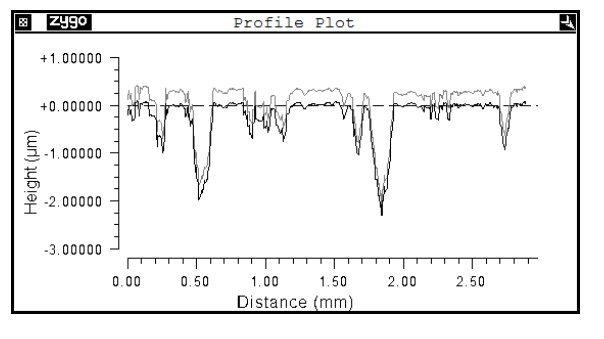
Filter Type: FFT Fixed  
 Filter: Low Pass  
 Filter Low Wavelen: 0.8 mm  
 Filter High Wavelen: 0.8 mm



Filter Type: FFT Fixed  
 Filter: High Pass  
 Filter Low Wavelen: 0.8 mm  
 Filter High Wavelen: 0.8 mm

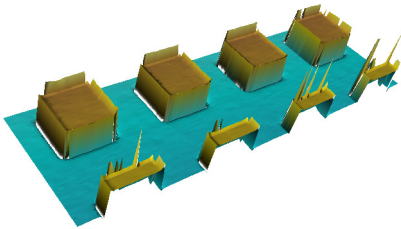


Filter Type: Robust Gauss Spline  
 Filter: Low Pass  
 Filter Low Wavelen: 0.8 mm  
 Filter High Wavelen: 0.8 mm

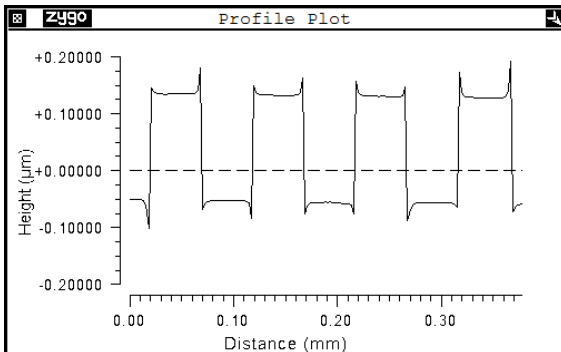


Filter Type: Robust Gauss Spline  
 Filter: High Pass  
 Filter Low Wavelen: 0.8 mm  
 Filter High Wavelen: 0.8 mm

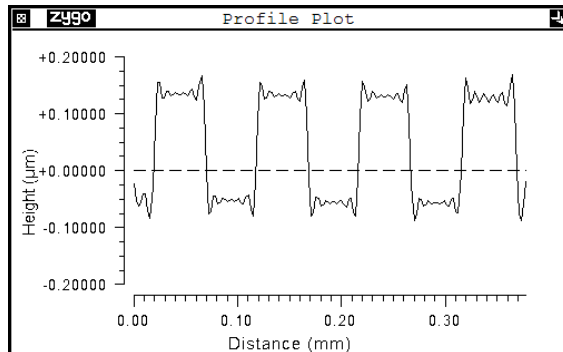
## Sample Data Sets Comparing Filter Settings



A stepped part was used for this series of measurements. The filters applied include: FFT Fixed, Gauss Spline, and Robust Gauss Spline. Settings for each analysis are provided.

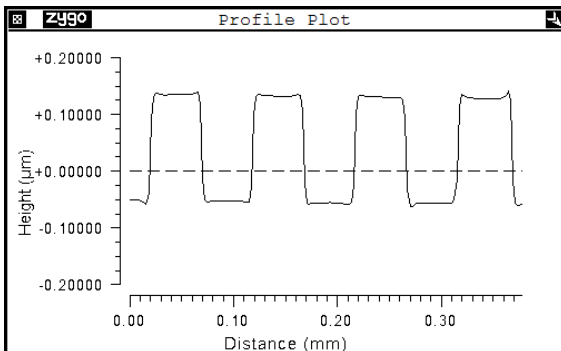


Original data. No filter applied.



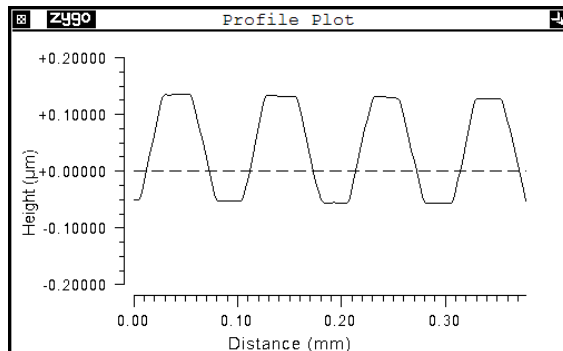
Filter Type: FFT Fixed  
 Filter: Low Pass  
 Filter Low Wavelen: 0.008 mm  
 Filter High Wavelen: 0.008 mm

For this data, FFT Fixed is not an optimal filtering choice. The filtered data shows noise not present in the original data.



Filter Type: Gauss Spline  
 Filter: Low Pass  
 Filter Low Wavelen: 0.008 mm  
 Filter High Wavelen: 0.008 mm

The Gauss Spline filter is an improvement over FFT Fixed. The edge effects are minimized and the original shape is intact. For this data, this is the optimal filtering choice.



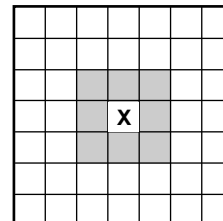
Filter Type: Robust Gauss Spline  
 Filter: Low Pass  
 Filter Low Wavelen: 0.008 mm  
 Filter High Wavelen: 0.008 mm

The Robust Gauss Spline filter shows even greater effects. The edge effects are totally eliminated, but the filtered shape is different than the original shape.

## Filter Window Size

Selects the number of data points used to generate a new filtered data point when the Filter Type control is set to Average, Median, or 2 Sigma. As the window size is increased, the effects of filtering are increased.

The box shown here represents a data array of 49 points. Each square represents a data point; X is the data point being filtered. Window Size 3 includes the shaded points. Window Size 7 includes all points shown. As the Window Size increases, more points are used in the filtering algorithm.



## Fit

For profile plots. Determines how shapes are fit to profile data. Settings are First Profile or All Profiles. First Profile fits the shape in the Remove control to the first slice only; it is removed from all. All Profiles fits the shape in the profile Remove control to all slices; it is removed from all.

## Fit Line button

This button is located in the plot controller for the Material Probability plot. It performs an automatic best-fit of the line to the curve.

## FlashPhase Run On Load

Selections are On or Off. When loading data from a file with this control On, MetroPro calculates new phase data by applying the FlashPhase algorithm to the first frame of intensity data. (If the file contains phase data, it is ignored.)

\*FlashPhase is no longer available as an acquisition/analysis mode. Information provided for reference purposes and backwards compatibility.

## Flip Data X button

Flips the current data set horizontally and redisplay. Part of a manipulate feature.

## Flip Data Y button

Flips the current data set vertically and redisplay. Part of a manipulate feature.



## f-number

Specifies the f-number of the test optic. The f-number of an optic or lens is a number expressing the ratio of its focal length to the diameter of its aperture. Settings: any number greater than 0; default is 0.000 (plano optic).

## Focus

This control enables or disables automated focus at the start of a measurement. Settings are On or Off. Applicable only to microscopes with at least a motorized z-drive.

## Focus Action

Selects how the auto focus function is performed. Settings are Calc & Move or Calc.Only.

Calc. & Move mode is the standard setting. When a SWLI acquisition is done, a delta-Z value for best focus is calculated. (The scan may be performed using either a scanner or the Z-motor.) The Z-axis is moved according to the delta-Z value, and the Focus Adjust attribute is set to the delta-Z value.

The Calc Only selection pertains to systems in which MetroPro does not have control over the Z-axis. Calc Only is not commonly used. Once a SWLI acquisition is done, a delta-Z value for best focus is calculated. (The scan may be performed using either a scanner or the Z-motor.) The Z-axis position is not changed (or, if it was changed, it is restored to its initial position). The Focus Adjust attribute is set to the delta-Z value.

*See also:* the Focus Max Adjust control.

## Focus Bailout (%)

Specifies a threshold that allows the auto focus and auto tilt operations to complete in less time. Settings range from 0 to 100 percent. This control affects the operation of both the auto focus and the auto tilt functions when the Acquisition Mode control is set to Scan, or if the Acquisition Mode control is set to Phase and the Focus Mode control is set to Scan.

If the Focus Bailout % control is set to any value less than 100, then the auto focus/tilt function uses a different algorithm that is optimized for high throughput. The high-throughput algorithm has the following characteristics: the height data is not filtered and no segmentation processing is performed (both the Focus N Surfaces control and the Focus Surface control are ignored). During the scan and acquisition of intensity data, a count is maintained of the pixels that have significant modulation. When the percentage of modulating pixels in the field of view reaches the Focus Bailout % value, the scan is stopped. The resulting partial height map is analyzed to determine best focus and tilt.

## Focus button

Click to make an auto focus adjustment based on the current settings of the focus controls.

## Focus Data

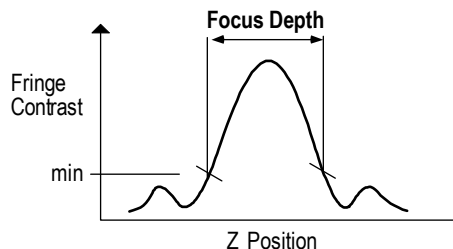
Specifies which type of data to examine for the purpose of selecting a surface for auto focus and tilt. Settings are: Height and Intens. Height uses the height data and looks for surfaces of different average height. Intens uses intensity data and looks at the intensity data (Fringe Remove: On) for surfaces of different average intensity.

(1) The Focus Data control, the Focus N surfaces control and the Focus Surface control all work in conjunction. Ultimately, a region of height data is analyzed for the auto focus and tilt calculations. If the part being measured has multiple regions (or surfaces) of different heights or different reflectivity, the controls can be set to select one of those surfaces. These three controls affect the operation of both the auto focus and the auto tilt functions when the Acquisition Mode control is set to Scan, or if the Acquisition Mode control is set to Phase and the Focus Mode control is set to Scan.

## Focus Depth

Specifies the dimension of a focus envelope; it only applies to a phase microscope with a motorized z-drive. The Focus Depth control affects the operation of auto focus when the Acquisition Mode control is set to Phase. The value is a measure of the Z position range over which good contrast fringes are obtained. A

plot of fringe contrast versus Z position resembles a bell-shaped curve. For lower magnification objectives, the bell shape is very wide. For higher magnification objectives, the bell shape is narrower and may have significant side lobes. The Focus Depth control should be set to a value no greater than the width of the useful portion of the bell.



The Focus Depth value is used to calculate step sizes for adjusting the Z position. The focusing algorithm consists of an initial coarse focus algorithm and a final fine focus algorithm. The goal of the coarse focus algorithm is to position the central lobe of the bell-shaped curve. The Z position is adjusted iteratively up and down from the starting position using a step size calculated as one-half of the Focus Depth control value. The algorithm is satisfied when a certain minimum average contrast and number of modulating points are obtained. The step size must be small enough so that the central lobe is not missed. However, if the step is too small, the algorithm will require too many iterations.

The goal of the fine focus algorithm is to obtain contrast of at least the value entered in the Focus Min Contrast control. The algorithm tries to find the peak of the bell using an initial step size calculated as one-fourth of the Focus Depth value. Whenever the peak is crossed over, the step size is cut in half and the direction is reversed. If the step becomes small enough so there is no significant change in contrast, the algorithm returns to the position of highest contrast and ends without error; even though the contrast is less than Focus Min Contrast.

## Focus Drop

Specifies the distance the objective drops down before it begins to auto focus. Applicable only to the Maxim•3D with a motorized z-axis, a Motion Controller, and a 40x Mirau objective. Settings: 0.0 to 1000  $\mu\text{in}$ , default 400  $\mu\text{in}$  (units selectable).

## Focus Light Level Offset Pct

This control specifies an adjustment (in percent) to the light level for both focus and tilt functions for the scanning technique only. The scanning technique normally requires a little more light than when measuring. Therefore, this control is normally set to a small positive number less than 10. The offset is applied relative to the Light Level Pct control. Applicable only to microscopes with the scanning focus and tilt option. The valid range of settings for this control is  $\pm 100$ . Refer to the following procedure for details on using this control

### ***Setting the Focus Light Level Offset Pct Control***

1. Set up a measurement for a typical part.
2. Set the Scan Type control as desired.
3. Set the Camera Mode control as desired, and record the setting.
4. Set the Shutter Speed control as desired, and record the setting.
5. Adjust the light level for optimal fringe contrast without saturation, and record the Light Level Pct Value as the *Measurement Light Level Pct*.
6. Set the Focus Scan Rate control as desired.
7. In the following table, look up the instrument camera type, then the frame rate matching the Camera Mode control setting.
8. From the table, obtain the frame rate that will be used for auto focus/tilt.
9. In the table, look up the Focus Scan Rate matching the control setting.
10. From the table, obtain the shutter speed that will be used for auto focus/tilt.
11. Set the Camera Mode control to any setting that matches the frame rate that will be used for auto focus/tilt.
12. Set the Shutter Speed control to match the value that will be used for auto focus/tilt.

13. Adjust the light level for optimal fringe contrast without saturation, and record the Light Level Pct value as the *AutoFocus/Tilt Light Level Pct*.
14. Subtract *Measurement Light Level Pct* from *Auto Focus/Tilt Light Level Pct* and set the Focus Light Level Offset Pct control to the difference.
15. Restore the Camera Mode, Shutter Speed, and Light Level Pct controls to the values required for measuring.

**Auto Focus and Auto Tilt Control Selection Table**

Camera Type	Frame Rate (Hz) per Camera Mode control setting	Frame Rate (Hz) used for auto focus/tilt	Focus Scan Rate control setting	Shutter Speed used for auto focus/tilt	
XC7500S	30 or 60	60	3X	no change	
			5X	1/250	
			7X to 11X	1/500	
TM6705	60 or 120	120	3X	no change	
			5X	1/500	
			7X to 11X	1/500 *	
	130	130	3X	no change	
			5X	1/500	
			7X to 11X	1/500 *	
	222	222	3X	no change	
			5X to 11X	1/500 *	
	TM6710	120	120**	3X	no change
				5X	1/500
				7X to 11X	1/1000
		238	238	3X	no change
5X				1/1000	
7X to 9X				1/2000	
11X				1/2000 *	
250		250	3X	no change	
			5X	1/1000	
			7X to 9X	1/2000	
			11X	1/2000 *	
417		417	3X	no change	
			5X	1/2000	
			7X to 11X	1/2000 *	

\* This shutter speed is too slow for reliable auto focus/tilt at the selected Focus Scan Rate.

\*\* Switch to 238 Hz if available.

## Focus Load Position

This control holds the location of the z axis corresponding to the focus load position that is saved with the application. This control is set when the Set Focus Load button is pressed. If a value is entered when the control is empty, the number typed is used for the focus load position. If a value is entered when the control already has a value, the number typed is added to the previous value. Clearing this control is the same as clicking the Unset Focus Load button.

## Focus Lock

When On, it disables the Focus button on the instrument's remote control. This is used with large aperture wavelength-shifting interferometers so the focus cannot be changed during a measurement.

## Focus Max Adjust

This control specifies a magnitude for the maximum allowed Z position adjustment. This value is used for the first auto focus attempt and also when the system is selecting the autofocus scan length. It is also used to limit the actual Z-position delta for the auto focus function. It applies to scanning microscopes only.

**Note:** The system performs scan length as follows:

A minimum scan length is calculated using:  $\text{MinScanLen} = 2 * \text{MaxAdjust}$ . When the instrument has a scanner, it searches through the available ramps to find the fastest one matching a variety of settings. If the system cannot find an appropriate ramp, or there is no scanner, then the Z motor is used to perform the scan. (This is similar to the extended scan with the exception that the auto focus scan is symmetric across the starting Z position.) Using the Z motor is not allowed if the Focus Scan Rate control is set faster than 3X. The actual scan length will be  $\text{MinScanLen} + 5$  microns.

If the Z-axis position is adjusted, then the delta-Z value is tested against the MaxAdjust value. If the magnitude of the delta-Z value is greater than MaxAdjust, an error is generated.

## Focus Min Contrast

Specifies the minimum contrast (in percent) for focus, it only applies to a phase microscope with a motorized Z-drive. Contrast is based on values from 0-100, with 100 being the highest contrast.

## Focus Min Mod (%)

This is the minimum modulation (in percentage) necessary to obtain a valid height data point for use in the auto focus calculation. A lower value includes weakly modulating points. A higher value includes only strongly modulating points. The value is usually a low number, and can be as low as 1.

## Focus Mode

This control, in conjunction with the Acquisition Mode control, determines how auto focus is performed. Settings are Software, Scan, or Hardware. Hardware applies only to instruments with applicable auto focus hardware.

<i>Acquisition Mode Setting</i>	<i>Focus Mode Setting</i>	<i>Auto Focus Technique</i>
Scan	Software	scanning
	Scan	scanning
Phase	Software	modulation
	Scan	scanning

## Focus N Surfaces

Specifies how many distinct surfaces to expect. See (1) under Focus Data.

## Focus Offset

Specifies the distance (negative or positive) to change the z-axis position for optimal focus. This control is used for all auto focus functions. The correct value to enter is part dependent. The focus algorithm focuses on the highest portion of the part. This control should be set to a distance halfway between the highest and lowest portions.

## Focus Position

The entry made for this control represents the position of the mechanical slide that holds a focus lens and is moved by the corresponding stepper motor. The unit used is millimeters. This control is used for both input and output. You may enter a numeric focus location value, load it from a settings file, or when adjusting focus using the Focus buttons on the Remote Control, click the Get Focus Position button. The subsequent value will then be displayed.

## Focus Retry Max Adjust

This control specifies a magnitude for the maximum allowed Z-position adjustment if the system must make a second auto focus attempt. This value is used when the system is selecting the scan length and to limit the actual Z-position delta. It applies to scanning microscopes only.

See also: The Focus Max Adjust control

## Focus Scan Rate

Selects the scan rate used to acquire data for the auto focus and tilt functions. Selections are: 1X, 3X, 5X, 7X, 9X, 11X. This control affects the operation of both the auto focus and the auto tilt functions when the Acquisition Mode control is set to Scan, or if the Acquisition Mode control is set to Phase and the Focus Mode control is set to Scan.

1X is the same scan rate used when acquiring height data for a measurement. The higher scan rates use sub-Nyquist sampling of the interference pattern. A slower scan rate provides the most accurate and reliable operation, but takes more time. A faster scan rate takes less time, but may be less accurate or less reliable, especially if the fringe contrast is low.

Some of the higher scan rates may not be usable if the instrument is not configured with the required ramps. In this case, the error message “No ramp data for selected Focus Scan Rate” is displayed.

For the 5X and higher rates, the software automatically adjusts the camera shutter speed to a higher rate (if the camera type has that capability). As a result, a higher light level may be needed for reliable operation. This is achieved by setting the Focus Light Level Offset Pct control. The description of this control includes steps for setting it appropriately and includes an “Auto Focus and Auto Tilt Control Selection Table.”

## Focus Surface

Specifies which surface in the part is used for auto focus and tilt. Settings are Highest and Largest. Highest specifies the highest (or brightest) surface. Largest specifies the surface having the largest number of data points. See (1) under Focus Data.

## Focus Zero Position

This control holds the location of the z axis corresponding to the focus zero position and is saved with the application. This control is set when the Set Focus Zero button is pressed. If a value is entered when the control is empty, the number typed is used for the focus zero position. If a value is entered when the control already has a value, the number typed is added to the previous value. Clearing this control is the same as clicking the Unset Focus Zero button.

## Focus/Tilt button

Microscope Applications. In one operation, this button initiates both auto focus and tilt. It is available in a Control Window via New Button.

## Focus/Tilt Delay

Specifies a time delay in seconds after the auto focus and tilt algorithm adjusts the microscope focus and stage tilt. This may be necessary in rare cases to allow the microscope and part to stabilize before a measurement is taken. Requires a motorized z-axis and programmable stage.

## Focus/Tilt X Offset

Specifies a distance in the x-axis that the part, prior to adjusting instrument focus and stage tilt, is moved to locate it under the focus spot. Applies only to a microscope with hardware auto focus and tilt.

## Focus/Tilt Y Offset

Specifies a distance in the y-axis that the part, prior to adjusting instrument focus and stage tilt, is moved to locate it under the focus spot. Applies only to a microscope with hardware auto focus and tilt.

## Forward button

Steps the movie playback one data file forward. Used with dynamic stroboscopic measurements. This button is available in a Control window with the New Button → Dynamic menu.

## Frames Per Sec

Specifies the speed of an .avi video file when it is created by clicking the Convert Movie button. The fewest frames per second is 1. Used with dynamic stroboscopic measurements. This control is available in the Control window with the New Control → Dynamic → Movie menu.

## Frequency

The Frequency control displays the frequency as read from the LED light source. The frequency is always expressed in kilohertz (KHz) units. Changing the frequency in this control actually changes the frequency at the waveform generator.



## Frequency Increment

Specifies the frequency sweep increment size for a Frequency or Frequency & Phase sweep measurement. It is not used for Phase only sweep measurements. Used with dynamic stroboscopic measurements. This control is available in the Control window with the New Control → Dynamic → Sweep menu.

## Gage Number

A numeric entry in the Q-DAS Report window for identifying the gage number. This entry is saved with the data.

## Gage Sequence

A Q-DAS Report window control to select the sequence during a gage study when the File Format control is set to Gage-Type 3. The settings are: Manual, All Parts Per Trial, or All Trials Per Part.

When set to *Manual*, you track the measurement sequence. For each measurement, you must specify the current part in the Current Part control. The “Current” attributes provide feedback on the sequence. The manual study is started with the Start Gage button and ends by clicking the Stop Gage button.

When set to *All Parts Per Trial*, every part is measured once in an ordered sequence and then this sequence is repeated. The Number of Trials control determines the number of sequences.

When set to *All Trials Per Part*, each part is measured multiple times in succession, and then the next part is measured and so on. The Number of Trials control determines how many times each part is measured.

For both All Parts Per Trial and All Trials Per Part settings, the study is started with the Start Gage button, but ends automatically. Also, the part number is automatically incremented after the data is logged, and the “Current” and “Next” attributes show the status of the gage study.

## Gen Setup Type

This control allows entry of a code number for a type of measurement. When generated data is saved to a file, the setup code will be saved with it. This will make it possible to load the data into certain MetroPro Applications.

<i>Setup</i>	<i>Code</i>	<i>Application</i>
Wedge (Transmitted)	1	Angles
Wedge (Reflection)	2	Angles
90 Degree Prism Ext	4	Angles
90 Degree Prism Int	6	Angles
Single Pass	0	Corner Cube
Double Pass	1	Corner Cube

## Generate Illumination Profile

Selections are On or Off. When this control is On, the analysis of the current measurement generates illumination profile data for the system. This data is subsequently used for vibration correction. The profile is stored in memory, and if the Illumination File control is not blank, the profile data is automatically saved to the specified file. This control takes precedence if the Vibration Correction control is also On. Once the generated illumination profile is complete, this control is automatically switched Off.

**Note:** If lateral calibration must be set, do so *after* acquiring the illumination profile data; otherwise, the lateral resolution value will be lost.

GPI/VeriFire PE instruments only.

## Generate button

Creates a data set based on the settings of the generate controls. Part of the generate function.

## Get GPI Encoded Zoom Var Mag button

Refer to *Section 4* of this manual.

## Get Zernikes button

Creates Zernike elements based on the current data set; it is used for generating data. It provides entries for the Center X, Center Y, Radius, Zernike Terms, and Coef X controls.

## **Goto Focus Position button**

Moves the hardware to the focus position identified in the Focus Position control.

## **Goto Focus Zero button**

Prompts the operator for confirmation, and then moves the Z axis to the focus zero position. This button applies only to microscopes with auto focus.

## **Goto Pos 1–5 buttons**

Moves the z-axis stage to the position stored in the matching Position control. The stage should be “homed” by clicking the Home button before going to set positions.

These buttons are available in the Micro LYNX window; and work only with applicable hardware.

## **Goto Tilt Zero button**

This button prompts the operator for confirmation, and then moves the pitch and roll axes to the tilt zero positions. This button applies only to microscopes with programmable pitch and roll stages.

## **GPI Encoded Zoom Std Mag**

Refer to *Section 4* of this manual.

## **GPI Encoded Zoom Var Mag**

Refer to *Section 4* of this manual.

## **GR&R Output File**

Specifies the name of the output file to be created by the GR&R Application. Available in the New Control → Miscellaneous menu.

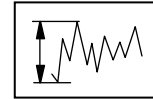
Obsolete button, left in for backwards compatibility.

## **Hardware Acquire**

This control is set to On for instruments with a very high resolution camera and a Matrox Genesis frame grabber board.

## Height Units

Selects the master unit system for all height-based results; settings are English, Metric, or Optical. It affects the Z units in the Filled plot and Oblique plot, and the Y units in the Profile plot. It also applies to most results, such as AvgHgt, H, Peak, PV, Ra, RadCrv, rms, R3z, Rtm, Rz, Sag, and Valley, and the y-axis in the Profile plot.



For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or  $\mu\text{m}$ .

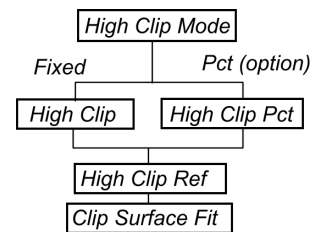
## High Clip

Specifies a vertical cutoff plane through the data, relative to zero. All data is removed above the entered value. The zero location is specified by the best fit surface with the Remove control. High Clip serves as a simple filter to remove spikes in the data. See also Low Clip.

## High Clip Mode

Specifies how high clipping is applied. Available selections include: Fixed (default), Pct Peak, Pct Valley, Pct PV, Pct AvgHt, or Pct Points. When using Fixed, enter a value in the High Clip control. When using any of the percentage-based selections, enter a value in the High Clip Pct control.

### Applicable Clip Controls



## High Clip Pct

Specifies the vertical cutoff plane through the data relative to the data's peak, valley, mean, average height, or zero plane as selected with the High Clip Mode control. This value represents the percentage of the selected parameter that is used as the vertical cutoff plane. All data above the specified value is removed. The zero location is calculated as a result of a best-fit surface specified with the Remove control.

## High Clip Ref

Specifies the reference position from which High Clip or High Clip Pct is applied. Selections are Zero (default), Peak, Valley, Mean, AvgHt, Rpk Threshold, Rvk Threshold, and Rk Midpoint. When this control is set to Zero, the zero plane position relative to the height of the data depends upon these controls: Remove, Clip Location, and Clip Surface Fit. The Remove and Clip Surface Fit options modify the data to subtract a best-fit surface, with the difference between the two surfaces centered around zero using a least squares fit. When set to Rpk or Rvk Threshold or Rk Midpoint, clipping is referenced to the absolute height contained in the result value of the same name. These settings are part of the Bearing Ratio analysis.

## Home All Axes button

Homes all available motion axes; for each axis, depending on stage configuration this will either move the stages to the pre-determined home location or set the current location as a virtual home location.

## Home button

Moves the Z-axis stage to the fixed upper limit switch. All positions are relative to this fixed reference location.

Click Home before recording stage positions and when the system is powered-on or reset. This button is available in the Micro LYNX window; and works only with applicable hardware.

## Home PR Axes button

Homes the pitch and roll stages; depending on stage configuration this will either move the stages to the pre-determined home location or set the current location as a virtual home location.

## Home Stage button

Moves the programmable stage to home position. Home is an absolute reference position for an axis. Applicable only to systems with programmable stages.

## Home Z Axis button

Homes the Z-axis stage; depending on stage configuration this will either move the stages to the pre-determined home location or set the current location as a virtual home location.

## Ignore Bright Pts

Reserved for future use.

## Illumination File

Specifies the name of an illumination profile data file, for either saving or loading. The filename should have a “.dat” extension. This control is used in conjunction with the Generate Illumination Profile and Vibration Correction controls. It may be left blank.

GPI /VeriFire PE instruments only.

## Image Zoom

Set the Image Zoom control to match the zoom setting selected with the microscope’s zoom thumbwheel. This ensures proper lateral resolution of each camera pixel. If the setting of the control and the thumbwheel do not match, results will be erroneous. Settings are 0.5X, 0.75X, 1X, 1.5X, 2X, or Free.

If your microscope is equipped with the encoded zoom option, then the control value is automatically switched to match the zoom thumbwheel setting. The control functions only for microscopes with the image zoom option; for other microscopes the control is locked at the 1X setting. If there is not an active instrument, the control displays None.

Select Free when the thumbwheel is set between detent positions. Each time the Image Zoom control is set to Free, you must perform calibration before making the measurement to provide absolute units of measure. Note that calibration performed at a Free setting is only temporary, settings are not saved. See Section 4 for calibration procedures.

## Incident Angle

Specifies the angle of the incoming light from the z-axis for the BRDF analysis. It is the polar angle of s-polarized in.

## Initialize Focus Position button

After power up of the GPI or VeriFire interferometer, this button finds the home position (zero) for the focus motor. This process may take up to 90 seconds to complete. The typical range of focus is between zero (0) and 33 millimeters. The initialization process does not need to be repeated unless the interferometer power is turned off and back on. The home position value is saved even when MetroPro is shut down.

## Instrument

Selects the active instrument when multiple instruments are connected to the computer. In a system with one instrument connected to the computer, the box has no function.

## Intens Avgs

This control is relevant only when the Acquisition Mode control is set to Phase or Intens. Specifies the number of intensity averages to be performed during subsequent measurements. Intensity averaging is performed by averaging the intensity values of each pixel of multiple camera frames. Settings: 0 to 62, default is 0. Zero and 1 have the same effect.

See also Section 4 of this manual.

## Intensity Field Flattening

Initiates the Intensity Field Flattening (IFF) algorithm. Selections are On or Off. It is used for measurements of color filters on flat panels. IFF can improve the quality of the intensity images by making the intensity more uniform across the field of view. This improves the images and results in better lateral measurements, which makes color filter recognition for the red, green and blue filters more straightforward. The calculation involves a comparison of the IDR file to the ISE file.

## Intf Path Length

This control is used with MST instruments in which the wavelength is tunable. It is used to specify the cavity length value the software should use to perform modulation or phase analysis on data acquired with a wavelength shifting system. The Acquisition Mode control must be set to Phase.

VeriFire MST instruments only.

## Intf Scale Factor

Applicable to interferometer applications. Interferometers function by dividing a wavefront into two or more parts, principally a reference wavefront and a test wavefront, which travel different paths and then combine to form an interference fringe pattern. The geometrical properties of the interference fringe pattern are determined by the difference in optical path traveled by the recombining wavefronts.

The interferometer receives as input information is the test wavefront. It cannot tell whether this wavefront has traveled through a window, reflected from a surface, what angle it has reflected from a surface, etc. The Intf (Interferogram) Scale Factor specifies how this input wavefront error (read directly from the fringe pattern as one wavelength per fringe) is scaled to properly represent the output parameters which the user wants to display in the results. The default setting is 0.5

### Why the Intf Scale Factor default of 0.5?

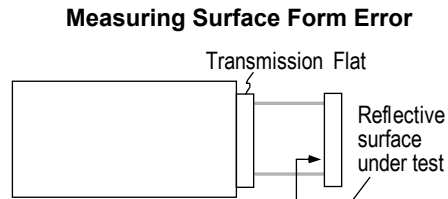
Consider the specific example of a wavefront reflecting off of a surface. This is exactly what happens in the setup of normal incidence, double pass testing of a flat surface.

For this setup, users often want to see results of the surface errors, not the reflected wavefront error that is being directly measured via the fringe pattern. They are different by a factor of 0.5.

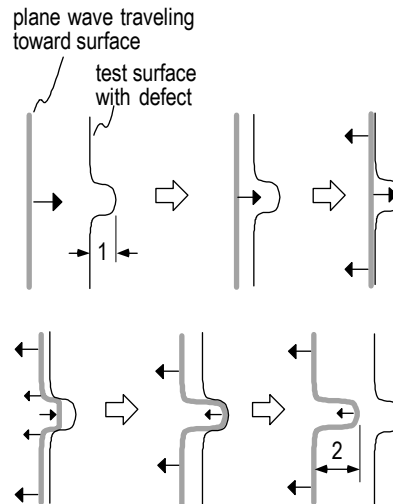
Let's examine what happens when a perfect plane wave is incident on a test surface, which has a defect 1 unit deep.

The wavefront hits the flat portion of the surface first; while part of the wavefront continues to travel into the defect the rest of the wave has already reflected off of the "good" portion of the surface and is traveling back toward the interferometer. By the time the center of the wave has reached the deepest part of the defect, the majority of the wave has traveled 1 unit away from the flat portion of the surface. As a result the returning wavefront has a defect that is 2 units deep, even though the surface defect is only 1 unit deep.

The following table shows some common Fizeau test setups and the appropriate Intf Scale Factor as based on the desired results. In the diagrams and text, TF refers to transmission flat, TS to transmission sphere, RF to reference flat, and normal incidence is when the laser beam is perpendicular to the surface under test.



### Plane Wavefront Incident on Test Surface





<i>Description</i>	<i>Example Test Diagrams</i>	<i>What to show in results</i>	<i>Intf Scale Factor</i>
Fizeau double-pass, normal incidence, one reflection from test surface		surface form error	0.5
		reflected wavefront error	1.0
		reflected wavefront error	1.0
Fizeau double-pass, transmission through window		double-pass transmitted wavefront error	1.0
		single-pass transmitted wavefront error	0.5
Fizeau double-pass, incident angle $\theta$ on test surface, two reflections from test surface		reflected wavefront error at angle theta ( $\theta$ )	$1/2 \cos \theta$
		surface form error at angle theta ( $\theta$ )	$1/4 \cos \theta$

## Invert Data button

Inverts the current data. What was a peak on the phase map becomes a valley, and what was a low region, becomes a high region. Clicking this button twice in succession puts the phase map back to its original state. Part of a manipulate feature.

## Jump to Frame

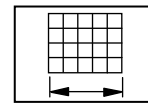
Specifies a frame number in the movie file. The movie immediately moves to the frame indicated by the number in this control when the Forward for Back button is clicked. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Movie menu.

## Keypress Shortens Scan

Selects if pressing any key on the keyboard stops a NewView acquisition scan. Settings are On or Off. It is available in a Control window with the New Control → Acquisition menu.

## Lateral Units

Selects the master unit system for all lateral based results; settings are English, Metric, or Camera (pixels). It affects the X units in the Profile, MTF Profile, Autocovariance, and Power Spectrum plots, and the X-Y units in the Oblique plot. Applies to any measurement derived from camera pixel positions, such as Length/Circum, RadCrv, and Radius.



For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or  $\mu\text{m}$ .

## LED Frequency

Specifies the frequency at which the instrument LED pulses when the LLC Mode control is set to Static. By default, this is set to 35 kHz. There should be no need to change this value. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic menu.

## LLC Mode

Selects the Light Level Controller mode. Choices are: Static or Dynamic. In Static mode, the instrument LED is not synchronized with the motion of the device under test. The LED pulse frequency is set to the value in the LED Frequency control and the Light Level Controller dialog adjusts the duty cycle of the LED from 0 to 100 percent intensity. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic menu.

## Light Level

Sets the starting position of the variable light level controller used during data acquisition when the Acquisition Mode control is set to Phase, and the AGC control is On. Settings: 0 (brightest) to 159 (darkest); the default is 80.

The variable light level controller is part of the instrument's automatic gain control (AGC) feedback loop, and is used to provide optimum illumination of the test part. The Light Level control provides manual attenuation control when AGC is off. By changing the value entered in the light level box, the amount of light used during data acquisition is varied.

Normally, the amount of light reaching the camera is regulated by the AGC feedback loop. If AGC is On, the AGC function uses the value specified in the light level box as a starting point for the position of the variable light level controller for subsequent measurements. If AGC is Off, the measurement is made with the variable light level controller in a fixed position and not changed during data acquisition.

## Light Level Pct

Specifies the light level in percentage to use when making the measurement. This may be different than the light level used for part viewing. The Light Level Pct control works in tandem with the Light Level window. The Light Level Pts control setting is changed when the light level window is opened, the light level is changed, and the Set button is clicked.

When the Acquisition Mode control is set to Phase and the AGC control is On, it specifies the starting point for the AGC function.

## Light Level Range

Selects the optical power range for the laser in the MESA instrument. Selections are Low or High. When High, the laser output is from zero to maximum. When Low, the maximum power level of the laser is reduced, and the light level control has finer resolution. The Light Level Range should be set to Low, unless there is not enough light to measure successfully.

## Limits Error

Determines how the user is notified when results are out of user set limits. When On, an error message is displayed on screen when a result is out of range of the user set limits. When Off, there is no user notification, other than the usual result box color change, which is green for pass and red for fail.

## Line Type

For profile plots. Specifies how fit is performed when the profile Remove control is set to Line; choices are 2 Point and Normal. Normal allows the software to find the points to fit a line. 2 Point uses entries the Ref Pt 1 and Ref Pt 2 controls to define the line to fit. 2 Point requires valid data at each point.

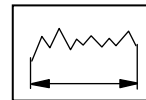
## Linear Interpolate Slice

Determines if the horizontal evaluation length (L), actual profile length (Lo), and profile length ratio (Lr) results are calculated when the slice type is Linear, Radial Ctr, Radial, or Crosshair in the Profile plot's controller. When On, the profile length results are calculated. When Off, the profile length results are blank when the slice type is one of those listed above. This control is available in a Surface/Wavefront Profile window.

If there are multiple Linear slices, the profile length results are calculated on the last slice. When using Crosshair slices, the y-axis slice is used to calculate results.

## Linear Units

Selects the master unit system for all linear based results; settings are English or Metric. Applies to boxes such as Wavelength-In and Camera Res.



For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or  $\mu\text{m}$ .

## Live Display Mode

Selects the operational mode of the Live Display window. Settings are: Fringes (default), FlashPhase Align, or Live Phase. Fringes shows a live image of the test part with fringes (when the instrument is properly adjusted). FlashPhase Align shows an alignment grid which is used as an aid to tilt the part the right amount and is applicable only when the Acquisition Mode control is set to FlashPhase. Live Phase displays a phase map of the part surface. This control is available in the Control window with the New Control → Live Display menu.

## Live Display Set Zero Plane

Selects the way the image is displayed in the Live Display window when the Live Display Mode control is set to Live Phase. Usually, removing plane from a surface makes a tilted part surface appears flat. The reference plane used to remove tilt is the mean (or the zero) plane of the tilted data. However, setting the Live Display Set Zero Plane control to Yes, sets the current tilt of the Live Phase as the mean plane. Therefore, later on with a different tilt setup for the part (and the Live Display Surface Remove set to Plane), the Live Phase display shows the tilt difference between the current tilt and the tilt that was set when the Live Display Set Zero Plane Control was set to Yes.

During a typical FlashPhase\* measurement the Live Display shows an image with 30 or more fringes oriented 45 degrees. If Live Display Set Zero Plane is set to Yes, the image in the Live Display appears as if this tilt is removed. In this case, the image on the Live Display looks similar to that on a standard phase-shifting interferometer.

The default setting is No. This control is available in the Control window with the New Control → Live Display menu.

\*FlashPhase is no longer available as an acquisition mode. Information is provided for reference purposes and backwards compatibility.

## Live Display SubSample (%)

Selects the percentage of pixels sampled to create the image in the Live Display window. Choices are 25%, 50%, 75%, 100% (default), 150%, or 200%. For example, if the Camera Size is 640 x 480 and Live Display SubSample is set to 50%, the data is sampled every other row and every other column in the data matrix, creating a 320 x 240 image. This control is available in the Control window with the New Control → Live Display menu.

## Live Display Surface Remove

Selects a surface to remove from the data in the Live Display window when the Live Display Mode control is set to Live Phase. Choices are Plane (default), Zero Plane, Piston, Sphere, Cylinder, and None. This control is available in the Control window with the New Control → Live Display menu. It functions similar to the Remove control but affects the Live Display only.

## Live Display Window

Selects the state of the Live Display window. Selections are Minimize or Restore (default). Serves as an alternative for the buttons on the window itself. This control is available in the Control window with the New Control → Live Display menu.

## Live Display Zoom (%)

Selects the overall size of the Live Display window. Choices are 25%, 50%, 75%, 100%, 150%, or 200%. There is no default setting for this control, the initial zoom is based on the camera resolution and the size of the Live Display window. This control is available in the Control window with the New Control → Live Display menu.

## LLC Delay

Specifies a time delay, in seconds and tenths, after the light level control (LLC) filter in moves until a frame of data is taken. Settings: 0.0 to 10 seconds, default is 0.0. Applicable only to Zygo instruments with a LLC, such as Mark IVxp or Maxim•3D.

This control is only used in extremely noisy environments that cause the filter to vibrate. The error message “Cannot calibrate for acquire” is a sign that you might have a noisy environment. Use of this control increases the time required to make a measurement.

## Load Cal Markers with Settings

Selections are On or Off. If this control is On, then when a settings file is loaded, a Cal Markers file is also loaded. The file name and directory are specified by the Cal Markers File and Cal Markers Dir controls.

It is available in a Control window with the New Control → Cal Markers.

VeriFire MST Applications only.

## Load Data button

Opens the File Handler, which is used to recall existing saved data files and load them into an application. Only one data set can be loaded into an application at a time.

To load a file, click the button. In the File Handler, click on the box with the name of the file you want to load. Click the Done button to close the File Handler.

## Load Fiducials with Settings

Selects if a fiducial file and a settings file are loaded simultaneously. Settings are On or Off. The fiducial file name is specified with the Fiducial File control.

## Load Masks with Settings

Selects if a mask file and a settings file are loaded simultaneously. Settings are On or Off. The mask file name is specified with the Masks File control.

## Load Pattern button

Opens a load file dialog box with the default file extension “.pat” for selecting a motorized stage pattern file, without opening the Pattern Editor. The loaded pattern can be run by clicking the Run Pattern button. It is available in a Control window with the New Button → Pattern menu.

## Load Settings button

Opens the File Handler, which is used to recall existing settings files and load them into an application. Only one settings file can be loaded at a time. A settings file contains information on the configuration of MetroPro controls.

To load a file, click the button. In the File Handler, click on the box with the name of the file you want to load. Click the Done button to close the File Handler.

## Load Zernikes button

Opens the File Handler, which is used to recall existing saved Zernike files and load them into an application. It can be used when generating data. When Zernike data is loaded, the settings of the Radius, Center X, or Center Y controls are blank.

To load a file, click the button. In the File Handler, click on the box with the name of the file you want to load. Click the Done button to close the File Handler.

## Lock GPI Encoded Zoom button

Refer to *Section 4* of this manual.

## Log Dir

Specifies the name of a directory path in which to log report files. The directory may have any number of levels. When a report is being logged, the directory will be automatically created if it doesn't already exist. It is possible to have additional information, such as Lot Number, Part Number, Part Serial Number, and Pattern File Name, appear in the Log Directory. See Section 11 and "Special Codes for Controls" for additional information.

## Log File

Specifies the name of a report file. The report file is an ASCII file containing a listing of the Result, Attribute, and Annotation boxes, inside the Report window, along with their contents. The report file can be downloaded to another computer for further processing. It is possible to have additional information, such as Lot Number, Part Number, Part Serial Number, and Pattern File Name, appear in the Log Directory. See Section 11 and "Special Codes for Controls" for additional information.

## Log Report button

Adds the present contents of the Report window to the report file. It can be used to selectively add only the applicable results or existing results to the report.

## Logging

When On, activates Report window or QDAS Report window logging. Logging appends the contents of the Report window to the report file after each measurement. Settings are On, Off, and On Load. When set to On, values are logged or added. When set to Off, values are not added.

The On Load setting is used in conjunction with the Avg LoadData button when working with multiple data sets. When multiple data files are loaded, On Load stores the averaged results of multiple data sets in the Report window. It does not store the individual results of each loaded file. The On Load setting only works when using the windows dialog boxes for loading and saving files. Windows dialog boxes are activated by entering the command line option `-windowsDialog` in the MetroPro properties dialog box after the Target entry.

## Lot Num

Used to enter a number for a lot or group of parts. The Lot Num control has three modes of operation: Normal, Auto-Increment, and Prompt. To enter a number, click on the box with the left mouse button, type a number with the keyboard and press [Enter].

The mode of operation of the Lot Num control is selected with the Mode command from the control's menu. The current mode of operation is indicated by an asterisk (\*). When the Mode is *Normal*, the data is saved under the specified lot number. When the Mode is *Prompt*, the software asks you to enter a lot number before each measurement.

When the Mode is *Auto-Increment*, the lot number is incremented by one for the next measurement. Only the right-most 15 digits are incremented until a non-digit character is found. For example: "1234" increments to "1235"; "Test-01-10" increments to "Test-01-11"; "Test-12X" is unchanged because the entry ends with a letter. One digit in the lot number provides for ten increments, two digits for 100 increments, and three digits for 1000. When reaching the maximum increment digits roll over, for example: 999 becomes 000.

## Low Clip

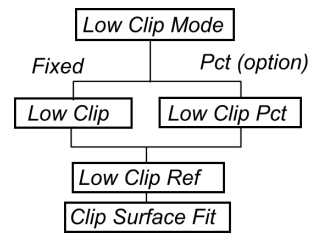
Specifies a vertical cutoff plane through the data, relative to zero. All data is removed below the entered value. The zero location is specified by the best fit surface with the Remove control. Low Clip serves as a simple filter to remove valleys in the data. See also High Clip.



## Low Clip Mode

This control specifies how low clipping is applied. Available selections include: Fixed (default), Pct Peak, Pct Valley, Pct PV, Pct AvgHt, or Pct Points. When using Fixed, enter a value in the Low Clip control. When using any of the percentage-based (Pct) selections, enter a value in the Low Clip Pct control.

### Applicable Clip Controls



## Low Clip Pct

Specifies the vertical cutoff plane through the data relative to the data's peak, valley, mean, average height, or zero plane as selected with the Low Clip Mode control. This value represents the percentage of the peak, valley, mean, average height, or data points that should be used as the vertical cutoff plane. All data below the specified value is removed. The zero location is calculated as a result of a best-fit surface specified with the Remove control.

## Low Clip Ref

Specifies the reference position from which High Clip or High Clip Pct is applied. Selections are Zero (default), Peak, Valley, Mean, or AvgHt. When this control is set to Zero, the zero plane position relative to the height of the data depends upon these controls: Remove, Clip Location, and Clip Surface Fit. The Remove and Clip Surface Fit options modify the data to subtract a best-fit surface, with the difference between the two surfaces centered around zero using a least squares fit.

## Lower Stp Height

Specifies the lower height value on the areal bearing ratio curve where the Lower Stp (%) result is derived, relative to the reference location specified by the Stp Reference control.

## Lower Stp (%)

Specifies the areal bearing ratio (expressed as a percentage) where the Lower Stp Height result is derived, relative to the reference location specified by the Stp Reference control. The default setting is 10.

## Lower tp Height

Specifies the lower height value on the profile bearing ratio curve where the Lower tp Height (%) result is derived, relative to the reference location specified by the tp Reference control.

## Lower tp (%)

Specifies the profile bearing ratio (expressed as a percentage) where the Lower tp Height result is derived, relative to the reference location specified by the tp Reference control. The default setting is 10.

## Machine Number

A numeric entry in the Q-DAS Report window for identifying the machine number. This entry is saved with the data.

## Mask Adjust button

Performs a Mask Adjust using the current settings of the Mask Adjust controls and the currently loaded mask.

## Mask Adjust Bitmap Data Height Bottom Pct

Specifies the percentage up from the valley of the data used to define the bottom limit of the converted data. This control setting is only applied when the Mask Adjust Method control is set to Sherlock.

## Mask Adjust Bitmap Data Height Top Pct

Specifies the percentage down from the peak of the data used to define the top limit of the converted data. This control setting is only applied when the Mask Adjust Method control is set to Sherlock.

## Mask Adjust Bitmap Data Type

Specifies the data to convert to a bitmap file for use with the Sherlock Mask Adjust Method. Valid settings are Intensity, Scaled Height, and Height Mask. When set to Intensity, the current intensity data is converted. When set to Scaled Height, the height data at the top level of MetroPro is converted with valid data being set to 128 and 0 if the data is not valid. This control setting is only applied when the Mask Adjust Method control is set to Sherlock.

## Mask Adjust Bitmap File

Specifies the file name to use when saving the bitmap that will be used by Sherlock for mask adjustment. This control setting is only applied when the Mask Adjust Method control is set to Sherlock.

## Mask Adjust Investigation File

Specifies the Sherlock Investigation file to use for mask adjustment. This control setting is only applied when the Mask Adjust Method control is set to Sherlock.

## Mask Adjust Method

Specifies the feature-finding method to use to perform a mask adjustment. Valid settings are: None, Sherlock, or Peak Region. When set to None, all mask adjust controls are ignored and no mask adjustment is attempted.

When the control is set to Peak Region, height data from the top level of MetroPro is used. A plane is first fit and removed from the data, then the Peak Region Low Clip control value is applied. Finally, the centroid of the largest region of data found with the data defined by the Mask Adjust Peak Region Search Window Width and Mask Adjust Peak Region Search Window Height controls is used to adjust all figures in the Mask editor.

When the control is set to Sherlock, Surveyor is used to locate a feature defined by a Sherlock investigation file. The data used by Sherlock is first saved using the values of the Mask Adjust Bitmap File, Mask Adjust Bitmap Data Type, Mask Adjust Bitmap Data Height Top Pct, and Mask Adjust Bitmap Data Height Bottom Pct controls. The Sherlock investigation file specified by the Mask Adjust Investigation File is then loaded into Sherlock, and then the bitmap saved in the previous step is loaded and the investigation initiated. The location of the feature found by the investigation is then used by MetroPro to adjust all the figures in the Mask Editor. In order to use an investigation for mask adjustment, the following criteria must be met. The investigation must have a stake out named soA; this is the stake out that the bitmap file will be loaded into. The investigation must define two variables PatCtrX and PatCtrY that will contain the location of the found feature once the investigation is complete.

## Mask Adjust Peak Region Low Clip

Specifies a vertical cutoff plane through the data, relative to zero. This control is only applied when the Mask Adjust Method control is set to Peak Region.

## Mask Adjust Peak Region Search Window Height

Specifies the height of a window within the data to search when the Mask Adjust Method control is set to Peak Region. The window is centered around the origin of the camera.

## Mask Adjust Peak Region Search Window Width

Specifies the width of a window within the data to search when the Mask Adjust Method control is set to Peak Region. The window is centered around the origin of the camera.

## Mask Adjust Result Coord Sys Origin

Specifies where the origin of the coordinate system used by mask adjustment is located. Valid settings are Lower Left, Upper Left, or Center. For mask adjustment using the Cartesian coordinate system, this control specifies where the origin of the system is located relative to the data.

## Mask Data button

Opens the Mask Editor, which is used to define sub-areas within the test part. See the section dealing with the Mask Editor.

As part of the manipulate feature, it applies any existing mask to the current data.

## Masks Dir

Specifies where mask files are located. If no directory is specified then the current working directory is used. It is available in a Control window with the New Control → Masks menu.

## Masks File

Specifies the name of a mask file to load automatically when the Auto Load Masks control is On. The mask file must exist prior to entering its name in the Masks File control. The name must be 14 characters or less, and usually ends with “.mas”.

## Max Area Size

Maximum Area Size specifies the largest contiguous number of data points in a valid data region. It is useful for eliminating the effect of large data areas that are not meant to be included in the measurement, without the need of defining a mask.

## Max Sat Pts

Maximum Saturation Points specifies the number of saturated camera pixels allowed by the AGC function. Settings: 0 to 9999, default value is 4. The AGC (Automatic Gain Control) function tries to adjust the light intensity from the instrument as high as possible without saturation. This produces the largest dynamic range. Max Sat Pts allows a specified number of pixels to become saturated. The most useful settings range from 0 to 20. If you have to set the control higher to acquire data, the instrument may have a faulty camera.

## Measure button

Causes the instrument to acquire measurement data based on the current control settings and perform an analysis of the obtained data. The F1 key is equivalent to clicking the Measure button.

## Measure Radius of Curvature

Enables or disables a radius of curvature measurement for the next measurement. Settings are On or Off. This control is only applicable to instruments measuring spherical parts with the appropriate X, Y, and Z programmable motorized stages.

## Measurement Id

An identifier for a measurement. The value identifies the measurement when it is part of a larger context, such as one of many measurements in stats or patterns.

## Measurement Sequence

Selects the sequence or order used when making a radius of curvature measurement. Settings are Confocal->Catseye, or Catseye->Confocal. This control is only applicable to instruments measuring radius of curvature.

## Merit Mode

Selections are Normal or LSQ (least squares method). Merit mode is part of the software routine that finds the top-most detected surface with or without the presence of films. Use Normal except for situations in which it is necessary to isolate a surface in a single film that is less than 1 micron.

Microscope applications only.

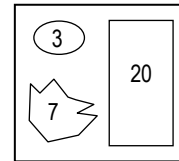
## MetroScript button

Runs a MetroScript file. To enter the name of a MetroScript file to run, position the pointer over the MetroScript button, press the right mouse button and select the File command. Using the keyboard, enter a file name, and then press [Enter]. Use the Name command to label the button with a descriptive name linking it to the MetroScript file.

## Min Area Size

Minimum Area Size specifies the smallest acceptable number of contiguous data points in a valid region of data. Settings: 7 to 9999999, default is 20. Decrease to allow smaller areas. Increase to accept larger areas and reject smaller. It is useful for eliminating the effect of isolated data areas that are not meant to be included in the measurement, without the need of defining a mask.

In the example shown here there are three regions of data. A Min Area Size of 7 would exclude the data area consisting of 3 data points. By increasing the value, it could exclude other larger areas that modulate but are not of interest, because of their small size.



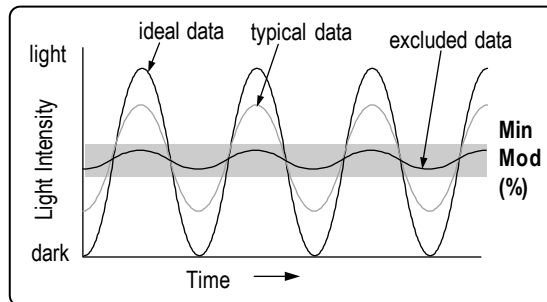
Min Area Size is not the same as Min Mod Pts. Min Mod Pts specifies the minimum number of data points required for a valid data set. Min Area Size specifies the minimum size of a valid measurement area. (An area is an island of data separated by bad data.)

## Min Mod (%)

Specifies the minimum modulation necessary for a valid data point. Decrease to accept areas with poor fringe contrast or low reflectivity. Increase to exclude unwanted data points. Settings: 0.0 to 100.0.

Full modulation is represented internally in the instrument as an intensity range, which is based on the frame grabber board in the instrument. An 8-bit board has range from 0 to 255, a 10-bit board has a range from 0 to 1023, and a 16-bit board has a range from 0 to 65535. When modulation occurs over less than a minimum portion (or percent) of this range, the data is considered invalid. During a measurement, the light intensity at any given camera pixel varies (or modulates) from light to dark as the phase of the interference pattern is shifted. The minimum modulation control sets the acceptable intensity range or minimum modulation necessary for data.

The drawing represents the modulation of three data points over time. Each sine wave is the signal from a given camera pixel when the PZT's are ramping. Ideal modulation is when the light intensity of each data point varies from zero to maximum. Typically, the light intensity from each data point does not have ideal contrast. When the modulation is insufficient, the data point is excluded.



Modulation relates to the signal-to-noise ratio and repeatability. The greater the modulation of each data point, the higher the signal-to-noise ratio and the better the repeatability. As the modulation decreases, the lower the signal-to-noise ratio and worse the repeatability, and thus the harder it is to obtain usable data from the test part.

Increase the minimum modulation percent ( $>15\%$ ) if you desire to exclude unwanted data points, such as with very smooth surfaces with high contrast fringes. Decrease the percentage ( $<15\%$ ) to include more data points, with the added penalty of decreasing the signal-to-noise ratio. Rough surfaces, surfaces with high slopes, or surfaces producing low fringe contrast fringes, will have points that do not modulate as well; thus a lower percentage will allow more points to pass as valid data points.

## Min Mod Pts

Minimum Modulation Points specifies the minimum number of data points, which pass the Min Mod (%) criteria that make up a valid data set. For data to be analyzed by the system, it must be made up of this minimum number of data points. Settings: 0 to 9999, default is 50.

Min Mod Pts is different than Min Area Size. Min Area Size specifies the minimum size of a valid measurement area, not the entire data set.

## Movie

When the Movie is On, the individual data files are saved to the Movie Data Dir with sequential file names starting with the string in Movie File Base control. Used with dynamic stroboscopic measurements. This control is available in the Control window with the New Control → Dynamic → Movie menu.

## Movie Data Dir

When the Movie control is set to On, the saved files are saved to a directory with the name of the string in Movie File Base in the directory indicated by the Movie Data Dir control. The default directory is ./, which indicates the MetroPro working directory. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Movie menu.

## Movie File Base

This control specifies both the name of the directory where the data files are saved and the starting string of the file names that are saved in the directory when the Movie control is set to On. MetroPro appends the appropriate indices and file suffix to the files saved. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Movie menu.

## Movie Window

Selects the window to use to create a movie when the Convert Movie button is pressed. To use this control, right click on the control and the pointer changes to an arrow with a star. Left click on the plot or window title bar which you would like to make a movie of. The title of that window is placed in the movie window control. Right click again anywhere on the screen to return the point to a normal arrow pointer. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Movie menu.

## Narrow

Determines how dark fringes are displayed. Settings are On or Off. When On, the width of the dark fringes is reduced. Part of the Synthetic Fringe window.

## nBins

Specifies the number of bins to use when the histogram plot is generated. For the 3D plot, the default value is 63. For profile plots, the default value is 50.



The histogram plot is updated automatically when any change is made to the nBins entry. Clicking the Update button in the plot controller is not necessary.

## Next Bucket button

When the Acquisition Mode control is set to Phase, the instrument acquires multiple "buckets" of intensity data for the phase algorithm. The Next Bucket button displays the next segment of intensity data in the plots in the Intensity Data window. It is primarily used as a diagnostic tool.

## Nominal RadCrv

Specifies the nominal or planned radius of curvature of the spherical part. This value must be entered before making a measurement. Use a negative sign for concave surfaces, convex surfaces are positive. Used when measuring tool offset.

## Nominal Radius of Curvature

Specifies the nominal radius of curvature of the spherical part. This value must be entered *before* making a measurement. This control is only applicable to instruments measuring radius of curvature.

## Normalize

For Profile plots. When On, all slices in a profile plot are adjusted to relate to one another. Linear slices shift so the first valid data point is at zero on the x-axis. Circular slices are made the same length with the x-axis in degrees.

## Number of Parts

A Q-DAS Report window numeric entry control for specifying the number of parts being measured during a Type-3 gage study. The default setting is 25.

## Number of Reference Measurements

A Q-DAS Report window numeric entry control for specifying the number of times the reference standard is measured during a Type-1 gage study. The default setting is 25.

## Number of Trials

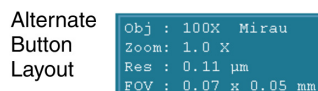
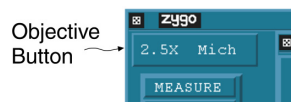
A Q-DAS Report window numeric entry control for specifying the number of times each part is measured during a Type-3 gage study. The default setting is 25.

## Objective

An Attribute box that shows the objective used during the measurement for a microscope instrument.

## Objective button

Selects the objective used for the next measurement in microscope applications. This button is permanent; it cannot be moved or deleted. For a manual turret, click on the Objective button with the left mouse button until the name on the button matches the objective you have selected on the instrument. It will only select designated objectives. For a motorized turret, clicking this button will move to the desired objective. For an encoded turret, the button functions as an indicator for the selected objective. Clicking it does nothing.



To display the alternate button layout or the current instrument settings, choose the Layout → Obj/Zoom/Res/FOV command from the Button's menu.

- Obj is the current objective (with motorized turret this automatically updates).
- Zoom is the image zoom setting (with encoded zoom this automatically updates).
- Res is the objective lateral resolution.
- FOV is the objective field of view (x, y).

## Offset

The offset voltage of the output waveform on the Tegram Arbitrary Waveform Generator (AWG) hardware. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Driver menu.

## Operator Id

Used to enter text or a number as an identifier for an operator of the instrument.

## Operator Number

A numeric entry in the Q-DAS Report window, which identifies the number of the operator of the machine. This entry is saved with the data.

## Part Description

A Q-DAS Report window text entry control. A required user-supplied description or name of the part being tested.

## Part Diameter

In the Radius Scale Application it specifies the diameter of the part whose radius is being measured. If an acquisition mask is used, enter the diameter of the area defined by the mask. If a mask is not used, enter the diameter of the test surface over which the fringe pattern occurs.

Specifies the nominal part diameter of the part being measured. This is a required entry. Part of the ISO 10110-5 window.

## Part Num

Use to enter a number for item being tested. Text and numbers may be entered.

## Part Radius

Specifies the radius of curvature of the test part in a GPI application. This control is used in conjunction with the Spherical Distortion Correction control. Part Radius has no effect if Spherical Distortion Correction control is turned off. Create the Part Radius control with the New Control → Distortion Correction → menu.

## Part Ser Num

Use to enter the serial number of the test part. The Part Ser Num control has three modes of operation: Normal, Auto-Increment, and Prompt. To enter a serial number, click on the box with the left mouse button, type a number with the keyboard and press [Enter].

The mode of operation of the Part Ser Num control is selected with the Mode command from the control's menu. The current mode of operation is indicated by an asterisk (\*). When the Mode is *Normal*, the data is saved under the specified serial number. When the Mode is *Prompt*, the software asks you to enter a serial number before each measurement.

When the Mode is *Auto-Increment*, the serial number is incremented by one for the next measurement. Only the right-most 15 digits are incremented until a non-digit character is found. For example: "1234" increments to "1235"; "Test-01-10" increments to "Test-01-11"; "Test-12X" is unchanged because the entry ends with a letter. One digit in the serial number provides for ten increments, two digits for 100 increments, and three digits for 1000. When the maximum increment is reached, digits roll over; 999 becomes 000.

## Pattern File

Specifies the name of a pattern file to load automatically when the Auto Load Pattern control is set to On. The pattern file must exist prior to entering its name in the control. The name must be 14 characters or less, and usually ends with “.pat”.

## Pattern Number

A user-specified identifier for a pattern position.

## Pattern Site Retries

When Auto Pattern Retry control is On, this is the number of times the pattern positions, meeting the retry criteria, will attempt to be remeasured. Only applicable to instruments with programmable stages.

## Pattern Units

Selects the units displayed in the stage readout for linear stage positions. Settings are Metric or English. Metric (default) displays positions in millimeters (mm). English displays positions in inches (in). Only applicable to instruments with programmable stages.

## Pause button

Stops movie playback on the currently displayed data file. Used with dynamic stroboscopic measurements. This button is available in the Control window with the New Button → Dynamic menu.

## Playback Action

Selects the playback mode used when the Play button is pressed. Available modes are: Once, Loop, or Loop—Bounce. Once plays the movie once from the first file to the last. Loop plays the movie from the first frame to the last an infinite number of times or until pause or the ESC key is pressed. Loop—Bounce plays the movie from the first to the last and back to the first file an infinite number of times or until Pause or the ESC key is pressed. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Movie menu.

## Play button

Plays back the saved movie data one file at a time. The playback speed is the time required to load and display data files and is not adjustable. Used with dynamic stroboscopic measurements. This button is available in the Control window with the New Button → Dynamic menu.

## Phase Avg Min N Pct

Specifies the percentage of the contributing height maps wherein a point must be valid in order to produce an averaged point. This control is used to reject dropouts in some of the contributing height maps so the final averaged height map is not missing data. Phase Avg Min N Pct is useful when points in the height map drop out intermittently, perhaps due to a low signal-to-noise condition.

For example, if the Phase Avgs control is set to 10 and the Phase Avg Min N Pct control is set to 50%, then only 5 out of 10 contributing height values need to be valid to produce an averaged height value.

## Phase Avg Pause

When On, the instrument is paused between multiple phase averages. To continue, the operator clicks an on-screen button. Phase Avg Pause is primarily used when making a system error file. It is only functional if the Phase Avgs control has an entry greater than 1.

## Phase Avgs

Specifies the number of phase averages performed during measurements; averaging improves repeatability. Values from 0 to 1024 can be entered. Averaging increases processing time.

See also Section 4 of this manual.

## Phase Correction

Selects the phase correction mode, which adjusts for phase changes due to parts consisting of dissimilar materials. Applicable only when the Acquisition Mode control is set to Phase. Settings are None, Offset, or n and k. Other Control boxes used with this control are: Ref Region k, Ref Region n, Test Region k, Test Region n, Ref Region Offset, and Test Region Offset.

The accuracy of phase measuring interferometers is limited when the measured test part consists of materials with dissimilar optical properties. The dissimilar optical properties cause relative phase shift error in the measured vertical heights of the dissimilar materials. Light reflected from glass or any homogeneous surface has a constant phase change and does not require correction.

**None** means that no correction is used. Normally, most measurements do not require phase correction because the part is made of a uniform material.

**Offset** uses values entered in the Ref Region Offset and Test Region Offset controls to correct for phase shift errors. An overview of this technique is: measure the test part; over-coat the part with an opaque specular material, such as aluminum; remeasure the same part; compare the first results to the second; and determine the offset value, which is the average difference between the coated and uncoated results. These offset correction values are applied to future measurements; they adjust the relative vertical position of dissimilar areas to more accurately represent the part.

**n and k** uses the index of refraction values entered in the Ref Region k, Ref Region n, Test Region k, and Test Region n Control boxes to correct for phase shift errors. The optical constants of a material are referred to as “n” and “k”. The index of refraction is  $n$ ; the absorption coefficient is  $k$ . It can be difficult to determine the correct n and k values. The optical constants vary depending on the material, the wavelength of light, and the numerical aperture of the objective. The values also vary depending on the material, how it is deposited, and what it is deposited on. For these reasons, offset correction is often preferred over n and k correction.

Phase correction may be necessary when thin film effects are present. The optical thickness ( $\tau$ ) of a thin film is given by:  $\tau = nd$  Where n is the index of refraction of the film material and d is the thickness of the film. Light which reflects off the bottom of the film travels two times the optical thickness farther than the light reflected from the top of the film. If  $2*\tau$  is larger than the interference depth of the objective, the thin film will not affect the measurement. If  $2*\tau$  is smaller than the interference depth, the light reflected from the bottom of the film could add to or subtract from the light reflected from the top of the film.

When either Offset or n and k correction is used, Test and Reference masks must be defined to coincide with the dissimilar test part areas. See the Mask Editor section for details on defining and using masks.

## Phase Delay

Sets the delay between the LED trigger pulse and the device driver signal. Valid entries are between 0 and 360 degrees. Applies only to the system when in Dynamic mode. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic menu.

## Phase Delay Increment

Specifies the phase delay sweep increment size for a Phase or Frequency & Phase sweep measurement. Integer between 0 and 360 degrees. It is not used for Frequency only sweep measurements. Used with dynamic stroboscopic measurements. This control is available in the Control window with the New Control → Dynamic → Sweep menu.

## Phase Res

Selects the resolution of the calculation of phase values. When the Acquisition Mode control is set to Phase, it also affects the number of buckets acquired. The Settings are Normal, High, or Super.

<i>Phase Res</i>	<i>Counts per Fringe</i>	<i>Phase Acquisition Buckets</i>
Normal	4096	7
High	32768	13
Super	131,072	13

High provides higher resolution, but a lower total range of heights. Normal provides a higher range of heights but lower resolution. Normal is the suggested setting for interferometers. High is the suggested setting for microscopes; though it should be set to Normal if the test part is curved, when there are many fringes, or when very fast processing is required. The Super setting is the most useful for smooth surfaces in a very stable environment.

## Phase Res—MST Instruments Only

The Phase Res control operates differently with MST instruments. Data is collected during the course of modulating the laser (not a PMR as with GPI type instruments) over some number of cycles. The number of cycles is set with the Phase Res control. Default settings exist to ensure that there is enough data/tuning range applied to distinguish the smallest cavity in the test setup.

For a simple two surface cavity measurement, setting Phase Res to High equates to four cycles. In any 3 surface or 4 surface setups, by default, MetroPro selects the tuning range (Phase Res High) so that the shortest cavity has 4 interference cycles.

Phase Res can be changed to Max or Custom in order to increase the tuning range for more data collection. With different thickness parts, the Phase Res Max factor will vary because the tuning range needed to scan a cycle representing different length cavities is not constant. When using the Custom setting, Phase Res can be set to any value; however, be aware that setting the value too high, such that the tuning range is above the 150 GHz limit (for a 633 nm MST system laser), results in a “Geometry calculation error.”

## Position 1–5

Shows the corresponding set position of a z-axis stage. Set positions are defined by clicking a Set Pos button or by clicking the Position control and entering a value directly. To clear a value, click on the control and press the Delete key.

These controls are available in the Micro LYNX window; and work only with applicable hardware.

## Post-log Command

Used to enter a command for performing external processing functions of report files. For example, a command can output the report file to a printer or to another computer.

## Post Phase Connect

Selections are On or Off. Enables additional phase connect processing to connect the centroid with the surrounding data. Useful when the data contains discontinuities caused by steep slopes.

Available in Surface/Wavefront Multi Test Map Data Window→New Control→Test + RefX Test, where X is 1 to 10. (A separate control by the same name is available for each of the test regions.)

Normally used with Flat Panel measurement applications.

## Pre-Connect Filter

Filters data before the connect process to help eliminate edge effects. It is used primarily with two wavelength measurements. Settings: 0 to 100, default is 0. A value of 60 or higher is recommended. When filtering is active, more processing time is required and data points may be eliminated.

An edge effect occurs along a vertical step in a part where there is very steep pixel-to-pixel slope greater than half the wavelength of the light source. The Pre-Connect Filter removes ambiguous edge effects before data points are joined together in a map representing the part; otherwise the ambiguous data may adversely affect results.



## Pressure (Torr)

Specifies the pressure of the radius slide test environment in Torrs. A Torr is a unit of pressure equal to 1/760 atmosphere or 1 mm Hg. Range: 0 to 9999, default 760. The Index of Air is recalculated as values are entered. Click the Reset Env button to reset the control to the default setting.

## Prev Bucket button

When the Acquisition Mode control is set to Phase, the instrument acquires multiple "buckets" of intensity data for the phase algorithm. The Prev Bucket button displays the previous segment of intensity data in the plots in the Intensity Data window. It is primarily used as a diagnostic tool.

## Print Live Disp Win button

Opens a print dialog box for printing the Live Display window from within MetroPro. Windows file dialogs must be enabled. It is available in a Control window with the New Button → Miscellaneous menu.

## Print Report button

Prints the contents of the Report window to a printer connected to the computer when clicked on with the left mouse button.

## Printing

Enables the auto printing of the contents of the Report window as text, after each measurement. When Off, the report is not printed at the end of each measurement. But selectively, you can print the report by clicking the Print Report button. When On, a report is printed automatically after each measurement. When the next measurement is made, another report is output.

## Product

A Q-DAS Report window text entry control for entering product information.

## PSD View Area (%)

Specifies the percentage of the viewing area of the power spectrum density plot that you want to see in the Filled plot. It functions like a zoom control. This control is used with FlashPhase\* acquisition to examine the Intensity Spectrum Map.

\*FlashPhase is no longer available as an acquisition mode. Information is provided for reference purposes and backwards compatibility.

## PSF Size

Selects the resolution of the array used in the computation of PSF analysis. Settings: 64, 128, or 256. Because the PSF computation uses a two-dimensional Fast Fourier Transform, a setting of 64 yields the fastest results, but the plot is relatively coarse. Conversely, a setting of 256 yields the most detailed plot, but takes longer to create.

## Pulse Width

The Pulse Width control displays the amount of time the LED light source is turned on. The pulse width is expressed in seconds (sec), milliseconds (ms), microseconds ( $\mu$ s) or nanoseconds (ns) units. When changing the pulse width, enter the new value alone to use the current units or the new value followed by a space and one of the above units.

The following expresses the relationship between frequency, duty cycle, and pulse width.

$$\begin{aligned} \text{Duty\_cycle} &= \text{pulse\_width} * \text{frequency} \\ \text{pulse\_width} &= \text{duty\_cycle} / \text{frequency} \end{aligned}$$

## PZT Cal

Piezoelectric Transducers Calibration enables automatic adjustment of modulation magnitude during data acquisition. If the PZT Cal control is On, the modulation of the instrument piezoelectric transducers (PZT's) is adjusted during data acquisition to obtain the correct phase relationships among the numerous readings of light level data.

When PZT Cal is On, the current modulation value, specified with the PZT Gain control, is used as a starting point and adjusted if necessary. If PZT Cal is Off, the PZT Gain value is used but is not adjusted. PZT Cal is most accurate when there are several (4 to 5) fringes across the measured area. Under most measurement conditions, it is preferable to have ramp calibration on.

PZT calibration is very stable when used with a single microscope objective or interferometer transmission element. If you are measuring a large batch of similar parts and want the maximum processing speed, turn the PZT Cal control to Off after the first measurement is completed.

## PZT Gain

Piezoelectric Transducers Gain specifies the modulation amplitude value used during data acquisition. The higher the value, the greater the PZT movement. Settings: 0 to 4095, default about 1600, set at factory. Under normal circumstances it is not necessary to change the PZT Gain value. There are certain interferometer setups that require one-half the normal PZT motion; this can be set by dividing the PZT Gain by two.

If the PZT Cal control is On, the modulation value is used as a starting point and adjusted if necessary to produce the correct phase differences. If PZT Cal is Off, the modulation value is used but not adjusted.

## PZT Scale Factor

Specifies the scale of PZT movement; it is used in special applications to scale the PZT movement up or down to achieve the required one fringe of phase modulation. Settings: 0.125 to 2.0, default is 1.000.

The Corner Cube application uses a PZT Scale Factor of 0.5 when measuring a corner cube in the double-pass configuration.

## Radius

Specifies the radius in pixels of a generated Zernike data set. An entry of -1 makes the radius as large as possible based on the Camera Size X and Camera Size Y controls.

## Radius (measured)

Specifies the actual measured radius of curvature of the part being measured. This radius is supplied from some other means, such as the Radius Scale Application. If using this control, do not enter a value in the Radius (Nominal) control. Part of the ISO 10110-5 window.

## Radius (nominal)

Specifies the nominal radius of curvature of the part being measured. If using this control, do not enter a value in the Radius (Measured) control. Part of the ISO 10110-5 window.

## Radius Calibrate button

Click to initiate the Radius of Curvature calibration routine. This function establishes the radius of curvature calibration factor and automatically updates the corresponding configuration (.cfg) file in the working directory. A radius calibration standard is required. This button is only applicable to instruments measuring spherical parts with the appropriate x, y, and z programmable motorized stages.

## Read button

Displays the current position of the z-axis stage in the Last Reading result box. This button is available in the Micro LYNX window; and works only with applicable hardware.

## Read button

Click to obtain measurement data from the ZMI system on screen. Click the mouse button (anywhere) to cancel the distance display. Part of the DMI Test window; used with the radius scale option.

## Reference Measurement

When the name of the data file is present, it is subtracted from all of the measurements present in a movie made by pressing the Play or Convert Movie buttons. This is useful for removing baseline form from a device and characterizing simply the motion of the device under test. If this control is blank, then no data is subtracted, and the raw data is used to make the movie. Used with dynamic stroboscopic measurements. This control is available in the Control window with the New Control → Dynamic → Movie menu.

## Ref Freq

Specifies a MTF reference frequency for a plano wavefront, or when the f-number is equal to zero. Range 0 to 1. The Ref MTF results are the modulation values at this reference frequency.

## Ref Pt 1

For profile plots. Specifies the starting point of the reference segment along the x-axis. Requires an entry in the Ref Pt 2 control. The Use Ref Pts control must be On.

## Ref Pt 2

For profile plots. Specifies the ending point of the reference segment along the x-axis. Requires an entry in the Ref Pt 1 control. The Use Ref Pts control must be On.

## Ref Region k

Ref Region k (Reference Region k) specifies the imaginary part of index of refraction constant of an area inside a Reference mask. The value is used along with the values in the Ref Region n, Test Region k, and Test Region n controls to correct for a phase shift condition. The value entered in this control is used only when the Phase Correction control is set to n and k.

## Ref Region n

Ref Region n (Reference Region n) is a numeric Control box used to enter the real part of the index of refraction of an area inside a Reference mask. The value is used along with the values in the Ref Region k, Test Region k, and Test Region n controls to correct for a phase shift condition. The value entered in this control is used only when the Phase Correction control is set to n and k.

## Ref Region Offset

Ref Region Offset (Reference Region Offset) is a numeric control used to enter an offset compensation value for an area inside a Reference mask. The value is used along with the value in the Test Region Offset control to correct for a phase shift condition. The value entered in this control is used only when the Phase Correction control is set to Offset.

## Refractive Index

Specifies the refractive index of the part being measured. The index of refraction is the ratio of the velocity of light in a vacuum to the velocity of light in a refractive material for a given wavelength.

Angle Measurement Application. Specifies the refractive index of the part being measured. It is preset in the Wedge (Trans) and 90 deg Prism Int setup to 1.50. You must enter the actual refractive index of the test optic; 1.50 is simply a default software entry.

Corner Cube Application. Specifies the refractive index of the corner cube material, if the corner cube is a solid piece of glass. If the cube is constructed from three mirrored planes, enter the refractive index of air. For example, the Refractive Index for BK-7 is 1.51633; the refractive index of air at STP is 1.0002714. This value is used for the calculation of the dihedral angles of the corner cube.

PHom Application. Specifies the refractive index of the test part. An entry is required so a scale factor for measuring surface 2 can be determined.

## Relative Humidity (%)

Specifies the relative humidity of the radius slide test environment in percent. Range: 0 to 100, default 50. The Index of Air is recalculated as values are entered. Click the Reset Env button to reset the control to the default setting.

## Remote Access\* button

Starts up a remote access server and puts MetroPro in “remote access mode” waiting for remote client connections. In this mode, MetroPro is not interactive and cannot be used by a local user (where MetroPro is running). The mouse and keyboard are disabled. This server allows remote users to control MetroPro from client applications by using the MetroProRemoteAccess.dll.

To terminate the remote access server, if idle, press the Escape key and hold for 2 seconds. If busy, you may need to hold the Escape key for an additional 2 seconds. The server may be temporarily suspended or halted if idle, by pressing and holding F11, allowing temporary local user control. To resume the server, press the F11 key again or click on the remote access button. For further details see the *MetroPro Remote Access* manual, OMP-0476.

\*The Remote Access functionality is no longer supported. This information is provided for reference purposes and backwards compatibility.

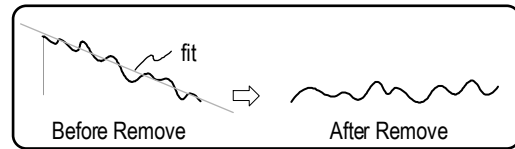
## Remote button

Obsolete button, left in for backwards compatibility.

## Remove (*interferometers*)

This control is applicable to the GPI, VeriFire, MESA, MicroLUPI, or DVD 400 instruments. Specifies the overall surface shape(s) to subtract from the data during analysis. If the overall shape is not removed, it may dominate the results making it difficult to determine the actual quality of the surface or wavefront. When overall surface shape is subtracted, MetroPro analyzes the difference between a mathematical surface and the actual surface. Note that as used in this description, “surface” means either the surface or the transmitted wavefront of the object being tested.

As shown here, removing plane (or tilt) causes this tilted data to be displayed flat, allowing the vertical scale to be expanded, thus revealing much greater detail about the surface.



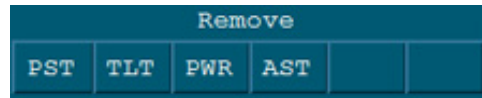
Remove performs a least-squares fit of a function to the data. The least-squares fit minimizes the rms difference between the selected “remove” shapes and the actual data by determining the optimal mathematical coefficients for the function. These coefficients are then used to generate a mathematical surface that is subtracted from the data, thus producing a residual map of the difference between the best fit surface and the original data.

The interferometer Remove control has four modes: Normal, Zernike, Cylinder, and Sphere, and within each of these modes, each button corresponds to a particular shape. To select a mode, right click on the Remove control box.



### Normal Mode

**PST** (Piston) Shifts or offsets data in the Z-axis.



**TLT** (Tilt) Removes tilt or incline in the data. It compensates for any residual tilt in the part and causes it to appear flat. For most measurements, remove plane to compensate for the tilt inherent in the equipment setup and the nulling of fringes.



#### Note

The four buttons are partly interdependent. Selections are cumulative from lowest to highest order. For example, if you select PWR, PST and TLT are also

**PWR** (Power) Compensates for spherical surfaces; they appear flat. This allows you to observe surface features instead of the dominant spherical shape.

**AST** (Astigmatism) Compensates for astigmatic (cylindrical) surfaces; they appear flat. This allows you to observe surface features instead of the dominant astigmatic shape.

automatically selected and removed.

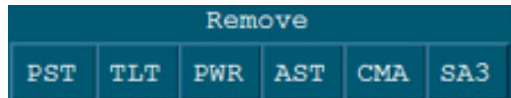
If you select AST, piston, tilt, power and astigmatism are removed.

If any of the buttons are selected, the Remove function is enabled.

Remove fits a Cartesian polynomial to the height map. The polynomial is used to generate values that are subtracted from the height map points.

### Zernike Mode

Refer to Normal Mode for a description of PST, TLT, PWR, and AST. These six buttons are completely independent of each other. The remove operation fits a Zernike polynomial to the height map only if CMA or SA3 are selected. Otherwise, the remove operation fits a Cartesian polynomial.



**CMA** (Coma) Compensates for coma in the data.

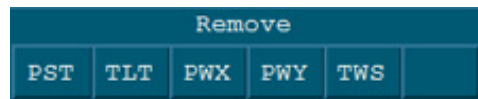
**SA3** (Spherical Aberration) Compensates for spherical aberration in the data.

CMA and SA3 are typically used when testing lens system to view residual wavefront errors after removing known aberrations. The residual errors are usually an indication of misalignment or fabrication errors of the elements in the optical system.

For explanations of PST, TLT, PWR, and AST see Normal mode. *CMA* and *SA3* or Coma and Spherical Aberration are usually used when testing lens systems to view residual wavefront errors after removing known aberrations. The residual errors are usually an indication of misalignment or fabrication errors of the elements in the optical system. The Mode command must be set to Zernike.

### Cylinder Mode

For explanations of PST and TLT see Normal mode.



**PWX** (Power X-Axis) Compensates for cylindrical surfaces.

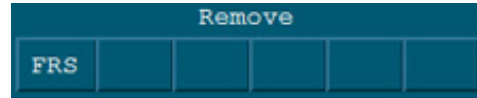
**PWY** (Power Y-Axis) Compensates for cylindrical surfaces. In general, if moving the part towards or away from the interferometer causes vertical fringes, select PWX. If this motion creates horizontal fringes, select PWY.



**TWS (Twist)** Also called “fan” by opticians because of the characteristic fan shaped fringes. Small misalignments of the surface can cause this aberration to appear in the measured wavefront. Removing twist improves measurement repeatability, though it also removes any twist that is part of the surface.

### **Sphere Mode**

FRS (Fixed Radius Sphere) Will remove the known value of the radius of a sphere. A convex surface will have a positive radius. A concave surface will have a negative radius.



### **The Remove Control and Results**

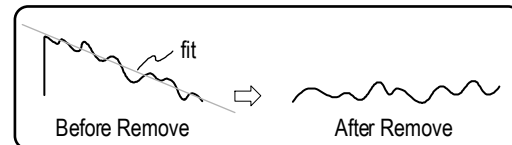
Results calculated *before* Remove include: Power, RadCrv, Sag, Sag X, Sag Y, Tilt X, Tilt Y, TltAng, TltMag, Seidels, Zernikes.

Results calculated *after* Remove include: AvgHgt, H, Peak, PV, Ra, Rku, rms, Rsk, R3z, Rtm, Rz, Valley, Vol Dn, Vol Up, VolNet.

### **Remove (microscopes)**

Specifies the overall surface shape(s) to subtract from the data during analysis. If the overall shape is not removed, it may dominate the results making it difficult to determine the actual quality of the surface. When overall surface shape is subtracted, MetroPro analyzes the difference between a mathematical surface and the actual surface.

As shown here, removing plane causes this tilted data to be displayed flat, allowing the vertical scale to be expanded, thus revealing much greater detail about the surface.



For the microscopes, the Remove control selects the surface to remove, this usually improves the analysis by eliminating form from the results, thus highlighting the surface irregularities. The results are the deviation from the surface you have removed. Settings are Piston, Plane, Sphere, Cylinder, Fixed Rad Sphere, Fixed Angle Cone, Variable Angle Cone, or None.

Piston, plane, sphere, and cylinder are removed by a least squares fit on the data. It calculates the coefficients of the best fit surface and other parameters related to the fit without modifying the data. If you have modified the data with an Acquisition mask, only those points remaining are used in the least squares fit. Piston and plane are an aspect of the interferometer configuration and the sample, while sphere and cylinder are inherent to the sample. Most analyses should be performed with plane removed, while sphere and cylinder should be removed only from samples of certain shapes. When sphere or cylinder is selected, piston and plane are also removed.

Removing *Piston* compensates for any offset in the z-axis after you null the fringes. Removing *Plane* compensates for any residual tilt present after you null the fringes. It causes a slanted sample to appear flat. For most analyses, you should remove plane to compensate for the tilt inherent in the equipment setup and the nulling of fringes. *Piston* is also removed.

Removing *Sphere* causes spherical samples such as ball bearings to appear flat. This allows you to observe surface roughness features instead of the dominant spherical shape. *Piston* and *Plane* are also removed. Removing *Cylinder* causes cylindrical samples such as rods to appear flat. This allows you to observe surface roughness features instead of the dominant cylindrical shape. It can remove two different orthogonal cylinders. *Piston* and *Plane* are also removed.

Removing *Fixed Rad Sphere* removes the radius of a sphere whose value is known. The sign convention for a convex surface is a positive radius. A concave surface will have a negative radius. A value must be entered for the Sphere Radius control.

Removing *Fixed Angle Cone* removes a specified cone angle from the data. This value must be entered using the Cone Angle control. An illustration of cone angle is included with the description of the control.

Removing *Var Angle Cone* removes a best fit cone angle from the data. While a cone angle value is not required for this remove routine, entering a valid value in the Cone Angle control can improve processing time.

Removing *4<sup>th</sup> Order* removes a best-fit, 4<sup>th</sup> order polynomial surface.

Select *None* when the surface is not continuous, when the surface has an asymmetrical structure such as a large hole or slope, or when you want to see the tilt.

### **The Remove Control and Results**

Results calculated *before* Remove include: Power, RadCrv, Sag, Sag X, Sag Y, Tilt X, Tilt Y, TltAng, TltMag, Seidels, Zernikes.

Results calculated *after* Remove include: AvgHgt, H, Peak, PV, Ra, Rku, rms, Rsk, R3z, Rtm, Rz, Valley, Vol Dn, Vol Up, VolNet.

## **Remove (profiles)**

For profile plots. Subtracts the selected shape from the all slices; choices are *Piston*, *Line*, *Circle*, and *None*. *Piston* compensates for offset in the z-axis. *Line* compensates for residual tilt. *Circle* removes a best fit circle from the data. *None* turns off remove.

## **Remove (spectrum)**

The Remove control in the Spectrum data window subtracts the selected shape from the data; choices are *Cylinder*, *Plane*, or *Sphere*. This control should only be used if surfaces have not been removed with the Remove control in the default data window. *Cylinder* removes any dominant cylindrical shape so the data appears flat. *Plane* compensates for any residual tilt present. *Sphere* removes any dominant spherical shape so the data appears flat.

## Remove Fringes

Removes fringes from the data displayed in the Intensity window. It does not affect the results in other Data windows. This control is required for the Pole Tip Recession (PTR) application. Removing fringes only works when the Acquisition Mode Control box is set to Phase.

When *Off*, a Filled plot in the Intensity window displays one frame of light level data similar to the image on the video monitor screen. When *On*, a Filled plot in the Intensity window displays a map of the light intensity without the interference pattern. In effect, the fringes are removed from the intensity data. This is accomplished by averaging a number of frames of intensity data. Processing time is increased.

## Remove Fringes Mode

The Remove Fringes Mode control is designed to get better fringe removal under some very special conditions. There are some situations in which the intensity data due to fringe removal, is incorrect. One reason this occurs is because of no modulation of intensity. When the Remove Fringe Mode control is On, the software attempts to use height values to aid in determining the correct fringe removed intensity. The Discr Mode control must be set to RAM.

## Remove Mode

When set to On, this control overrides the setting of the Remove control and fits data to the dominant slope surface. The reference or 0 position in the data is set at the mean of surface data that intersects with the dominant slope surface. This control applies only to Test+Reference (T+R) data windows.

## Remove 1 UPR

UPR is undulation per revolution. Selections are On or Off. Round parts, such as cones, undergo a variety of manufacturing processes, for example, grinding, in which the part is spinning at the same time as it is being ground. As a result of this multi-step process, the part can exhibit form deviation that corresponds to one or more harmonic frequencies. When this control is On, the software removes the data associated with one frequency, effectively acting as a filter.

## Remove Spikes

Determines if spikes are removed from the data. When On, a RMS is calculated for the entire surface and then each point is tested to determine if its height differs by at least that global amount from the average height of points in its averaging window. Spikes are only removed within the data window where the control is accessed. When Off, spikes are not removed.

## Remove Tilt Bias

Activates a remove function associated with movement of the Piezoelectric Transducers (PZT's). The physical process of PZT movement during data acquisition introduces into the phase data a slight tilt bias that is unrelated to the fringe orientation. This control allows the removal of this tilt bias during a measurement before analysis.

Tilt bias normally has no affect on results because the Remove control is usually set to remove overall tilt. Set Remove Tilt Bias to *On* in situations when removal of overall tilt from the data set is not appropriate. An example is measuring a corner cube in the double-pass configuration.

## Reset button

Resets the application. This means that controls will revert to the values they had when the application was last saved. Hardware is not re-initialized.

## Reset button, Micro LYNX

Clears home and current z-axis stage positions; positions entered in the Position controls are not cleared. After clicking Reset, be sure to click the Home button.

This button is available in the Micro LYNX window; and works only with applicable hardware.

## Reset Data button

Clears the currently loaded or acquired data from the analysis.

## Reset MC button

Initializes the motion control software and communication to ZYGO Motion Controller. After the button is clicked, programmable stage home positions must be found again.

## Reset Zernikes button

Changes the settings in the Center X, Center Y, Radius, and Coef x Zernike controls to factory default settings. It is used when generating data.

## Ring/Spot Mode button

This button selects the light source of the GPI or VeriFire instrument, if it has the appropriate hardware. The source can be switched between Ring Mode and Spot Mode. This is the same as pressing the corresponding button on the instrument's remote control.

In the Spot Mode, the source is a point, and back reflections and diffraction patterns may show up in the data as part of the measurement. In the Ring Mode, the source is changed to a holographic-generated ring of small diameter, which desensitizes the instrument to artifacts, narcissus fringes, and dirt.

However, the ring source has some limitations:

- The transmission element must be precisely aligned to the optical axis.  
Transmission flats must be aligned in spot mode with a retroreflector.  
Transmission spheres must be aligned in spot mode at Catseye position.
- The test optic must be in optimum focus.
- Ring mode cannot be used to measure cavities that invert the wavefront, such as prisms (internal angles or retroreflectors) or at Catseye in a transmission sphere.
- The maximum cavity length is limited to about 5 meters.

## Rotate Data button

Redisplays the current data set at the entered angle. Part of the manipulate features.

## Run Align Pattern Script

This control is used in conjunction with the Align Pattern Script File control and the Align Pattern button. When this control is set to on, it runs the script (specified with Align Pattern Script File) at each pattern alignment site. This is part of the alignment procedure that is activated when the Align Pattern button is clicked. Applicable to systems that have the programmable stage option.

## Run Pattern button

Activates the stage to run the data in the current pattern file when clicked on with the left mouse button. It runs either the current pattern in the Pattern Editor, or those listed in the SC Pattern List control. Applicable only to systems with programmable stages.

## Sample

Specifies an interval for sampling the rows and columns of the height map when calculating the slope map. It reduces the resolution of the slope analysis. It affects the plots and results displayed in the slope data window. Available in slope data windows only.

## Save Data button

Opens the File Handler, which is used to specify a data file name and save the file to the hard drive. A data file contains measurement information only; it can be loaded into different applications and reanalyzed. Raw or unprocessed data is saved with the Save Data button in the Control window; processed measurement data is saved with the Save Data button in the Data window.

To save your data click the Save Data button. In the File Handler, click the “Current Selection” box, enter a name for the settings file, ending with “.dat”, and then press [Enter]. Click the Done button to close the File Handler.

Synthetic Fringe Map Data window. Saves fringe data as it has been manipulated in the Synthetic Fringe map Data window.

## Save Each Data button

Saves each region of the data into its own data file.

## Save Report button

Opens the File Handler, which is used to save the current report file to the hard disk. The Save Report button saves only one report file; to save multiple report files use the Logging control.

To save your report, click the Save Report button. In the File Handler, click the “Current Selection” box, enter a name for the file, ending with “.rep”, and then press [Enter]. Click the Done button to close the File Handler.

## Save Settings button

Opens the File Handler, which is used to save the current configuration of control settings to the hard disk. Normally, the settings of controls return to factory default settings when an application is closed and reopened.

To save your control settings click the Save Settings button. In the File Handler, click the “Current Selection” box, enter a name for the settings file, ending with “.set”, and then press [Enter]. Click the Done button to close the File Handler.

## Save Zernikes button

Opens the File Handler, which is used to save the current Zernike file to the hard disk. Saved Zernike data does not preserve the settings of the Radius, Center X, or Center Y controls.

To save your data click the Save Zernikes button. In the File Handler, click the “Current Selection” box, enter a name for the file, ending with “.zfr”, and then press [Enter]. Click the Done button to close the File Handler.

## SC Pattern List

Specifies the name of one or more pattern files that are run consecutively when the Run Pattern button is clicked. When the last pattern runs, the software loops back to the first pattern and continues running. Pattern files control the movement of a motorized programmable stage.

One or more pattern files can be specified. Separate each file name with a blank space.

## Scale

Multiples or divides the number of fringes per wave. Entries  $<1$  divides, entries  $>1$  multiplies. Part of the Synthetic Fringe window.

## Scale Data button

Redisplays the current data set at the entered Z-axis (height) scale.

## Scale Range

MetroPro intensity data has historically been normalized to a standard range of 0 to 1023, depending upon the data analysis algorithm being used. This made it possible to take very large raw data sets and sample them to obtain a more realistic number. Beginning with version 7.10 of MetroPro, intensity data is no longer normalized. The default setting for this control is Off. The optional 1023 setting normalizes the data and provides for version compatibility.

## Scan Direction

Specifies the scan direction of the NewView scanner when obtaining data. Settings are upward or downward. The default is based on the instrument.

***For extended scans only***—This control is ignored because an extended scan is only done in the upward direction. For auto focus or auto tilt in the Z direction, this control determines movement direction, either up or down.

## Scan Length

The Scan Length control determines the actual vertical length of the scan made by the scanning microscope's pifoc during a measurement. The control's selections vary based on microscope model. The longer the scan, the longer the processing time. Set the Scan Length control so the setting shown encompasses the details you are measuring.

Note that the Scan Length selections also display the time in seconds required to perform the scan, and the type of scan. The time varies based on the setting of the Camera Mode control. If there is not an active instrument, the control displays None.

## Scan Type

This control selects how the microscope objective is moved during the measurement cycle. The settings for this control are: Bipolar, 3X Bipolar, and Phase. Bipolar scan employs a vertical scanning interferometry technique. A 3X Bipolar scan uses the same process but the scan is completed three times faster. In measurement situations in which scan time is critical, 3X Bipolar can be used; however, it is less precise than Bipolar. A Phase scan combines vertical scanning techniques with phase shifting algorithms. Scan Type control settings interact with FDA Res settings as shown below.

<i>Scan Type Choices</i>	<i>FDA Res Settings</i>
Bipolar	High 2G,* High, Normal, Low
3X Bipolar	High 2G, * High, Normal, Low
5X Bipolar	High 2G, * High, Normal, Low
Phase	Phase 1,* Phase 2

\*Default value of FDA Res with corresponding Scan Type selection.

Selecting the 3X Bipolar scan type automatically changes the Shutter Speed selection. The new value for the Shutter Speed depends on the Camera Rate. Selecting either Bipolar or Phase scan type restores the previous Shutter Speed selection.

When using a sub-nyquist scan, accuracy and repeatability decrease. Objectives with higher NA will have less accuracy and less repeatability compared to using a normal scan. Objectives with a lower NA will only decrease slightly in accuracy and repeatability compared to a normal scan.

## Scanning Seq

Selects whether to traverse the part rows in a serpentine or raster fashion. Settings are Serp or Rast. It is recommended that Rast be used for more accurate stage movement.



## Scattering Angle

Specifies the angle of the outgoing light relative to the plane of incidence for the BRDF analysis. Results are calculated based on this angle. It is the polar angle of s-polarized out.

## Script File

Specifies the name of the script file automatically run when the application is opened, if the Auto Run Script control is On.

## Sector

A Q-DAS Report window text entry control for entering sector information.

## Select Results

Selects which ISO figure specification results are calculated. They can be selected in any combination. Choices are SAG, IRR, RSI, RMSt, RMSi, and RMSa. Part of the ISO 10110-5 window.

## Seq File

Name of the file that contains all relative locations of a stitching sequence. When a stitch sequence is run and the Auto Save Seq control is set to On, the relative locations are saved into the file specified by this control. When the Type control is set to Run Sequence, the stitching sequence defined by the file specified, is run. This way multiple stitching sequences may be defined, saved, and loaded.

## Set Focus Load button

Prompts the operator for confirmation, and then sets the current z axis position as the new focus load position. The focus load position is used to move the objective above the part and fixture.

## Set Focus Zero button

Prompts the operator for confirmation, and then sets the current z axis position as the new focus zero position. Readout values displayed on screen are relative to this zero position. After a stage pattern is run, the z-axis is returned to this zero position. At startup, the initial z-axis position is considered focus zero position until it is set by clicking this button.

## Set GPI Encoded Zoom Max Mag button

Refer to *Section 4* of this manual.

## Set GPI Encoded Zoom Min Mag button

Refer to *Section 4* of this manual.

## Set GPI Encoded Zoom Std Mag

Refer to *Section 4* of this manual.

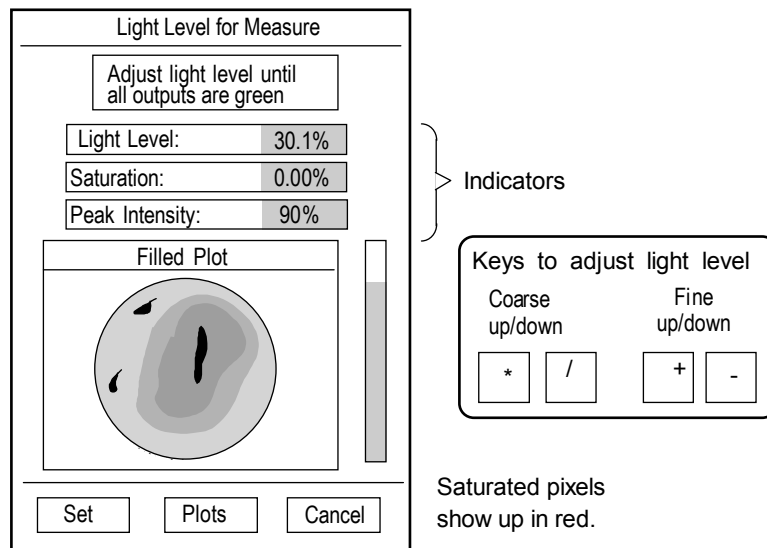
## Set GPI Encoded Zoom Var Mag

Refer to *Section 4* of this manual.

## Set Light button

When clicked with the left mouse button, it opens the Light Level window, which is used to manually adjust the measure light level for some instruments. Same as pressing the F4 key.

Using the keyboard adjust light level until all outputs are green. Then click the Set button.



## Set Pos 1–5 buttons

Stores the current position of the z-axis stage into the matching Position control. The stage should be “homed” by clicking the Home button before setting positions.

These buttons are available in the Micro LYNX window; and work only with applicable hardware.

## Set Tilt Zero button

This button prompts the operator for confirmation, then sets the current pitch and rolls axes positions as the new tilt zero positions. Pitch and roll readout values displayed on screen are relative to this zero position. After a stage pattern is run, the pitch and roll axes return to this zero position. At startup, the initial pitch and roll axes positions are considered tilt zero position until it is set by clicking this button.

## Shape

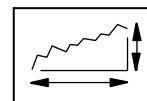
Selects the actual physical shape of the data you are analyzing in the Spectrum Data window. Settings: Rectangular (default) or Circular. If the incoming data is not of these shapes and windowing is used, create a rectangular or circular mask.

## Show Masks

Selects if masks are displayed on the video monitor screen. When On, masks are displayed on the video monitor screen. When Off, masks are not displayed. If masks are being displayed and you turn Show Masks Off, the existing masks are displayed until you make a measurement or click the Update button in the Video Monitor window.

## Slope Units

Selects the master unit system for all slope-based results; settings are English, Metric, Optical, Degree, or Radian. It applies to results in a Slope Data window, such as PV, Peak, and Valley.



For this control to affect a result or plot, the result or plot's Unit command must be set to "Master". The item's Unit command is also used to select the specific measurement units, such as mm or  $\mu\text{m}$ .

## Sphere Radius

This control specifies the radius of the sphere to be removed. The sign convention is: a convex surface has a positive radius; a concave surface has a negative radius.

## Spherical Distortion Correction

GPI Application. When on, the Spherical Distortion routine is applied to the data. Part Radius must also be defined with the Part Radius control and Spherical calibration performed. See section 4 of this manual for information on Lateral Calibration.

## Spike Height (xRms)

Spike Height is used to remove spurious spikes in the data. An indication of data spikes is a single color and an extremely flat oblique plot. The entry specifies a multiplier applied to the RMS whose resultant specifies a height above which all points are deleted.

The Remove Spikes control must be set to On. RMS is calculated for the entire surface and then each point is tested to see whether its height differs by at least that global amount from the average height of the points in its averaging window. Or in other words, single data points higher than the spike height are removed.

## Split Data File

A Q-DAS Report window control that selects whether the report is saved as one file or two. When Off, the file is saved as one, with the extension as .dfq. When On, the file is split into a header file, with the extension .dfd, and a data file, with the extension .dfx. The files will have the base name specified in the Log File control.

## Spline Beaton Coeff

This control is set for optimal functioning for the associated Gaussian Spline filtering algorithms. Do not adjust the setting of this control.

## Spline Fill

This control is set for optimal functioning for the associated Gaussian Spline filtering algorithms. Do not adjust the setting of this control.

## Spline Tension

This control is set for optimal functioning for the associated Gaussian Spline filtering algorithms. Do not adjust the setting of this control.

## Stage Positions

Selects how stage positions are tracked from one position to the next. Settings are Instr Relative or Part Relative. When set to *Instr Relative* (default), stage positions are reported referenced to the instrument as the stage moves. For example, moving the X stage to the left will result in decreasing or negative position readouts and moving it to the right will display increasing or positive numbers. When set to *Part Relative*, the stage positions are reported referenced to the part in the field of view. For example, moving the X stage to the left will result in increasing or positive numbers because the field of view is traversing the part from the left to the right as the stage moves left. Only applicable to instruments with programmable stages.

## Stage Readout

Selects if stage positions are displayed when the programmable stage is moved. Settings are None or Temporary. When set to None, stage positions are not displayed. When set to Temporary (default), stage positions are displayed while the stage is moving. And the last positions will remain visible until mouse is moved or key is pressed. Only applicable to instruments with programmable stages.

## Standard Description

A Q-DAS Report window text entry control for entering a description of the reference standard used on a Type-1 gage study.

## Standard Number

A Q-DAS Report window text entry control for entering the part number of the reference standard used on a Type-1 gage study.

## Start Frequency

Specifies the starting frequency for a Frequency or Frequency & Phase sweep measurement. It is not used for Phase only sweep measurements. Used with dynamic stroboscopic measurements. This control is available in the Control window with the New Control → Dynamic → Sweep menu.

## Start Gage button

A Q-DAS Report window button. When clicked, clears existing data and starts the gage test. The File Format control must be set to Gage-Type 1 or Gage-Type 3. All gage studies are started by clicking this button.

## Start Phase Delay

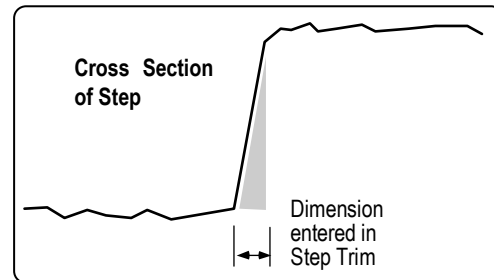
Specifies the starting Phase Delay for a Phase or Frequency & Phase sweep measurement. Enter a value between 0 and 360 degrees. It is not used for Frequency only sweep measurements. Used with dynamic stroboscopic measurements. This control is available in the Control window with the New Control → Dynamic → Sweep menu.

## Start Sweep button

Starts the Frequency, Phase, or Frequency and Phase sweep measurement sequence indicated by the Sweep Mode control setting. Used for dynamic stroboscopic measurements. This button is available in a Control window with the New Button → Dynamic menu.

## Step Trim

Specifies the dimension of an area trimmed along the vertical edges of the Step Height Standard. Step Trim has no function except with the Step Height Application included with MetroPro since version 3.0.3. It removes the affect the vertical step has on the step height results.



## Stitch button

Invokes a stitch measurement sequence based on the settings of the stitch controls. Requires a programmable stage.

## Stitch Diagnostics

Selects if diagnostic information from the stitch algorithm is provided. Settings are On or Off.

## Stitch Processed Data

Selects whether to pass raw data or processed data to the stitch algorithm. Settings are On or Off. It is recommended that this control be Off. The stitching of processed data is only recommended in rare cases.

## Stop Gage button

A Q-DAS Report window button. When clicked, stops a running gage test. This button is used to end a “manual” gage sequence or to abort an active gage study.

## Store button

Places the measurement results displayed on screen into temporary memory, which also places these values into Process Stats and Control Charts.

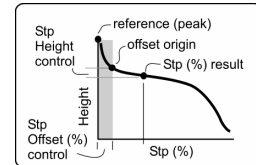
The Store button serves two main purposes. First, it allows you to select the results stored in Control Charts and Process Stats when the Auto Store control is Off. Second, it provides a way to enter existing data into Control Charts and Process Stats.

## Store Process Stats

Selects whether to store the stitched image into Process Stats. Settings are On or Off. If On, the final overall stitched measurement results are stored.

## Stp1 Height

Part of the Bearing Ratio analysis. Refer to the *Plots* section of this manual for additional information. This control specifies the height value of on the areal bearing ratio curve where the Stp1 (%) result is derived, relative to the height reference location specified by the Stp Reference control, and the value in the Stp1 Offset (%) control.



## Stp2 Height

Specifies the height value on the areal bearing ratio curve where the Stp2 (%) result is derived, relative to the height reference location specified by the Stp Reference control, and the value in the Stp2 Offset (%) control.

## Stp3 Height

Specifies the height value on the areal bearing ratio curve where the Stp3 (%) is derived, relative to the height reference location specified by the Stp Reference control, and the value in the Stp3 Offset (%) control.

## Stp1 Offset (%)

Specifies an offset value, in the X-axis, from the selected Stp Reference location to ignore when determining the Stp1 (%) result.

## Stp2 Offset (%)

Specifies an offset value, in the X-axis, from the selected Stp Reference location to ignore when determining the Stp2 (%) result.

## Stp3 Offset (%)

Specifies an offset value, in the X-axis, from the selected Stp Reference location to ignore when determining the Stp3 (%) result.

## Stp1 (%)

Specifies the areal bearing ratio (expressed as a percentage) where the Stp1 Height result is derived, relative to the reference location specified by the Stp Reference control and the Stp1 Height control value.

## Stp2 (%)

Specifies the areal bearing ratio curve (expressed as a percentage) where the Stp2 Height result is derived, relative to the reference location specified by the Stp Reference control and the Stp2 Height control value.

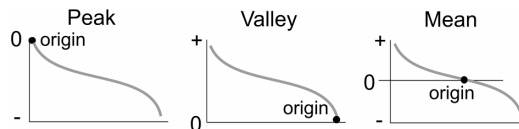
## Stp3 (%)

Specifies the areal bearing ratio (expressed as a percentage) where the Step3 Height result is derived, relative to the reference location specified by the Stp Reference control and the Stp3 Height control value.

## Stp Reference

Selects the height reference location or origin used for the corresponding profile Stp height controls and results. Choices are Zero, Peak, Valley, or Mean. Zero refers to the zero point in the sample, and depending on the data, it may be close to the Mean location.

For this control to function, the areal Remove control must be active (typically set to Plane), and the filtering controls must be active (typically set to high-pass).



## Subgroup Size

A numeric entry in the Q-DAS Report window for the subgroup or sample size. This entry is saved with the data.

## Subtract

Subtracts the current generated Zernike wavefront from the current wavefront data. Settings are Off or Gen Zern (default).



## Subtract Data button

Opens a text entry box, which is used to specify the name of an existing data file in the current directory. The specified data file is subtracted from the current data.

To cancel the action, press the right mouse button or the ESC key. The manipulated data set must exist in the current directory. You can change directories by clicking the Save Data or Load Data button, and specifying the directory with the File Handler.

**Note:** For applications in which the data sets contain multiple height maps, this button functions as follows: If both the current data set and the selected data file contain multiple height maps, then the height maps in each corresponding pair are subtracted. Applicable only to MST, MicroLUPI, and FTP.

## Subtract Sys Err

Subtract Sys Err stands for Subtract System Error. When On, it activates a software system error subtract function. The name of the file to subtract from the measurement is specified by the Sys Err File control.

## Surface Type

Selects the method used to generate data. Part of the Generate function.

## Sweep Mode

Selects the sweep mode. Choices are: Frequency, Phase, and Frequency & Phase. This control applies only to measurements made in Dynamic Mode. Used with dynamic stroboscopic measurements. This control is available in the Control window with the New Control → Dynamic → Sweep menu.

## Sys Err Dir

Specifies where system error files are located. If no directory is specified, then the current working directory is used. It is available in a Control window with the New Control → Masks menu.

## Sys Err File

Sys Err File stands for System Error File. It specifies the name of a system reference data file, which is subtracted from current measurements when the Subtract Sys Err control is On. The system error or reference file must already exist, or any entry in this control is meaningless.

The reference data file should contain measurement results taken from a "perfect" test part. In theory, this file contains only aberrations inherent in the instrument; these aberrations are then subtracted from measurement to improve accuracy.

Enter the @ character in the Sys Err File control to activate an automatic system error file naming function for both creating and selecting the data file to subtract from measurements. The software automatically creates the system error file name when the Save Sys Err Data button is clicked.

The software also automatically selects the system error file to subtract from future measurements as based on the current objective selection and the settings of the Image Zoom and Camera Mode controls. Use this function to help manage multiple system error data files.

Refer to *Section 4*.

## System Command button

Windows MetroPro only. Runs a user-entered MS-DOS command. The command is entered with the Command command in the button's menu. For example, it can launch an application or execute a command line.

To enter an MS-DOS command, position the pointer over the System Command button, press the right mouse button and select the Command command. Using the keyboard, enter a system command, and then press [Enter]. Use the Name command to label the button with a descriptive name linking it to the input command. If the command is left blank, it opens a console window when clicked.

## System Resolution

A Q-DAS Report window numeric entry control for entering the vertical resolution of the instrument.

## Target Range

Specifies the acceptable tolerance limits of the light intensity level used during data acquisition. Settings: 0.00 to 0.99; default value is 0.10. Target Range is part of the Automatic Gain Control (AGC) feedback loop, which tries to maximize the signal-to-noise of the camera data by raising the light intensity to a point just below where any camera pixels become saturated. Target Range sets the acceptable limits to which the light intensity can adjust. See AGC.

The instrument has an intensity range from 0 to 1023, which is output by the electronics and used internally in the AGC feedback loop. Target range specifies the acceptable intensity level before saturation (1023). For example, if the maximum light level is 1023 and the Target Range is 0.010, the acceptable maximum intensity level is  $1023 - (1023 \times 0.10)$ , or 920.7.

A smaller range causes the software to search longer to find an intensity level, which will fall within this range. If the Target Range is too small, the AGC function may not be able to find an acceptable intensity level. A larger Target Range may decrease the signal-to-noise ratio (decreased contrast) but will take slightly less time to find the acceptable intensity level.

## Test Location

A Q-DAS Report window text entry control for entering the location of the test.

## Test Part Number

A Q-DAS Report window text entry control. A required user-supplied number for identification of the part being tested.

## Test Plan Creator

A Q-DAS Report window text entry control for entering a person's name.

## Test Region k

Specifies the complex part of the index of refraction of an area inside a Test mask. The value is used along with the values in the Test Region n, Ref Region k, and Ref Region n Control boxes to correct for a phase shift condition. The value entered in this control is used only when the Phase Correction control is set to "n and k".

## Test Region n

Specifies the real part of the index of refraction of an area inside a Test mask. The value is used along with the values in the Test Region n, Ref Region k, and Ref Region n Control boxes to correct for a phase shift condition. The value entered in this control is used only when the Phase Correction control is set to “n and k”.

## Test Region Offset

Specifies an offset compensation value for an area inside a Test mask. The value is used along with the value in the Ref Region Offset Control box to correct for a phase shift condition. The value entered in this control is used only when the *Phase Correction* control is set to “Offset”.

## Test Time (min)

Specifies the time in minutes for the DMI test. Enter a value from 1 to 60 (0.1 minute = 6 seconds). Enter a value that approximates the amount of time it takes to make a measurement. Part of the DMI Test window; used with the radius scale option.

## Text

A text entry in the Q-DAS Report window for adding additional textual information. This entry is saved with the data.

## Tilt Direction

Specifies the orientation of the tilt fringes in degrees. Part of the Synthetic Fringe window.

## Tilt Fringes

Specifies the number of fringes to add to the cavity. Part of the Synthetic Fringe window.

## Tool Offset Sign

Changes the sign of the Tool Offset result to accommodate different test setups or lathe polarity. Settings are Unchanged or Changed. Used when measuring tool offset.

## Top Area Low Clip

Specifies the height distance (Z) from the peak of the data down to where the Top Area result is calculated. The Top Area Low Clip Mode control must be set to Fixed.

Available in Surface/Wavefront Multi Test Map Data window→New Control→Test & Ref X→Test→Top Area, where X is 1 to 10. (A separate control by the same name is available for each of the test regions.)

Used with Flat Panel measurement applications.

## Top Area Low Clip Mode

Specifies how clipping will be applied during the Top Area calculation. Selections are: Fixed or Pct Peak. When Fixed is selected, the value in the Top Area Low Clip control is applied. When PctPeak is selected, the value in Top Area Low Clip Pct is applied.

Available in Surface/Wavefront Multi Test Map Data window→New Control→Test & Ref X→Test→Top Area, where X is 1 to 10. (A separate control by the same name is available for each of the test regions.)

Normally used with Flat Panel measurement applications.

## Top Area Low Clip Pct

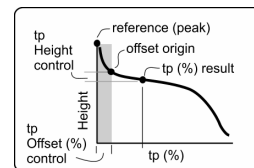
Specifies a percentage value of the peak height data as the distance down to where the Top Area result is calculated. For example, if the peak of the data is 100 nm high, and the percentage is set to 10, then the Top Area will be calculated 10 nm down from the peak.

Available in Surface/Wavefront Multi Test Map Data Window→New Control→Test + Ref X→Test→Top Area, where X is 1 to 10. (A separate control by the same name is available for each of the test regions.)

Normally used with Flat Panel measurement applications.

## tp1 Height

Specifies the height value on the profile bearing ratio curve where the tp1 (%) result is derived, relative to the height reference location specified by the tp Reference control, and the value in the tp1 Offset (%) control.



## tp2 Height

Specifies the height value on the profile bearing ratio curve where the tp2 (%) result is derived, relative to the height reference location specified by the tp Reference control, and the value in the tp2 Offset (%) control.

## tp3 Height

Specifies the height value on the profile bearing ratio curve where the tp3 (%) result is derived, relative to the height reference location specified by the tp Reference control, and the value in the tp3 Offset (%) control.

## tp1 Offset (%)

Specifies an offset value, in the X-axis, from the selected tp Reference location to ignore when determining the tp1 (%) result.

## tp2 Offset (%)

Specifies an offset value, in the X-axis, from the selected tp Reference location to ignore when determining the tp2 (%) result.

## tp3 Offset (%)

Specifies an offset value, in the X-axis, from the selected tp Reference location to ignore when determining the tp3 (%) result.

## tp1 (%)

Specifies the profile bearing ratio (expressed as a percentage) where the tp1 Height result is derived, relative to the reference location specified by the tp Reference control and tp1 Height control value.

## tp2 (%)

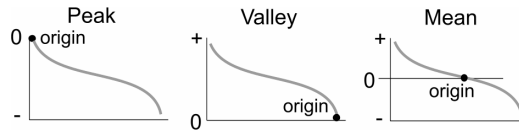
Specifies the profile bearing ratio (expressed as a percentage) where the tp2 Height result is derived, relative to the reference location specified by the tp Reference control and tp2 Height control value.

### tp3 (%)

Specifies the profile bearing ratio (expressed as a percentage) where the tp3 Height result is derived, relative to the reference location specified by the tp Reference control and tp3 Height control value.

### tp Reference

Selects the height reference location or origin used for the corresponding profile tp height controls and results. Choices are Zero, Peak, Valley, or Mean. Zero refers to the zero point in the sample, and depending on the data it may be close to the Mean location.



### Track button

Displays and tracks the current z-axis stage position in the Last Reading box. The track position is hidden when a key or mouse button is pressed, or the Touchscreen is touched. To reactivate the display, click the Track button again.

This button is available in the Micro LYNX window; and works only with applicable hardware.

### Translate Data button

Moves the origin (upper left corner) of the current data to the entered coordinates. Only applicable to instruments with programmable stages.

### Trim

Specifies the number of pixel layers removed from edges and around isolated obscurations. It is useful for removing bad data points from the measurement, such as those caused by diffraction at edges. From one to ten pixel layers can be removed. The action of the Trim control is controlled by the Trim Mode control.

The trim function is illustrated here. A sample data set of 9 x 9 pixels is shown. The shaded area represents an obscuration. A trim of 1 is shown by the X's.

x	x	x	x	x	x	x	x	x
x								x
x								x
x		x	x					x
x		x		x				x
x		x		x				x
x		x	x	x				x
x								x
x	x	x	x	x	x	x	x	x

A Trim of 1 is represented by the x's

The Trim control is available in both Control and Data windows. Trim in a Control window removes bad data points right after data is acquired, but before phase processing. Trimming in the Control window may be required if you measure a part with multiple discontinuous areas with substantial edge diffraction. Trim in a Data window removes bad data points after data is acquired and converted to phase values, but before it is analyzed and results are displayed. The advantage of trimming in the Data window is that you can change the trim value and reanalyze without remeasuring.

## Trim Data button

Applies the entry in the Trim control to the current data.

## Trim Mode

Selects how data is trimmed. The Trim Mode control is available in both control and data windows; the control works in union with the Trim control in the same window. Settings are All or Outside.

*All* trims pixel layers at the edges of all data including outside edges and edges around internal holes or obscurations. *Outside* trims pixel layers at the outside edges only and not around internal holes. This is useful for removing diffraction edge effects without trimming holes in the data due to dropouts from poor modulation or nonfunctional camera pixels.

## Tst Pt 1

For profile plots. Specifies the starting point of the test segment along the x-axis. Requires an entry in the Tst Pt 2 control. The Use Tst Pts control must be On.

## Tst Pt 2

For profile plots. Specifies the ending point of the test segment along the x-axis. Requires an entry in the Tst Pt 1 control. The Use Tst Pts control must be On.

## Turret LLC

Selects if the instrument light level is automatically adjusted when objectives are switched with the Objective button. When On, the light level automatically adjusts after changing objectives. It is equivalent to pressing the F5 key after switching an objective. The default value is Off.



## Two Wavelength

When On, activates two wavelength analysis for instruments with multi-wavelength capability. When On, data is acquired twice; once using the primary wavelength source, and again using the secondary wavelength source. These two wavelengths are then combined into a synthetic wavelength. When Off, data is acquired once with the primary source.

Two wavelength measurements are sensitive to mechanical vibration and edge effects or high to low transitions that fall on a single pixel. Use the Intens Avgs control to minimize the affect of mechanical vibration. Use the Pre-Connect Filter control to minimize edge effects.

## Undo button

Removes the last stored measurement values from temporary memory, which also removes these values from Process Stats and Control Charts. Each click removes one set of measurement values until the temporary memory is empty.

## Unlock GPI Encoded Zoom button

Refer to *Section 4* of this manual.

## Unset Focus Load button

Prompts the operator for confirmation, and then erases the focus load position.

## Unset Focus Zero button

Prompts the operator for confirmation, then erases the focus zero position.

## Unset Tilt Zero button

This button prompts the operator for confirmation, and then cancels the use of the tilt zero positions when running a pattern.

## Update button

Updates the video monitor screen or the software Live Display with the contents of the Video Monitor window.

## Upper tp Height

Specifies the upper height value on the profile bearing ratio curve where the Upper tp (%) result is derived, relative to the reference location specified by the tp Reference control.

## Upper tp (%)

Specifies the profile bearing ratio (expressed as a percentage) where the Upper tp Height result is derived, relative to the reference location specified by the tp Reference control. The default setting is 90.

## Upper Stp Height

Specifies the upper height value on the areal bearing ratio curve where the Upper Stp (%) result is derived, relative to the reference location specified by the Stp Reference control.

## Upper Stp (%)

Specifies the areal bearing ratio curve (expressed as a percentage) where the Upper Stp Height result is derived, relative to the reference location specified by the Stp Reference control. The default setting is 90.

## Use Ref Pts

For profile plots. When On, the Ref Pt 1 and Ref Pt 2 controls are active; they specify where the fit is done.

## Use Tst Pts

For profile plots. When On, the Tst Pt 1 and Tst Pt 2 controls are active; they specify over what area the profile results are calculated.

## Vibration Correction

Enables post-acquisition processing that corrects phase errors introduced by vibration.

Selections are: None(Off), Piston(On), and Tilt. The default setting is None.

GPI/VeriFire PE instruments only.

## Vibration Correction Avg Error

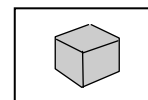
This control specifies how an error in vibration correction is handled during phase averaging. The message associated with the error is “Add more fringes.” When the control is set to Stop, the vibration error halts the phase averaging sequence and displays the message. When the control is set to Skip, the vibration correction error causes that acquisition to be skipped (omitted from the phase averaging summation) and allows the sequence to continue. For this control to work, the Phase Avg N Pct control must be set to a value of less than 100.

## View Pattern Pos button

Opens the Position Status window, which shows the current location of the pattern and can drive the stage to a location. Applicable only to systems with programmable stages.

## Volume Units

Selects the master unit system for all volume based results; settings are English or Metric. It applies to Volume results in a Test+Reference Data window, such as Up Vol.



For this control to affect a result or plot, the result or plot’s Unit command must be set to “Master”. The item’s Unit command is also used to select the specific measurement units, such as mm or  $\mu\text{m}$ .

## Waveform

Selects the waveform. Choices are: Sine, Triangle, Square, or Custom. Used with dynamic stroboscopic measurements. This control is available in a Control window with the New Control → Dynamic → Driver menu.

## Wavelength

ISO 10110-5 window. Selects the wavelength of the output results for the ISO 10110-5 window. This defaults to 546.07 nm by the ISO 10110-5 specification and corresponds to the green emission line of mercury.

BRDF window. Specifies the wavelength of the output data. It is used to display results as if the measurement was performed at a wavelength other than the instrument’s wavelength.

## Wavelength Fold

Selects how two wavelength data is analyzed. This control is only applicable for multi-wavelength capable instruments and when the Two Wavelength control is On.

When On, it combines synthetic wavelength data with the primary wavelength data to produce data with less noise; use this setting for measuring smooth surfaces. When Off, synthetic wavelength data is used; this is useful when measuring rough parts near the roughness limits.

## Wavelength Select

Specifies which Wavelength-In controls are used and the order of acquisition. The first number specifies the wavelength for viewing and the reference wavelength, if making multiple wavelength measurements with folding. This control is only applicable for multi-wavelength capable instruments and when the Two Wavelength control is On.

The entry can be a sequence of up to four digits (1, 2, 3, 4) separated by commas. When “1”, wavelength 1 is used for the single-wavelength measurement and viewing. When “2”, wavelength 2 is used.

## Wavelength-In

Specifies the wavelength of the light source used in the instrument. It is used to enter the laser wavelength when another type of laser is used. Settings: 0.25 to 10.6  $\mu\text{m}$ , default 0.6328  $\mu\text{m}$ . Do not confuse with the Wavelength-In X controls.

## Wavelength-In 1

Specifies the wavelength of the  $\lambda_1$  filter for a phase microscope. The wavelength of the filter is printed on the instrument's filter tray. This control is applicable only when the Two Wavelength control is On.

## Wavelength-In 2

Specifies the wavelength of the  $\lambda_2$  filter for a phase microscope. The wavelength of the filter is printed on the instrument's filter tray. This control is applicable only when the Two Wavelength control is On.

## Wavelength-In 3

Specifies the wavelength of a third light source. This control is only applicable for multi-wavelength capable instruments and when the Two Wavelength control is On.

## Wavelength-In 4

Specifies the wavelength of a forth light source. This control is only applicable for multi-wavelength capable instruments and when the Two Wavelength control is On.

## Wavelength-Out

Specifies the wavelength of the data displayed within an application. It is used to display results as if the measurement was performed at a wavelength other than 0.6328  $\mu\text{m}$ . Wavelength-Out scales the data in terms of the wavelength entered. Settings: 0.25 to 10.6  $\mu\text{m}$ , default 0.6328  $\mu\text{m}$ .

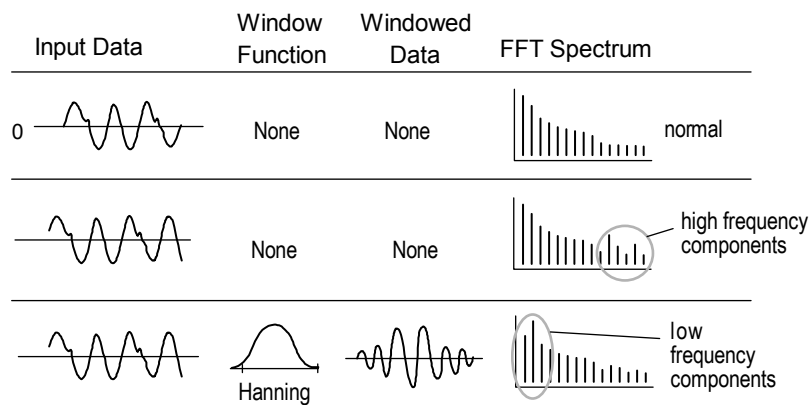
Wavelength-Out is useful to see how an optic performs at another wavelength. It affects only results that use waves as the measurement unit. It does not affect PSF and MTF results.

## Window

Selects windowing functions to minimize the effects of spatial-domain truncation in the Spectrum data window. Settings are None, Hamming, or Hanning. The Spectrum Data window performs a Fast Fourier Transform (FFT) on the surface data, breaking it into its frequency components. The FFT algorithm is based upon the assumption that the frequency data is periodic in space. Because this is not usually the case, the windowing function multiplies the input data by a function forcing the sample period to or near to zero at the ends.

Windowing improves the FFT analysis of data that is not periodic; however, the input data is modified and the FFT spectrum peaks are broadened somewhat. Generally, windowing is needed on a test part with pronounced low frequency content, and not needed on a fairly random test part.

Hanning and Hamming are variations of the windowing function. The Hanning window forces the sample period to zero; the Hamming window, near to zero. A one dimensional representation of windowing is shown here for simplicity.



## Window Size

Specifies the maximum number of result values that can be stored in temporary memory. It determines the x-axis on Control Charts and number of measurements that can be displayed in Process Stats. Settings: 0 to 999, the default setting is 5.

## Within Field Pattern File

Specifies the sub-pattern file to be used to measure each field on the part. The attribute indicates what sub-pattern file was used. Only applicable to instruments with programmable stages.

## Zernike Sample

Specifies the number of data points used in the Zernike calculation; it also reduces processing time. Selecting 1 uses every data point; selecting 2 uses approximately one-quarter of the data points; 3 uses approximately one-ninth of the data points; and 4 uses approximately one-sixteenth of the data points. However, no matter what number is selected, the data points on the x and y axes and diagonally through the center are always used. The fewer the data points sampled, the less accurate the Zernike result.

This drawing illustrates the effect of the Zernike Sample control. The box represents a sample data set. Points with X's are always selected. The bold X marks the center of the data. Selecting 1 chooses all points. Selecting 2 includes points with X's and 2's. Selecting 3 includes points with X's and 3's.

The user determines the proper setting for the Zernike Sample control. A simple way to check the effect is to make a series of Zernike calculations at different settings and cross compare results.

X		2	3	2		X		2	3	2		X
	X					X						X
2		X		2		X		2		X		2
3			X			X			X			3
2		2		X		X		X		2		2
						X	X	X				
X	X	X	X	X	X	<b>X</b>	X	X	X	X	X	X
						X	X	X				
2		2		X		X		X		2		2
3			X			X			X			3
2		X		2		X		2		X		2
	X					X						X
X		2	3	2		X		2	3	2		X

## Zernike Terms

In a data window, it specifies how many Zernike terms are analyzed and displayed in the “Zernikes” specialized window. In the control window, it specifies how many terms are used when generating a Zernike wavefront. Settings: none, 3, 4, 9, 16, 25, 36, or 37 (terms). You must specify that at least 9 terms be analyzed if you want to display Seidel coefficients results.

## Zoom LLC

Selects if the instrument light level is automatically adjusted when the zoom setting is changed. When On, the light level automatically adjusts after changing the zoom setting with the Image Zoom control. It is equivalent to pressing the F5 key after changing zoom settings. The default value is Off.





# ***Instrument Control***

## **Section 4**

*Controlling the light, instrument calibration, and error removal are important features that should be used with all measurements.*

### **This Section Includes...**

Instrument control functions listed in alphabetical order.

<b><i>Feature</i></b>	<b><i>Quick Overview</i></b>
<i>Auto Focus</i>	Focus the instrument on the part prior to the measurement. Motorized z-axis required.
<i>Auto Null</i>	Adjust the instrument in x, y, and z axes to null the fringes when measuring a spherical part. Motorized stage required.
<i>Auto Sequence Function</i>	Automate the process for a series of measurements.
<i>Auto Tilt</i>	Adjust the tip and tilt in the part to minimize the number of fringes prior to making a measurement. Motorized tip/tilt part stage required.
<i>Averaging</i>	Improve instrument measurement repeatability.
<i>Dynamic Stroboscopic Measurement Support</i>	Supports dynamic measurement of MEMS devices (micro-mechanical systems) while in motion. The associated controls apply only to NewView instruments with a strobe LED light source.
<i>Encoded Zoom and Encoded Focus GPI, VeriFire</i>	Provides simple computer control of hardware which enables repeatable positioning. The instrument must have CAN electronics and zoom and focus lens associated hardware.
<i>Error Removal</i>	Remove systematic instrument errors from the measurement results.
<i>Lateral Calibrator GPI, DVD-400, VeriFire</i>	Establish lateral measurement resolution of each camera pixel. Necessary for absolute units of measure other than pixels. Includes spherical calibration information.

<i>Lateral Calibrator Microscopes</i>	Establish lateral measurement resolution of each camera pixel. Necessary for absolute units of measure other than pixels. Includes designating objectives, creating TRC, and automatic lateral calibration information.
<i>Light Level Control</i>	Manually set light level for applicable instruments.
<i>Live +Display Window</i>	Applicable instruments display a live image of the part that serves as a focus and null aid.
<i>Micro LYNX Window</i>	Control applicable instrument's z-axis or focus stage.
<i>Video Monitor Output</i>	Display results and annotations on the external video monitor or in the software Live Display window.

## Auto Focus

### Overview of Auto Focus

<i>Feature</i>	<i>Function</i>	<i>Applicable Instrument</i>
<i>Auto Focus</i>	Focus the instrument on the part prior to making a measurement.	NewView with motorized Z-axis

### Using Auto Focus

Auto focus is a standard feature of the microscopes with a motorized z-axis. The auto focus function works best when:

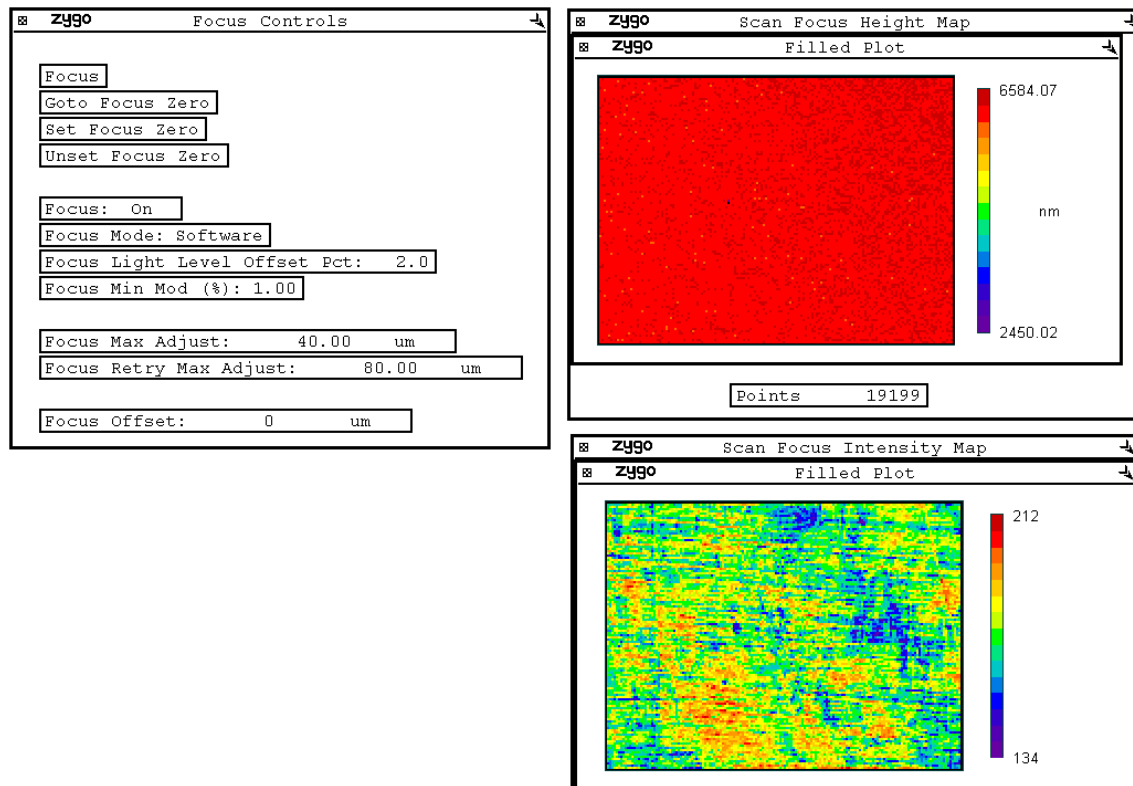
- using 320 x 240 Camera Mode
- measuring identical parts
- measuring multiple locations on the same part
- using a secure and repeatable part fixture
- measuring shiny and smooth parts

For scanning microscopes, auto focus is a quick, coarse measurement used to determine the best modulation within the scanned data. Because of this, it sometimes requires more or less light than the actual measurement. Focusing light level is adjusted with the Focus Light Level Offset Pct control. The focus data obtained is determined by the setting of the Focus Min Mod (%) control. This control is usually set to 5 or less. The setting of the Focus Light Level Offset Pct and Focus Min Mod (%) controls are critical for reliable auto focus operation.

To use auto focus, you may have to add the auto focus buttons and controls to a Control window. Data windows, available in the Microscope application, called Scan Focus Diagnostics, can also be created with Filled plots, to help fine-tune the settings of the controls. For explanations of all the auto focus controls, refer to *Section 3* under "Focus..."

Sample windows are shown in the following image.

## Example of Auto Focus Controls and the Scan Focus Windows



### Auto Focus Setup

1. Perform a normal measurement: Manually focus on the part. Set the light level. Measure the part. Ensure that focus and light level are optimally adjusted.
2. Set the Focus Mode control to Scan.
3. Press the Set Focus Zero button. This sets the current z-axis position of the microscope as zero; and on-screen readout values for Z are relative to this position.
4. Define the focus envelope. Enter a value in the Focus Max Adjust control that encompasses the part detail; an initial value can be the same as the Scan Length control setting. Double this value and enter it in Focus Retry Max Adjust.
5. Using the Value Format menu command, change the decimal places of the Focus Min Mod (%) to 2. This increases the sensitivity of the control and allows you change settings by hundredths.
6. Click the Focus button and observe the results. Observe the Scan Focus Height Map; if there is not enough data, try lowering the Focus Min Mod (%). The goal is to minimize noise and maximize the number of data points. Observe the Scan Focus Intensity Map; if the plot does not resemble the part try adjusting the Focus Light Level Offset Pct.
7. Test the software settings by changing the focus and pressing the Focus button. When the software is able to find focus and obtain sufficient data after a number of tests, the controls are properly set.
8. To activate auto focus for all measurements set the Focus control to On.

## Auto Null

### Overview of Auto Null

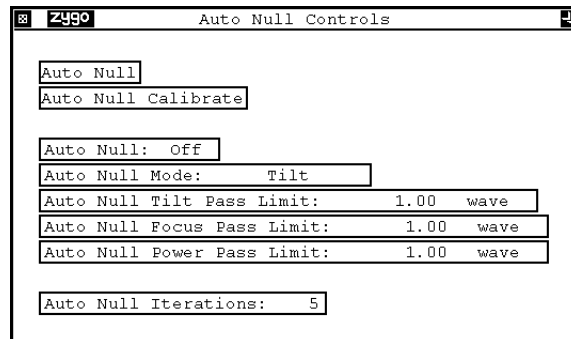
<i>Feature</i>	<i>Function</i>	<i>Applicable Instrument</i>
<i>Auto Null</i>	Adjust the instrument in x, y, and z axes to null the fringes when measuring a <i>spherical</i> part.	GPI, VeriFire, DVD400, or MicroLUPI with motorized x, y, and z axes

### Using Auto Null

Auto null requires an instrument equipped with a motorized programmable x, y, and z stage. Auto null is used when measuring the radius of curvature. In summary, auto null uses the x, y, and z calibration factors and the Auto Null Tilt Pass Limit values to adjust part positioning. The z-axis is moved to find optimum location for fringes and power; the x and y axes are moved to minimize the number of tilt fringes. The auto null function works best when:

- measuring similar spherical parts
- using a secure and repeatable part fixture
- measuring shiny and smooth spherical parts

To use auto null, you may have to add the auto null buttons and controls to a Control window. For explanations of all the auto null controls, refer to Section 3 under “Auto Null...”



### Auto Null Setup

1. Define a circular Acquire Mask.
2. Manually null the fringes at the confocal position.
3. Press the Auto Null Calibrate button. Check all four boxes (x, y, z, z)
4. After completion, enter values in the following controls for pass criteria: Auto Null Tilt Pass Limit, Auto Null Focus Pass Limit, and Auto Power Pass Limit. These values should be in waves or fringes.
5. Set Auto Null Iterations. Typically 6 or less is good.
6. Set the Auto Null Mode.
7. Test the software settings by changing the part x, y, and z positions and pressing the Auto Null button. When the software is able to find fringes and reduce the number of fringes, the controls are properly set.
8. To activate auto null for all measurements set the Auto Null control to On.

## Auto Sequence Function

MetroPro has the ability to automatically make a number of measurements and automatically save data. Various sequences of events can be controlled, from the number of measurements, the type of sequence, the auto saving of data files, to the time delays for events. A series of items are used together to command auto sequence functions.

The auto sequence function is useful for:

- Making a series of automatic measurements and saving data.
- Determining instrument repeatability and drift.
- Monitoring a surface over a period of time to study temperature effects or distortion after a manufacturing process.

### Auto Sequence Controls

The auto sequence controls are available in a Control window. Most of the controls are created with the New Control → Auto Sequence command.

<i>Item</i>	<i>Function</i>
<i>Auto Seq button</i>	Activates an auto sequence.
<i>Escape key</i>	Cancels the auto sequence function when pressed.
<i>Auto Seq Operation</i>	Determines the auto sequence mode. Measure tells the system to make a series of measurements. Run Pattern uses the current pattern file for a system with a programmable stage.
<i>Auto Seq Max Count</i>	Specifies the number of sequences to make. The Auto Seq Count attribute shows the number of sequences made.
<i>Auto Seq Delay</i>	Specifies a time delay before a sequence starts; in hours, minutes and seconds.
<i>Auto Seq Interval</i>	Specifies a time delay between sequences; in hours, minutes and seconds.
<i>Auto Save Data</i>	Activates automatic saving of measurement data.
<i>Auto Save Data File</i>	Specifies the data file name for auto saved data and selects the auto save data mode. To choose the mode, access the menu for this item and select the Mode command. The Auto-Increment mode automatically saves data files without user input.

## Auto Tilt

### Overview of Auto Tilt

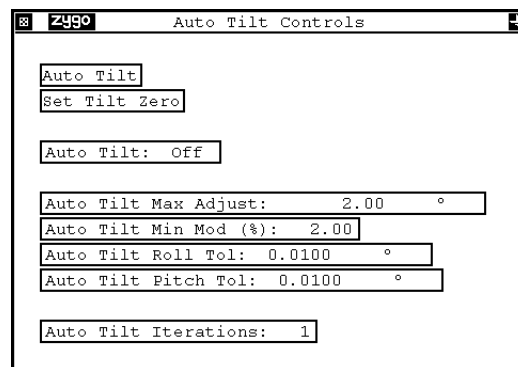
<i>Feature</i>	<i>Function</i>	<i>Applicable Instrument</i>
<i>Auto Tilt</i>	Adjust the tip and tilt in the part to minimize the number of fringes prior to making a measurement.	NewView, GPI, or VeriFire with motorized tip/tilt part stage

### Using Auto Tilt

Auto tilt requires an instrument equipped with a motorized programmable tip (or roll) and tilt (or pitch) part stage. Auto tilt takes a quick measurement, observes the tilt in the part and moves the stages to compensate. The auto tilt and auto focus functions can be used together in the NewView. The auto tilt function works best when:

- the surface is at the parcentric point of the stage
- measuring similar parts
- measuring multiple locations on the same part
- using a secure and repeatable part fixture
- measuring shiny and smooth parts

To use auto tilt, you may have to add the auto tilt buttons and controls to a Control window. For explanations of all the auto tilt controls, refer to Section 3 under “Auto Tilt...”



### Auto Tilt Setup

1. Perform a normal measurement: Manually focus on the part. Set the light level. Measure the part. Ensure that focus and light level are optimally adjusted.
2. Press the Set Tilt Zero button. This sets the current tip and tilt positions of the part stage as zero; and on-screen readout values for pitch and roll are relative to this position.
3. Define the tilt envelope. Enter a value in the Auto Tilt Max Adjust control that encompasses the part detail.
4. Using the Value Format menu command, change the decimal places of the Auto Tilt Min Mod (%) to 2. This increases the sensitivity of the control and allows you to change settings by hundredths.

5. Click the Auto Tilt button and observe the results. If there is not enough data, try lowering the Auto Tilt Min Mod (%). The goal is to minimize noise and maximize the number of data points.
6. Test the software settings by changing the tip and tilt and pressing the Auto Tilt button. When the software is able to find fringes and reduce the number of fringes, the controls are properly set.
7. To activate auto tilt for all measurements set the Auto Tilt control to On.

## Averaging

MetroPro provides averaging controls to improve the instrument measurement repeatability by increasing the signal-to-noise ratio of the data acquisition system. MetroPro has both intensity averaging and phase averaging. Both averaging techniques can be used together. Averaging increases the time required to analyze data. The time is dependent on the computer speed, the complexity of the data, and the number of data points.

Intensity averaging is faster than phase averaging, but should be used only when there is no perceptible fringe drift. Drift and vibration in the interferometer cavity can limit the effectiveness of averaging. But drift is less of a factor in phase averaging than intensity averaging, since sets of data are acquired in small intervals of 100-200 microseconds and then averaged. The sensitivity of phase averaging to drift is approximately 10 times to 120 times less than intensity averaging.

For intensity averaging, the camera and instrument board must be synchronized, otherwise you will receive an error. Normal resolution intensity averaging is performed at a rate of five acquisitions per second, allowing rapid measurements to be performed with improved repeatability. However, drift and vibration in the instrument can limit the effectiveness of intensity averaging. Since the intensity values are averaged over time, drift in the interferometer cavity causes the contrast of the interference fringes to decrease. If the drift is great enough, the contrast can be significantly reduced, decreasing the signal-to-noise ratio and negating the advantages of averaging, or causing data loss. A drift of one full fringe in the interferometer cavity during measurement time reduces the contrast and causes data loss.

## Averaging Controls

The averaging controls are available in a Control window. Most of the controls, except Intens Avgs, are created with the New Control → Phase Processing → menu.

<i>Item</i>	<i>Function</i>
<i>Intens Avgs</i>	Specifies the number of intensity averages performed during measurements. Intensity averaging averages the intensity values of each pixel of multiple camera frames. Enter a value from 0 to 62. Only applicable when the Acquisition Mode control is set to Phase or Intens.
<i>Phase Avgs</i>	Specifies the number of phase averages performed during measurements. Enter a value from 0 to 1024.
<i>Phase Avg Min N Pct</i>	Specifies the percentage of the contributing height maps wherein a point must be valid in order to produce an averaged point. This control is used to reject dropouts in some of the contributing height maps so the final averaged height map is not missing data.
<i>Phase Avg Pause</i>	When set to On, the measurement sequence is paused between multiple phase averages to allow time for the measurement cavity to stabilize. Click the on-screen button to continue. The Phase Avgs control must be set to 2 or greater.

## Dynamic Stroboscopic Measurement Support

MetroPro now supports dynamic measurement of MEMS (micro-electromechanical systems) devices while in motion. A series of measurements and 3D images are captured and stored as the device cycles through its range of motion. The data is acquired by synchronizing the frequency of the light source to the motion of the device; this acts as a strobe that effectively freezes the image for measurement. This provides full 3D characterization of devices while they are moving.

Dynamic controls apply only to NewView models equipped with a strobe LED light source, a frequency and waveform generator, a high voltage amplifier, and the proper software license. These features are licensed as “Dynamic” in the License/View window. For information on licensing, refer to the *MetroPro Quick-Start Guide*.

The following table includes a list of Dynamic controls. Refer to “Section 3” of this guide for a description of each control.



<b>Dynamic Controls - General</b>		
Dynamic Light Level	Dynamic Light Level Pct	LED Frequency
LLC Mode	Phase Delay	
<b>Dynamic - Driver Controls</b>		
Amplitude	Custom Waveform	Driver Frequency
Offset	Waveform	
<b>Dynamic - Movie Controls</b>		
Back (button)	Clear Movie (button)	Convert Movie (button)
Failure Action	Forward (button)	Frames Per Sec
Jump to Frame	Movie	Movie Data Dir
Movie File Base	Movie Window	Pause (button)
Play (button)	Playback Action	Reference Measurement
<b>Dynamic - Sweep Controls</b>		
End Frequency	End Phase Delay	Frequency Increment
Phase Delay Increment	Start Phase Delay	Start Frequency
Start Sweep (button)	Sweep Mode	

## Encoded Zoom and Encoded Focus

Encoded zoom and focus help minimize user variability and increases production throughput by providing simple computer enabled control with repeatable positioning. Preset positions for zoom and focus can be saved and loaded in software, reducing setup time and variability when measuring similar parts. The encoded zoom feature provides a calibrated 1X to 5X zoom range with bidirectional positioning accuracy of less than 2%.

The following controls, buttons and attributes are found in the GPI\_Encoded.app in the Encoded Zoom control window. They may also be added to the standard GPI application and are located as follows.



Item—Control or Button	Description
<p>There are two new controls which are located in a control window under New Control... → Interferometer... → GPI Encoded Zoom. They are described below.</p>	
<p><b>GPI Encoded Zoom Std Mag</b> (used in conjunction with the Set GPI Encoded Zoom Std Mag button)</p>	<p>From the pull down menu, select one of the pre-defined zoom lens positions (or magnification), to be used for the GPI encoded zoom hardware. Selections include: 1.0, 1.25, 1.50, 1.75, 2.0, 2.5, 3.0, 4.0, and 5.0X. This value can be saved with the application, or in a settings file.</p>
<p><b>GPI Encoded Zoom Var Mag</b> (used in conjunction with the Set GPI Encoded Zoom Var Mag button)</p>	<p>Enter a value for the magnification to be used for the GPI encoded zoom, or move to the appropriate zoom position using the Zoom buttons on the Remote Control. This value can be saved with the application, or in a settings file.</p>
<p>There are seven new buttons which are located in a control window under New Button... → GPI Encoded Zoom. They are described below.</p>	
<p><b>Set GPI Encoded Zoom Std Mag</b></p>	<p>Drives the encoded zoom hardware to the magnification setting selected with the GPI Encoded Zoom Std Mag control.</p>
<p><b>Set GPI Encoded Zoom Var Mag</b></p>	<p>Drives the encoded zoom hardware to the magnification setting established with the GPI Encoded Zoom Var Mag control.</p>

<b>Get GPI Encoded Zoom Var Mag</b>	There may be measurement conditions in which the zoom setting established with the GPI Encoded Zoom Std Var Mag control requires a small adjustment. Once the zoom position has been adjusted using the Remote Control, click this button to replace the value displayed in the GPI Encoded Zoom Var Mag control.
<b>Set GPI Encoded Zoom Min Mag</b>	Drives the GPI encoded zoom hardware to the minimum available magnification.
<b>Set GPI Encoded Zoom Max Mag</b>	Drives the GPI encoded zoom hardware to the maximum available magnification. Both of these buttons can be used as shortcuts instead of adjusting zoom with the Remote Control.
<b>Lock GPI Encoded Zoom</b>	This button prevents the zoom position from being adjusted using the Zoom buttons on the Remote Control, or with other methods as listed below. Locking the zoom is useful in preventing any minor change in the zoom (due to encoder noise), which preserves the data magnification value. When locked, zoom cannot be changed using any of these methods: <ul style="list-style-type: none"> <li>• Clicking buttons or controls</li> <li>• Pressing the Remote Control Zoom Up or Down buttons</li> <li>• MetroScript functions</li> </ul>
<b>Unlock GPI Encoded Zoom</b>	Unlocks encoded zoom. Magnification may vary slightly due to encoder noise.
There are two new attributes which are located in a control window under New Attribute... → Interferometer... → GPI Encoded Zoom. They are described below	
<b>GPI Encoded Zoom Instr Mag</b>	Indicates the current state of the instrument, or the current magnification setting.
<b>GPI Encoded Zoom Data Mag</b>	Indicates the magnification setting used when the measurement was taken. This value is saved with the data.

## Error Removal

MetroPro has built-in capabilities to compensate for ` by subtracting a data file made from a measurement of a known high quality part. Subtracting system errors improves measurement accuracy by subtracting instrument aberrations during the analysis cycle.

### Controls Used for Error Removal

<i>Control</i>	<i>Description</i>
<i>Subtract Sys Err</i>	When On, activates a system error correction function to improve measurement accuracy. A data file (or error file) must be created for the specific instrument setup in use, before activating this function.
<i>Sys Err File</i>	Specifies the name of a data file to subtract from measurements.

There are two methods you can use to create a system error file—the static method or the step and measure method. In both cases, it is necessary to measure a component or reference standard of known high quality.

<i>Instrument</i>	<i>Standard to Measure for Error Removal</i>
<i>Microscope (NewView)</i>	ZYGO Reference Flat or test part with $\leq 2$ angstroms rms
<i>Interferometer (GPI)</i>	Optic 2 times better than transmission element
<i>MESA</i>	ZYGO Reference Flat



The system error file is specific to the instrument's optical components and software settings. ZYGO strongly recommends creating a new error file when:

- The microscope objective is removed and installed. This does not apply when switching objectives with the turret.
- The interferometer's transmission element is removed and installed.
- The microscope's Image Zoom setting is changed.
- The Camera Mode control setting is changed.
- Environmental conditions changed.

### Static Method of Creating a System Error File

1. If necessary, create the Subtract Sys Err and Sys Err File controls in a Control window using the New Control → System Error command.
2. Set the Subtract Sys Err control to Off.
3. Focus the instrument on the known high quality test part and null the interference pattern. If necessary, create the Phase Avgs or Intens Avgs controls in a Control window using the appropriate New Control → menu. Then enter “8” in the average control.
4. Click the MEASURE button. Click the Save Data button. In the File Handler, click the Current Selection box, enter a name for the file that has an inherent meaning, such as “SysErrFile.dat” and press [Enter], then click Done to close the File Handler.

- Click the left mouse button on the Sys Err File control and enter the name of the reference data file named above. Set the Subtract Sys Err control to On. Subsequent measurements will have system errors subtracted from the data.

### **Step and Measure Method of Creating a System Error File**

Moving the test part between phase averages moves the errors contributed by the test part to different places so their magnitude in the system error file is reduced due to averaging.

- If necessary, create the Subtract Sys Err and Sys Err File controls in a Control window using the New Control → System Error command.
- Set the Subtract Sys Err control to Off.
- If necessary, create the Phase Avgs, Phase Avg Pause, Intens Avgs, and Remove controls in a Control window using the New Control → Phase Processing command.



For Microscopes: Set the Remove control to “Plane.”

For Interferometers: Select PST and TLT in the Remove Window.

This eliminates the influence of surface form from the averaging calculations.

- Click the left mouse button on the Phase Avgs control and enter at least “8” (for eight phase averages). Do the same for the Intens Avgs control. Set the Phase Avg Pause control to On.
- Focus the instrument on the known high quality test part and null the interference pattern. Click the MEASURE button.
- During the measurement cycle between each phase average cycle, the software will respond-
 

“Paused before phase averaging iteration of \* of \*. Press a mouse button.”

At this point, slightly move the test part in the X or Y axis (or rotate the part) and click one of the mouse buttons to continue. Repeat until the measurement is complete.
- Click the Save Data button. In the File Handler, click the Current Selection box, enter a name for file that has an inherent meaning, such as “SysErrFile.dat” and press [Enter], then click the Done button to close the File Handler.
- To turn off the averaging function, enter 0 in the Phase Avgs and Intens Avgs controls. Set the Phase Avg Pause control to Off.
- Click the left mouse button on the Sys Err File control and enter the name of the reference file named above. Set the Subtract Sys Err control to On. Subsequent measurements will have system errors subtracted from the data.

## ***Naming System Error Files***

The naming of the data files can be done manually or automatically. When the automatic mode is invoked, the software not only names the system error file during the creation phase, but also selects it during the measurement to match the current microscope objective and software settings.

### **Manual System Error File Names**

1. Click the Save Data button and enter a name for the system error file. Use a name that you will recognize and indicates the objective, zoom, and camera mode, such as "10X6401X.dat". Names must not exceed 20 characters, including the ".dat" extension.
2. Click on the Subtract Sys Err control so it says "On".
3. Click on the Sys Err File control and enter the name of the reference error file for the objective in use. Subsequent measurements will have system errors subtracted from the data.

### **Automatic System Error File Names**

1. Click on the Subtract Sys Err control so it says "On".
2. Click on the Sys Err File control and enter the @ character.
3. Measure the reference.
4. Click the Save Sys Err Data button to save the current measurement as the system error file. The software automatically generates the file name.
5. Repeat the above steps with other software settings and objective selections, if applicable.



The @ character in the Sys Err File control activates an automatic system error file naming function for both creating and selecting the data file to subtract from measurements. The software automatically creates the system error file name when the Save Sys Err Data button is clicked. The software also automatically selects the system error file to subtract from future measurements as based on the current objective selection and the settings of the Image Zoom and Camera Mode controls. Use this function to help manage multiple system error data files.

## ***Using System Error Data Files***

1. Click on the Subtract Sys Err control so it displays "On".
2. Click on the Sys Err File control and enter the @ character.
3. Select a desired combination of settings for Camera Mode, etc.
4. Measure a part. MetroPro will automatically generate the correct system error filename and subtract that data file from the current measurement.



The Sys Err File attribute displays the actual filename used.

### Naming Convention for MetroPro Generated Error Files

<i>Instrument</i>	<i>Name Convention</i>	<i>Example</i>
Microscopes	XXXXYYYYMMMMZZ.dat	0640 0480 0050 05.dat
Simetra	XXXXYYYYFF.dat	0640 0480 01.dat
Other Instruments	XXXXYYYYY.dat	0640 0480.dat

Where:

- XXXX = camera x dimension (pixels)
- YYYY = camera y dimension (pixels)
- MMMM = objective magnification
- ZZ = image zoom
- FF = field of view

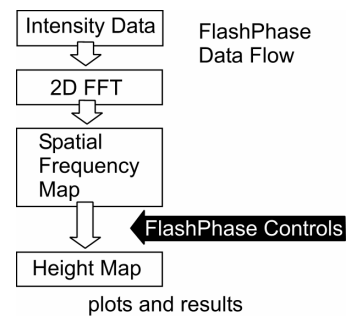
### FlashPhase™

*This acquisition mode is no longer available with the release of MetroPro 9.0. The following information is provided for reference purposes and backward compatibility only.*

#### Overview of FlashPhase

<i>Feature</i>	<i>Function</i>	<i>Applicable Instruments</i>
FlashPhase	Make fast, high-accuracy measurements in situations where traditional phase-shifting interferometry is not possible. It is useful for environments with vibration problems or interferometers without phase capability.	GPI, VeriFire, PTI 250, and Mark IVxp

FlashPhase is a very fast data acquisition technique, which is useful when operating the interferometer in environments with vibration and air turbulence. It is based on a mathematical Fourier analysis of intensity data to extract height information. The spatial frequency map is used to separate the intensity map into frequencies and isolate the 1st order signal, which contains the test part information. Tilting the part before measuring is required so the algorithm can separate the different orders.



Various FlashPhase controls influence the isolation of the spatial frequencies of the intensity map.



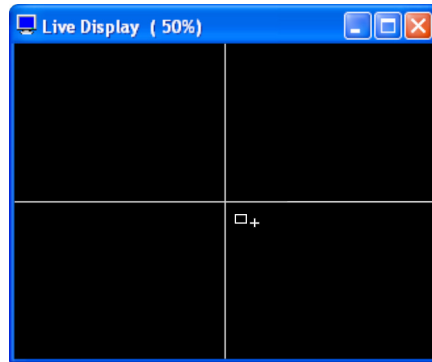
To activate FlashPhase, the Acquisition Mode control must be set to FlashPhase. Also, the FlashPhase option must be licensed in the MetroPro Edit/View Licenses window for this feature to function.

## Using FlashPhase

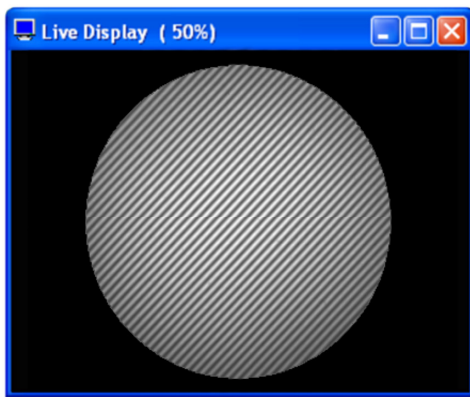
It is necessary to have approximately 30 to 60 fringes oriented on a 45 degree angle to separate the spatial frequencies. Controls used with Live Display window provide tools to help you tilt the part in this orientation.

It is helpful to use the Intensity Spectrum Map to visualize the complex spatial frequencies. When used with a Radial Ctr slice and the Intensity Spectrum Profile plot, you can measure the distance from one order (peak) to the next on the Profile plot with the inspect feature.

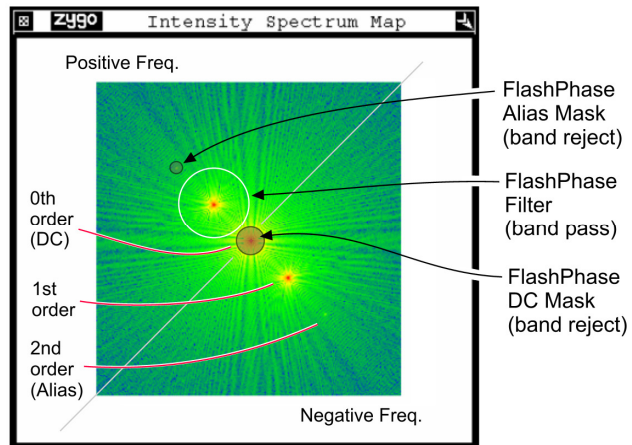
Remember, the goal of FlashPhase processing is to isolate the 1st order peak and minimize the effects of the other orders.



Put the Live Display window in the align mode by selecting FlashPhase Align with the Live Display Mode control. Adjust the tip/tilt of the part to move the small box over the small crosshairs. This introduces the correct tilt into the part.



The Live Display window shows a properly aligned part with multiple fringes oriented at 45 degrees. The Live Display Mode control is set to Fringes.



The Intensity Spectrum Map displays spatial frequencies. The Filled plot shows a mirror image of the positive and negative frequencies. Notations show how the plot relates to the FlashPhase controls.



Here is another example of an Intensity Spectrum Map zoomed up with the PSD View Area (%) control. A Radial Ctr slice is drawn over the peaks in the Filled plot.

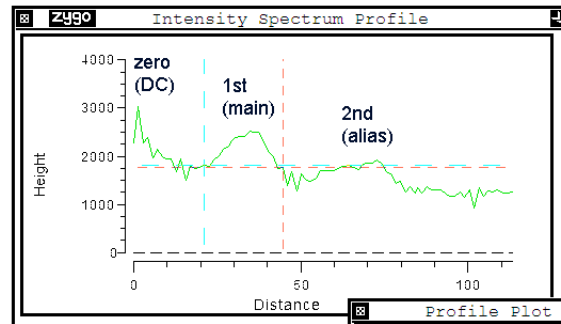
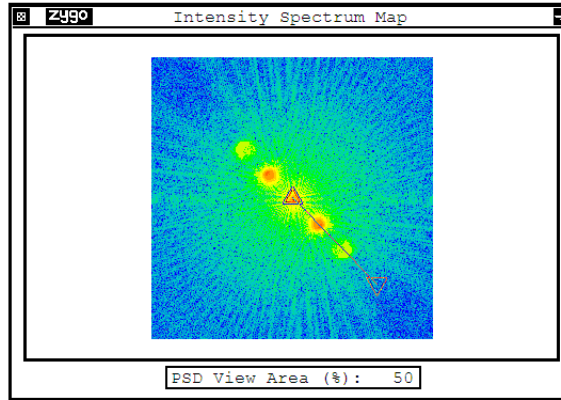


To help visualize the peaks in the Filled plot, turn off the Color Fit option in the plot controller.

The distance between peaks or zero and 1st orders in the Filled plot can be measured directly with the Intensity Spectrum Profile plot. Open the profile plot controller, set the Inspect button to Inspector 2 and move the crosshairs over the profile to determine spacing. The xDst readout displays the distance in pixels. In this case, xDst shows an example of a frequency band that can be isolated for analysis.



Notations added to the Profile plot are to clarify the use of these terms:  
 zero order or DC  
 1st order or Main  
 2nd order or Alias



Profile Plot	
yMax:	
yMin:	
xMax:	
xMin:	
yDst:	-39
xDst:	23.3
angle:	degs
Update	Inspector 2
Reset	Prof EV
Set	Trace
Level	AxesCtlOff

## FlashPhase Controls

The following controls relate to FlashPhase data acquisition; they are available in a Control window. Refer to the *FlashPhase Application booklet, OMP-0497*, for a description of each control.

- FlashPhase Target Fringe Number
- FlashPhase DC Mask
- FlashPhase Filter
- FlashPhase Alias Mask
- FlashPhase Trans. Sphere
- Live Display Mode

## Obtaining Maximum Accuracy with FlashPhase

- Minimize cavity error whenever possible (e.g. minimize defocus in spherical cavities).
- Cavities with larger errors require a greater amount of part tilt to adequately isolate the 1<sup>st</sup> order peak.
- Cavities with larger errors require larger FlashPhase control settings to pass (or reject) the specific peak.
- Use an acquisition mask to remove the background area.
- Minimize edge affects by reducing the aperture size with the Aperture controls.
- Use a system error file to remove tilt-induced errors.

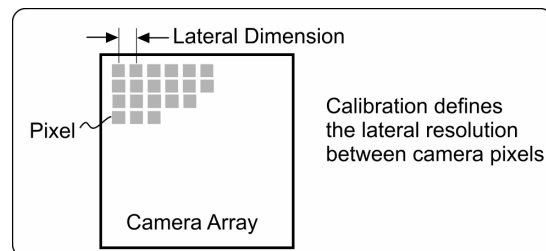
For the PTI 250, set the FlashPhase Subtract control to On and select the transmission sphere in use with the FlashPhase Trans. Sphere control. This is not required when using a transmission flat on the PTI 250.

## Lateral Calibration

### Why Calibrate?

Calibration establishes the lateral measurement resolution of each camera pixel. Calibration is performed with the Lateral Calibrator window; this window is opened by clicking on the Calibrate button. The Lateral Calibrator window allows you to provide MetroPro with a reference dimension with which it can compute the lateral dimension “seen” by each pixel of the instrument’s camera. The Lateral Calibrator window varies depending on the instrument.

Calibration is necessary for MetroPro to calculate some results and to provide absolute units of measure, such as millimeters or micrometers. Without calibration, MetroPro uses camera pixels, which are relative units of measure.



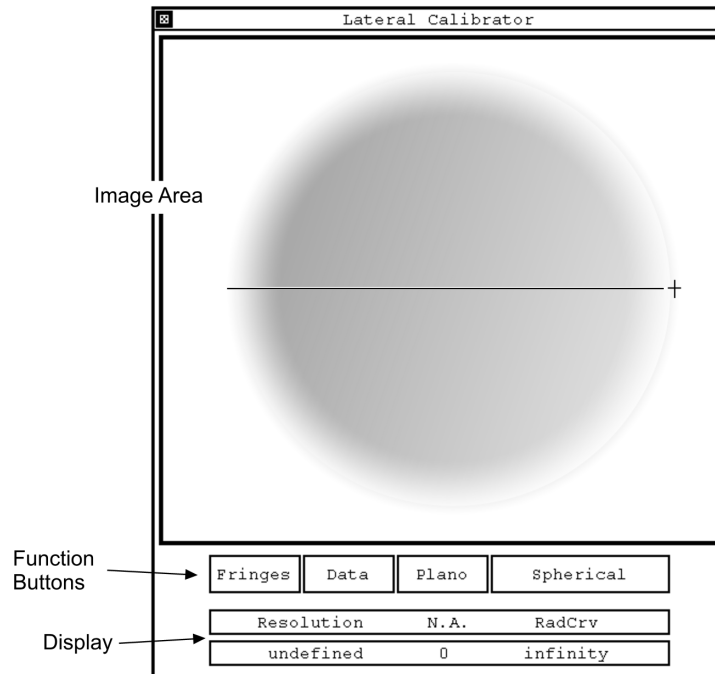
## Lateral Calibrator – GPI, VeriFire, DVD-400

Calibration establishes the lateral resolution of each camera pixel. Calibration is required to use lateral dimensions other than pixels, and whenever the GPI’s zoom setting is changed. The Lateral Calibrator window serves these basic functions:

- Establish “real” measurement units for the lateral dimensions of plano (flat) parts.
- Correct for spherical distortion within the instrument when measuring spherical parts. This applies only to the GPI and requires a Zygo Lateral Calibration Artifact matched to the Transmission Sphere or objective in use.

To open the interferometer Lateral Calibrator window, click the Calibrate button.

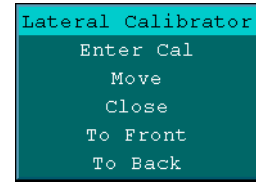
**Lateral Calibrator Window for the GPI, VeriFire, and DVD-400**



### Lateral Calibrator Description

<i>Item</i>	<i>Description</i>
<i>Image Area</i>	Displays image of intensity data. The data source is selected with the Fringes or Data buttons. An image only appears if the instrument is active.
<i>Function Buttons</i>	Fringes or Data – click to select source of image. Fringes display the current fringe pattern. Data displays data from the current measurement. Plano or Spherical – click to specify the wavefront to the interferometer. Plano refers to a flat wavefront; Spherical refers to a spherical wavefront.
<i>Display</i>	Resolution – shows the lateral dimension for each camera pixel. “undefined” means that the instrument is not calibrated. N.A. – shows the numerical aperture of the Calibration Artifact. Refers to spherical calibration only. RadCrv - shows the radius of curvature of the Calibration Artifact. Refers to spherical calibration only.

The menu for the Lateral Calibrator is accessed by pressing the right mouse button. The menu provides you with basic window commands. The window can be moved with the menu command or by pressing the middle mouse button on the window title bar. The window can be closed with the menu command or by clicking in the window close box with the left mouse button. The Enter Cal command is for use with microscope objectives.



**Plano Calibration Procedure**

The Lateral Calibrator window opens with “Plano” selected; this setting is used for calibrating the instrument for flat or plano parts.

Calibration can only be performed if an instrument is connected and working. Calibration must be made before making measurements. You cannot recalibrate existing data that is loaded into the application. Although the Lateral Calibrator window uses metric units, actual measurement results are displayed in whatever units of measure you choose for the results or plots.

1. Set up the interferometer and test part as instructed in the operation manual. Align the test part. Set the GPI’s zoom setting as desired.
2. Click the MetroPro Calibrate button to open the Lateral Calibrator window. Click either the Fringes button or Data button to specify the source of the fringe pattern.
3. Position the crosshairs over the part image and press the left mouse button, move the mouse to draw a line across some portion of the image, and release the mouse button.

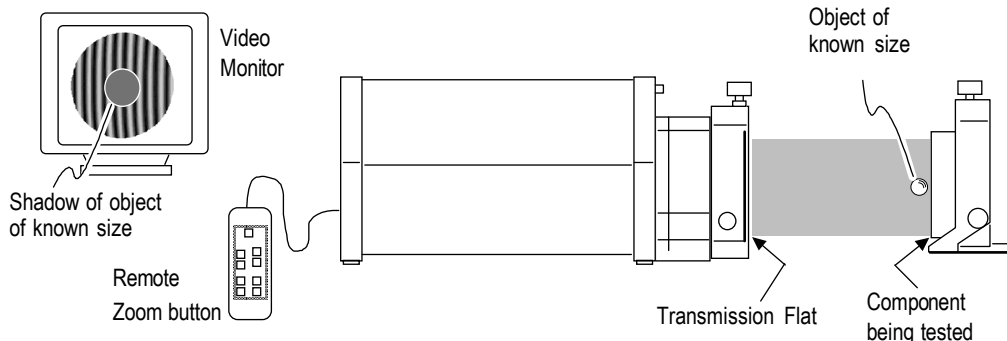


The longer the line is drawn the greater the accuracy.

4. In the entry box, type the dimension in millimeters for the line just drawn and press Enter.

**Plano Calibration Hints**

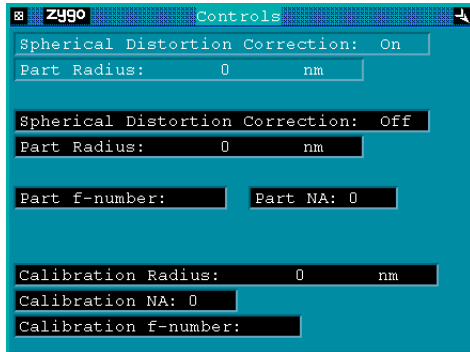
When using a transmission flat, a simple way to calibrate is to place an object of known size in the field of view. In the Lateral Calibrator window, draw the definition line across the shadow of the object and enter its dimension in the entry box. This method works at any zoom setting, as long as the edges of the reference object are visible in the image area of the Lateral Calibrator window.



## Spherical Distortion Correction

The Lateral Calibrator, along with several MetroPro controls, can be used to correct for spherical distortion within the instrument when measuring spherical parts. This applies only to the GPI and requires a Zygo Lateral Calibration Artifact. The Artifact used for spherical calibration must be matched to the objective or Transmission Sphere you are using.

### Spherical Distortion Controls and Attributes



When correcting for spherical distortion, you must enter the nominal part radius in the Part Radius control, and make sure the Spherical Distortion Correction control is On. These controls are available within a Control window with the New Control → Distortion Correction command. There are also a number of attributes for this feature. The attributes are available within a Control window with the New Attribute → Distortion Correction command. The Control window shown here was created using these commands.

<i>Control or Attribute</i>	<i>Description</i>
<i>Spherical Distortion Correction</i>	When On, spherical measurements use the spherical calibration data to correct for distortion. The corresponding Attribute shows the state of this control for the current measurement. A value is also required in the Part Radius control.
<i>Part Radius</i>	Specifies the nominal radius of the part under test. The units can be changed with the Unit command from the Control Box's menu. The Spherical Distortion Correction control must be On.
<i>Part f-number</i>	Attribute that displays the f-number of the test part.
<i>Part NA</i>	Attribute that displays the numerical aperture of the test part.
<i>Calibration Radius</i>	Attribute that displays the radius of the Calibration Artifact as entered during the spherical calibration procedure.
<i>Calibration NA</i>	Attribute that displays the numerical aperture of the Calibration Artifact as entered during the spherical calibration procedure.
<i>Calibration f-number</i>	Attribute that displays the f-number of the Calibration Artifact as entered during the spherical calibration procedure.

## Spherical Calibration Procedure

Calibration can only be performed if an instrument is connected and working. Calibration must be made before making measurements. You cannot recalibrate existing data that is loaded into the application. Although the Lateral Calibrator window uses metric units, actual measurement results are displayed in whatever units of measure you choose for the results or plots.

1. Place the Calibration Artifact, that is matched to the Transmission Sphere or objective in use, in the output beam of the interferometer. Adjust the interferometer to center the Calibration Artifact into a bulls-eye fringe pattern. Set the GPI's zoom setting as desired.
2. Click the Measure button to make a measurement of the Artifact.

3. Click the MetroPro Calibrate button to open the Lateral Calibrator window. Make sure the Spherical and Data buttons are selected.

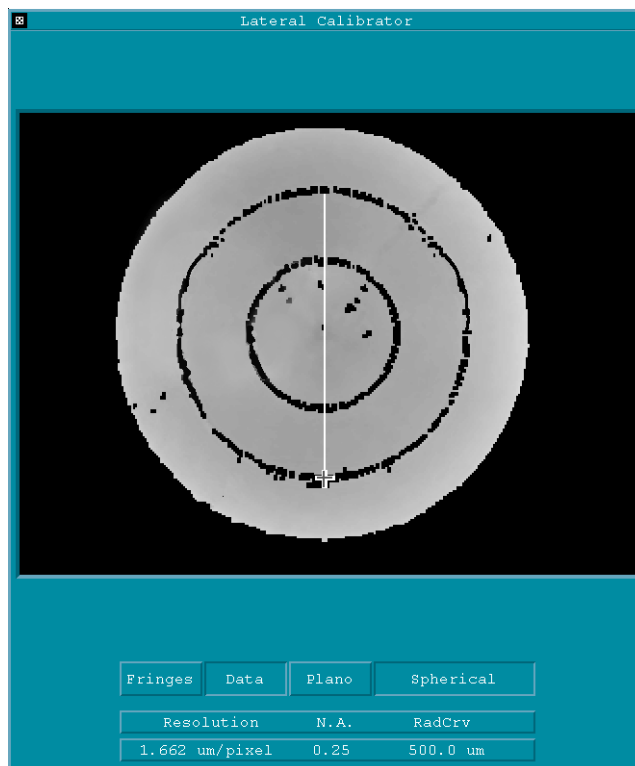
4. Position the crosshairs over the part image and press the left mouse button, move the mouse to draw a line between the inside edges of the second concentric ring. Then release the mouse button

5. In the first entry box, enter the actual diameter of the ring the line was drawn across. (Provided with each artifact.)

6. In the second entry box, type in the radius of curvature of the Calibration Artifact.

7. To activate spherical correction for subsequent measurements, set the Spherical Distortion Correction control to On and enter the nominal radius of the test part in the Part Radius control. These controls are available within a Control window with the New Control → Distortion Correction command.

The Lateral Calibrator - Used to Correct for Spherical Distortion



Note that the line drawn over the artifact data is from the inside edges of the second concentric ring.

## Lateral Calibrator - Microscopes

Calibration specifies the actual magnification for each objective and establishes the accuracy of the lateral measurements for each microscope objective with a given zoom lens. A Lateral Calibration Standard is required to perform calibration. The Lateral Calibrator window for microscopes serves these functions:

- Establish “real” measurement units for the lateral based results, such as the units in the Oblique plot and the Profile plot, and the Length and RadCrv results.
- Designate what objectives are installed. This determines what choices show up in the MetroPro Objective button when it is clicked.
- Verify what zoom lenses are installed (for applicable NewView models only).
- Create turret reference coordinates (TRC) so test parts stay aligned and in focus when objectives are switched. Motorized turret and stages are required.
- Provide for improved calibration with the Auto Cal (automatic lateral calibration) function.
- Remaster objectives to a “golden” part standard with the Enter Cal command.

To open the microscope Lateral Calibrator window, click the Calibrate button.

### Lateral Calibrator Window for NewView Models with Motorized Turret

The screenshot shows the 'Lateral Calibrator' window. At the top, there is a title bar with the text 'Lateral Calibrator'. Below the title bar is a large 'Image Area' displaying a grayscale microscope image of a surface with a dark spot. Below the image area is a table with columns for Objectives, zoom levels (0.5X, 0.75X, 1X), and calibration status (Cal, TRC). To the right of the table are several function buttons: Set TRC, Clear TRC, Clear Cal, Auto Cal, Fringes, Data, and Close. Brackets below the table and buttons group them into categories: Calibrate (#) buttons, Objective buttons, Zoom buttons (hardware dependent), and Function buttons.

	Objectives				0.5X zoom		0.75X zoom		1X zoom		Set TRC
	Title	N.A.	Nom		Cal	TRC	Cal	TRC	Cal	TRC	
1	5X Mich	0.130	5.0X		2.56X	no	3.82X	yes	5.05X	yes	Clear Cal
2	empty				-	-	-	-	-	-	Auto Cal
3	empty				-	-	-	-	-	-	Fringes
4	empty				-	-	-	-	-	-	Data
5	20X Mirau	0.400	20.0X		10.02X	yes	15.33X	yes	21.72X	yes	Close
6	empty				-	-	-	-	-	-	

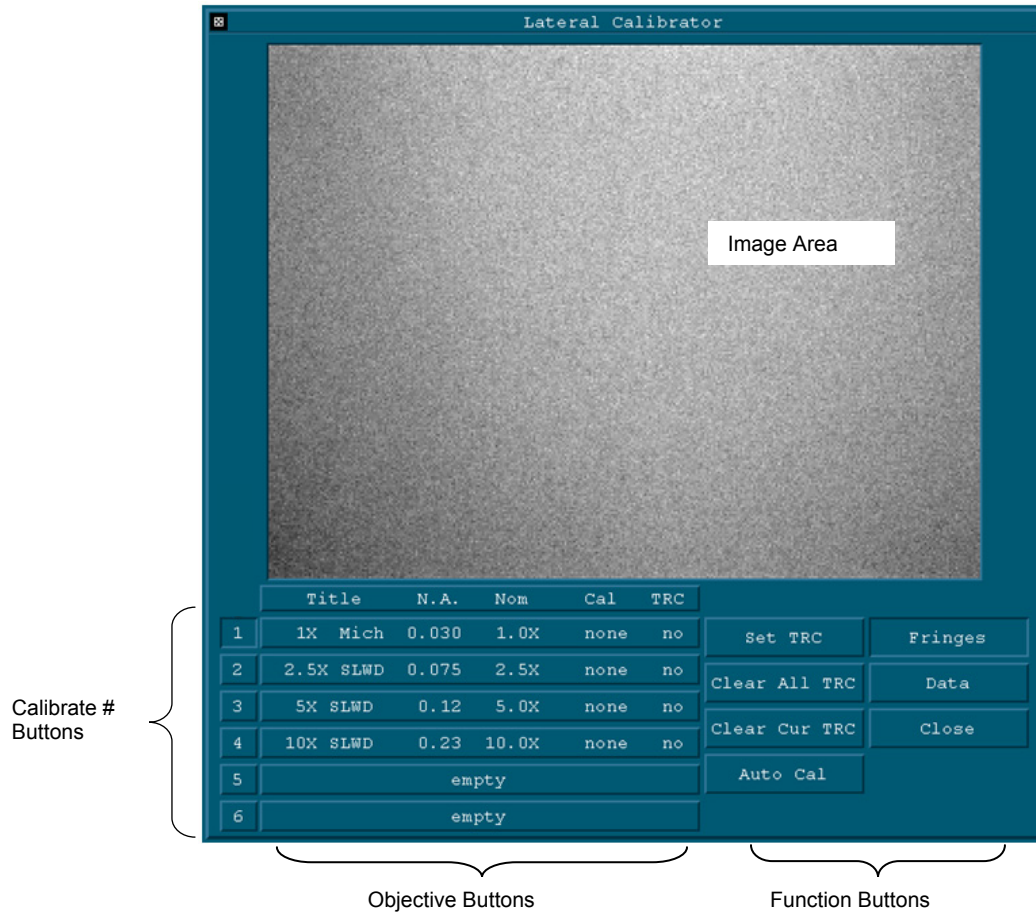
Calibrate (#) buttons      Objective buttons      Zoom buttons (hardware dependent)      Function buttons

## ***Lateral Calibrator-Motorized Turret Description***

<b><i>Item</i></b>	<b><i>Description</i></b>
<b><i>Image Area</i></b>	Displays a frame of camera data. The data source is selected with the Fringes or Data button. An image only appears if the instrument is active.
<b><i>Calibrate Buttons</i></b>	These “number” buttons select the objective being calibrated and will move the motorized turret to that position if the instrument is so equipped.
<b><i>Objective Buttons</i></b>	Click each objective button until the objective listed matches the objective in place. Select “empty” when there is no objective in the turret opening. Title – objective power and type. N.A. – numerical aperture. Nom. – (nominal) theoretical magnification.
<b><i>Zoom Buttons</i></b>	The specific zoom lens listed in the button is based on what zoom lens is installed; this setting is automatically updated whenever a zoom lens is installed. Up to three discrete zoom lenses can be used depending upon the NewView model. Some NewView models have hardware for only one zoom lens.  Click a zoom button to change the zoom turret to that selection; this is the same as selecting the zoom with the Image Zoom control. The word “empty” indicates that a zoom lens is not installed. The words “zoom n/a” indicates that the system does not support multiple zoom lenses.  Cal. – displays the actual calibrated objective magnification with the listed zoom lens; a dash “-” means the zoom lens and/or objective is empty, “none” means not calibrated. TRC – Indicates if TRC (Turret Reference Coordinates) are defined; “yes” means coordinates are stored, “no” means coordinates are not stored, a dash “-” means the zoom lens and/or objective is empty.
<b><i>Function Buttons</i></b>	<b>Set TRC</b> – click to set and store coordinates for the selected objective at a given zoom. It first verifies that the coordinates are within the range of all other objectives; if not an error message is displayed. <b>Clear TRC</b> – click to access options to clear coordinates. Clear Current clears the current objective and zoom lens. Clear Column clears the current zoom column. Clear All clears coordinates for all objectives at all zoom settings. <b>Clear Cal</b> – click to access options to clear calibration settings. Clear Current clears the current objective and zoom lens. Clear Column clears the current zoom column. Clear All clears calibration for all objectives at all zoom settings. <b>Auto Cal</b> – click only when performing automatic lateral calibration. <b>Fringes</b> – click to display current fringe pattern. <b>Data</b> – click to display data from the current measurement. <b>Close</b> – click to close the Lateral Calibrator window.



**Lateral Calibrator Window for NewView Models with Manual Turret**



<i>Item</i>	<i>Description</i>
<i>Image Area</i>	Displays a frame of camera data. The data source is selected with the Fringes or Data button. An image only appears if the instrument is active.
<i>Calibrate Buttons</i>	These buttons identify the objective being calibrated.

<i>Item</i>	<i>Description</i>
<i>Objective Buttons</i>	<p>Click each row until the objective Title matches the objective in place.                      Select “empty” when there are no objectives to designate.</p> <p>Title –objective power and type.                      N.A. – numerical aperture.                      Nom. – (nominal) theoretical magnification.                      Cal. – (calibrate) the actual calibrated magnification, “none” means not calibrated.                      TRC – (Turret Reference Coordinates), “yes” means coordinates are stored; “no” means coordinates are not stored.</p>
<i>Function Buttons</i>	<p><b>Set TRC</b> – click to set and store coordinates for the selected objective. It first verifies that the coordinates are within the range of all other objectives; if not an error message is displayed.  <b>Clear ALL TRC</b> – click to clear all coordinates.  <b>Clear Cur TRC</b> – click to clear coordinates for current objective.  <b>Auto Cal</b> – click only when performing automatic lateral calibration.  <b>Fringes</b> – click to display current fringe pattern.  <b>Data</b> – click to display data from the current measurement.  <b>Close</b> – click to close the Lateral Calibrator window.</p>

### Lateral Calibrator Window for NewView 5000

Image Area  
(image from  
Lateral Calibration  
Standard is shown)

	Title	N.A.	Nom	Cal	TRC	
1	2.5X Mich	0.075	2.5X	2.43X	yes	Set TRC
2	5X Mirau	0.130	5.0X	4.48X	yes	Clear All TRC
3	10X Mirau	0.300	10.0X	10.05X	no	Clear Cur TRC
4	20X Mirau	0.400	20.0X	none	no	Close
5	empty					Auto Cal

Calibrate Buttons

Objective Buttons  
(each row is a button)

Function Buttons

## ***NewView 5000 Lateral Calibrator Description***

<b><i>Item</i></b>	<b><i>Description</i></b>
<b><i>Image Area</i></b>	Displays a frame of camera data. The data source is selected with the Fringes or Data button. An image only appears if the instrument is active.
<b><i>Calibrate Buttons</i></b>	These buttons select the objective being calibrated and will move the motorized turret to that position if the instrument is so equipped.
<b><i>Objective Buttons</i></b>	Click each row until the objective Title matches the objective in place. Select “empty” when there are no objectives to designate.  Title –objective power and type. N.A. – numerical aperture. Nom. – (nominal) theoretical magnification. Cal. – (calibrate) the actual calibrated magnification, “none” means not calibrated. TRC – (Turret Reference Coordinates), “yes” means coordinates are stored; “no” means coordinates are not stored.
<b><i>Function Buttons</i></b>	<b>Set TRC</b> – click to set and store coordinates for the selected objective. It first verifies that the coordinates are within the range of all other objectives; if not an error message is displayed. <b>Clear ALL TRC</b> – click to clear all coordinates. <b>Clear Cur TRC</b> – click to clear coordinates for current objective. <b>Auto Cal</b> – click only when performing automatic lateral calibration. <b>Fringes</b> – click to display current fringe pattern. <b>Data</b> – click to display data from the current measurement. <b>Close</b> – click to close the Lateral Calibrator window.

### ***Designating Objectives***

This determines the objective choices in the MetroPro Objective button and associates a particular objective with a turret position.

1. Click on each row in the objective display with the left mouse button until the objective title appearing in the display matches the objective.



Make sure the numbered position in the Calibrator window matches the position of the objective in the turret.

2. Select “empty” when there is no objective to designate.

## Standard Microscope Calibration Procedure



### Warning!

Do not experiment with the Calibrator window. Clicking on an objective display which has been calibrated (denoted by a number under the “Cal.” column) deletes that objective’s calibration data.

Calibration can only be performed if an instrument is connected and working. Calibration must be made before making measurements. You cannot recalibrate existing data that is loaded into the application.

Objectives are factory calibrated if they are purchased with the original system; recalibration is not required on these objectives. Perform the calibration procedure if you want to verify the calibration or add different objectives.



A ZYGO Lateral Calibration Standard, P/N 1670-000-020, is required to calibrate the objectives.

If calibration is not performed for an objective, MetroPro uses the nominal magnification.

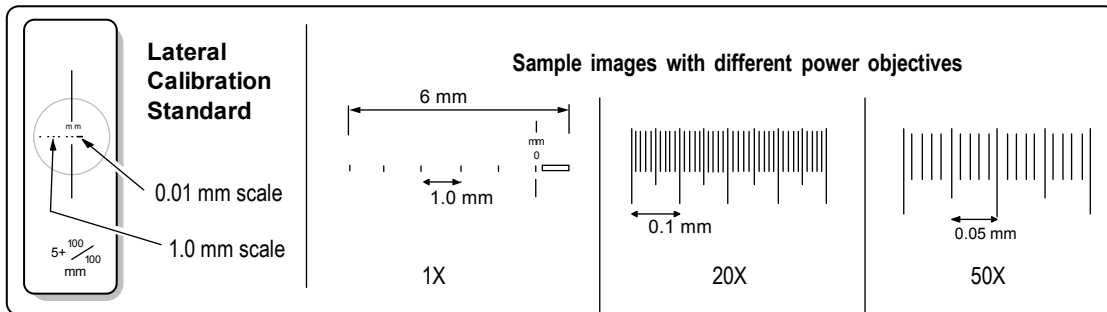
1. Designate objectives as previously described.
2. Position the Lateral Calibration Standard under the objective. Focus the objective on the standard's lines and then null the fringe pattern. The lines in the Lateral Standard should be aligned parallel to the borders of the image window.



Handle the Standard with care. The features are very fine and are easily damaged. Do not touch the measurement surface. To remove dust from the Standard, use a short burst of dry, filtered air. Store the Standard in its case when not in use.

3. Click the Calibrate button to open the Lateral Calibrator window. Then click the Fringes button. If you have problems seeing the lines on the standard, measure the Standard and then click the Data button in the Lateral Calibrator.

### Sample Images of the Lateral Calibration Standard



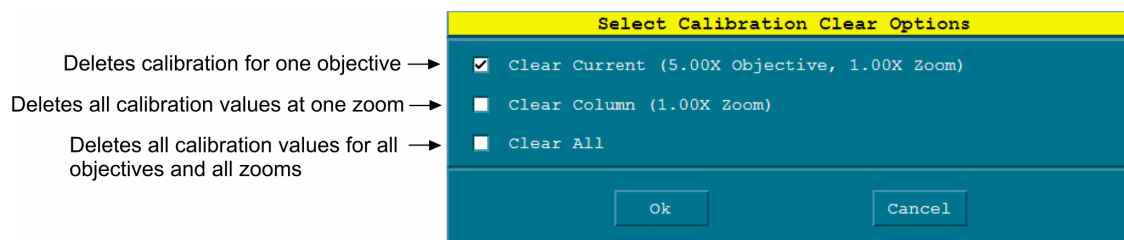
4. Select the objective to calibrate by clicking on the small numbered box to the left of its title in the Lateral Calibrator window.
5. Draw a line across the image. Position the crosshairs over the image, press and hold the left mouse button; move the mouse to draw a line parallel to the Standard's scale; and release the mouse button for the end point. The longer the line drawn, the more accurate the calibration.
6. Using the keyboard, enter the length of the drawn line in millimeters, as determined by reading the Calibration Standard scale, then press Enter. Values obviously out of range for a given objective will not be accepted.

The calibrated objective magnification value is displayed under "Cal" when it is present.

7. Repeat steps 2 through 6 for other objectives. Calibration data is automatically saved when the Lateral Calibration window is closed.

### **Clearing Calibration (NewView 6000/7000)**

1. To remove stored calibration, click Clear Cal and select the appropriate options in the dialog box.



### **Automatic Microscope Lateral Calibration Procedure**

Automatic Lateral Calibration is for the NewView microscope and requires a Precision Lateral Calibration Standard, ZYGO P/N 6300-2198-01, and the current version of MetroPro. The Automatic Lateral Calibration application, AutoLatCal.app, facilitates this calibration procedure.

Automatic Lateral Calibration significantly improves the lateral measurement performance of the microscope. Automatic Lateral Calibration should be used, in place of the regular Lateral Calibration, when true three-dimensional measurements are required. A true three-dimensional measurement precisely maps height (z) data to the lateral (x-y) dimensions of the part. This higher level of calibration is recommended for spacing and angle results, such as S or Cone Angle. It is *not* required for roughness results or height-based results, such as Ra, PV, or rms.

1. Load and open the Automatic Lateral Calibration application (AutoLatCal.app).
2. Make sure the objectives are designated as previously described in this section.
3. Select the objective you want to calibrate with the MetroPro Objective button. If you have a motorized turret, the objective will move into position. Otherwise, move (manual turret) or mount (single objective mount), the applicable objective into position on the microscope.

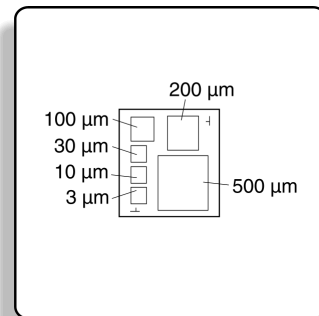
4. Open the Measure Cntrl window and ensure the following controls are set correctly. Change the Image Zoom control to match the zoom setting on the microscope (NewView 5000 only). If the microscope is equipped with encoded zoom, the Image Zoom control will automatically match the instrument zoom setting. Ensure the Camera Mode control is set to the highest available resolution; this applies even if measurements will occur at a different Camera Mode setting.
5. Position the Precision Lateral Calibration Standard under the objective.



Handle the Standard with care. The features are very fine and are easily damaged. Do not touch the measurement surface. To remove dust from the Standard, use a short burst of dry, filtered air. Store the Standard in its case when not in use.

6. Select the appropriate test area on the standard according to the applicable Automatic Lateral Calibration Test Area Chart. Move the stage to place the selected test area within the field of view. If the objective and zoom setting are not listed in the chart, then move the stage to place 8-25 rows of dots within the field of view.

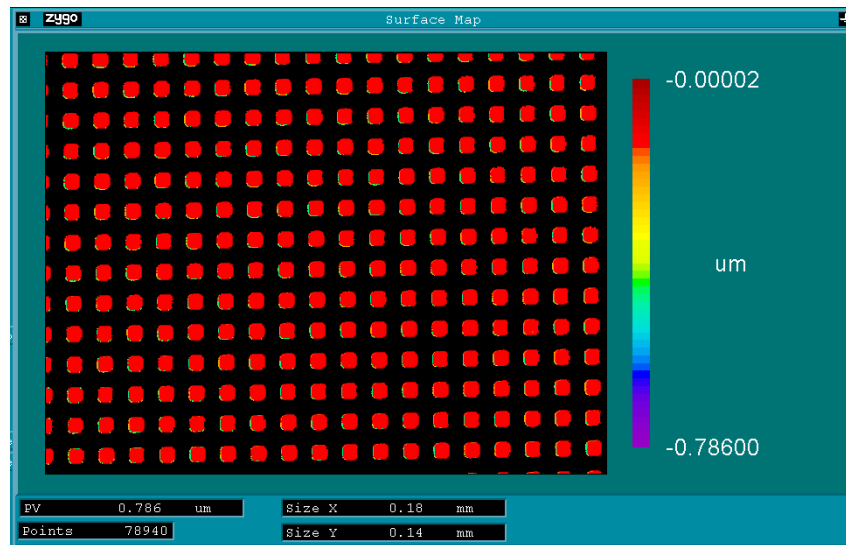
**Precision Lateral Calibration Standard**



For the 3-30 μm pitch clusters, select calibration areas away from the left edge of the standard.

7. Focus the objective on the standard until the dots are clearly visible on the video monitor. Adjust light level to make the dots visible if necessary.
8. Make sure that the dots either fill the view screen or are centered within the field of view. The dots should be aligned fairly parallel to the borders of the video monitor. Adjust the rotation of the standard if it is skewed more than the distance between two dots.
9. For a few of the lower magnification selections, the dots will not fill the entire view screen. To calibrate correctly, an acquisition mask is necessary. Create a square acquisition mask. Center the mask using the move control in the Mask Editor. The mask should be sized to contain all of the dots. There should be a small gap between the borders of the mask and the dots. Once the mask is created you must define the mask using the Define button in the Mask Editor.
10. Focus the objective and null the fringe pattern. There should be at most three fringes visible. Set light level to eliminate over-saturation and resultant data drop out.
11. Click the Measure button.
12. The measurement is valid if the dots are well defined with no data drop out and only dots are visible within the filled plot. There should only be dots visible; all other areas of the test mask should be black indicating no data is present.

**Sample Measurement Showing Valid Data**



13. If data is not valid, the Light Level is the most likely the cause. Readjust the Light Level and remeasure. If the data is still not valid, try another area on the test standard with the same grid spacing.
14. Click the Calibrate button to open the Lateral Calibrator window. Select the objective you are calibrating by clicking on the small box to the left of its title.
15. Click the Auto Cal button in the Lateral Calibration window. A prompt will appear for a length in microns. Enter the mean spacing for the measured area of the standard. The mean spacing value can be read from the certificate of calibration included with each standard.
16. Repeat steps 3 through 15 for other objectives or zoom settings. Calibration data is automatically saved when the Lateral Calibration window is closed.



**NewView 5000 Automatic Lateral Calibration Test Area Chart (640x480)**

Objective	Zoom Setting	Approximate Magnification	Proper Test Area (mean spacing $\mu\text{m}$ )	Approximate Number of Rows, Columns
1x	0.4x	0.4x	500	15, 15*
1x	0.5x	0.5x	500	15, 15*
1x	0.8x	0.8x	500	14, 15*
1x	1.0x	1.0x	500	11, 14
1x	1.3x	1.3x	200	21, 23*
1x	2.0x	2.0x	200	13, 17
2x	0.4x	0.8x	500	14, 15*
2x	0.5x	1.0x	500	11, 14
2x	0.8x	1.6x	200	17, 22
2x	1.0x	2.0x	200	13, 17
2x	1.3x	2.6x	200	10, 13
2x	2.0x	4.0x	100	13, 17
2.5x	0.4x	1.0x	500	11, 14
2.5x	0.5x	1.25x	200	22, 29
2.5x	0.8x	2.0x	200	13, 17
2.5x	1.0x	2.5x	200	11, 14
2.5x	1.3x	3.25x	100	16, 21
2.5x	2.0x	5.0x	100	11, 14
5x	0.4x	2.0x	200	13, 17
5x	0.5x	2.5x	200	11, 14
5x	0.8x	4.0x	100	13, 17
5x	1.0x	5.0x	100	11, 14
5x	1.3x	6.5x	100	8, 10
5x	2.0x	10.0x	30	18, 24
10x	0.4x	4x	100	13, 17
10x	0.5x	5x	100	11, 14
10x	0.8x	8x	30	22, 29
10x	1.0x	10x	30	18, 24
10x	1.3x	13x	30	14, 18
10x	2.0x	20x	30	9, 12
20x	0.4x	8x	30	22, 29
20x	0.5x	10x	30	18, 24
20x	0.8x	16x	30	14, 18
20x	1.0x	20x	30	9, 12
20x	1.3x	26x	10	22, 29
20x	2.0x	40x	10	13, 17
50x	0.4x	20x	30	9, 12
50x	0.5x	25x	10	22, 29
50x	0.8x	40x	10	13, 17
50x	1.0x	50x	10	11, 14
50x	1.3x	65x	10	8, 10
50x	2.0x	100x	3	18, 24
100x	0.4x	40x	10	13, 17
100x	0.5x	50x	10	11, 14
100x	0.8x	80x	3	22, 29
100x	1.0x	100x	3	18, 24
100x	1.3x	130x	3	14, 18
100x	2.0x	200x	3	9, 12

\* for proper calibration, a square Acquisition mask is required when using these objective and zoom settings. This chart is used to: 1) determine which test area on the standard to use, as based on the objective and zoom settings, and 2) provide the micrometer ( $\mu\text{m}$ ) mean spacing value to enter during the automatic lateral calibration procedure.

**NewView 6000 Automatic Lateral Calibration Test Area Chart (640x480)**

Objective	Zoom Setting	Approximate Magnification	Proper Test Area (mean spacing $\mu\text{m}$ )	Approximate Number of Rows, Columns
1x	0.5x	0.5x	500	15, 15*
1x	0.75x	0.75x	500	
1x	1.0x	1.0x	500	11, 14
1x	1.5x	1.5x	200	
1x	2.0x	2.0x	200	13, 17
2x	0.5x	1.0x	500	11, 14
2x	0.75x	1.5x	200	
2x	1.0x	2.0x	200	13, 17
2x	1.5x	3x	200	
2x	2.0x	4.0x	100	13, 17
2.5x	0.5x	1.25x	200	22, 29
2.5x	0.75x	1.86x	200	
2.5x	1.0x	2.5x	200	11, 14
2.5x	1.5x	3.25x	100	
2.5x	2.0x	3.75x	100	11, 14
5x	0.5x	2.5x	200	11, 14
5x	0.75x	3.75x	100	
5x	1.0x	5.0x	100	11, 14
5x	1.5x	7.5x	100	
5x	2.0x	10.0x	30	18, 24
10x	0.5x	5x	100	11, 14
10x	0.75x	7.5x	30	
10x	1.0x	10x	30	18, 24
10x	1.5x	15x	30	
10x	2.0x	20x	30	9, 12
20x	0.5x	10x	30	18, 24
20x	0.75x	15x	30	
20x	1.0x	20x	30	9, 12
20x	1.5x	30x	10	
20x	2.0x	40x	10	13, 17
50x	0.5x	25x	10	22, 29
50x	0.75x	37.5x	10	
50x	1.0x	50x	10	11, 14
50x	1.5x	75x	10	
50x	2.0x	100x	3	18, 24
100x	0.5x	50x	10	11, 14
100x	0.75x	75x	3	
100x	1.0x	100x	3	18, 24
100x	1.5x	150x	3	
100x	2.0x	200x	3	9, 12

\* for proper calibration, a square Acquisition mask is required when using these objective and zoom lenses.

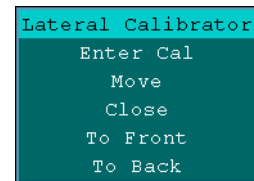
This chart is used to: 1) determine which test area on the standard to use, as based on the objective and zoom lens, and 2) provide the micrometer ( $\mu\text{m}$ ) mean spacing value to enter during the automatic lateral calibration procedure.

## Troubleshooting Automatic Lateral Calibration

<i>Problem</i>	<i>Possible Solutions</i>
The data has holes or there is data in the background behind the dots.	Check the light level to ensure there is no saturation. The FDA Res control must be set to High. Check for dust on the Standard; remove with filtered air. Make sure the microscope's Measure filter is in place.
Error Message: "Standard too rotated"	The standard is not square to the measurement area. Realign the standard.
Error Message: "Did not find enough regions"	Check the items mentioned in the first row. Also check that the appropriate test area is being measured and Camera Mode is set to the highest resolution option.
Error Message: "Sorting failed"	There most likely is a missing dot or data showing up between dots. Check the items mentioned in the first row.
Error Message: "Magnification out of allowable range"	The objective and zoom selections don't match the expected results. Check the Image Zoom setting and designed objective. Also check that the proper grid spacing was entered when prompted.

### Using the Enter Cal command

The Enter Cal command, accessed from the Lateral Calibrator menu, is used with microscope objectives for entering known calibrations without performing actual calibration.



1. Install the objective in the instrument. Click the Calibrate button to open the Lateral Calibrator.
2. To designate the objective, click the objective display with the left mouse button until the objective title appearing in the display matches the objective that was installed.
3. Click on the small box to the left of the objective you want to calibrate.
4. Select the Enter Cal command from the Lateral Calibrator menu. Enter the known magnification and press [Enter].

### Remastering Objectives

The Enter Cal command may also be used for remastering. Remastering allows an objective to be calibrated to match a specific existing standard.

For example, you may have an extremely accurate standard ball bearing with a known radius of curvature. The RadCrv result in MetroPro may not precisely match this radius. With the Enter Cal command, you can change the magnification of a particular objective until the results match. Note that if your standard is not accurate, you will introduce a measurement error.

## Creating TRC (Turret Reference Coordinates)

Using this function in MetroPro keeps the image of the sample part centered and in focus as objectives are switched. The TRC function automatically remembers each objective's coordinates and adjusts positioning in 5 axes (X, Y, Z, and tip and tilt) when objectives are switched with the Objective button. A motorized turret and motorized stages are required.



New TRC values must be established for all installed objectives when an objective is removed, remounted, replaced, and/or the turret itself is removed and replaced.

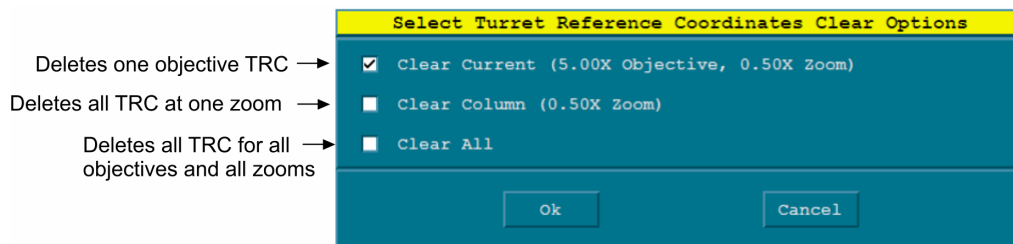
1. Mount all desired objectives into the motorized turret.
2. Click the Calibrate button to open the Lateral Calibrator. Use the Calibrator to designate that the objectives in the turret match the objectives specified in the Calibrator window as previously described in this section.
3. Select an objective in the Calibrator by clicking an objective button, and then click the Set TRC button.
4. Focus and null the microscope on a feature on a sample part. Move the stage to locate the feature under the on-screen crosshair.
5. After the objective is properly focused and nulled, click Yes.
6. Repeat steps 3 through 6 for other installed objectives.



MetroPro expects only small movements of the stage between objectives. The error message: "A turret reference coordinate is out of range. No stage axis was moved." indicates that an objective's TRC's were not properly set up, or an objective was switched or replaced.

## Clearing TRC (NewView 6000/7000)

1. To remove stored coordinates, click Clear TRC and select the appropriate options in the dialog box.



## Light Level Control

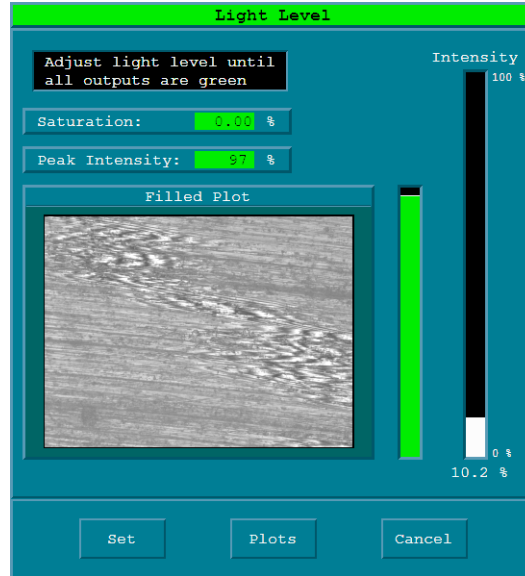


The proper light level is critical to obtaining an accurate measurement.

<i>Key</i>	<i>Function</i>
F4	Open Light Level Window to manually set light level.
F5	Automatically set light level.

### The Light Level Dialog

1. Adjust the instrument for proper focus as described in the operation manual.
2. Press the F4 key to open the window.
3. Use the numeric keypad to adjust levels until all indicators are green. Saturation causes data dropout. Saturated areas appear red in the Filled Plot.
4. Click the Set button or press Enter to change the light level. To cancel light level adjustment, click the Cancel button or press the Esc key.



### The Light Level Keys

These keys adjust the light level for the instrument. To set the light level, use the Light Level dialog, press F5 for automatic control, or enter a value in the Light Level Pct control.

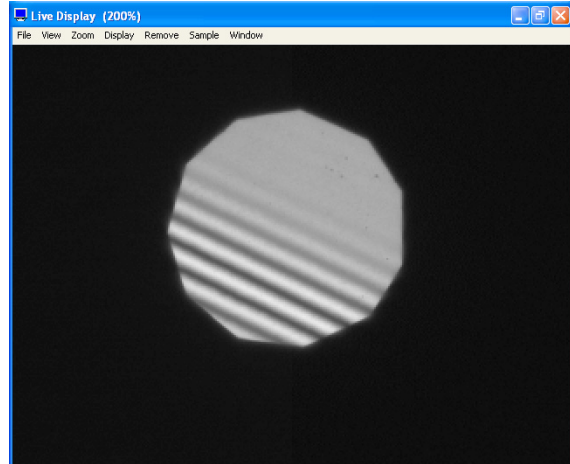
<i>Key</i>	<i>Function</i>
* /	Coarse up (*) and down (/).
+ -	Fine up (+) and down (-).
1 2 3 ...	Adjust level in 10% steps, 1 = 10%, 3 = 30%, 9 = 90%
Tab	Toggle between last two light settings.
Esc	Exit Light Level dialog.

For automatic light level adjustment, press F5. To set a specific light level for measuring, enter a value in the Light Level Pct control.

## Live Display Window

The Live Display window displays a live image from the system's frame grabber board. It is automatically displayed within MetroPro when the instrument is not equipped with an external video monitor. It is not displayed if the system has an external video monitor. The Live Display is useful as:

- A focus and null aid.
- A saturation indicator.
- A convenient way to print fringe patterns without a video printer.



### Moving the Live Display

1. Point to the window and click and drag. Release the mouse button when the window is located where you want it to be.

### Resizing the Live Display



The aspect ratio of the Live Display window is linked to the instrument camera and cannot be changed.

1. Point to the Zoom menu and select a percentage.
- or
2. Position the cursor over the window border. When you see  $\leftrightarrow$ , click and drag the window border. Release the mouse button when the window is the desired size.

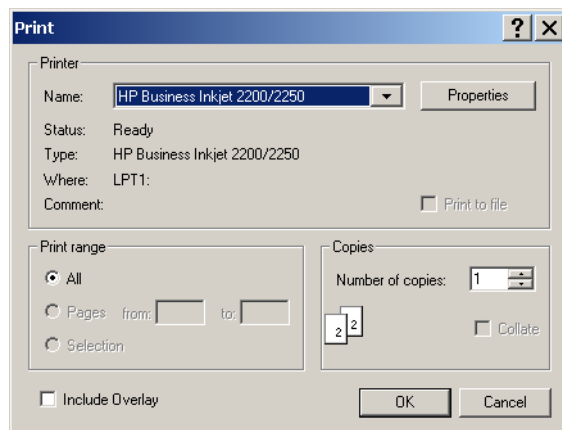
### Printing the Live Display

1. Point to the File menu and select Print.



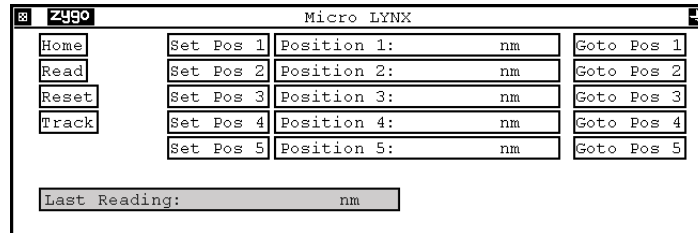
A typical Print dialog is shown here.

To print results, annotations, and masks displayed on the live image, select the Include Overlay check box.



## Micro LYNX Window

The Micro LYNX window is used to control the z-axis or focus stage used in some ZYGO instruments. Common uses include setting and using multiple focus positions and part load positions. The Micro LYNX window is created with the Application Window menu New Data Window → Micro LYNX command. This window is available in the standard microscope and GPI applications.



These controls are only applicable to instruments with the appropriate hardware.

<i>Item</i>	<i>Function</i>
<i>Home button</i>	Moves the stage to the fixed upper limit switch. All positions are relative to this fixed reference location. Click Home before recording stage positions and when the system is powered-on or reset.
<i>Read button</i>	Displays the current position of the stage in the Last Reading result box.
<i>Reset button</i>	Clears home and current stage positions; positions entered in the Position controls are not cleared. After clicking Reset, be sure to click the Home button.
<i>Track button</i>	Displays and tracks the current stage position in the Last Reading box. The track position is hidden when a key or mouse button is pressed, or the Touchscreen is touched. To reactivate the display, click the Track button again.
<i>Set Pos 1–5 buttons</i>	Stores the current position of the stage into the matching Position control. The stage should be “homed” before setting positions.
<i>Goto Pos 1–5 buttons</i>	Moves the stage to the position stored in the matching Position control. The stage should be “homed” before going to set positions.
<i>Position 1–5</i>	Shows the corresponding set position. Set positions are defined by clicking a Set Pos button or by clicking the Position control and entering a value directly. To clear a value, click on the control and press the Delete key.
<i>Last Reading result</i>	Displays the position of the stage when one of the following buttons has been clicked: Home, Read, Reset, Track, Set Pos X, or Goto Pos X.

## Video Monitor Output

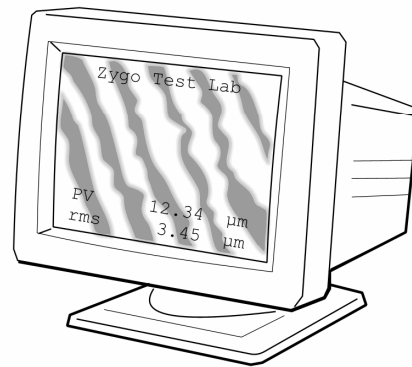
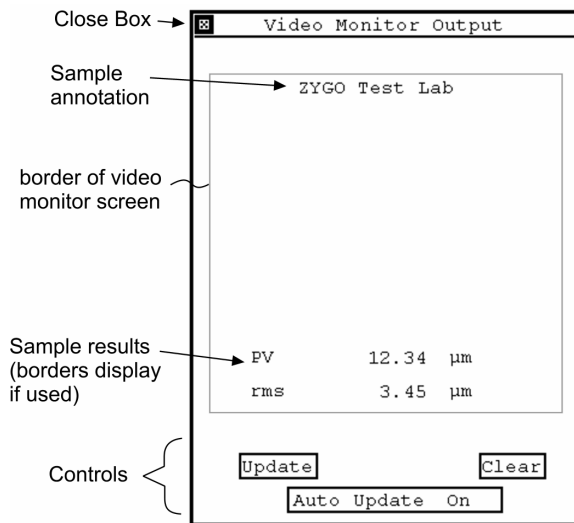


Use the Video Monitor Window to display results and annotations on the external video monitor or in the software Live Display window. Masks are automatically displayed.

### The Video Monitor Window

The Video Monitor window is used to compose results and text you want to display on the Video Monitor screen or Live Display window. This is particularly useful when you are using a video printer to make a copy of the Video Monitor screen. The Video Monitor window is created with the Application Window menu New Video Monitor Window command.



When created, the Video Monitor window is equipped with two buttons and a control; these controls do not appear on the video monitor screen. Results and text can be placed anywhere within the bordered area in the window. Some MetroPro applications are supplied with a Video Monitor window already complete with text and results.



<i>Item</i>	<i>Function</i>
<i>Update button</i>	Click to send the contents of the Video Monitor window to the video monitor screen.
<i>Clear button</i>	Click to clear the video monitor screen of information.
<i>Auto Update</i>	Determines if the contents of the Video Monitor window are output to the video monitor screen after each measurement. Settings are On or Off.



### ***Creating a Video Monitor Window***

1. Create the Video Monitor window using the Application Window menu New Video Monitor Window command.
2. Select the Copy Output Box from the window's menu. The cursor turns to an arrow with an asterisk .
3. Point to the result that you want to copy and press and hold the left mouse button. An outline of the box appears.
4. Move the mouse to position the box inside the Video Monitor window and release the mouse button. The box appears at this location.
5. The cursor remains  for further copying. To copy additional results repeat steps 3 and 4.
6. When done copying output boxes, click the right mouse button.
7. Use the New Annotation command to create an Annotation box for special text to display on the video screen.
8. Customize the boxes in the Video Monitor window with their respective menus. You can move them, change or add a border with the Border command, or change the type style with the Font command.
9. Click the Update button to see what the boxes look like on the Video Monitor.
10. If you always want the Video Monitor to display results and text, turn the Auto Update control to On by clicking it with the left mouse button.
11. To save your work, select the Re-save Application command from the Application Window menu.



# Mask Editor

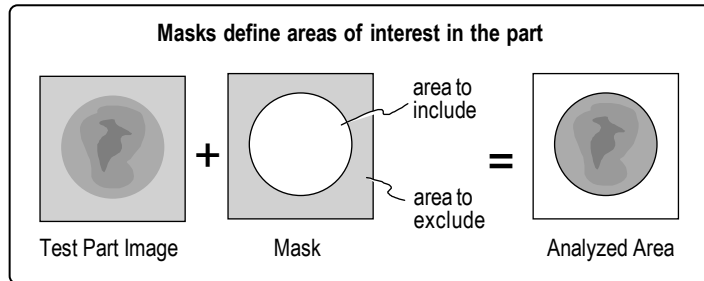
## Section 5

*The Mask Editor defines areas of interest in the part.*

### Masks

The Mask Editor is a specialized window used to create and modify masks. The Mask Editor allows you to select areas of interest, called masks, in a view of the test part called an “image area”. Masks may be used to restrict the measurement to a particular area of interest or exclude a known bad area, such as a defect in a surface, from the measurement. Click the Mask Data button to open the Mask Editor. Masks identify subsets of the full camera image to include and/or exclude in a measurement or analysis. To open the Mask Editor click the Mask Data button.

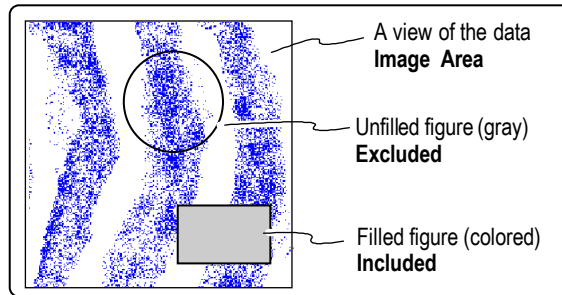
Masks can be used to speed the measurement cycle, to compare one area of a part to another area on the same part, or to isolate various test areas on the part.



### What is a Mask?

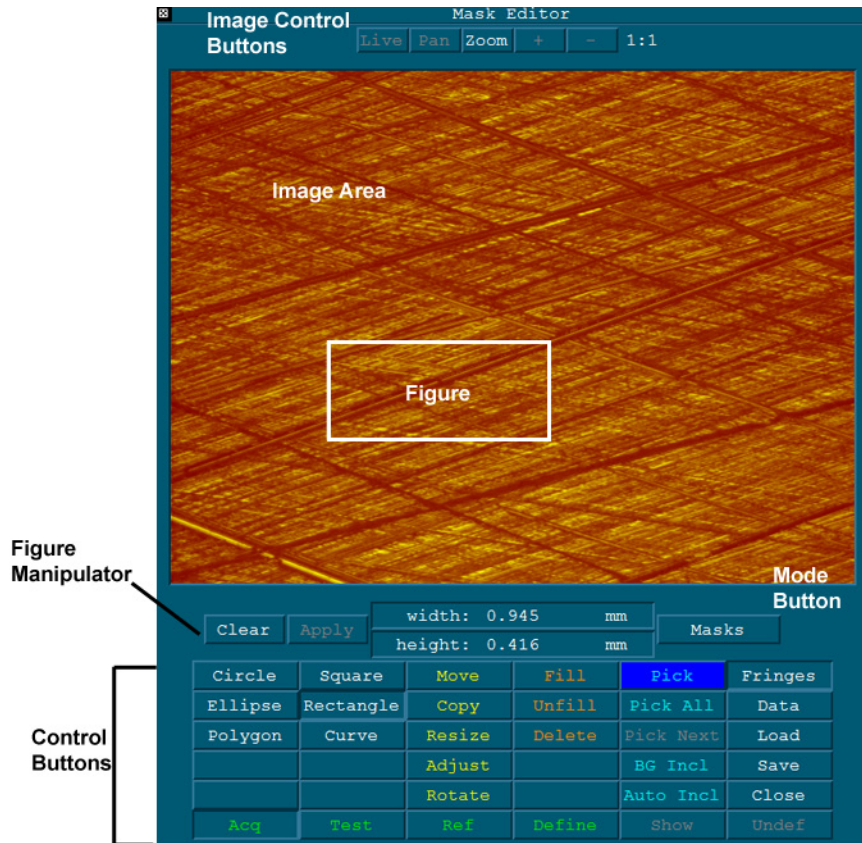
Masks identify subsets of the full camera image to include and/or exclude in a measurement and/or analysis. If masks are not used, the entire camera image is acquired and analyzed.

A mask is made up of one or more figures. A figure is a shape that defines an area in the data; these areas may be filled (colored) or unfilled (gray). If an area is colored, it is included; if an area is not colored, it is excluded.



## The Mask Editor Window

The Mask Editor is a specialized window used to select areas of interest in the test part. Masks or figures define area in the data. Greater details on using the Mask Editor and the buttons are provided over the following pages in this section.

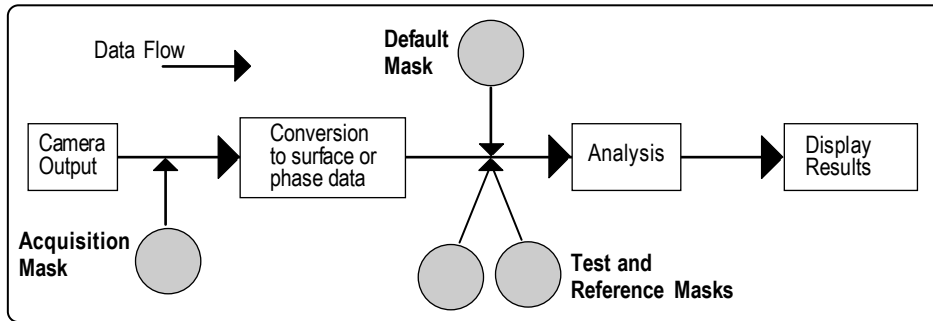


<i>Item</i>	<i>Description</i>
<i>Image Control Buttons</i>	Provides access to live fringes display or pan and zoom features.
<i>Image Area</i>	Displays a frame of camera data. The data source is selected with the Fringes or Data buttons. An image only appears if the instrument is active.
<i>Figure</i>	A defined area in the data. Colored areas are included for analysis; gray areas are excluded. One or more figures form a “mask.”
<i>Figure Manipulator</i>	Used to adjust the size and position of figures.
<i>Mode Button</i>	Selects the function mode as Masks, Fiducials or Cal Markers (MST applications only).
<i>Control Buttons</i>	Used to create, load, and modify figures or masks.

### The Four Masks of MetroPro

There are four types of masks: Default, Test, Reference, and Acquisition. All masks are created in a similar manner, but affect processing in different ways. Once a mask is created, it is applied automatically during any future analysis of all data.

The drawing below indicates the part of the process affected by the different types of masks. It also indicates how the masks can be used in combination. The Acquisition mask can be used with either the Default mask or the Test and Reference mask set, but not both. To prevent any conflicts, the software automatically disables the Default mask when a Test mask is defined. The following table describes the four masks.



<i>Mask Type</i>	<i>Description</i>
<i>Default</i>	Applied to the data during analysis. If masks are not defined with the Mask Editor, it is assumed you are using a Default mask. The Default mask is disabled when the Test mask is defined.
<i>Acquisition</i>	Applied to the data while it is being acquired, before the data is converted to surface or phase data, and before it is analyzed. An Acquisition mask is used to exclude areas that cause problems during the acquisition of data, such as excessive slopes from part edges (cause discontinuity errors), extreme differences in reflectivity (cause AGC errors), and excessive spurious data (cause connect errors). The Acquisition mask can also be used to speed up processing because it reduces the number of data points that are used in analysis.
<i>Test</i>	Defines an area of interest on the test part; this area is compared to a reference area on the same test part during the analysis process. The Test mask must be used in conjunction with the Reference mask. Used within Test+Reference data windows. If you use another data window and Test and Reference masks, you will see only data in the area defined by the Test mask.
<i>Reference</i>	Defines a reference area (or a standard for measuring against) on the test part against which the test area is compared during the analysis process. It must be used in conjunction with the Test mask.

## Image Control Buttons



<i>Buttons</i>	<i>Function</i>
<i>Live</i>	<p>Activates live fringes mode. When activated, the button turns bright blue. In this mode, the fringe pattern from the camera is refreshed automatically. The following conditions must be met in order for live fringes to operate.</p> <ul style="list-style-type: none"> <li>• There is an active instrument.</li> <li>• The current fringe pattern is from a measurement made with the instrument, and is not a data set loaded from a file.</li> <li>• The Fringe button is selected.</li> </ul> <p>The Live button will be grayed out if this mode is not available. If you have loaded a data set, click the Reset Data button* to return to the instrument camera. To exit this mode, either click the Live button or press the Esc key.</p> <p>*The Reset Data button is different from the Reset button. Refer to Chapter 3 for additional information on the Reset button.</p>
<i>Pan</i>	<p>Pan mode is only available when zoom mode is active and zoomed in. The Pan button will be grayed out if this mode is not available. The button color changes to bright blue when activated.</p> <p>Click to start or end pan mode. Zoom in so that less than the full camera field is visible. Use the scroll bars on the left or bottom of the window, or click the left mouse button within the image and drag to move from one area of the camera to another.</p> <p>While in pan mode, other mouse operations are temporarily overridden, such as creating or moving a new figure.</p>

Image Control Buttons, continued-

*Zoom/1:32*

Click Zoom to start or end zoom mode. This feature enables digital zooming of the graphic so that data points can be plotted with more resolution *or* less resolution. At the highest zoom magnification, each data point is plotted as a square block of 32 graphic pixels.

The Zoom Readout is located beside the minus button and shows the relationship of data points to graphic pixels. For example, a camera resolution of 1000 x 1000 with the lowest zoom magnification will display “2:1”, indicating that 2 data rows/columns correspond to 1 graphic pixel/row column. For the highest zoom magnification, the readout will display “1:32”, indicating that 1 data row/column corresponds to 32 graphic pixel rows/columns.

The software selects a zoom center point as follows:

For one figure, the center of that figure is used.

For multiple figures, the center of the rectangle enclosing the figure is used.

When changing the zoom mag with the mouse wheel, the cursor location is used.

Otherwise, for any other figure type, the center of the graphic is used.

In Fringes mode, any change made to the zoom magnification will result in a new camera image.

*Plus & minus(+ -)*

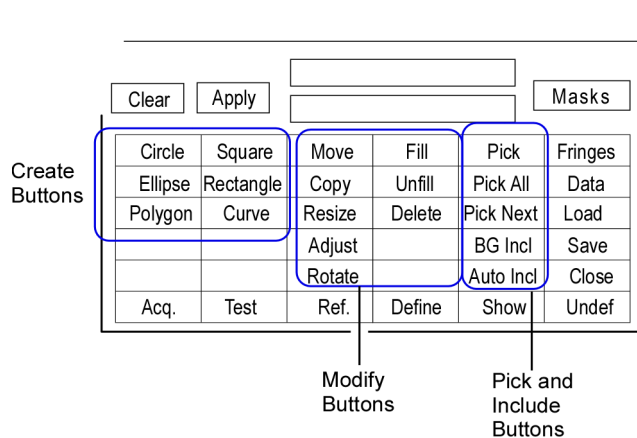
Increases and decreases zoom magnification.




















You may also control zoom using the Ctrl + or Ctrl – key combinations. Or, move the mouse over the editor window and use the mouse wheel, or position the cursor within the graphic and roll the mouse wheel.

Forward motion zooms in; backward motion zooms out.

**The Mask Editor Buttons**

These buttons are used to make and modify figures. Buttons are activated by pointing to the button and clicking the left mouse button.



<b>Buttons</b>	<b>Function</b>												
<i>Create Buttons</i>	<p>Use to create figures of different shapes. When the figure button is clicked it stays selected until another button is clicked.</p> <table border="0"> <tr> <td><b>Circle</b></td> <td></td> <td><b>Square</b></td> <td></td> </tr> <tr> <td><b>Ellipse</b></td> <td></td> <td><b>Rectangle</b></td> <td></td> </tr> <tr> <td><b>Polygon</b></td> <td></td> <td><b>Curve</b></td> <td></td> </tr> </table>	<b>Circle</b>		<b>Square</b>		<b>Ellipse</b>		<b>Rectangle</b>		<b>Polygon</b>		<b>Curve</b>	
<b>Circle</b>		<b>Square</b>											
<b>Ellipse</b>		<b>Rectangle</b>											
<b>Polygon</b>		<b>Curve</b>											
<i>Modify Buttons</i>	<p>Use to modify or change a selected or “picked” figure(s). Move, Copy, Resize, Adjust, and Rotate require additional input. Fill, Unfill, and Delete immediately work on “picked” figures.</p> <p><b>Move-</b> moves picked figures.  <b>Copy-</b> makes duplicates of picked figures.  <b>Resize-</b> resizes picked figures proportionally.  <b>Adjust-</b> changes the height to width ratio size of picked figures.  <b>Rotate-</b> rotates picked figures about their center.</p> <p><b>Fill-</b> fills picked figures; filled figures are in color and included in analysis.  <b>Unfill-</b> unfills picked figures; unfilled figures show borders only.  <b>Delete-</b> erases picked figures.</p> <p> The arrow keys can be used to Move, Resize, and Adjust figures in small increments. Press the shift key at the same time to multiply the action.</p>												
<i>Pick and Include Buttons</i>	<p>Pick buttons are used to select figures to edit. Note that the Pick or PickAll button labels turn light blue when figures are picked. Include buttons select what is used in the analysis.</p> <p><b>Pick-</b> selects figures one by one to edit.  <b>PickAll-</b> selects all figures so they can be edited simultaneously.  <b>Pick Next-</b> selects the next figure (when multiple figures are selected). The Tab key can also be used to pick the next figure. The Shift-Tab key combination will pick the previous figure (when there is more than one figure).</p> <p>If zoomed in, the image is automatically panned to best center the figure. Any Current operation, such as Move, Resize, or Adjust, remains in effect.</p> <p><b>BG Inc-</b> determines how the background area is used in the analysis. BG Inc is background include. BG Exc is background exclude.  <b>AutoInc-</b> determines if figures are created filled or unfilled. AutoInc is auto include and fills figures as they are created . AutoExc is auto exclude and unfills created figures.</p>												



### ***Creating a Circle, Square, Ellipse, or Rectangle Figure***

These figures can be created with the mouse or with the Figure Manipulator. The mouse method is described below; the Figure Manipulator is described later.

1. Click on the shape button with the left mouse button.
2. Position the pointer over the image area.
3. Press the left mouse button for the start point, drag the mouse, and then release the mouse button for the end point.

### ***Creating a Polygon Figure***

1. Click on the Polygon button with the left mouse button.
2. Position the pointer over the image area.
3. Click the left mouse button to begin the polygon and move the pointer to create a side of the polygon.
4. Click the left mouse button each time you wish to create a new corner point. Click the right mouse button for the last corner point. The polygon will automatically connect the last point to the first point.

### ***Creating a Curve Figure***

1. Click on the Curve button with the left mouse button.
2. Position the pointer over the image area.
3. Press and hold the left mouse button, move the mouse to draw the figure shape, then release the button to end. The curve will automatically close to the start point.

### ***Picking or Selecting Figures***

Figures must be selected or “picked” before they can be moved, copied, resized, adjusted, unfilled, filled, or deleted. *The most recently created figure is automatically picked.* Individual figures are picked with the Pick button, all figures are picked at once with the PickAll button. Any of the figure modify buttons can be used in sequence without repicking figures. When the Pick or PickAll buttons are highlighted in light blue it means a figure(s) is picked.

1. Click the Pick or PickAll button with the left mouse button. If the button is light blue, clicking it deactivates the currently picked selection.
2. Position the pointer on the border of a figure and click the left mouse button. The picked figure will flash momentarily.
3. You can continue to pick additional figures by clicking on their borders.

## ***Moving Figures***

Figures can be moved with the mouse or with the Figure Manipulator. The mouse method is described below; the Figure Manipulator is described later.

1. Pick the figure(s) (as explained previously) and then click on the Move button with the left mouse button.
2. Press and hold the left mouse button, drag the mouse to position the figure, and then release the mouse button. Or press the arrows keys for finer control.

## ***Copying Figures***

Figures can be copied with the mouse or with the Figure Manipulator. The mouse method is described in the following paragraph; the Figure Manipulator is described later.

1. Pick the figure(s) (as explained previously) and then click on the Copy button with the left mouse button. The copy appears directly over the top of the figure(s) being copied so you will not see it until you move the mouse.
2. Press and hold the left mouse button, drag the mouse to position the figure, and then release the mouse button.

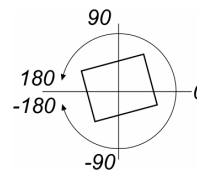
## ***Resizing or Adjusting Figures***

Use the Resize button to change the size of a figure without affecting its proportions. Use the Adjust button to change the proportions of a figure. Figures can be resized or adjusted with the mouse or with the Figure Manipulator. The mouse method is described below.

1. Pick the figure(s) (as explained previously) and then click on the Resize or Adjust button with the left mouse button.
2. Press and hold the left mouse button, drag the mouse to modify the figure size, and then release the mouse button. Or press the arrow keys for finer control.

## ***Rotating Figures***

The Rotate button rotates selected figures about the center of the minimum enclosing rectangle. The Figure Manipulator must be used for this function.



1. Pick the figure(s) (as explained previously) and then click on the Rotate button with the left mouse button.
2. Click the mouse in the angle entry box, enter a value, and press Enter. Then click the \*Apply\* button.

## ***Filling and Unfilling Figures***

Filled (colored) figures are included in the analysis and unfilled figures are excluded.

1. Pick the figure(s) (as explained previously) and then click on the Fill or Unfill button with the left mouse button.

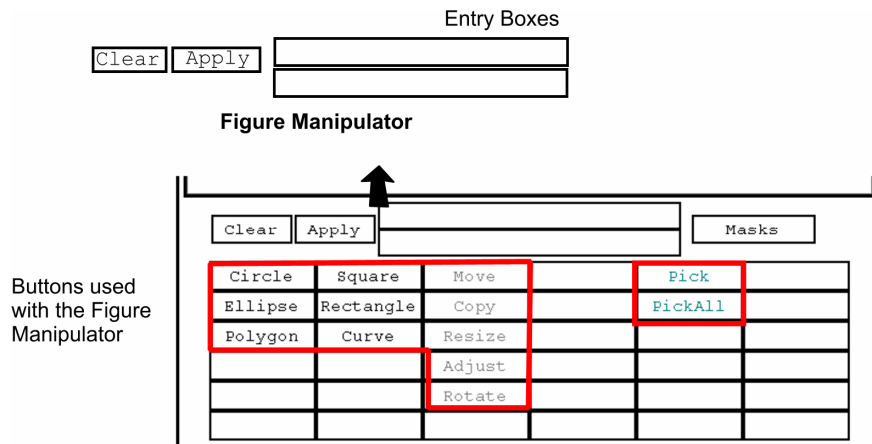
## Deleting Figures

The Delete button erases all picked figures; it is permanent and cannot be undone. The Clear button removes all figures and defined masks.

1. Pick the figure(s) (as explained previously) and then click on the Delete button with the left mouse button.
2. Verify your action by clicking on the YES button in the Warning Message. Click NO to cancel the delete function.

## Using the Figure Manipulator

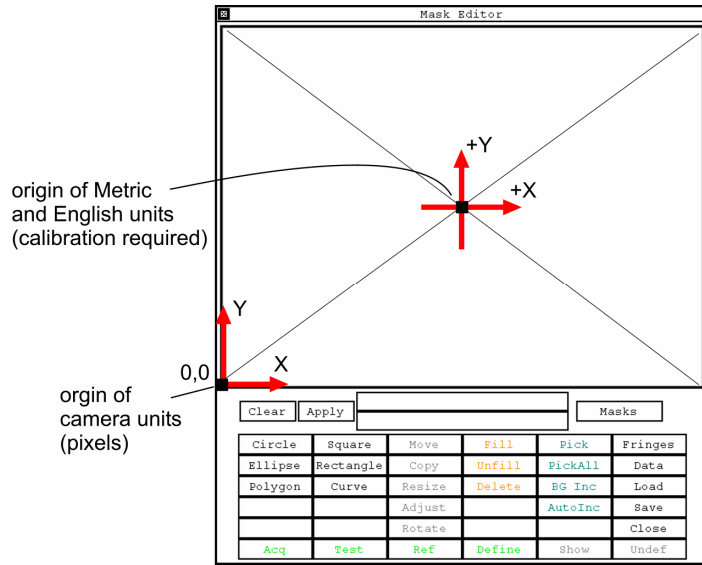
The Figure Manipulator is used during the creation of circle, square, ellipse, and rectangle figures to specify their size, or to specify the size of figures when using the Mask Editor Resize or Adjust buttons, or to specify the position of figures when using the Mask Editor Move or Copy buttons. The Figure Manipulator also functions as a readout device providing the size and location of figures.



<i>Item</i>	<i>Function</i>
<i>Clear Button</i>	Erases all figures and masks.
<i>Apply Button</i>	Applies the information entered in the entry boxes. The button label changes to *Apply* to indicate when the button is functional.
<i>Entry Boxes</i>	Used to enter values and dimensions when editing figures. To enter a value, click the box, type in a value and press [Enter]. To apply the value to a figure, click the *Apply* button. Any units shown within these boxes are set by the Lateral Units control.

To use the Figure Manipulator, you enter numbers into the entry boxes one at a time and then click the Mask Editor's Apply button with the left mouse button.

The lateral units displayed in the entry boxes depend upon the units selected with a Lateral Units control. Notice that any numbers shown in the entry boxes are referenced to coordinate systems of the image area as shown here.



### ***Creating Circle or Square Figures with the Figure Manipulator***

1. Click on the Circle or Square button.
2. Click on the “size” Entry box and type a dimension and press [Enter].
3. Click the Apply button. The figure will appear centered in the image area. If the dimension is too large the figure may fall outside the image area.

### ***Creating Ellipse or Rectangle Figures with the Figure Manipulator***

1. Click on the Ellipse or Rectangle button.
2. Click on the “width” Entry box and type a dimension and press [Enter]. Then click the “height” Entry box and type the second dimension for the figure and press [Enter].
3. Click the Apply button. The figure will appear centered in the image area. If the dimensions are too large the figure may fall outside the image area.

### ***Moving Figures with the Figure Manipulator***

1. Pick the figure(s) (as explained previously) and then click on the Move button. This also can be used to find the location of an existing figure.
2. Click on an Entry box, type in a dimension and press [Enter].
3. Click the Apply button. The center of the picked figure(s) will move to the location indicated in the Entry boxes.

### ***Copying Figures with the Figure Manipulator***

1. Pick the figure(s) (as explained previously) and then click on the Copy button.
2. Click on an Entry box, type in a dimension and press [Enter].
3. Click the Apply button. The center of the new figure(s) is positioned over the location indicated in the Entry boxes.

### Resizing Figures with the Figure Manipulator

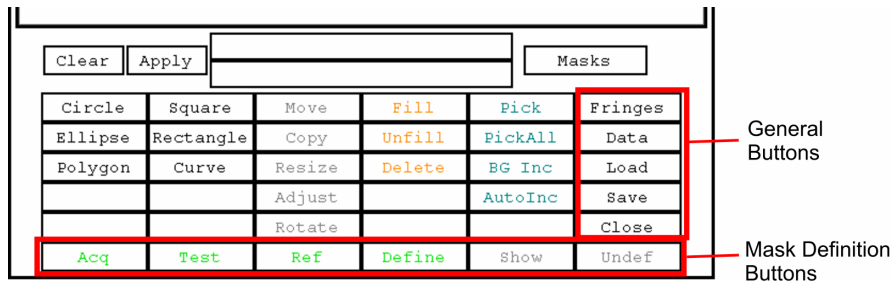
1. Pick the figure(s) (as explained previously) and then click on the Resize button.
2. Click on the “percent” Entry box, type in a percentage and press [Enter]. A number greater than 100 makes the figure larger; a number less than 100 makes the figure smaller.
3. Click the Apply button. The center of the new figure(s) is positioned over the location indicated in the Entry boxes.


### Adjusting Figures with the Figure Manipulator

1. Pick the figure(s) (as explained previously) and then click on the Adjust button. This also can be used to find the size of an existing figure.
2. Click on an Entry box, type in a dimension and press [Enter].
3. Click the Apply button.


## Working with Mask Files

There are four types of masks in MetroPro: Default, Acquisition (Acq.), Test, and Reference (Ref.) masks. Generally, the Default mask is all you need for most applications; it is any mask that is not defined as Acq., Test, or Ref. The buttons used for defining, saving, and loading mask files are shown below.



<i>Buttons</i>	<i>Function</i>
<i>General Buttons</i>	This group of buttons is used for general file functions.
	<b>Fringes-</b> displays one camera frame in the image area.
	<b>Data-</b> displays current measurement data in the image area.
	Note that only one image source button may be selected at a time.
	<b>Load-</b> opens the File Handler, which is used to select a saved mask file to load.
	<b>Save-</b> opens the File handler, which is used to save a mask file.
	<b>Close-</b> closes the Mask Editor window.
	Acq, Test, and Ref masks must first be defined with the Define button before they can be saved. A mask file can contain one or more defined mask types.

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<i>Mask Definition Buttons</i>	<p>This group of buttons is used to define mask types and to select what masks are displayed in the Mask Editor.</p> <p><b>Acq-</b> Acquisition mask <b>Test-</b> Test mask <b>Ref-</b> Reference mask</p> <p> The Acq, Test, and Ref buttons operate as a bank of toggle switches; only one button can be selected. When a mask is defined the button labels turns bright blue. When any of these buttons is not bright blue, you are working the Default mask.</p> <p><b>Define-</b> makes the figures in the image area into the mask type indicated by either the Acq, Test, or Ref button. <b>Show-</b> displays the Acq, Test, or Ref mask in the image area when the corresponding button is clicked. <b>Undef-</b> (undefined) erases the defined mask type that is selected by either the Acq, Test, or Ref buttons.</p>
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### ***Defining Masks***

When a mask is defined, its “type” button is highlighted in bright blue. You can define an Acquisition mask, a Test mask, and a Reference mask and then save them all together in one mask file. The Define and Undef. buttons are nonfunctional with the Default mask. The Default mask does not have to be defined before it can be saved.

If you have not defined an Acquisition mask, a Test mask, or a Reference mask, then what you save will be a Default mask. When a Test mask is defined, the Default mask is disabled.

1. Create the desired figures; only colored figures are included in analysis.
2. Select the desired mask type by clicking on the Acq., Test, or Ref. button with the left mouse button. After a mask is defined, the mask button will turn bright blue.
3. Click on the Define button with the left mouse button.

### ***Hints for Defining Multiple Masks***

First, start with a gray unfilled screen, and create all the figures together on the screen; remember that only filled (colored) figures are used in the analysis. Then, fill and unfill the figures you want for a particular mask type and define it. Continue to define the other masks in the same fashion, filling and unfilling the figures as desired. Verify your definitions with the Show button as described below. Remember to save your defined masks with the Mask Editor’s Save button.

## Showing Masks

The Show button allows you to view each defined mask to confirm what has been defined. A mask must be defined before show will work. Only one mask is shown at a time in the image window. Colored areas are included in the analysis.

1. Select the mask type by clicking on the Acq., Test, or Ref. button with the left mouse button.
2. Press the Show button with the left mouse button. As long as the button remains pressed, the selected mask will show in the image area. Release the mouse button.

## Undefining Masks

1. Select the mask type by clicking on the Acq., Test, or Ref. button with the left mouse button.
2. Click on the Undef. button with the left mouse button. The selected mask button will revert to its original blue color.

## Removing Masks

Click the Clear button with the left mouse button to erase all figures and all defined masks.

## Saving Mask Files

Saving will store all *defined* masks or the Default mask to a specified file name. To save masks, click the left mouse button on the Mask Editor's Save button.

1. In the File Handler, click on the Current Selection box.
2. Type in a name for the mask file, ending with ".mas" and press [Enter]. If you want to save the file to a specific directory, click the File Handler's Dirs button and specify the directory before entering the name of the file.
3. Click the File Handler's Done button.

## Loading Mask Files

Masks must already exist before they can be loaded. To reload a previously-saved mask file, click the left mouse button on the Mask Editor's Load button.

1. In the File Handler, click on the name of the mask file you want to load.
2. If you want to load the file from a specific directory, click the File Handler's Dirs button and specify the directory before clicking the file.

## Automatic Mask File Loading

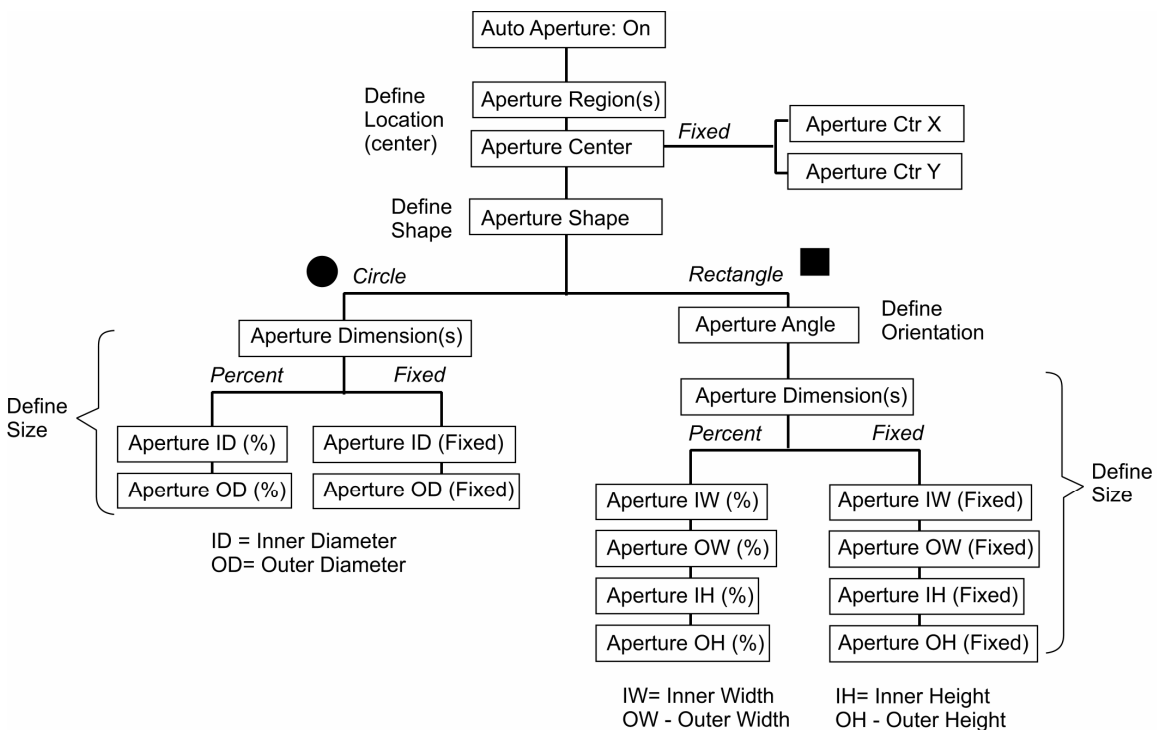
With the Auto Load Masks and Masks File controls an application can be setup to automatically load a specified mask file. The Auto Load Masks control activates the auto load function and the Masks File control specifies the name of the mask file to load. These controls are available in the Control window with the New Control → Masks command.

## Auto Aperture Function

The Auto Aperture masking function makes it possible to apply a mask automatically when a measurement is made. The shape of this automatic mask may be either a circle or rectangle. By using the appropriate controls, the location of this auto aperture mask may be selected along with the size or extent of the mask.

To activate this function set the Auto Aperture control to On. If necessary, use the New Control → Auto Aperture menu to create the additional controls needed. For more information on auto aperture controls, look in Section 3 under Aperture...

### Overview of the Auto Aperture Controls



## Automatic Masking Based on Data

The Mask Editor is used to define areas of interest based on location relative to the captured image area. However, MetroPro can automatically create masks based on part data, overcoming problems aligning regions on the part to predefined masks.

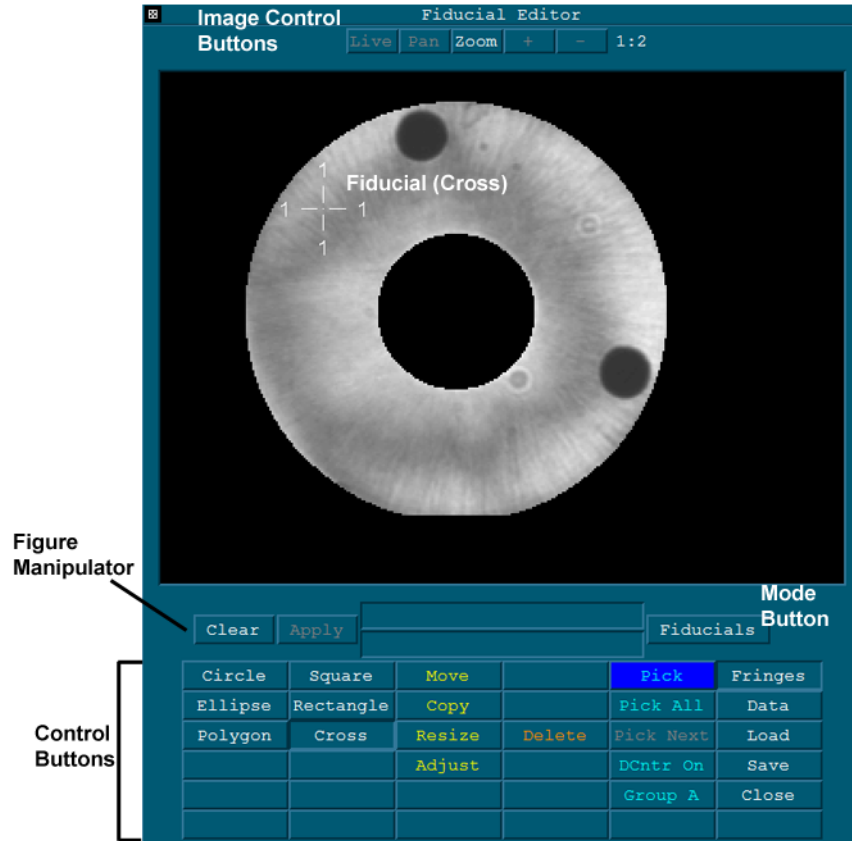
To use MetroPro’s “masking on the fly” features, refer to the MetroPro *MultiSurf Application Booklet, OMP-0376*. The MultiSurf Application is based on Test and Reference Data Windows, where a reference surface serves as the standard to which test surfaces on the same part are compared during the analysis process. This application segments or divides a single data set into multiple test areas.

The controls for segmenting are available in most standard applications with the Test/Reference Map window New Control → Segmentation → menu.



## Fiducials

The Mask Editor has a fiducial operation mode. The fiducial mode is used to define reference points on the data, which assist with precise part alignment. Click the Mode button in the Mask Editor to select the Fiducials.



<i>Item</i>	<i>Function</i>
<i>Image Control Buttons</i>	Refer to the “Mask Editor” section of this chapter.
<i>Fiducial</i>	Reference marker.
<i>Figure Manipulator</i>	Used to adjust the size and position of figures.
<i>Mode Button</i>	Selects the Mask/Fiducials Editor function mode.
<i>Control Buttons</i>	Used to create figures and operate the Mask Editor fiducials mode.  Most buttons have identical functions as previously described in this section, with the following exceptions: <b>Cross-</b> selects a fiducial cross figure. <b>DCntrOn-</b> Data Center button selects how fiducials are centered to data. When data center is On, the fiducial is automatically centered over a hole in the data area where it is created. This feature only works when viewing Data, not Fringes.

**Group A-** The editor supports five (5) independent groups of fiducials, named A, B, C, D, and E. The Group button allows the operator to switch among multiple fiducial groups.

Each group may contain an unlimited number of fiducial figures, but the number that can be saved in a data file is limited. See the “Saving Fiducial Files” section below.

**Group A—Primary**

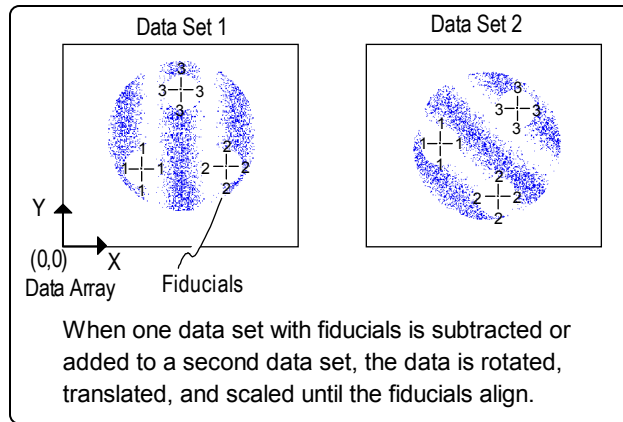
Group A is considered the primary group. Only Group A fiducials are used when MetroPro performs an operation requiring fiducials, e.g., subtracting two data sets with the Alignment control set to Fiducials. Only Group A fiducials are used by the MetroScript commands: `delfid`, `findfid`, `getfidctrx`, `getfidctry`, `getfidorgx`, `getfidorgy`, `getfidsizy`, and `makefid`.

**Groups B, C, D, and E—Secondary**

These groups are considered to be secondary. They are for use by customer specific/customer created programs, and are also helpful when used as alignment aids. They are not used when MetroPro performs an operation requiring fiducials.

**What are Fiducials?**

Fiducials are reference or data location markers that are used as an alignment aid or to compare two data sets. When comparing data sets, fiducials on one data set are compared to a similar set of fiducials on the second data set; if necessary, the second data set is translated, rotated, and scaled until the fiducials align.



Fiducials are useful in evaluating optical systems and as an alignment aid in tests in which one part must be critically aligned to another. They may also be used as an alignment aid in certain test setups, such as in the Three Flat Application.

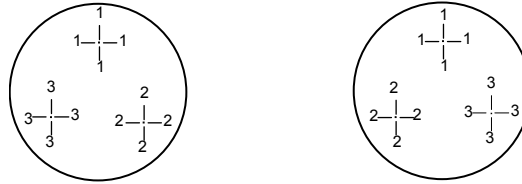
**Creating Fiducials**

A fiducial is created using tools similar to those used to define a mask figure. A fiducial may be a circle, square, ellipse, polygon, square, rectangle, or cross. The most common fiducial shape is a cross. The fiducial should be drawn over a permanent mark or feature on the test part. When possible, try to match the fiducial shape to the feature.

If data sets are being compared, at least two fiducials must be created for each of the data sets. This makes it possible for the software to handle translation and rotation. When

three fiducials are defined, the software also performs isomorphic and/or anamorphic scaling. Isomorphic scales both axes equally; anamorphic scales to the best fit.

Any number of fiducials may be created, but only the first seven are used for calculations. Fiducials must be placed on both data sets in the same numerical sequence. This is necessary in order to have the software scale, translate, and rotate data correctly.



Fiducials assigned to two data arrays in which numerical order is not followed. This will produce a significant out-of-tolerance error.

1. Click on the Mask Data button. Then click on the Mask Editor's Masks button to switch to the Fiducial mode.
2. Before defining fiducials, determine whether or not the feature on the part is most visible in fringe or data mode. The default mode is fringe. To display data, click the Fringe button to toggle it to Data. (When displaying data, you can use the DCntrOn button so created fiducials are centered to holes in the data. If the button is DCntrOff, the fiducial will go where you put it.)
3. Click on the Cross button (or the most applicable shape button for the fiducial) with the left mouse button. Position the pointer over the image area. Click the left mouse button to create the fiducial marker. Repeat for additional markers.
 

**What happens to marker with DCntrOn ?**

**Cross**

finds center of a single no data area

**Other Shapes**

finds centroid of all no data areas within its boundary

circle fiducial marker

centroid

areas of no data
4. To move the fiducial marker, click the Move button, position the cursor over the center of the marker, press and hold the left mouse button, drag the mouse to move the marker, then release the button when the fiducial is at the desired location.

### ***Moving, Copying, Resizing, Deleting or Adjusting Fiducials***

Fiducials are moved, copied, sized, deleted, and adjusted like figures.

### ***Saving and Loading Fiducials***

Fiducials are saved and loaded like mask files. However, there are three file format types in which fiducials may be saved. These include: .dat, .fid, or .csv. When saving in the .dat format, use the Save Data button and select .data. This preserves the first seven (7) fiducials in Groups A, B, C, and D in the header of the resulting .dat file.

Fiducials may also be saved as .fid or .csv. Refer to the chart below.

File Format	Group	Fiducials Saved	Used by
.dat	A	1 ... 7	MP Calculation
	B	1 ... 7	Other
	C	1 ... 7	Other
	D	1 ... 7	Other
.fid	A	All	MP Calculation—only uses fiducials 1 through 7
	B, C, D & E	All	Other
.csv	A,	All	MP Calculation—only uses fiducials 1 through 7
	B, C, D, & E	All	Other

**A Note on Saving Files in the .fid Format**

Previously, when saving fiducials using the Save button in the fiducial editor, all fiducials were saved to a file with the .fid extension. As of MetroPro version 8.3.2, this function continues to be supported, and all .fid files created in earlier versions can still be read. In addition, there is backward compatibility with earlier versions of MetroPro as follows:

When saving fiducials to the .fid format in 8.3.2, if only Group A has fiducials defined, and Groups B, C, D and E (secondary) are empty, (no fiducials defined), then the resulting fiducial file will be able to be read by earlier versions of MetroPro. However, if the secondary group has fiducials defined, the saved file will not be readable by earlier versions of MetroPro.

***Additional Fiducial File Format —.csv***

There is a new file format available for saving fiducials. It has a .csv extension and uses a comma-separated-value format. When saving a fiducial set, select the .csv extension within the Save dialog.

The new file format is a simple text file and can be edited with any standard text editor. Each fiducial is specified by one(1) line containing three(3) columns specifying a name and the X and Y coordinates. Additional columns are ignored. Most lines are short—less than about 20 characters, but long lines—up to approximately 512 characters are accepted. Blank lines are ignored, and comment lines begin with the pound (#) sign.

***.CSV File Format Programming Considerations***

When creating customer specific programs which use the MetroPro .csv fiducial file type, refer to the following.

**Header Lines**—The fiducials .csv file has a header consisting of two lines:

```
#Zygo Fiducials CSV File
CameraSize, 1000,1000
```

**Fiducial Lines**—Each fiducial is specified by a line containing three (3) columns specifying a name and the X and Y coordinates. Additional columns are ignored.

Examples:

A1,46,213  
 A2,41.75,165.25  
 A3,79.25,86.25  
 A4,138.25,80.25  
 A5,250,75,44.25

A fiducial name consists of a group letter followed by an integer index (one-based). MetroPro recognizes only group letters A through E. Any other group letter is ignored. The range of index values is [1, 999]. The order of fiducial lines in the file is unimportant. For example, the lines need not appear in order of increasing index.

A fiducial group contains a sequence of N fiducials with indices ranging from 1 to N. If an index in the sequence is missing, MetroPro will discard fiducials with higher indices.

The coordinate system is defined as follows:

The origin (0,0) is the center of the upper-left camera pixel.

X increases to the right.

Y increases downward.

The center of the lower right pixel is (CamSizeX-1, CamSizeY-1).

**Other Lines**—Lines that are unrecognized as either header lines or fiducial lines are ignored.

## ***What Can Fiducials Be Used For?***

### *Simple Alignment Aid*

Create at least two fiducials for the test part, and save the fiducials. One fiducial mark should serve as a zoom guide; the second fiducial is an alignment mark that is aligned to some permanent feature or mark on the test part. Make a measurement and save the data. After additional manufacturing processes, the part can be realigned and zoomed to the saved fiducials, which are displayed on the video monitor. Measure the part again. You can directly compare the results of different measurements.

### *Tracking the Progress of a Part*

Create at least three fiducial marks for the test part; the fiducials should be located over holes in the data. Data holes can be created by sticking wax or targets to the part; these items will show up in the data as areas of no data. Measure the part and save the data. After additional manufacturing processes, place the part in the test setup, and create similar fiducial marks over the same features. Measure the part again. Set the Alignment control to Fiducials and the Alignment Scaling control to Anamorphic. Click the Subtract Data button and enter the name of the first data set. Subtracting the first data set from the second will show you what changed by the manufacturing processes.

*Match Part*

Place the “perfect” or ideal part in the test setup. Create at least three fiducial marks over features that can be identified in all parts being measured. Measure the part and save the data. Place the “test” part in the test setup and create similar fiducial marks. Measure the test part. Set the Alignment control to Fiducials and the Alignment Scaling control to Anamorphic. Click the Subtract Data button and enter the name of the “perfect” data set. This will show you the difference between the test part and the perfect part.

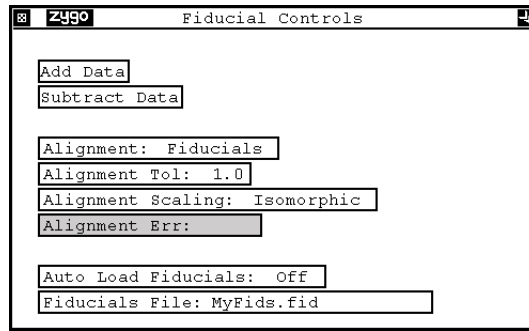
***Fiducial Controls and Buttons***

In order to compare data sets with fiducials you need to create buttons and controls in a Control window. A sample window is shown after the table.

To create a Control window, select the New Control Window command from the Application Window menu. You might want to rename the window to “Fiducial Controls”. Buttons are created in Control window with the New Button → Manipulate command. Fiducial controls are created in Control window with the New Control → Manipulate command. The attribute is created with the New Attribute → Miscellaneous command.

<b><i>Item</i></b>	<b><i>Function</i></b>
<i>Add Data button</i>	Click to add a named file from the existing data set. You must enter the file name.
<i>Subtract Data button</i>	Click to subtract a named file from the existing data set. You must enter the file name.
<i>Alignment</i>	Selects the type of alignment done when subtracting data with fiducials. Settings are Fiducials or None. Click it to select Fiducials.
<i>Alignment Tol</i>	Specifies the pixel tolerance allowed when aligning fiducials. Enter a numeric value. This control is used in conjunction with the Alignment Scaling control.
<i>Alignment Scaling</i>	Selects how fiducials are aligned. Settings are Isomorphic or Anamorphic. Isomorphic scales both axes equally. Anamorphic scales to the best fit.
<i>Alignment Err</i>	Displays the fiducial actual alignment error in pixels. This is an Attribute only.
<i>Auto Load Fiducials</i>	Selects if a stored fiducial file is loaded automatically. Settings are On or Off.
<i>Fiducials File</i>	Specifies the name of the stored fiducials file.

Sample Control Window configured with Fiducial controls







# Pattern Editor

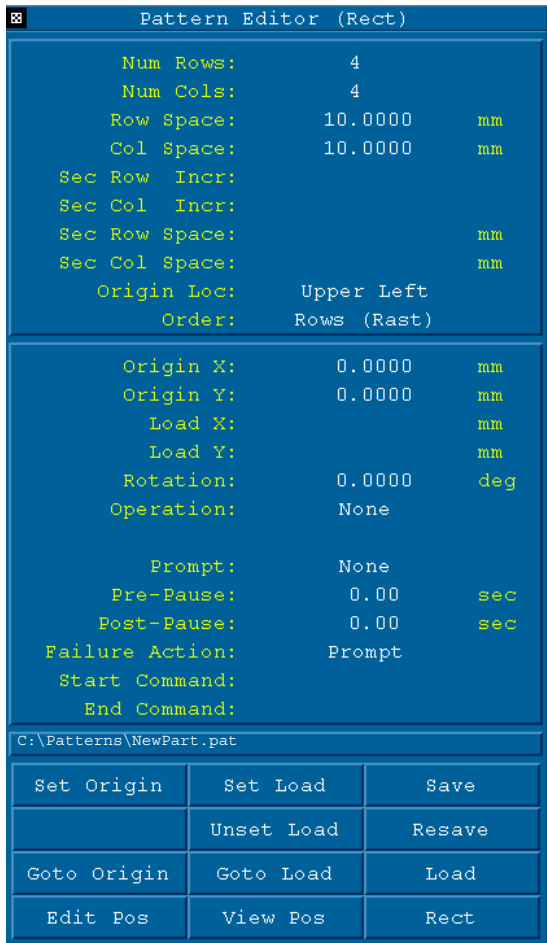
## Section 6

*If your instrument has motorized stages you can program measurement locations and patterns to automate the measurement process.*

### The Pattern Editor Window

The Pattern Editor and associated software controls provide for creating, editing, saving, and loading stage control pattern files. Pattern files direct the movement of programmable motorized stages.

Click the Edit Pattern button to open the Pattern Editor.



The screenshot shows the Pattern Editor window with the following settings:

Num Rows:	4	
Num Cols:	4	
Row Space:	10.0000	mm
Col Space:	10.0000	mm
Sec Row Incr:		
Sec Col Incr:		
Sec Row Space:		mm
Sec Col Space:		mm
Origin Loc:	Upper Left	
Order:	Rows (Rast)	
Origin X:	0.0000	mm
Origin Y:	0.0000	mm
Load X:		mm
Load Y:		mm
Rotation:	0.0000	deg
Operation:	None	
Prompt:	None	
Pre-Pause:	0.00	sec
Post-Pause:	0.00	sec
Failure Action:	Prompt	
Start Command:		
End Command:		


Below the settings is the current pattern filename: C:\Patterns\NewPart.pat

Set Origin	Set Load	Save
	Unset Load	Resave
Goto Origin	Goto Load	Load
Edit Pos	View Pos	Rect

Annotations on the right side of the image:

- Change the setting of a control by clicking on the line. Some controls cycle through choices. For others, use the keyboard to enter values and press [Enter].
- Some controls are variable based on pattern type.
- Common controls (described under "Common Controls – Pattern Editor")
- Displays the pathname of the file for the current pattern.
- Buttons (described below).

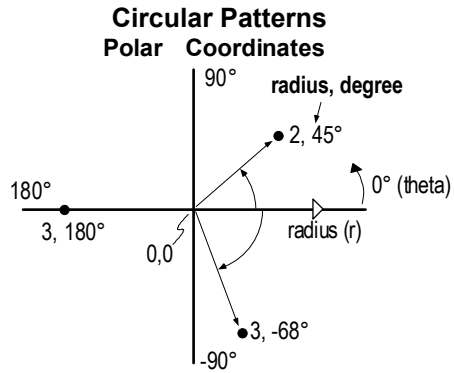
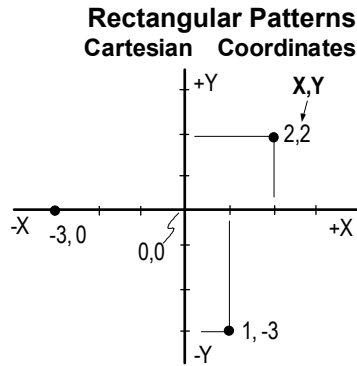
### Pattern Editor Buttons

<i>Button</i>	<i>Function</i>
<i>Set Origin</i>	<p>Sets current stage coordinates as the first pattern position. Set*Origin denotes a location is set as the origin.</p> <p> The origin for an R-Theta Stage is always at the center of the stage (0,0).</p>
<i>Goto Origin</i>	Drives the stage to the first pattern position.
<i>Edit Pos</i>	Open the Position Editor window, which is used to edit pattern positions.
<i>Set Load</i>	Sets current stage coordinates as the load position. Set*Load denotes a load position is set.
<i>Unset Load</i>	Erases the set load position.
<i>Goto Load</i>	Drives the stage to the pattern position for loading parts.
<i>View Pos</i>	Open the Position Status Window.
<i>Save</i>	Open the File Handler, which is used to save the pattern file.
<i>Resave</i>	Resaves the pattern to the current pathname, avoiding the filename selection dialog.
<i>Load</i>	Open the File Handler to specify a pattern file to load.
<i>Rect</i>	<p>Selects the pattern type. Also referred to as the "Mode" button.</p> <p>Rect – Rectangular</p> <p>Circ – Circular</p> <p>Free Rect – Free Rectangular</p>

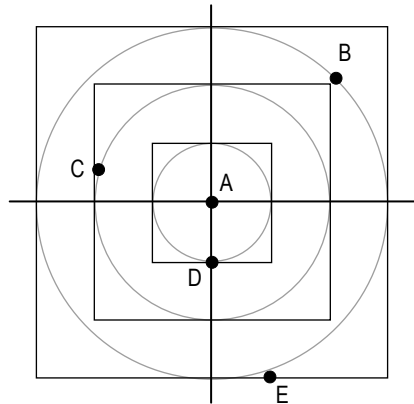
## Coordinate Systems

The X-Y programmable stage is based on a Cartesian coordinate system. The R-Theta programmable stage is based on a polar coordinate system.

Any of the pattern types - Rectangular, Circular, or Free Rectangular, can be used with either programmable stage. The type of pattern is selected with the Pattern Editor's "Mode" button. A rectangular pattern is based on a Cartesian coordinate system. A circular pattern is based on a polar coordinate system.

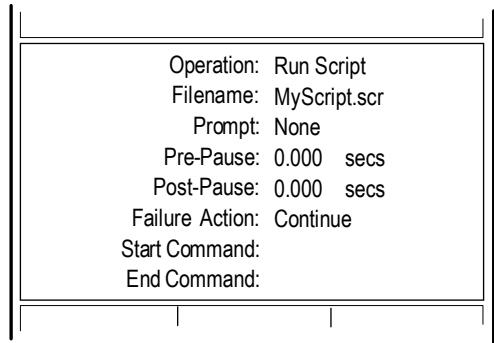


An example showing both Cartesian and polar coordinates superimposed is shown below.



<i>Position</i>	<i>Cartesian</i>	<i>Polar</i>
A	0, 0	0, 0
B	2.1, 2.1	3.0, 45°
C	-1.9, 0.6	2.0, 163°
D	0.0, -1.0	1.0, -90°
E	1.0, -3.0	3.1, -71°

## Common Controls - Pattern Editor



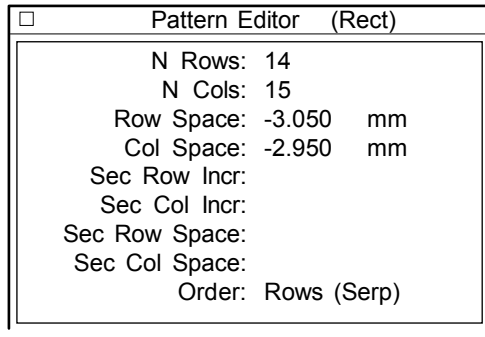
### Portion of Pattern Editor common to all pattern types

Change the setting of a control by clicking on the line. Some controls cycle through choices. For others, use the keyboard to enter values and press [Enter].

<i>Control</i>	<i>Function</i>
<i>Operation</i>	Selects what is done at each pattern point. Measure takes a measurement at each point. Set to None when checking pattern spacing. Run Script executes the MetroScript file specified after Filename.
<i>Filename</i>	Specifies the name of the script file when Operation is set to Run Script. Only appears when applicable.
<i>Prompt</i>	Selects when the operator is prompted at each pattern position. A prompt shows the current position and waits for the user to respond. Choices are Before, After, Before & After, or None (default).
<i>Pre-Pause</i>	Specifies a time delay before the measurement.
<i>Post-Pause</i>	Specifies a time delay after the measurement before the stage moves to the next position.
<i>Failure Action</i>	Selects what is done when there is a measurement error. A prompt asks the user what to do. Retry repeats the measurement and aborts the pattern if it fails again. Continue ignores the error and goes to the next position; the error position is not measured.
<i>Start Command</i>	Specifies a command that is executed before the start of a pattern.
<i>End Command</i>	Specifies a command that is executed when the pattern ends. An example is sending the data or a report file to another computer.

## Rectangular Pattern Controls

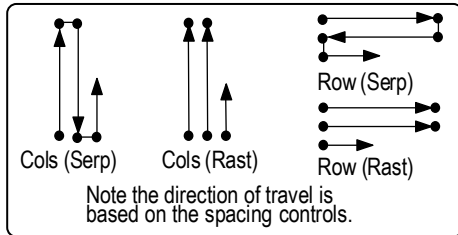
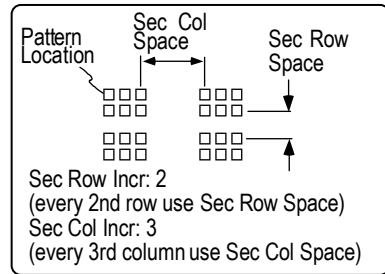
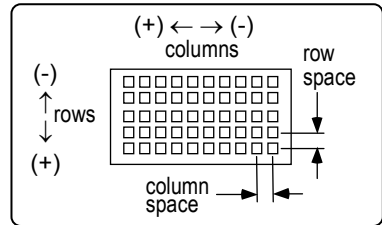
A rectangular pattern specifies points based on a Cartesian coordinate system. These controls are displayed when the Pattern Editor's "Mode" button is set to Rect.



### Rectangular Pattern Controls

Change the setting of a control by clicking on the line. Some controls cycle through choices. For others, use the keyboard to enter values and press [Enter].

<i>Control</i>	<i>Function</i>
<i>N Rows</i>	Sets the number of horizontal rows in the pattern. (999 max.)
<i>N Cols</i>	Sets the number of vertical columns in the pattern. (999 max.)
<i>Row Space</i>	Specifies the distance between each horizontal row. The direction of motion depends on the sign.
<i>Col Space</i>	Specifies the distance between each vertical column. The direction of motion depends on the sign.
<i>Sec Row Incr</i>	Specifies which rows use secondary row spacing.
<i>Sec Col Incr</i>	Specifies which columns use secondary column spacing.
<i>Sec Row Space</i>	Specifies the distance between each row in the secondary pattern. The sign determines motion direction.
<i>Sec Col Space</i>	Specifies the distance between each column in the secondary pattern. The sign determines motion direction.
<i>Order</i>	Selects how the pattern is run. Serp - Serpentine Rast - Raster



### Rectangular Patterns - Position Editor

To open the Position Editor window, click the Pattern Editor's Edit Pos button or the Edit Pattern Pos button. The Position Editor is used to edit the pattern to include or exclude pattern locations.

Goto Load	Rect
<b>Edit Pos</b>	View Pos

The Position Editor edits the pattern file to include or exclude positions.

*Pattern Editor Button*

Click on row number to toggle row from I to X.

The number of rows and columns is determined from settings in the Pattern Editor.

Position Editor

	1	2	3	4	5	6	7	8	9	10
1	I	I	X	I	I	X	I	I	I	X
2	I	I	X	I	I	X	I	I	I	X
3	I	I	X	I	I	X	I	I	I	X
4	I	I	X	I	I	X	I	I	I	X
5	I	I	X	I	I	X	I	I	I	X
6	I	I	I	I	I	X	I	I	I	X
7	I	I	I	I	I	X	I	I	I	X
8	I	I	I	I	I	X	I	I	I	X
9	I	I	I	I	I	X	I	I	I	X

Click on column number to toggle column from I to X.

Click on single position to toggle from I to X.

I = include  
X = exclude

Scroll controls appear when the pattern is too big to fit on the screen.

### Rectangular Patterns - Position Status

To open the Position Status window click the Pattern Editor's View Pos button or the View Pattern Pos button. The Position Status window shows the current status of the pattern; click on a location to drive the stage that position.

Load Pos	Rect
	<b>View Pos</b>

Position Status shows the pattern's status; it can also drive the stage to any location.

*Pattern Editor Button*

The number of rows and columns is determined from settings in the Pattern Editor.

Current location, when measured I changes to P, F, O, or ?

After pattern is complete, click on ? to move stage to that location and remeasure.

Position Status

	1	2	3	4	5	6	7	8	9	10
1	P	P	X	P	F	X	P	P	F	X
2	P	P	X	?	P	X	P	P	P	X
3	P	P	X	I	I	X	I	I	I	X
4	I	I	X	I	I	X	I	I	I	X
5	I	I	X	I	I	X	I	I	I	X
6	I	I	I	I	I	X	I	I	I	X
7	I	I	I	I	I	X	I	I	I	X
8	I	I	I	I	I	X	I	I	I	X
9	I	I	I	I	I	X	I	I	I	X

Click on any location to drive stage to that position.

**CODES:**  
 I = include  
 X = exclude  
 P = pass  
 F = fail  
 O = out of limits  
 # = skipped  
 ? = not measured  
 A = aborted

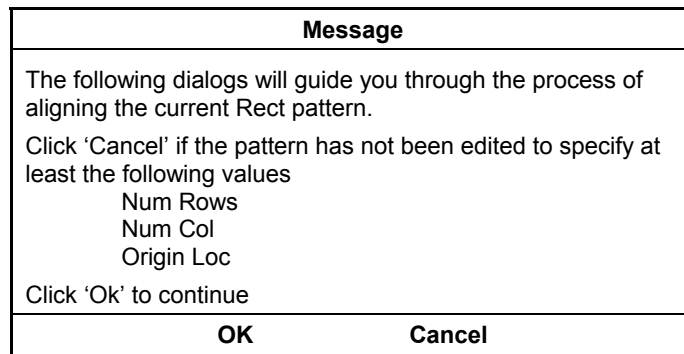
Scroll controls appear when the pattern is too big to fit on the screen.

## **Rectangular Patterns – Align Pattern (Determining the Rotation Value)**

This function provides for semi-automatic calculation of the misalignment of the programmable stage in the x and y axes to the pattern positions. Once the rotation values are determined, they are factored into the pattern during the Run Pattern operation. The rotation value may be copied to a Circular or Free Rect pattern, but a rectangular pattern must be used for set up.

The rotation value may be based upon the row coordinates, column coordinates, or both. The programmable stage must be able to access the pattern origin. During the alignment, movement to all the pattern coordinates may not be possible. When this happens, the following error message is generated: “One or more invalid coordinates.”

1. Be sure that a valid pattern file has been loaded.
2. Open the Pattern Editor.
3. Select Rect as the pattern type.
4. Check that the origin location is set correctly.
5. Click the Align Pattern button (or Control → New Button → Pattern Align → Pattern). A dialog box with the following message is displayed:



6. To continue, click OK.
7. The system will prompt you to move the stage to the origin location. Click the Goto Origin button.
8. Use the joystick to move to the last column and click OK.
9. Click Yes in response to the Calculate column Spacing and Row Spacing prompts.



The View Pos button is in the main Pattern Editor window.

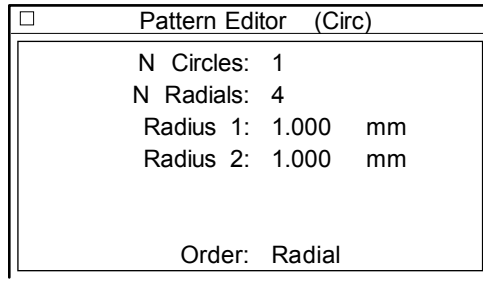
When checking position status, select None for Operation type.

This will enable you to view every position without making a measurement at each position.

10. Select Both as the alignment type. Follow the prompts to move to the last row/last column.
11. Click Done to complete the Align Pattern routine. A value should be displayed in the Rotation control. This value may be copied to a Circular or Free Rect pattern.

## Circular Pattern Controls - Pattern Editor

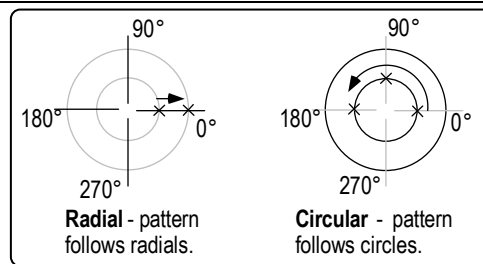
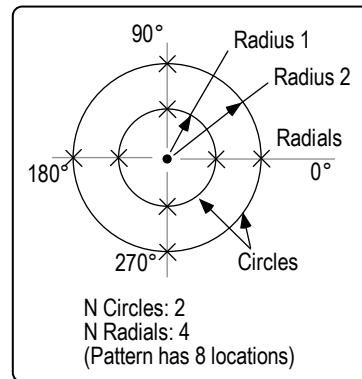
A circular pattern specifies points in a polar coordinate system. The center of each circular pattern is assumed to be the center of the theta axis. These controls are displayed when the Pattern Editor's "Mode" button is set to Circ.



### Circular Pattern Controls

Change the setting of a control by clicking on the line. Some controls cycle through choices. For others, use the keyboard to enter values and press [Enter].

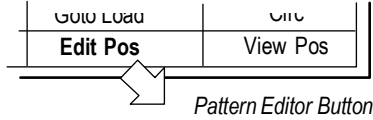
<i>Control</i>	<i>Function</i>
<i>N Circles</i>	Sets the number of circles in the pattern. (10 max.)
<i>N Radials</i>	Sets the number of equally spaced measurement points around each circle. For example, a setting of 4 places measurements at 90 degree intervals. (24 max.)
<i>Radius 1</i>	Specifies the dimension for the first measurement circle. If N Circles is 3 or more, additional measurements are made at equally spaced locations between Radius 1 and Radius 2.
<i>Radius 2</i>	Specifies the dimension for the last measurement circle. If N Circles is 1, Radius 2 is ignored.
<i>Order</i>	Selects how the circular pattern is executed. Choices are Radial or Circular. Radial starts at the 0 degree mark and jumps between radii. Circular starts at the 0 degree mark and completes one circle before going to the next.





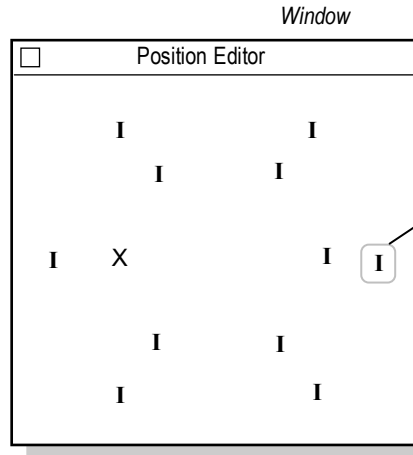
### Circular Patterns - Position Editor

To open the Position Editor window click the Pattern Editor's Edit Pos button or the Edit Pattern Pos button. The Position Editor is used to edit the pattern to include or exclude pattern locations.



The Position Editor edits the pattern file to include or exclude positions.

The number of radials and circles are determined from settings in the Pattern Editor. In this example:  
N Circles: 2  
N Radials: 6

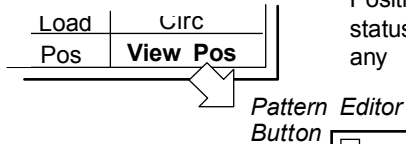


Click on single position to toggle from I to X.

CODES:  
I = include  
X = exclude

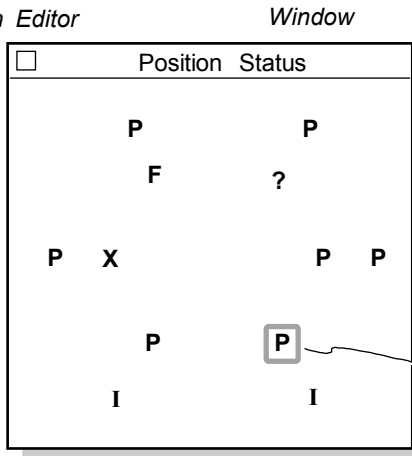
### Circular Patterns - Position Status

To open the Position Status window click the Pattern Editor's View Pos button or the View Pattern Pos button. The Position Status window shows the current status of the pattern; click on a location to drive the stage to that position.



Position Status shows the pattern's status; it can also drive the stage to any location.

The number of radials and circles are determined from settings in the Pattern Editor. In this example:  
N Circles: 2  
N Radials: 6



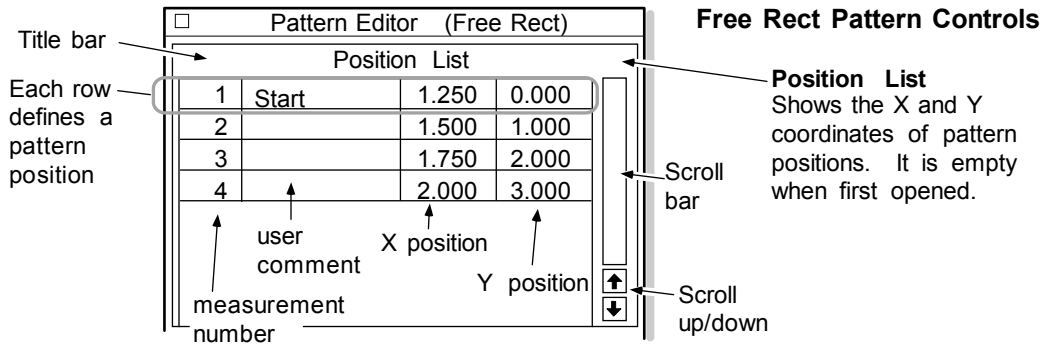
Click on any location to drive stage to that position.

CODES:  
I = include  
X = exclude  
P = pass  
F = fail  
O = out of limits  
# = skipped  
? = not measured  
A = aborted

After pattern is complete, click on ? to move stage to that location and remeasure.

## Free Rect Pattern Controls

A Free Rect pattern specifies pattern positions in an X and Y Cartesian coordinate system; it can be used with all programmable stages. These controls are displayed when the Pattern Editor's "Mode" button is set to Free Rect. The Position List is empty when first opened.



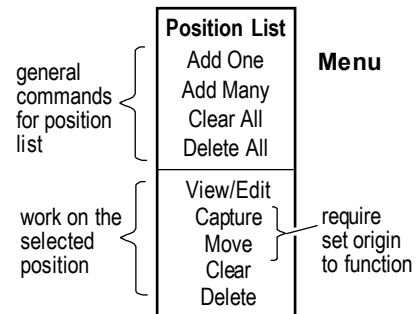
### Adding Positions (on-line) - Free Rect Pattern

On-line refers to when the programmable stage is present. There are two basic ways of adding positions. One is to step the stage through each measurement location and select the Add One command at each location. Another way is to add many positions with the Add Many command, then move the stage to each measurement location and select the Capture command.

1. Drive the programmable stage to the desired position.
2. Move the cursor over the Position List title bar, press the right mouse button and select the Add One command. The current stage location is automatically entered in this position.
3. Repeat the above steps until all positions are added.

or

1. Move the cursor over the Position List title bar, press the right mouse button, and select the Add Many command.
2. Drive the stage to the desired position.
3. Select a position in the Position List by clicking on it with the left mouse button.
4. Press the right mouse button and select the Capture command. (Note: the pattern origin must be set for Capture to work.)

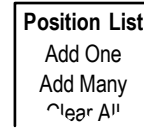


Add One	Adds one pattern position.
Add Many	Adds the specified number of pattern positions.
Clear All	Erases information from all positions.
Delete All	Removes all pattern positions.
View/Edit	Opens the Position Editor.
Capture	Captures the stage location for the selected position.
Move	Moves the stage to the selected position.
Clear	Erase information from the selected position.
Delete	Remove the selected position.

### **Adding Positions (off-line) - Free Rect Pattern**

Off-line refers to when the programmable stage is not present.

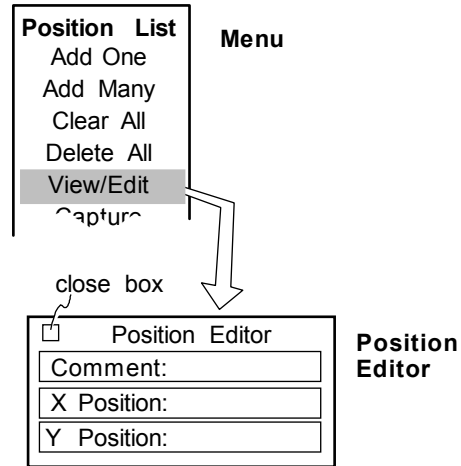
1. Move the cursor over the Position List title bar, press the right mouse button and select the Add One or Add Many command. Positions are added with coordinates of 0, 0.



### **Editing Positions - Free Rect Pattern**

There are two basic ways of editing positions. One is to select the View/Edit command and enter information in the Position Editor. Another way is to move the stage to the measurement location and select the Capture command.

1. Select a position in the Position List by clicking on it with the left mouse button. Press the right mouse button and select the View/Edit command.
2. In the Position Editor, edit applicable information by clicking on a line and typing the comment or coordinate position. Click the close box to close the Editor.



or (not available when off-line)

1. Drive the stage to the desired position.
2. Select a position in the Position List by clicking on it with the left mouse button. Press the right mouse button and select the Capture command. (Origin must already be set.)

### **Changing the Order of Positions - Free Rect Pattern**

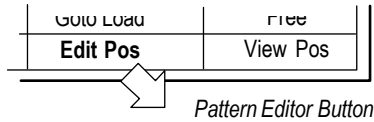
1. Move the cursor over the position in the Position List you want to move. Press the left mouse button and drag the position to its new location, then release the mouse button. Measurement numbers are automatically renumbered.

### **Deleting Positions from the Position List – Free Rect Pattern**

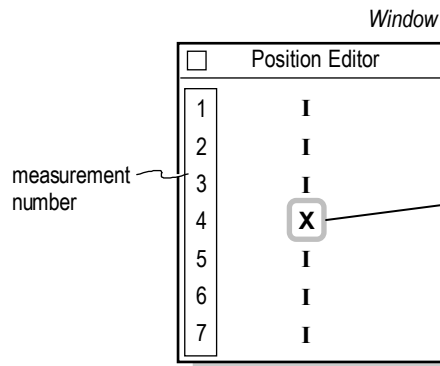
1. To remove all pattern positions, move the cursor over the Position List title bar, press the right mouse button, and select the Delete All command.
2. To remove one pattern position, select a position in the Position List by clicking on it with the left mouse button. Then press the right mouse button and select the Delete command.

### Free Rect Patterns - Position Editor

To open the Position Editor window click the Pattern Editor's Edit Pos button or the Edit Pattern Pos button. The Position Editor is used to edit the pattern to include or exclude pattern locations.



The Position Editor edits the pattern file to include or exclude positions.

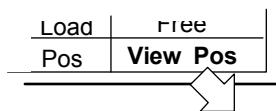


Click on single position to toggle from I to X.

CODES:  
I = include  
X = exclude

### Free Rect Patterns - Position Status

To open the Position Status window click the Pattern Editor's View Pos button or the View Pattern Pos button. The Position Status window shows the current status of the pattern; click on a location to drive the stage to that position.



Position Status shows the pattern's status; it can also drive the stage to any location.

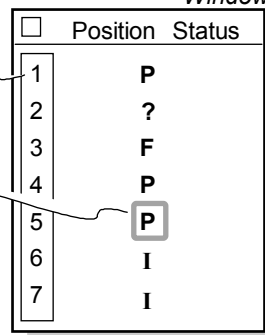
Pattern Editor Button

Window

measurement number

Current location, when measured I changes to P, F, O, or ?

After pattern is complete, click on ? to move stage to that location and remeasure.



Click on any location to drive stage to that position.

CODES:  
I = include  
X = exclude  
P = pass  
F = fail  
O = out of limits  
# = skipped  
? = not measured  
A = aborted

### ***Free Rect Align Pattern (Determining the Rotation Value)***

The following steps cover alignment of a Free Rect pattern. This procedure may also be used for a normal rectangular pattern as long as alignment positions are selected.

1. Before using this procedure, be sure the stage has been homed, and AutoCalibrate has been run.
2. Open the Pattern Editor and use the Load button to open a valid pattern.
3. Click on the EditPos button and open the Position Editor. Use the middle mouse button to click on the position(s) that will be used as alignment positions. They will be highlighted yellow. Alignment positions do not have to be included in the pattern.



For a pattern with one alignment position, follows steps 4 through 7. For a pattern with 2 or more alignment positions follows step 8 through 13.

4. For one alignment position, click the Align Pattern button. The following dialog box is displayed. Follow the screen prompts.

<b>Message</b>	
The following dialog will guide you through the process of adjusting ONLY THE ORIGIN of the current pattern.	
Click 'Ok' to continue. Click Cancel to abort.	
<b>OK</b>	<b>Cancel</b>

5. To continue, click OK.
6. The system moves the stage to the location where it thinks the position is. You may need to use the X/Y joystick to adjust the position so that fringes are visible. Click OK. The pattern's origin is automatically updated and "Pattern Alignment Complete" is displayed.
7. Click the Save button to save the aligned pattern.
8. For two or more alignment positions, click the Align Pattern button. The following dialog box is displayed. Follow the screen prompts.

<b>Message</b>	
The following dialog will guide you through the process of adjusting the ORIGIN and ROTATION of the current pattern.	
Click 'Ok' to continue. Click Cancel to abort.	
<b>OK</b>	<b>Cancel</b>

9. To continue, click OK.
10. The system moves the stage to the location where it thinks the first position is. You may need to use the X/Y joystick to adjust the position so that fringes are visible. At each position the system temporarily calculates and updates the rotation value. The same process is repeated for all of the alignment positions.

11. After the stage has been moved to the last alignment position, the pattern's origin and rotation will be automatically updated and a message indicating "Pattern Alignment Complete" will be displayed.
12. Click the Goto Origin button to check the first position.
13. Click on the Save button to save the aligned pattern.

## Creating a Pattern - Pattern Editor

This procedure provides a generic approach to creating and using a pattern file. Multiple pattern files can be created and saved.

1. Click the Edit Pattern button to open the Pattern Editor.
2. Select the pattern type with the Pattern Editor's "Mode" button.
3. Enter values for the applicable Pattern Editor controls, as shown in previous sections.
4. Define Origin and Load. Using the motion controller, drive the stage to the first pattern position and set the origin by clicking the Set Origin button. Then drive the stage to the location for loading parts and click the Set Load button.
5. Make a trial pattern test run. Set the Pattern Editor's Operation control to None. Click the Run Pattern button.
6. To save your defined pattern file, click the Pattern Editor's Save button. In the File Handler, click on the Current Selection field, type in a file name ending, with ".pat", and press [Enter], then click Done to close the File Handler.
7. Click the Auto Load Pattern control to On. Enter the name of the pattern in the Pattern File control.
8. Save your changes to the application. If it is a supplied application from Zygo, select the Save Application command from the Application Window menu. In the File handler, enter a name for the file, ending with ".app", and press [Enter], then click the Done button.

## Configuring MetroPro for the Programmable Stage

MetroPro must be configured for the programmable stage and the Pattern Editor to function properly. Configuration procedures are included in case it becomes necessary to reinstall or update the programmable stage configuration file.

Perform the appropriate procedure, as based on the operating system, after MetroPro is installed and the equipment is up and running. MetroPro configuration file names are listed in the following table.

Instrument	Stage	File Name
NewView 100/200	2-axis: 6-inch XY stage w/increased speed	xy15.cfg
NewView 100/200	5-axis: 6-inch XY stage w/increased speed, tip/tilt stage, and Z stage	xy20.cfg
NewView 100/200	5-axis: 6-inch XY stage, tip/tilt stage and Z stage	xy22.cfg
NewView 5000	5-axis: 6-inch XY stage, tip/tilt stage, and Z stage	xy31.cfg
NewView 5000	3-axis: 6-inch XY stage with content drivers	xy53.cfg
NewView 5000	3-axis: 6-inch XY stage, and Z stage	xy32.cfg
NewView 5000	2-axis: 6-inch XY stage	xy33.cfg
GPI	2-axis: tip/tilt stage	xy34.cfg
Mesa	2-axis: tip/tilt stage	xy35.cfg
Mesa	3-axis: tip/tilt stage, and Z stage	xy36.cfg
Large Aperture GPI-18"	2-axis: tip/tilt stage	xy37.cfg
Downward MESA	3-axis: tip/tilt stage, and Z stage	xy38.cfg
Downward GPI VWS	3-axis: tip/tilt stage, and Z stage	xy39.cfg
Downward GPI MetroCell	Z-Axis, encoded	z06.cfg
Downward GPI MetroCell	5-axis: 1/2-inch XY stage, tip/tilt stage, and Z stage	xy49.cfg
Downward GPI MetroCell	Z-axis with Linear Encoder	z03.cfg
Downward GPI MetroCell	5-axis: X, Y, Z and tip/tilt	xy54.cfg

## METROPRO REFERENCE GUIDE

GPI MPT	2-axis: tip/tilt stage	xy49.cfg
MicroLUPI	3-axis: XY stage, and Z stage, plus Z stage encoder	xy52.cfg
GPI MPT	2-axis: tip/tilt stage	xy60.cfg
DVD400	3-axis: 8-mm XY stage, and Z stage	xy70.cfg
Maxim XR/GP	Z Stage	z01.cfg
NewView 5000	Z Stage	z02.cfg
Upward GPI MetroCell	Z-axis with Linear Encoder	z04.cfg
Upward GPI MetroCell	Z-axis only, encoded	z07.cfg
NewView 100/200	5-axis: fast X, slow Theta, tip/tilt, and Z stage	rt06.cfg
NewView 100/200	2-axis: fast X and slow Theta	rt07.cfg
NewView 5000	2-axis: X and Theta	rt08.cfg
NewView 5000	3-axis: X, Theta, and Z stage	rt14.cfg
NewView 5000	5-axis: X, Theta, tip/tilt and Z stage	rt15.cfg
NewView 5000	5-axis: X, Theta, tip/tilt and Z stage with content drivers	rt16.cfg
NewView 6000	5-axis: Y, Theta, tip/tilt and Z stage	rt17.cfg
NewView 6000	Z-stage only	z05.cfg
NewView 6000	Z-stage only for Schneeberger stage	z08.cfg
VeriFire Asphere	5-axis: X, Y, Z and tip/tilt	xy71.cfg
VeriFire Asphere	5-axis: X, Y, Z and tip/tilt	xy72.cfg

---



## ***Configuring the Motion Controller for the Programmable Stage***

1. Exit MetroPro.
2. Open Windows Explorer. Go to the "MetroPro\cfg" directory. Open the calibration file; it is the name of the computer and ends with ".1". If it does not open immediately, select Notepad as the application to read the file.



In the following procedure "xxxx.cfg" denotes the configuration file for a particular stage; substitute the correct file name from the previous table.

3. Find the line that begins with "MotionCtrl". Check to see that the appropriate configuration file is listed. If necessary, edit the line as follows:
 

```
MotionCtrl XXXX.cfg com2
```
4. If changes were made to the file, save the file and exit Notepad. If no changes were made to the calibration file, skip this step.
5. Open an MS-DOS prompt window.
6. Switch directories by typing: `cd c:\metropro\cfg`
7. Load information into the Motion Controller memory by typing:
 

```
mc_update com2: XXXX.cfg [Enter]
```
8. Reset the Motion Controller: press the Motion Stop button; press and hold the AXIS SELECT button and release the Motion Stop by turning it clockwise.
9. Open MetroPro and click the Home Stage button.



# Filled Plot and Profile Plot

## Section 7

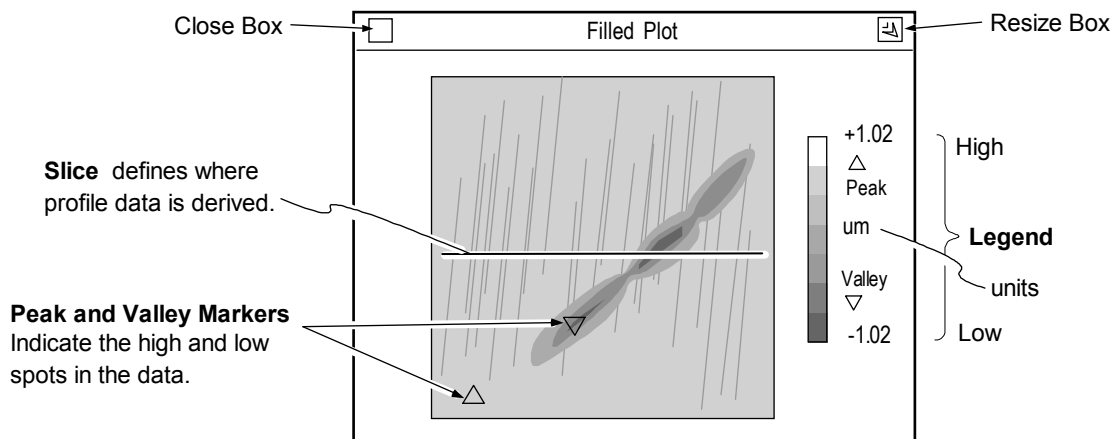
*The two most common plots are the Filled Plot and the Profile Plot; they work in tandem.*

The Filled plot shows a topographical contour map of the test part surface, providing dimensional information in three axes. The Profile Plot shows data along a slice through a corresponding Filled Plot, providing two-dimensional information. The slice may be straight or circular and can be positioned anywhere over the Filled Plot.

### Filled Plot

A Filled plot shows different heights in different colors, like a geographical contour map. Technically speaking, it displays surface data as a function of the magnitude as viewed along the instrument's z-axis. Areas with different magnitudes, or height, are represented by different colors, or in a one color plot as different shades. The Filled plot is also used to define slices.

Filled Plots are created in a data window using the New Plot → command. To open the plot Controller, click on the plot with the middle mouse button.



## The Filled Plot's Controller

To open the plot controller position the pointer over the Filled plot and click the middle mouse button.

To activate a button, position the pointer on the button and click the left mouse button.

Filled Plot		
Value: um		} <b>Hilite Tool</b>
zMax: um		
zMin: um		} <b>Z-Axis Fixed Scale Tool</b>
Width: pix		
Radius: pix		} <b>Slice Modify Tool</b> Width specifies the width of a Linear, Circular, or Circ Ctr slice. Radius specifies exact radius for a Cric Ctr or Cric MinPV slice.
Update	Slice Off	
Reset	Zoom	} <b>Buttons</b>
Set	Legends	
Bands	Show PV	
HiliteOff	Color Fit	
Limit Off		

## Filled Plot Controller Buttons

**Update** - Redraws the plot to match the current Controller settings.

**Reset** - Restores button settings to match the “set” Controller settings.

**Set** - Makes the current Controller settings the master or “set” display.

**Color** - Selects the color of the plot. Choices: Bands (16 colors), Golds, Greys, CMYK (cyan, magenta, yellow, and black), Spectrum, and Neon (a variation of Spectrum). Colors other than Bands use 2000 colors.

**Hilite** - Adds bright green highlights to grey plot contours. Only functional when the Color button set to Greys. HiliteOff turns highlighting off.

For more information, see “Using the Filled Plot’s Hilite Tool” in this section.

**Limit** - Determines if and how the PV (peak-to-valley) limits are highlighted in red in the plot. Limit Off displays no limits in the plot.



To display limits in the plot, high limits must be set in a PV Result box in the same data window.

For more information, see “Displaying Limits in the Filled Plot”.

**Slice** - Selects the type of slice you can draw on the Filled plot. Slice Off turns slicing off.

For other selections, see “Slicing the Filled Plot” in this section.

**Zoom** - Determines how the plot is drawn. When on, the plot fills as much of the window as possible. When off, data is displayed relative to its camera position.

**Legends** - When on, displays a color key and scale to the right of the plot. The scale denotes magnitude.

**ShowPV** - When on, marks the highest and lowest points on the plot with triangles.

**Color Fit** – When on, plot colors are adjusted to display a greater range of colors for surfaces that are predominately one color. This affects the plot display only and not numeric results.



Not all plot Controllers for Filled plots are identical. For example, an MTF Filled plot Controller is not identical to a phase Filled plot Controller, though both are Filled plots. The MTF Filled plot Controller contains a subset of the features of the Filled plot Controller. The full-featured Filled plot Controller is described herein.

### ***Opening the Plot Controller***

1. Position the pointer on the plot window and press the middle mouse button.
2. If this is the first time the controller opened, an outline of the Controller appears. Drag the mouse to position the Controller and release the mouse button. The Controller appears when you let go of the mouse.

### ***Using the Plot Controller***

All plot Controller buttons are activated by positioning the pointer over the button and clicking the left mouse button. If there are several choices to a button, repeat click the mouse to cycle through the selections. Click the right mouse button to cycle through choices in the opposite direction. The general procedure is:

1. Click the plot Controller button(s). Some actions occur immediately, others require updating.
2. If necessary, update the plot by clicking the Update button.
3. Store new plot Controller settings by clicking the Set button.



When a measurement is taken or data is loaded, the plot Controller settings revert or reset to the stored settings.

4. Make other temporary modifications to the plot using the Controller. Reverse the Controller settings back to the stored settings by clicking the Reset button.

### ***Permanently Saving Plot Settings***

1. After you have changed the plot display with the Controller, you can save these settings by clicking the Set button with the left mouse button. This temporarily preserves changes made with the Controller.
2. To permanently preserve changes made to the plot with the Controller, Plot menu, or Resize box, the application must be saved. To save the application, access the Application Window menu and select the Re-save Application command.

### ***Resizing the Filled Plot***

When resizing the window, the plot will automatically resize if the size of the window allows the next incremental plot size to fit, and the Zoom button is on. There is no interpolation of the camera data in a Filled plot. The plot is displayed at the nearest integer multiple. For example, one camera pixel may equal one pixel on the color monitor; or one camera pixel may equal four pixels on the color monitor.

1. Click the Zoom button so the zoom function is on.
2. Position the pointer on the window Resize box and press the left mouse button; or, if the title bar is hidden, select the Plot menu's Resize command. Then drag the mouse to resize the window and release the mouse button.

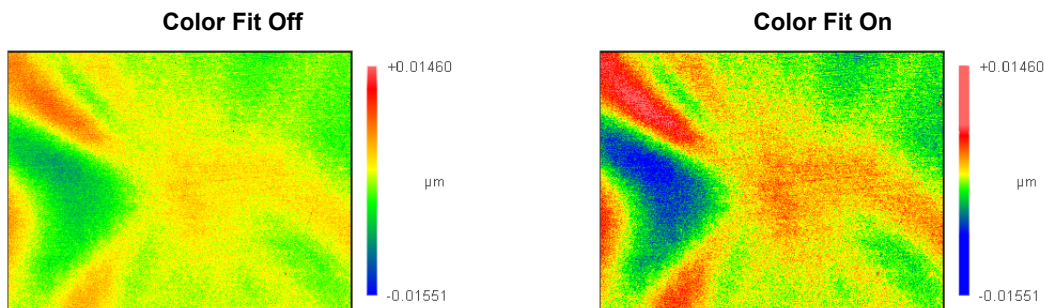
### ***Using Colors in the Filled Plot***

Click the plot Controller Color button to change the color of the plot. Suggestions regarding choice of colors are:

- Spectrum shows the greatest detail in the center of plotted height values.
- Neon shows the greatest detail near the top and bottom of plotted height values.
- Greys or Golds help you to see slices; Greys must be used for the Hilite tool and to display limits.

### ***Color Fit***

Click the plot Controller Color Fit button to activate or deactivate this function. Color Fit applies a non-linear scaling to the surface to bring out detail in plots that are predominately one color. The upper 0.5% of the data and the lower 0.5% of the data are mapped to the highest and lowest colors respectively. The remainder of the colors are used for the rest of the data. Color Fit is for display only; it does not affect result calculation.



### ***Changing the Plot Units***

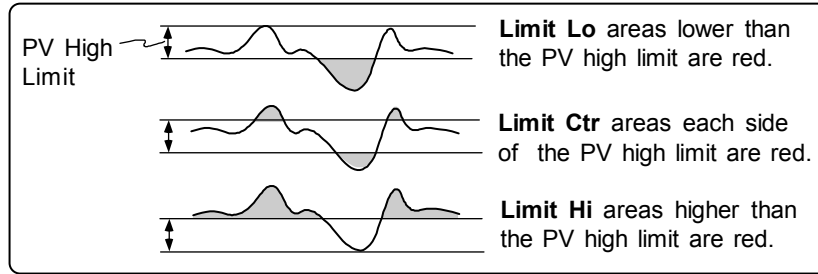
The measurement units for the legend are specified with the Filled Plot menu's Z Units command. The measurement units for the Slice Info box are specified with the Filled Plot menu X-Y Units command. The number of decimal places is set automatically.

### ***Using Peak and Valley Markers***

1. Click the plot Controller Show PV button with the left mouse button.
2. Click the Update button. If Legends is on, the legend displays a key to the markers.

### Displaying Limits in the Filled Plot

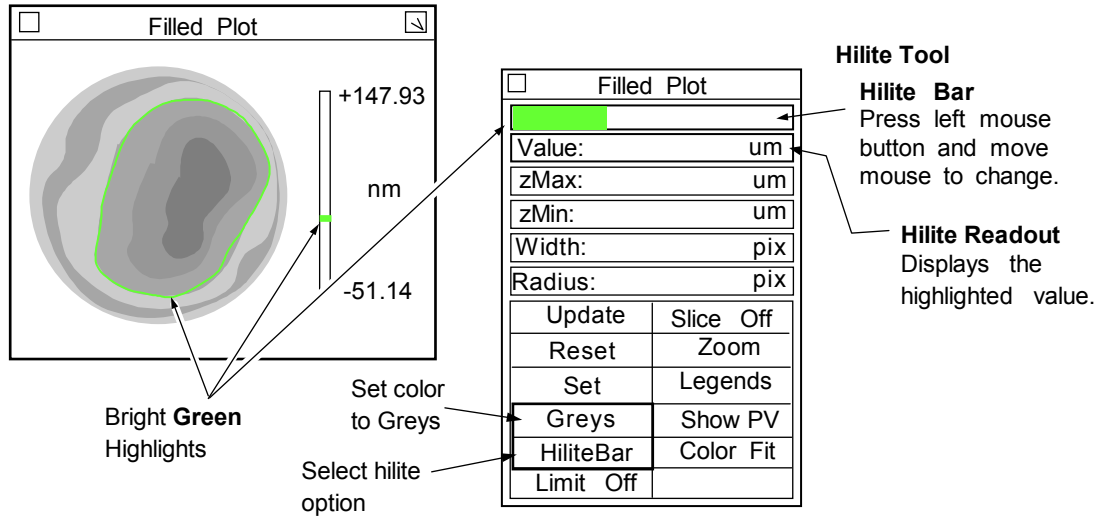
The plot Controller Limit button is used in conjunction with the PV result to display red limits in the Filled plot. The Color button must be set to Greys.



1. Click the plot color to Greys. Click the Limits button to select the limit mode. Then click the Controller's Update button.
2. In the PV result in the same data window, select the Limits → High command from the result's menu. Enter a high limit for the PV result and press [Enter].

### Using the Filled Plot's Hilite Tool

The plot Controller Hilite button and the Hilite Tool are used to highlight contours through the Filled plot data. The Color button must be set to Greys.

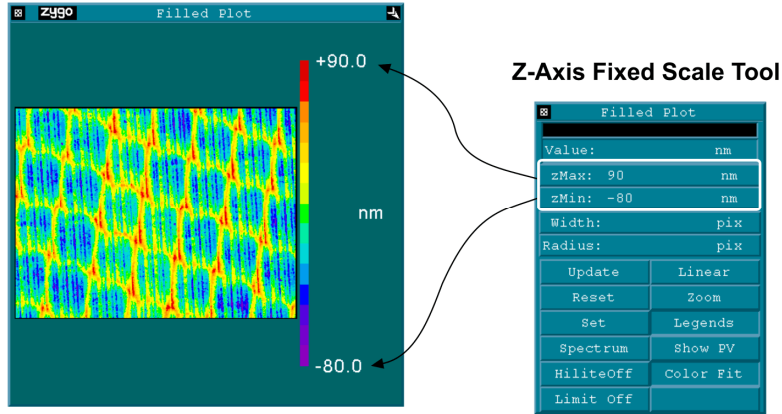


- HiliteOff** Highlights are not displayed.
- HiliteBar** Shows green highlights through the data based on the setting of the hilite bar.
- HiliteTop** Shows green highlights on all data above the position of the hilite bar.
- HiliteBtm** Shows green highlights on all data below the position of the hilite bar.

1. Click the plot color to Greys. Click the Hilite button to select the hilite mode. Then click the Controller's Update button.
2. Position the pointer over the plot Controller Hilite Tool and press the left mouse button. Drag the mouse to move the Hilite bar. The corresponding Filled plot and Hilite readout update automatically to the movements of the mouse.

### Using the Filled Plot's Z-Axis Fixed Scale Tool

The Z-Axis Fixed Scale Tool enables you to adjust the range (minimum/maximum) of values for the Filled plot height data. It is useful for comparing the height data of a similar group of test parts. Use caution with fixed scaling, as inappropriate values may obscure data by clipping it (height is too small) or compressing it (height is too large). And if the plot is blank, it is because the data does not fall within the range of the Z-Axis.



### Selecting the Z-Axis Fixed Scale Mode

Position the pointer over the Z-Axis Fixed Scale Tool. Click the right mouse button to change modes.



Values must be entered in the tool for this function to operate. Zero (0) is a valid entry.

### Z-Axis Fixed Scale Modes

<i>Mode</i>	<i>Description</i>
<b>ZMax</b>	Max specifies the upper value. If left blank, ZMax defaults to the peak of the data.
<b>ZMin</b>	Min specifies the lower value. If left blank, ZMin defaults to the valley of the data.
<b>ZMax</b> <b>ZRng</b>	Max specifies the upper value. If left blank, ZMax defaults to the peak of the data. Rng specifies the range of the scale. If left blank, the scale expands downward to show the data.
<b>ZMin</b> <b>ZRng</b>	Min specifies the lower value. If left blank, ZMin defaults to the valley of the data. Rng specifies the range of the scale. If left blank, the scale expands upward to show the data.
<b>ZCtr</b> <b>ZRng</b>	Ctr specifies the center of the scale. If left blank, ZCtr defaults to the mean of the data. Rng specifies the range of the scale. If left blank, the scale expands to show the data.
<b>ZMax</b> <b>ZRng</b>	Max specifies the upper value. ZMax (blank) defaults to the peak. ZRng (negative) specifies the upper data range to exclude from the plot (when used with ZMax).
<b>ZMin</b> <b>ZRng</b>	Min specifies the lower value. ZMin (blank) defaults to the valley. ZRng (negative) specifies the lower data range to exclude from the plot (when used with ZMin).





The Z-Axis Fixed Scale Tool ZRng setting has dual functions. When a positive number is entered, it specifies the overall size of the axis. When a negative number is entered, it invokes an exclude option, which works only with the ZMax and ZMin settings.

**Entering Values in the Z-Axis Fixed Scale Tool**

1. Position the pointer over one of the two boxes in the Z-Axis Fixed Scale Tool.
2. Click the left mouse button, enter a numerical value and pres [Enter]. To erase values, click the left mouse button, delete all characters, the press [Enter].
3. Click the Plot Controller’s Update button to redraw the plot.
4. To preserve changes, click the Plot Controller’s Set button.

**Using the Filled Plot’s Width Tool**

The Width tool specifies the width of a Linear, Circular, or Circ Ctr slice. The typical width of a slice is one pixel. A wider slice provides an average of the data over the specified area of interest. If multiple slices are drawn, they all use the specified width. The range for a valid entry, in pixels, is from 1 to 469. When entering the value, the current X-Y units for the Filled plot are used. The range for a valid entry in real units depends upon the lateral resolution set with the lateral calibration procedure. If the lateral calibration procedure is not done for the instrument, the only available unit is pixels.

When Legends are active, a “Width” label and the actual value of the width of the slice appear at the bottom of the Filled plot legend. Note however, that the slice drawn on the plot does not reflect the width setting.

**Width Tool**  
specifies the line width of Linear, Circular, and Circ Ctr slices

Note the Width label.

Slices must be active

**Entering a Slice Width**

1. Access the Filled plot Controller. Click the Slice button with the left mouse button to select either Linear, Circular, or Circ Ctr as the slice type.
2. Position the pointer over Width and click the left mouse button. Type a value within the valid range and press [Enter].
3. Draw the slice through the Filled plot.

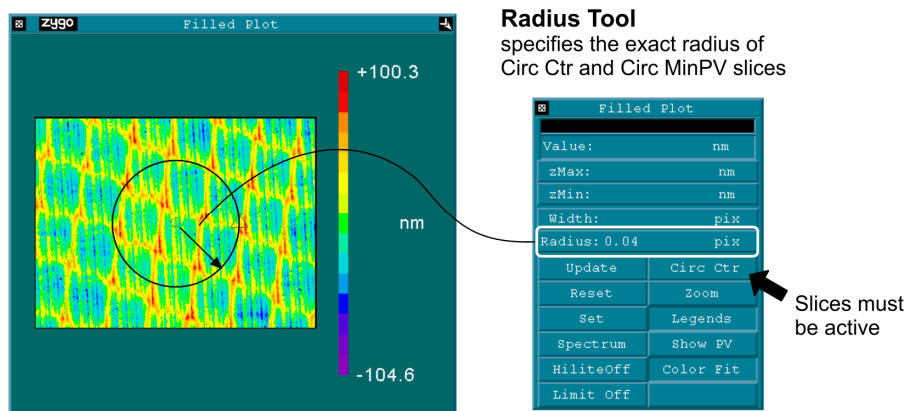
## How the Software Applies the Width Settings

<i>Slice</i>	<i>How Width is Applied</i>
<i>Linear</i>	For each point on the slice, a linear slice normal to the drawn slice is calculated. The length of the normal slice is equal to the value entered in the width control. Each normal slice is centered exactly upon the point at which it is calculated, extending above and below each point on the drawn slice. Each point on the wide slice is the average of the normal slice calculated at that point.
<i>Circular</i> <i>Circ Ctr</i>	For each point on the slice, a linear slice radial to the drawn slice is calculated. The length of the radial slice is equal to the value entered in the width control. Each radial slice is centered exactly upon the point at which it is calculated, extending above and below each point on the drawn slice. Each point on the wide slice is the average of the radial slice calculated at that point.

### Using the Filled Plot's Radius Tool

The Radius tool used to enter a specific radius value for the Circ Ctr and Circ MinPV slice types. When a value is entered, a slice is automatically drawn using the specified radius and centered appropriately. Only one slice can be specified, and the slice cannot be resized using the mouse.

The range for a valid entry, in pixels, is from 5 to 8192. When entering the value, the current X-Y units for the filled plot are used. The range for a valid entry in real units depends upon the lateral resolution set with the lateral calibration procedure. If the lateral calibration procedure is not done for the instrument, the only available unit is pixels.



### Entering a Slice Radius

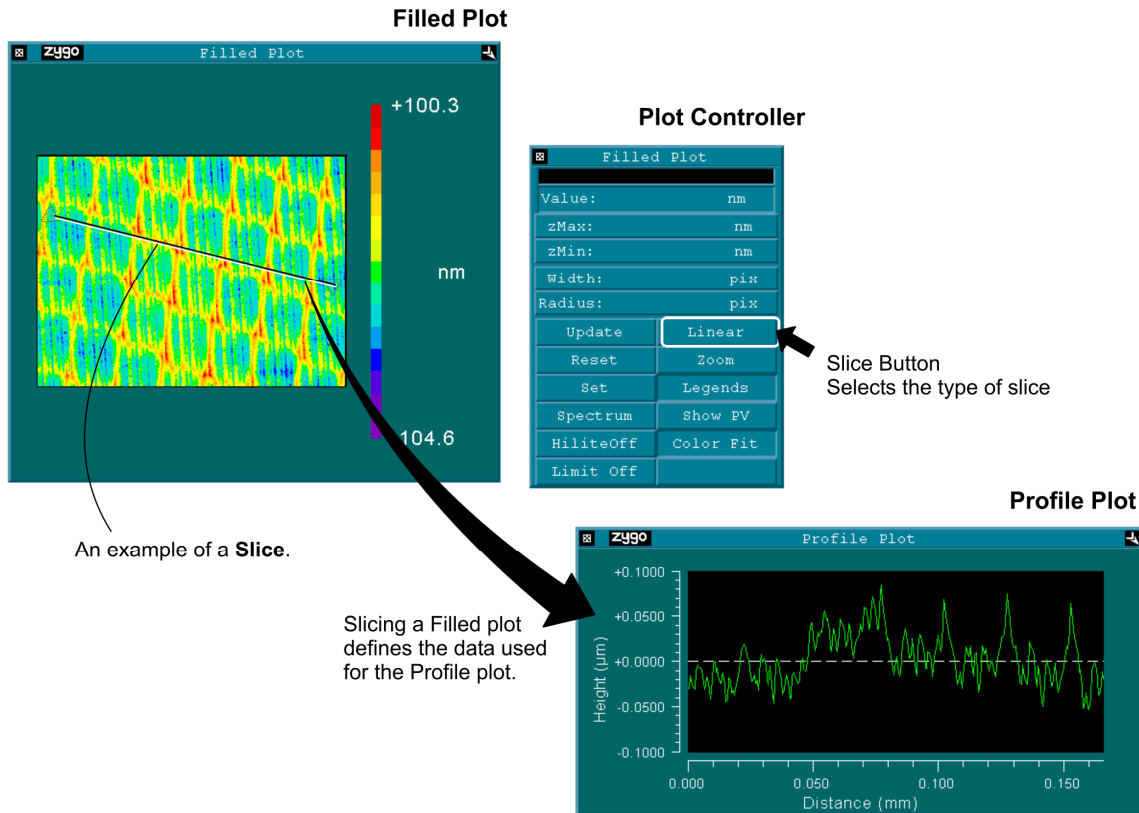
1. Access the Filled plot Controller. Click the Slice button with the left mouse button to select either Circ Ctr or Circ MinPV as the slice type.
2. Position the pointer over Radius and click the left mouse button. Type a value within the valid range and press [Enter].

## Slicing the Filled Plot










Drawing a line over the Filled plot is called “slicing”. Slicing defines a line or lines from which profile data is derived.



Results related to slices are displayed in a separate corresponding profile data window. For example, the slice is created on the Filled plot in the map Test/Default data window and the slice data is displayed in a Profile plot in a corresponding profile Test/Default data window.



**Plot Controller Slice Button Options**

<i>Slice Button</i>	<i>Example</i>	<i>Characteristics</i>
<i>Slices Off</i>	NA	Slicing function is off, no profile data is generated.
<i>Linear</i>		Straight line slice, freely positionable. Supports multiple slices.
<i>Radial Ctr</i>		Straight line slice, fixed to the center of the data and radiating outward. Supports multiple slices.
<i>Radial</i>		Straight line slice with a freely positionable center. Supports multiple slices.
<i>Circular</i>		Circular shape slice, freely positionable. Supports multiple slices.
<i>Circ Ctr</i>		Circular shape slice fixed to the center of the data. Supports multiple slices.
<i>AvgRad Ctr</i>		An average radius slice fixed to the center of the data, and representing multiple circular slices. Each pixel along the slice represents the average of all points on a circle. Each point on the corresponding Profile plot is the result of averaging the height along a circular slice.
<i>Circ MinPV</i>		Circular shape slice, for use with spheres and cones, with the center automatically fixed to the minimum PV value in the center $\pm 3$ pixels of the data array. The slice center is determined by searching the central portion of the data in increments of 1/16 of a pixel until the lowest PV is found.
<i>Crosshair</i>		Two straight linear slices, one vertical and the other horizontal, typically perpendicular to each other, with the end points of both slices defined (and fixed) by the size of the plot.
<i>Cross Ctr</i>		This slice type creates X and Y slices through the data whose origin is the center of the coordinate system instead of the lower right-hand corner. The slice is fixed in position and cannot be moved. The associated profile plots will have zero as the center of the horizontal axis.

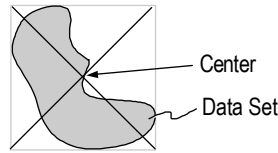
**Plot Controller Slice Button Options—continued**

<i>AvgRad</i>		An average radius slice that is freely positionable, and represents multiple circular slices. See AvgRad Ctr above for more information.
<i>Poly</i>		Slice that contains segments. The segments are straight, and the endpoints do not have to meet.

**Slicing Concepts**

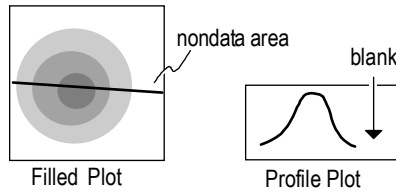
*Data Center*

The center of the data set is the center of a hypothetical rectangle enclosing the data.



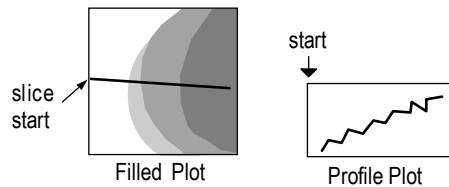
*Blank Areas*

Portions of the profile plot are blank when the slice is drawn over non-data areas.



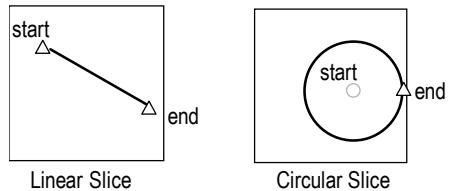
*Starting Points*

The start of a linear slice is always at the left side of the profile plot, no matter what direction the slice is created.



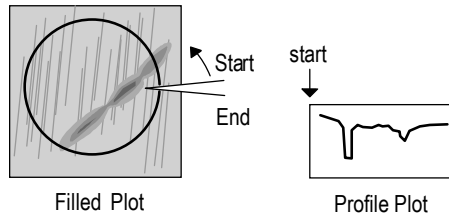
*Start and End Points*

Slices have start points and end points. These points are marked on the plot.



*Plotting Circular Slices*

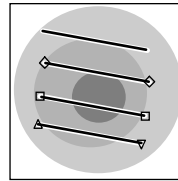
The circular slice is automatically cut and unwrapped to create the profile plot.



*Labeling Multiple Slices*

Slices are tagged in reverse order with the

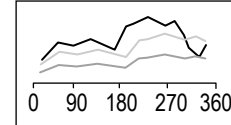
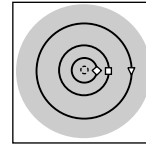
last created or current slice labeled with triangles. After the third slice no tags are used.



Creation Order	Tag	Working Order	Color in Profile
1	none	4	red
2	◇	3	blue
3	□	2	cyan
4	▽	1	green

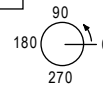
*Multiple Circular Slices*

Multiple circular slices are normalized to 360 degrees of a circle.



Filled Plot

Profile Plot



**Creating a Slice (Linear, Radial, Circular, AvgRad)**

1. Click the plot Controller’s Slice button to select the slice type.
2. Position the pointer over the Filled plot at the start point. Press and hold the left mouse button, move the mouse to where you want the slice to end, then release the mouse button.

Slice Info
length: 3.2 mm angle: 2.01 deg

When creating slices, a dynamic Slice Info Box appears; use this data to help you define the slice.

3. To save created slices, click the plot Controller’s Set button.

**Creating a Slice (Radial Ctr, Circ Ctr, AvgRad Ctr, Circ MinPV)**

1. Click the plot Controller’s Slice button to select the slice type.
2. Press and hold the left mouse button, move the mouse to where you want the slice to end, then release the mouse button. The start point for these slices is fixed to the center of the data.

Slice Info
length: 3.2 mm angle: 2.01 deg

When creating slices, a dynamic Slice Info Box appears; use this data to help you define the slice.

3. To save created slices, click the plot Controller’s Set button.

**Creating a Slice (Crosshair)**

1. Click the plot Controller’s Slice button to select Crosshair.
2. The Crosshair slice is automatically created.

### **Creating Multiple Slices (Linear)**

1. Click the plot Controller's Slice button to select Linear.
2. Position the pointer over the Filled plot at the start point. Press and hold the left mouse button, move the mouse to where you want the slice to end, then release the mouse button.
3. Repeat step 2 to create multiple slices. Or to copy a slice position the pointer near the center of the slice and press and hold the left mouse button. Click the middle mouse button for each duplicate slice. Then release the left mouse button when done.
4. To save created slices, click the plot Controller's Set button.

### **Creating Multiple Slices (Radial, Radial Ctr, Circular, Circ Ctr)**

1. Click the plot Controller's Slice button to select slice type.
2. Press and hold the left mouse button. Click the middle mouse button for each slice. Then release the left mouse button when done.
3. To save created slices, click the plot Controller's Set button.

### **Creating a Poly Slice**

1. Click the plot Controller's Slice button to select slice type.
2. To draw the slice, hold down the left mouse button and draw the line, but do not release the left mouse button. To create a pivot point, click the middle mouse button and continue drawing the line over the plot. When done, release the left mouse button. A number will be displayed at the end of the slice.\*
3. To save created slices, click the plot Controller's Set button.

\* When more than one slice is added to the plot, the new slice becomes number one, and the existing slice becomes number 2. This order is observed for each new slice added. However, there is a start-up flag called -staticOrder Slice which will make the Poly Slice number constant when adding or selecting a slice. In other words, a new slice will become number 2, the next slice number 3 etc. This flag does not affect other slice types. To add the flag, refer to the "Command Line" section of *Appendix C*.

### **Moving a Slice (Linear, Radial, Circular, Crosshair, Poly)**

1. For a Linear, Radial, or Circular slice, position the pointer at the center of the slice. For a Crosshair slice, position the pointer near the slice but away from the intersection.
2. Press and hold the left mouse button, move the mouse to move the slice, then release the mouse button.
3. Or, position the pointer inside the plot window, and press the arrow keys. Hold the [shift] key and press the arrow keys to move in larger increments.

### ***Moving All Slices (Linear, Radial, Circular, Poly)***

1. Position the pointer at the center of one slice.
2. Hold down the [shift] key.
3. Press and hold the left mouse button, move the mouse to move the slice, then release the mouse button.

### ***Moving the Slice Intersection (Crosshair)***

1. Position the pointer at the intersection of the slices.
2. Press and hold the left mouse button, move the mouse to move the intersection, then release the mouse button. Note that the on-screen readout displays the point position of the intersection.
3. Or, position the pointer inside the plot window, and click the left mouse button. The crosshair intersection will move to this position.

### ***Changing the Slice Size (Linear, Radial Ctr, Radial, AvgRad Ctr, AvgRad, Poly)***

1. Position the pointer at the end of the slice.
2. Press and hold the left mouse button, move the mouse to change the slice size, then release the mouse button.

### ***Changing the Slice Size (Circular, Circ Ctr, Circ MinPV)***

1. Position the pointer over the slice.
2. Press and hold the left mouse button, move the mouse to change the slice diameter, then release the mouse button.

### ***Changing the Slice Angle (Linear, Radial Ctr, Radial, Crosshair)***

1. For a Linear slice, position the pointer at the end of the slice. For a Radial or Radial Ctr slice, position the pointer at the center of the slice. For a Crosshair slice, position the pointer at the end of the slice and hold down the [shift] key.
2. Press and hold the left mouse button, move the mouse to change the slice orientation, then release the mouse button.

### ***Resetting the Slice (Crosshair)***

1. To reset the crosshair to the plot center and make the two slices perpendicular, position the pointer over the Filled plot and not over a slice, hold down the [Ctrl] key and press the left mouse button.
2. To set the two slices perpendicular, position the pointer over a slice, hold down the [Ctrl] key and press the left mouse button.



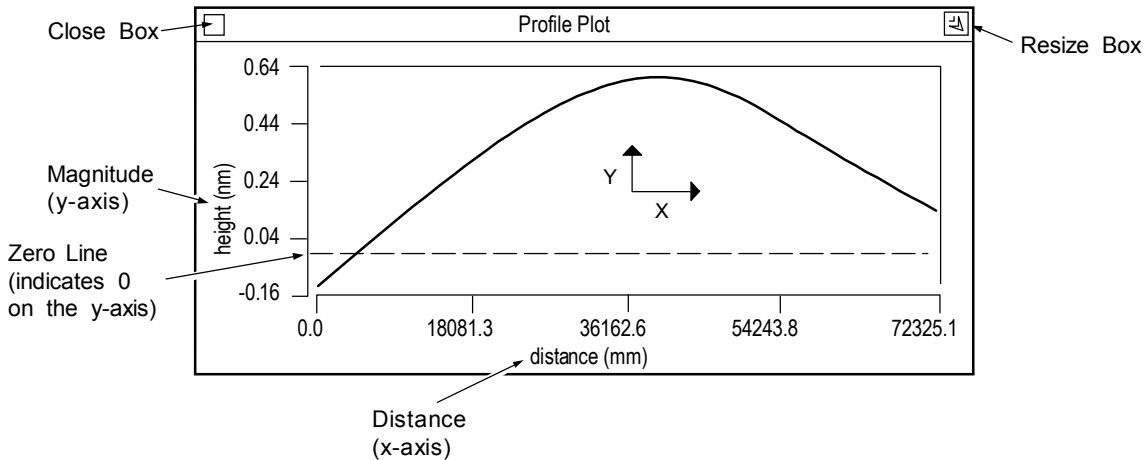
### Deleting Slices

1. Hold down the [Ctrl] key. Position the pointer over the slice and click the left mouse button.
2. To delete all slices, hold down the [Ctrl] key. Position the pointer over the Filled plot and click the left mouse button.

### Profile Plot

A Profile plot is a two dimensional display of the data as a cross section through the Filled plot. Data is viewed in two dimensions: distance (x direction) and magnitude (y direction). Distance is determined by the length of the slice, magnitude by the data itself. Notice slices drawn over non-data areas are represented as blank areas on the plot.

The Profile plot is only available in a *profile* data window and is created using the New Plot → Profile Plot command. To open the Controller, click on the plot with the middle mouse button.



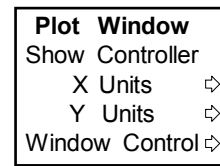
### The Profile Plot's Menu

**Show Controller** opens the plot controller.

**X Units** selects measurement units for the horizontal or x-axis. If x-axis units are pixels, instrument calibration is required.

**Y Units** selects measurement units for the vertical or y-axis.

**Window Control** used to move, resize and delete the window, and to rename or hide the window's title bar.



## Displaying the Plot



The Profile plot is blank if there are no slices defined in a corresponding Filled plot.

1. In a corresponding map data window, define a slice through the data within the Filled plot. To create a slice, see “Slicing the Filled Plot”.
2. If the Profile plot is blank, make sure that you are using corresponding map data windows, and that the slice is drawn over an image area in the Filled plot.

## Slice Colors, Printing and Saving

There are now 10 unique colors for the first 10 slices in the profile. After 10 slices, the colors repeat, beginning with red.

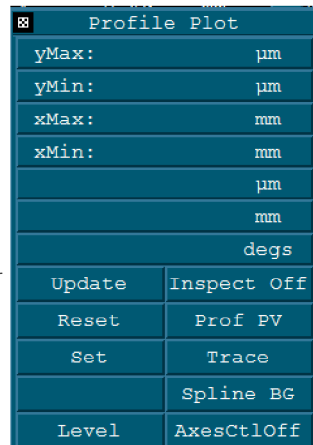
Slice data printing and saving from the profile plot have been made to save/output all slice data points, including NO DATA points. For example, if there are 10 slices, all 10 slices are printed. This is different from previous versions of MetroPro in which only the first slice was saved and printed and NO DATA points were omitted.

It is possible to save in the older format in which only the first slice is printed. To do so, add the following startup flag: `-oldSlicePrintFormat`. Refer to *Appendix C* for information on adding a command line option.

## The Profile Plot's Controller

### Plot Controller

Access by clicking the middle mouse button on the plot.



**Y-Axis Fixed Scale Tool**  
See “Scaling the Profile Plot’s Y-axis.”

**X-Axis Fixed Scale Tool**  
See “Scaling the Profile Plot’s Y-axis.”

**Inspect Readout**  
(blank if Inspect Off)  
See “Inspecting the Profile Plot.”

To activate a button, position the pointer over the button and click the left mouse button.

- Update** - Redraws the plot to match the current Controller settings.
- Reset** - Restores button settings to match the “set” Controller settings.
- Set** - Makes the current Controller settings the master or “set” display.

**Level** - Works along with inspect feature to temporarily fit and remove the plot area between two crosshairs. The angle of the data (between the Inspectors) must be between  $\pm 45^\circ$  or  $\pm 135^\circ$  of the X-Axis for Level to operate correctly.

*The information in this section is applicable to the Autocovariance, Power Spectrum, Histogram, Bearing Ratio, Encircled Energy, and MTF Profile plots.*

**Inspect** - Turns inspect features on and off. When off, the readouts and the plot crosshairs are non-functional. For other selections see “Inspecting the Profile Plot”.

**PV** - Selects automatic scaling of the plot's y-axis. ProfilePV scales the plot to fill the entire area. MapPV scales the plot to the entire data set or Filled plot from which the plot was derived.

**Trace** - Selects how data is displayed. Trace displays data as a line graph. Bar displays data as a series of vertical bars. Scatter displays data as points.

**Spline BG** – Displays the original slice profile and the filtered slice profile. The Filter control must be set to any setting besides off. The Filter Type control must be set to one of the following: FFT Auto, FFT Fixed, Gaussian Spline Fixed, Gaussian Spline Auto, or Robust Gaussian Spline Fixed. If there are multiple slices, the profile plot displays the currently selected slice in green. The original slice and the filtered slice are in the background and are displayed in gray.

**Axes CtlOff** - Selects options for the axes scales; opens a secondary button panel. See “Controlling the Profile Plot’s Axes”.



This discussion covers using the plot Controller for the Profile plot. Most of this information also pertains to the Autocovariance, Power Spectrum, Amplitude Spectrum, Power Spectral Density, Histogram, Bearing Ratio, Encircled Energy, and MTF Profile plots. Some of the plot Controller’s functions are disabled for these other types of two dimensional plots.

### **Opening the Plot Controller**

1. Position the pointer on the plot window and press the middle mouse button.
2. If this is the first time the controller opened, an outline of the Controller appears. Drag the mouse to position the Controller and release the mouse button. The Controller appears when you let go of the mouse.

### **Using the Plot Controller**

All plot Controller buttons are activated by positioning the pointer over the button and clicking the left mouse button. If there are several choices to a button, repeat click the mouse to cycle through the selections. Click the right mouse button to cycle through choices in the opposite direction. The general procedure is:

1. Click the plot Controller button(s). Some actions occur immediately, others require updating.
2. If necessary, update the plot by clicking the Update button.

3. Store new plot Controller settings by clicking the Set button.



When a measurement is taken or data is loaded, the plot Controller settings revert or reset to the stored settings.

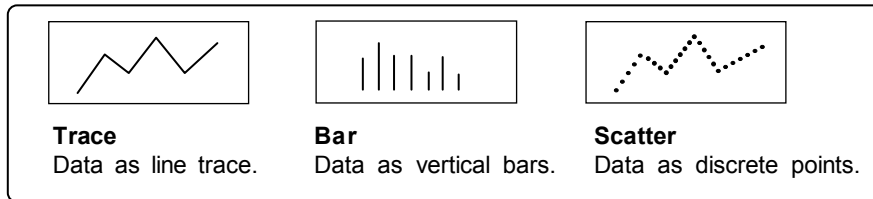
4. Make other temporary modifications to the plot using the Controller. Revert the Controller settings back to the stored settings by clicking the Reset button.

### ***Permanently Saving Plot Settings***

1. After you have changed the plot display with the Controller, you can save these settings by clicking the Set button with the left mouse button. This temporarily preserves changes made with the Controller.
2. To permanently preserve changes made to the plot with the Controller, Plot menu, or Resize box, the application must be saved. To save the application, access the Application Window menu and select the Re-save Application command.

### ***Changing the Profile Plot Display***

Click the plot Controller's Display button to change the display.



### ***Resizing the Plot***

The plot can be resized to any proportions allowed by the data window it resides in. When you resize the plot, keep in mind that the aspect ratio of width to height can be distorted so much that the plot does not even resemble the test part.

1. Click the window Resize box or select the Plot menu's Resize command.
2. Press the left mouse button and drag the lower right corner bracket of the window outline until it is the desired size, and release the mouse button.

## Inspecting the Profile Plot

The inspect feature is used to examine areas of interest in the plot. It incorporates three parts of the plot Controller, the Inspect button, the Inspect Readouts, and the Level button.

Profile Plot	
yMax:	µm
yMin:	µm
xMax:	mm
xMin:	mm
	µm
	mm
	degs
Update	Inspect Off
Reset	Prof PV
Set	Trace
	Spline BG
Level	AxesCtlOff

**Inspect Readouts**  
Display information about selected points on the profile.

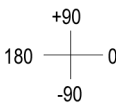
yPos:

xPos:

angle:

Blank if Inspect Off. If Inspect 1 shows x and y position of crosshair. If Inspect 2 or Calipers shows x and y distance between points.

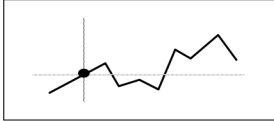
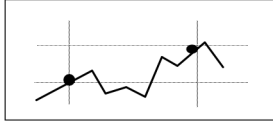
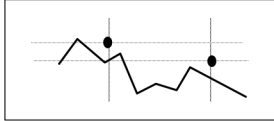
Blank if Inspect Off or Inspect 1. If Inspect 2 or Calipers shows angle between points.



**Level** \*

Functional only when in Inspector 2 or Calipers. Click the Level button to temporarily fit and remove a surface between the two crosshairs. Click the Reset button to change the plot back to the original plot.

### Inspect Options

		
<p><b>Inspector 1</b> One set of crosshairs is displayed; it can be positioned anywhere over the data.</p>	<p><b>Inspector 2</b> Two sets of crosshairs are displayed; they can be positioned anywhere over the data.</p>	<p><b>Calipers</b> Two sets of crosshairs are displayed; they can be positioned anywhere in the plot. <i>Useful when comparing multiple slices.</i></p>



Crosshairs are only displayed when the Controller is open and the Inspect button is on Inspector 1, Inspector 2, or Calipers.

\* The angle of the data (between the Inspectors) must be between  $\pm 45^\circ$  or  $\pm 135^\circ$  of the X-Axis for Level to operate correctly.

### ***Moving the Inspect Crosshairs***

1. Click the left mouse button on a location on the plot; the nearest crosshairs will jump to the location.
2. Or press and hold the left mouse button on a location on the plot; the nearest crosshairs will jump to the location. Move the mouse to position the crosshairs, then release the mouse button to place the crosshairs.



If you are using multiple slices, Inspector 1 and Inspector 2 are linked to the last created or modified slice. This slice is the green line in the profile plot.

### ***Sample Use of Inspect Feature for Two-dimensional Plots***

<i>Plot</i>	<i>Sample Use</i>
<i>Profile</i>	Inspector 1 – measure an individual peak or valley. Inspector 2 – measure distance between two points on profile.
<i>Autocovariance</i>	Inspector 1 – measure the correlation length.
<i>Power Spectrum</i>	Inspector 1 – show the power and spatial frequency at a given point.
<i>Histogram</i>	Inspector 1 – show the number of data points at a particular height.
<i>Bearing Ratio</i>	Inspector 1 – show the bearing ratio exposed at any depth. Inspector 2 – show the height between two bearing ratios.
<i>Encircled Energy</i>	Inspector 1 – show the spot radius at a specific percentage.
<i>MTF Profile</i>	Inspector 1 – show the modulation value at a specific spatial frequency.
<i>Material Probability</i>	Inspector 1 – establish the upper peak limit. Inspector 2 – establish the lower valley limit.

## Scaling the Profile Plot's Y-axis

The y-axis or vertical axis of the plot has both auto scaling and user selectable fixed scaling. The auto scale mode is determined by the plot Controller's PV button. The plot Controller Y-axis Fixed Scale Tool is used for configuring the fixed scale options. If the Fixed Scale Tool is used, auto scaling is disabled.

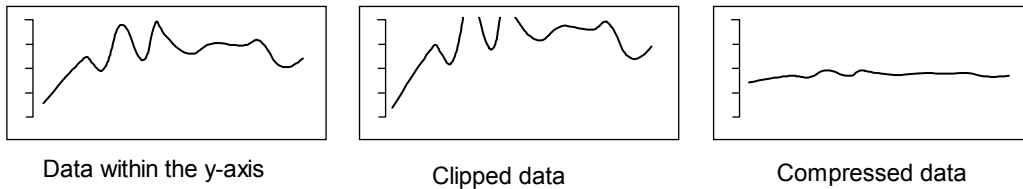
**Y-axis Fixed Scale Tool**  
Click with right mouse to select scaling mode.  
Click with left mouse button to enter values.

**Y-axis Auto Scale Button**  
Nonfunctional when Y-axis Fixed Scale Tool is used.

**ProfilePV**  
Scales the y-axis to the PV of the slice.

**MapPV**  
Scales the y-axis to the PV of the entire data set.

The Y-axis Fixed Scale Tool is useful when comparing the results of many similar parts; the y-axis scale does not change every time a measurement is made. Fixed scaling should be used with caution, data may be obscured if you input inappropriate values. Data can be clipped by making the y-axis too small; data can be compressed by making the y-axis too big; and the plot may be blank because the data does not fall within the range of the y-axis.



### Changing the Y-axis Fixed Scale Mode

1. Position the pointer over the Y-axis Fixed Scale Tool. Click the right mouse button to change modes.



There must be values entered in the fixed scale tool for it to function. Note that 0 (zero) is an entry.

### Entering Values in the Y-axis Fixed Scale Tool

1. Position the pointer over one of the two boxes in the Y-axis Fixed Scale Tool.
2. Click the left mouse button, enter a numeric value and press [Enter]. To erase values, click the left mouse button, delete all characters, then press [Enter].
3. Click the plot Controller's Update button to redraw the plot.
4. To preserve your changes, click the plot Controller's Set button.

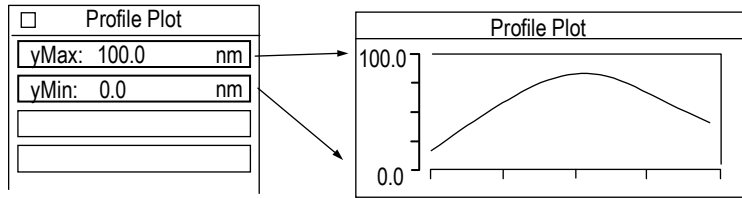
## Example Use of the Y-axis Fixed Scale Tool

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**Fixed Scale Modes**      **Example**

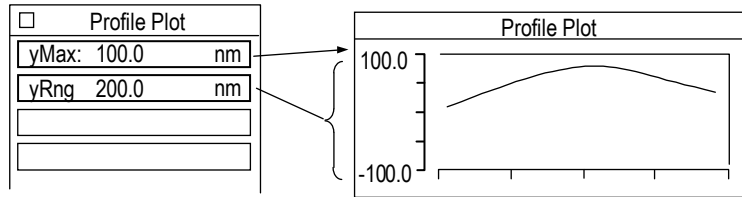
---

**yMax** specifies the upper value. If left blank, yMax defaults to the peak of the data.



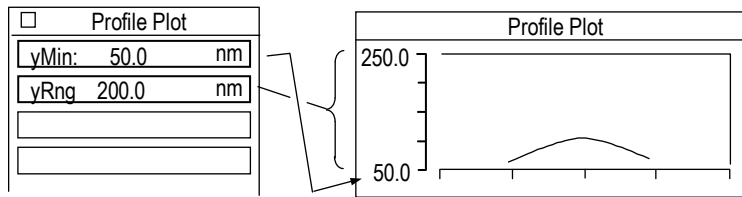
**yMin** specifies the lower value. If left blank, yMin defaults to the valley of the data.

**yMax** specifies the upper value. If left blank, yMax defaults to the peak of the data.



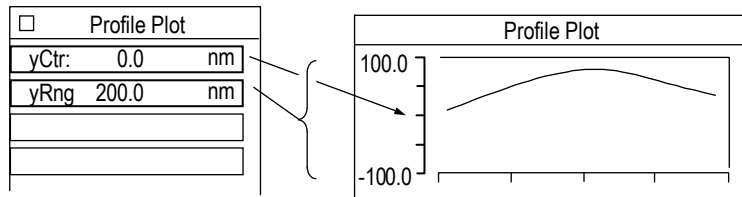
**yRng** specifies the range of the scale. If left blank, the scale expands downward to show the data.

**yMin** specifies the lower value. If left blank, yMin defaults to the valley of the data.



**yRng** specifies the range of the scale. If left blank, the scale expands upward to show the data.

**yCtr** specifies the center of the scale. If left blank, yCtr defaults to the mean of the data.



**yRng** specifies the range of the scale. If left blank, the scale expands to show the data.

---



### The Y-axis Fixed Scale Tool's yRng Function

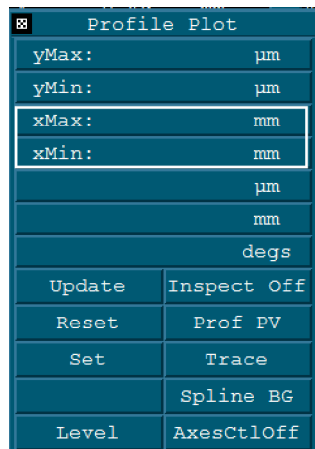
The Y-axis Fixed Scale Tool yRng setting has dual functions. When a positive number is entered it specifies the overall size of the axis. When a negative number is entered, it invokes an exclude option; which works only with the yMax and yMin settings.

<i>YRng Function</i>	<i>Example</i>
<p><b>yRng (positive)</b> Specifies the overall size of y-axis.</p>	
<p><b>yMax</b> specifies the upper value. yMax (blank) defaults to the peak.</p> <p><b>yRng (negative)</b> specifies the upper data range to exclude from the plot. (When used with yMax.)</p>	
<p><b>yMin</b> specifies the lower value. yMin (blank) defaults to the valley.</p> <p><b>yRng (negative)</b> specifies the lower data range to exclude from the plot. (When used with yMin.)</p>	

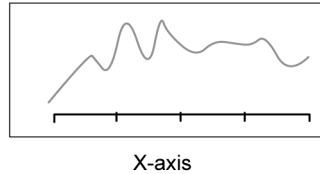
## Scaling the Profile Plot's X-axis

The x-axis or horizontal axis of the plot is dependent upon the size of the slice drawn in the corresponding map data window Filled plot. All slices start at position zero on the x-axis. Multiple linear slices all start at zero no matter their location. Single circular slices display in units, multiple circular slices are normalized to 360 degrees.

Normally, the plot automatically defaults to the length of the slice. The X-axis Fixed Scale Tool can be used override the default x-axis. If The X-axis Fixed Scale Tool is used, the x-axis will always be the same no matter what changes are made to the slices. The same cautions mentioned under y-axis fixed scaling apply to x-axis fixed scaling.



**X-axis Fixed Scale Tool**  
 Click with right mouse to select scaling mode.  
 Click with left mouse button to enter values.  
 If no values are entered, the x-axis matches the length of the slice.



## Changing the X-axis Fixed Scale Mode

1. Position the pointer over the X-axis Fixed Scale Tool. Click the right mouse button to change modes.



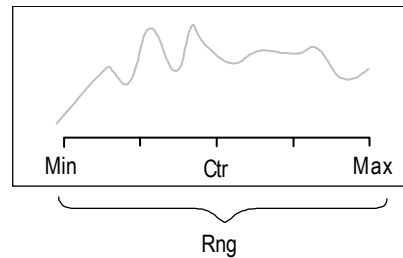
There must be values entered in the fixed scale tool for it to function. Note that 0 (zero) is an entry.

**xMax** specifies the upper value. If left blank, xMax defaults to the length of the longest slice.

**xMin** specifies the lower value. If left blank, xMin defaults to zero.

**xCtr** specifies the center of the scale. If left blank, xCtr defaults to the mean of the data.

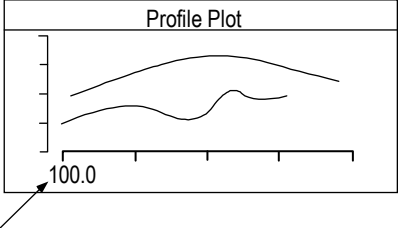
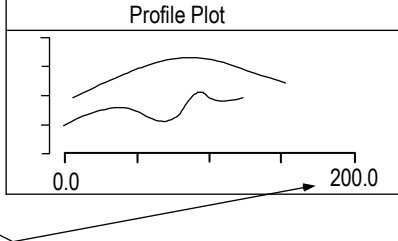
**xRng** specifies the range of the scale. If left blank, the scale expands to show the data.



### Entering Values in the X-axis Fixed Scale Tool

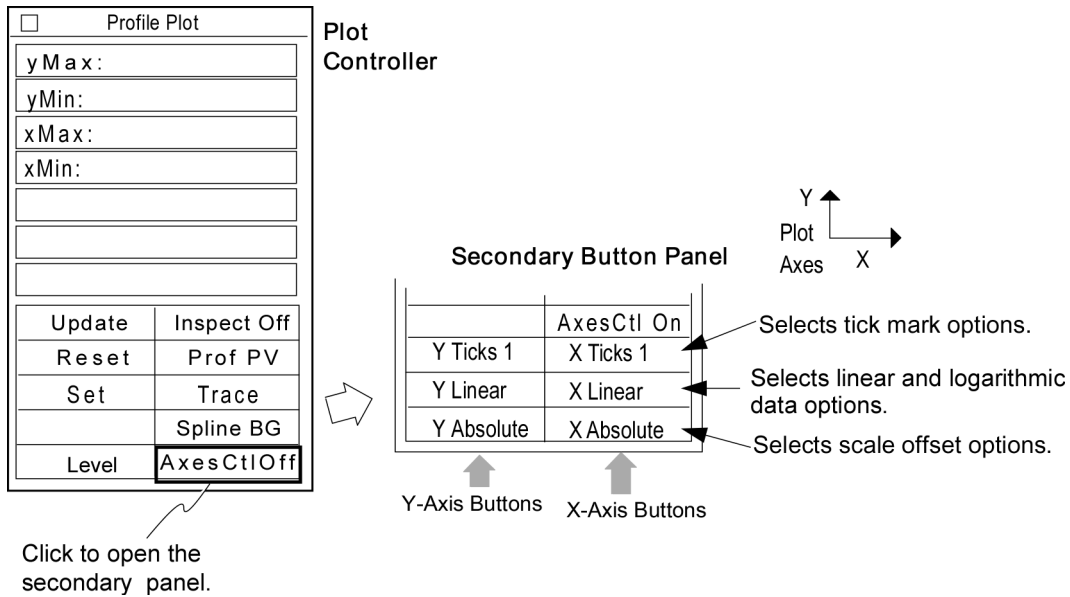
1. Position the pointer over one of the two boxes in the X-axis Fixed Scale Tool.
2. Click the left mouse button, enter a numeric value and press [Enter]. To erase values, click the left mouse button, delete all characters, then press [Enter].
3. Click the plot Controller's Update button to redraw the plot.
4. To preserve your changes, click the plot Controller's Set button.

### Example Use of the X-axis Fixed Scale Tool

Fixed Scale Modes	Example
<p><b>xMax</b> specifies the upper value. If left blank, xMax defaults to the length of the longest slice.</p> <p><b>xMin</b> specifies the lower value. If left blank, xMin defaults to zero.</p>	<div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 5px; margin-right: 20px;"> <p><input type="checkbox"/> Plot Controller</p> <p> </p> <p> </p> <p>xMax:           mm</p> <p>xMin: 100.0   mm</p> </div> <div style="text-align: center;">  </div> </div> <p>By specifying xMin you zoom in on the upper section of the plot. xMax defaults to the longest slice.</p>
<p><i>The other modes work similar to those shown for the Y-axis Fixed Scale Tool.</i></p>	<div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 5px; margin-right: 20px;"> <p><input type="checkbox"/> Plot Controller</p> <p> </p> <p> </p> <p>xMax: 200.0   mm</p> <p>xMin:           mm</p> </div> <div style="text-align: center;">  </div> </div> <p>By specifying xMax you can compare multiple data files with the same x-axis. xMin defaults to 0. The beginning of all profile plots is always 0.</p>

## Additional Profile Plot Axes Control

Additional control over the plot display is available through the plot Controller by clicking on the Axes Ctl button with the left mouse button. This opens a secondary button panel.



### Secondary Button Panel Selections

<p><b>Ticks 1</b></p> <p>The difference between data extremes is divided into four equal parts; numbers are not rounded.</p>	<p><b>Ticks 2</b></p> <p>Expands plotting area, divides it into four parts with “nice” numbers; tick marks are added.</p>	<p><b>Ticks 3</b></p> <p>Plots only data area, divides the axes to display “nice” numbers, more tick marks are added.</p>
<p><b>Linear</b></p> <p>Plot data linearly.</p>	<p><b>Log 10, Log e, Log 2</b></p> <p>Plots logarithm of the data; it expands small values hidden in a linear scale.</p>	<p><i>Log scales are generally used with the Power Spectrum Plot.</i></p>
<p><b>Absolute</b></p> <p>Plots the values as they occur in the data.</p>	<p><b>Min Rel</b></p> <p>Plots the values starting at zero.</p>	<p><b>Max Rel</b></p> <p>Plots the values ending at zero.</p>

### Selecting an Axes Control Option

1. Click the Axes CtlOff button to open the secondary button panel.
2. Click the Tick, Linear, or Absolute button with the left mouse button to cycle through the choices for the applicable axis.
3. Click the plot Controller's Update button to redraw the plot.
4. To preserve your changes, click the plot Controller's Set button.

### Using Test and Reference Areas in Profile Plots

A number of controls used together provide the ability to define test and reference segments on profile data. The test segment, defined by the Tst Pt controls, is compared to the reference segment, defined by the Ref Pt controls. Profile plots and results are based on the test segment.

Other controls available in the same menu provide the ability to fit and remove shapes from the reference segment. These controls are created using the profile data window menu's New Control → command.

An example of a window configured with the profile controls is shown below. The controls are explained in the following table.

**Example of window with test and reference profile controls**

*Icon*

Profile Cntrl

*Window*

zygo Profile Control	
Normalize: On	
Remove: Piston	
Fit: All Profiles	
Line Type: Normal	
Use Tst Pts: On	
Use Ref Pts: On	
Ref Pt 1: 0.029 in	
Ref Pt 2: 0.150 in	
Tst Pt 1: 0.029 in	
Tst Pt 2: 0.150 in	

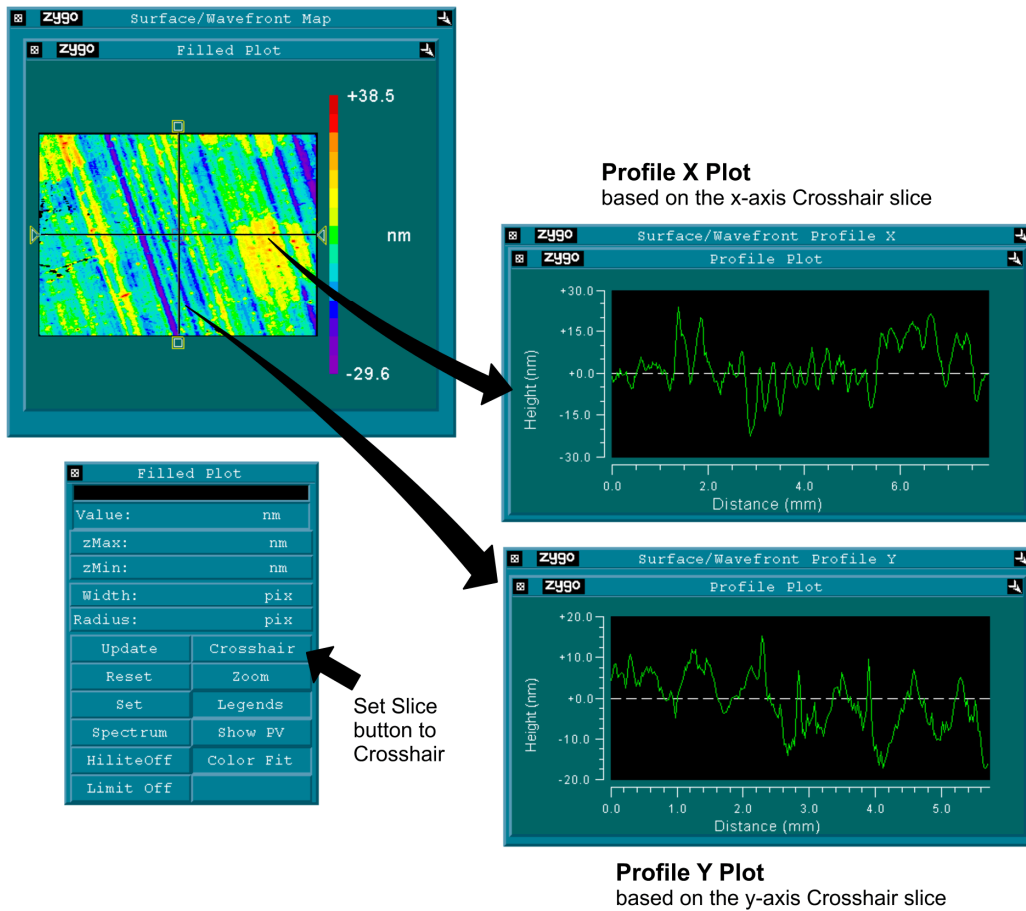
Selections are made by clicking on a control with the *left* mouse button.

## Test and Reference Profile Controls

<i>Controls</i>	<i>Description</i>
<i>Normalize</i>	When On, all slices are adjusted to relate to one another. Linear slices shift so the first valid data point is at zero on the x-axis. Circular slices are made the same length with x-axis in degrees.
<i>Remove</i>	Subtracts the selected shape from all slices; choices are Piston, Line, Circle, and None. Piston compensates for offset in the z-axis. Line compensates for residual tilt. Circle removes a best fit circle from the data. None turns off remove.
<i>Fit</i>	Determines how shapes are fit; choices are First Profile and All Profiles. First Profile fits the shape in the Remove control to the first slice only; it is removed from all. All Profiles fits the shape in the Remove control to all slices; it is removed from all.
<i>Line Type</i>	Specifies how fit is performed when the Remove control is set to Line; choices are 2 Point and Normal. Normal allows the software to find the points to fit a line. 2 Point uses Ref Pt 1 and Ref Pt 2 to define the line to fit; 2 Point requires valid data at each point.
<i>Use Ref Pts</i>	When On, the Ref Pt 1 and Ref Pt 2 controls are active; they specify where the fit is done.
<i>Ref Pt 1</i>	Specifies the starting point of the reference segment along the x-axis.
<i>Ref Pt 2</i>	Specifies the ending point of the reference segment along the x-axis.
<i>Use Tst Pts</i>	When On, the Tst Pt 1 and Tst Pt 2 controls are active; they specify over what area the profile results are calculated.
<i>Tst Pt 1</i>	Specifies the starting point of the test segment along the x-axis.
<i>Tst Pt 2</i>	Specifies the ending point of the test segment along the x-axis.

## The Profile X and Profile Y Plots

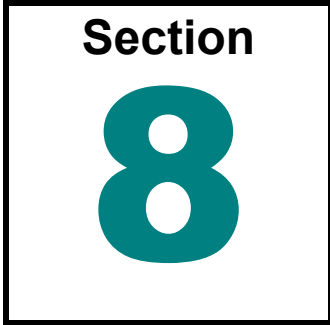
The Profile X and Profile Y plots are used along with the Crosshair slice to display profile data that lies in the x-axis and y-axis. There must be a Crosshair slice in the corresponding Filled plot for data to display in either plot.







# Other Plots



*MetroPro provides numerous ways to display data. Some plots are three dimensional views of data, while others provide special analysis functions.*

A plot is a graphic representation of measurement data. This section provides details on plots other than the Filled Plot and Profile Plot. Plots reside in data windows and are created by selecting the New Plot command from the data window's menu. Each plot display is controlled with a plot Controller, which is accessed by clicking the plot with the middle mouse button. The availability of each plot varies depending on the application.

## Plots Described in this Section

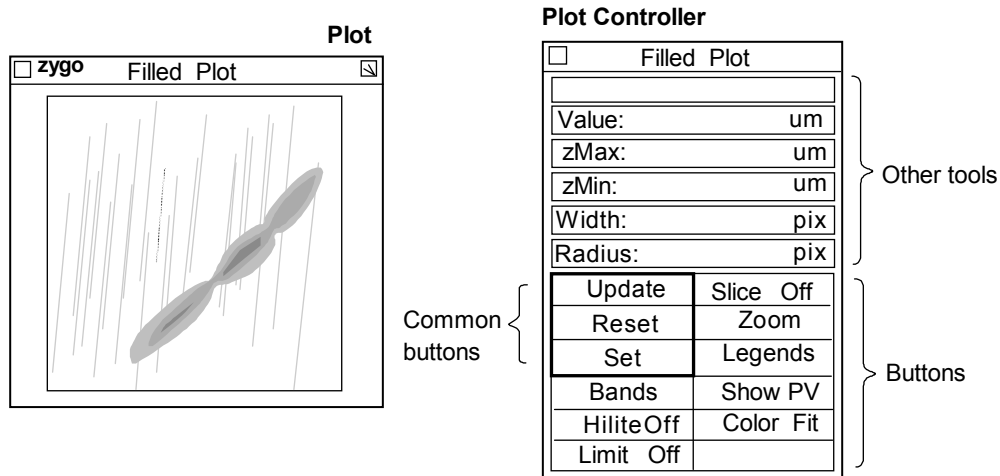
<i>Plot</i>	<i>Description</i>
<i>3D</i>	Displays surface data in a three dimensional wire frame or solid representation that can be rotated in any orientation. Areas with different magnitudes (height) are represented by different colors, or in a one color plot as different shades. The plot is resizable.
<i>3D Model</i>	Displays surface data in a three-dimensional realistic model representation that can be rotated, zoomed, and moved. Areas with different magnitudes (height) are represented by different colors, or in a one color plot as different shades.
<i>Autocovariance</i>	Used to determine the periodicity of a surface; it shows the dominant spatial frequencies along a cross section or slice of the test surface. The x-axis is the length along the slice and the y-axis is normalized height values. The plot is resizable. Requires a defined slice in a corresponding Filled plot.
<i>Bearing Ratio</i>	Displays the bearing ratio at a range of depths for the <i>entire</i> data matrix. It simulates the effect of wear on a bearing surface. The x-axis is the bearing ratio and the y-axis is the depth from the highest peak. The plot is resizable.

**Plots in this Section (continued)**

<b><i>Plot</i></b>	<b><i>Description</i></b>
<i>CSA X and Y</i>	Displays CSA slice data in the X or Y direction. These plots are specific to the Cross Sectional Area analysis, which finds the area under a curve by taking slices in the X or Y direction.
<i>Encircled Energy</i>	Displays the distribution of energy within a PSF; it is representative of the <i>entire</i> data matrix. The x-axis is the radius of a circle and the y-axis is the percent of total energy contained within that circle. It illustrates the quality of the optic. The plot is resizable.
<i>Material Probability</i>	Displays filled and profile plots of peak and valley distribution representative of a surface with coarse and fine texture. Enables characterization of surface textures independently of one another. Two inspectors are used to identify upper peak and lower valley limits.
<i>Oblique</i>	Displays data in three dimensions with the x-axis horizontal, the y-axis inclined from horizontal, and the z-axis vertical. All three axes of the plot normally include labeled scales. Areas with different magnitudes (height) are represented by different colors, or in a one color plot as different shades. The plot is resizable.
<i>Roundness Polar and Chart</i>	The Polar plot shows the locations of peaks in the data, and the Chart plot is a profile of the surface as represented by the selected slice.
<i>Profile Spectrum Plots</i>	Includes: Amplitude Spectrum, Peak Amplitude Spectrum, Power Spectral Density, and Power Spectrum. Plots the spatial frequency component of the data versus the frequency. The plot is resizable. Requires a defined slice in a corresponding Filled plot.
<i>Solid</i>	Displays surface data as a function of slope as viewed along the instrument's z-axis. Areas with different slopes are represented by different shades. The Solid plot displays high frequency irregularities better than the Filled plot. The Solid plot size is fixed, even though the Plot window size is not fixed. If the Solid plot does not display, your data is too large to fit in the window; simply make the plot window larger.

## General Procedures for all Plots

The display within the plot window is modified by a plot Controller. Each plot has its own controller.



### Opening the Plot Controller

1. Position the pointer on the plot window and press the middle mouse button.
2. If this is the first time the controller opened, an outline of the Controller appears. Drag the mouse to position the Controller and release the mouse button. The Controller appears when you let go of the mouse.

### Using the Plot Controller

All plot Controller buttons are activated by positioning the pointer over the button and clicking the left mouse button. If there are several choices to a button, repeat click the mouse to cycle through the selections. Click the right mouse button to cycle through choices in the opposite direction. The general procedure is:

1. Click the plot Controller button(s). Some actions occur immediately.
2. If necessary, update the plot by clicking the Update button.
3. Store new plot Controller settings by clicking the Set button.



When a measurement is taken or data is loaded, the plot Controller settings revert or reset to the stored settings.

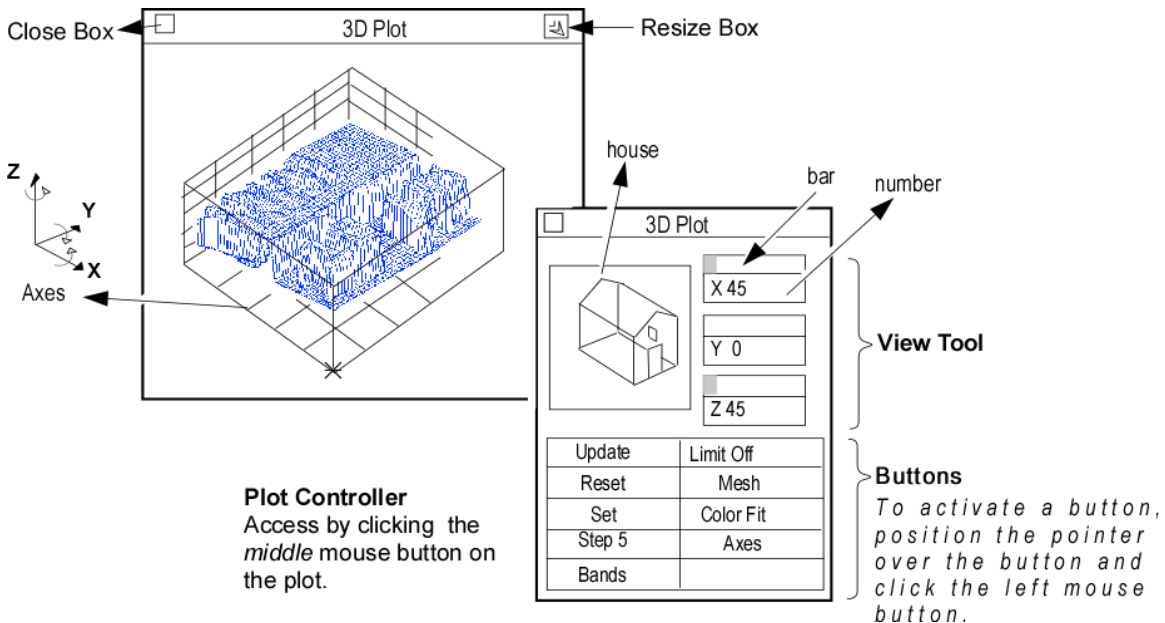
4. Make other temporary modifications to the plot using the Controller. Revert the Controller settings back to the stored settings by clicking the Reset button.

### Permanently Saving Plot Settings

1. After you have changed the plot display with the Controller, you can save these settings by clicking the Set button with the left mouse button. This temporarily preserves changes made with the Controller.
2. To permanently preserve changes made to the plot with the Controller, Plot menu, or Resize box, the application must be saved. To save the application, access the Application Window menu and select the Re-save Application command.

## 3D Plot

A 3D plot displays surface data as viewed in a three-dimensional wire frame or solid model that can be rotated. The 3D plot can be viewed in any orientation. Areas with different magnitudes or heights are represented by different colors, or in a one color plot as different shades. A 3D plot is available in a map data window and is created using the New Plot command. To open the Controller, click the plot with the middle mouse button.



**Update** - Redraws the plot to match the current Controller settings.

**Reset** - Restores button settings to match the “set” Controller settings.

**Set** - Makes the current Controller settings the master or “set” display.

**Step** - Selects how much of the data is plotted. 1 = all data, 2 = every 2nd data point, etc... up to 12. Auto Step - automatically selects the step size for optimum display of the plot.

**Color** - Selects the color of the plot. Choices: Bands (16 colors), Golds, Greys, CMYK (cyan, magenta, yellow, and black), Spectrum and Neon (a variation of Spectrum). Colors other than Bands use 2000 colors.

**Limit** - Determines if and how the PV (peak-to-valley) limits are highlighted in red in the plot. Limit Off limits are not displayed in the plot. *Note:* To display limits in the plot, high limits must be set in a PV Result box in the same data window.

For more information, see “Displaying Limits in the 3D Plot”.

**Mesh** - Selects how the plot is displayed. Mesh displays data as wire frame. Mono displays data as a monochrome, or one color mesh.

**Color Fit** – When on, plot colors are adjusted to display a greater range of colors for surfaces that are predominately one color. This affects the plot display only and not numeric results.

**Axes** - When on, the plot display includes an outline of a three dimensional box with reference lines.

### Using the 3D Plot's View Tool

1. Click the middle mouse button on the plot to open its Controller.
2. *House* Position the pointer on the house, press the left mouse button, move the mouse to reposition the house, and then release the mouse button.
3. *Bar* Position the pointer on the bar for one axis, press and hold the left mouse button, move the mouse to resize the bar, then release the mouse button.
4. *Number* Position the pointer on the number for one axis, click the left mouse button, enter a numeric value from the keyboard, then press [Enter].
5. To activate your changes, click the plot Controller's Update button.

### Selecting 3D Plot Resolution

1. Click the left mouse button on the Plot Controller's Step button until the desired step is displayed. When set to Auto Step, the number of data points used in the plot is automatically selected so the plot displays with optimum detail and speed.
2. To activate your changes, click the plot Controller's Update button.

### Using Colors in the 3D Plot

Click the plot Controller's Color button to change the color of the plot.

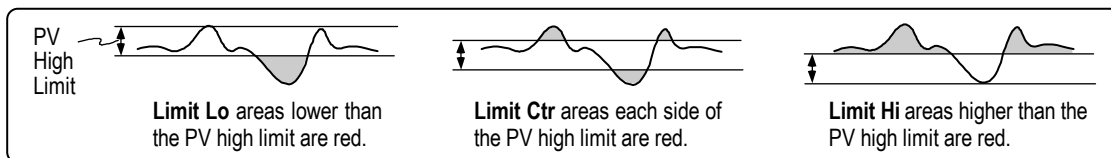
- Spectrum shows the greatest detail in the center of plotted height values.
- Neon shows the greatest detail near the top and bottom of plotted height values.
- Greys to display limits.

### Resizing the 3D Plot

The plot can be resized to any proportions allowed to by the data window it resides in. The 3D plot is designed with square proportions. The plot can be resized so the width to height aspect ratio is distorted so much that the plot does not even resemble the test part.

1. Click the plot window Resize box or select the Plot menu's Resize command.
2. Press and hold the left mouse button, drag the lower right corner bracket of the window outline until it is the desired size, then release the mouse button.

### Displaying Limits in the 3D Plot



1. Click the plot color to Greys. Click the Limits button to select the limit mode. Then click the Controller's Update button.
2. In the PV result in the same data window, select the Limits → High command from the result's menu. Enter a high limit for the PV result and press [Enter].

## 3D Model Plot

A 3D Model plot displays surface data in a three-dimensional realistic model representation that can be rotated, zoomed, and moved. Areas with different magnitudes (height) are represented by different colors, or in a one color plot as different shades. The 3D Model plot is rendered as if a virtual light source is pointing at the surface from the viewer's perspective. Flat surfaces perpendicular to this line are displayed in full color intensity. Surfaces tilted from this perspective are progressively darkened.

A 3D Model plot is available in a map data window and is created using the New Plot command. To open the Controller, point to the title bar of the plot window to access the menu and select the Show Controller command.



The middle mouse button does not open the plot Controller for the 3D Model plot. This is different than all other plots. Use the plot menu to access the plot Controller.

**Plot Controller**  
Access with the Plot's menu, *not* the middle mouse button

3D Model	
Ambient	0.00
Diffuse	0.00
Reflect	0.00
Specular	0
Update	Auto Size
Reset	Color Fit
Set	Axes
AutoStep	Legend
Spectrum	Auto Light
Limit Off	Fixed Light
Normals Off	Compass Off

**Light Controls**

**Buttons**

Opens a secondary panel when Auto Light is off.

To activate a button, position the pointer over the button and click the left mouse button.

### Changing the 3D Model Plot

Action	Mouse Button	Procedure
Rotate	Left	Click on the plot to rotate toward the mouse pointer. Press on the plot for continuous rotation.
Move	Center	Click on the plot. The plot moves or pans in the direction of the pointer.
Zoom	Right	Click on the plot. To zoom in, click above the plot center. To zoom out, click below the plot center.



The farther away from the plot center the pointer is, the faster the action. Full data resolution is not shown when rotating, moving, or zooming.

### 3D Model Plot Controller- Buttons

**Update** - Redraws the plot to match the current Controller settings.

**Reset** - Restores button settings to match the “set” Controller settings.

**Set** - Makes the current Controller settings the master or “set” display.

**Step** - Selects how much of the data is plotted. 1 = all data, 2 = every 2nd data point, etc... up to 12. Auto Step - automatically selects the step size for optimum display of the plot.

**Color** - Selects the color of the plot. Choices: Bands (16 colors), Golds, Greys, CMYK (cyan, magenta, yellow, and black), Spectrum, and Neon (a variation of Spectrum). Colors other than Bands use 2000 colors.

**Limit** - Selects if and how the PV (peak-to-valley) limits are highlighted in red in the plot. Limit Off turns off this function.



To display limits in the plot, high limits must be set in a PV Result box in the same data window. For more information, see “Displaying Limits in the 3D Plot,” as the same principles apply.

**Normals** – Selects if and how many “normals” are displayed in the plot. A normal is a small reference line drawn perpendicular to the surface. The distance between the “normals” is the shorter of the two sides of the image times the fraction selected within the Normals button.



The following buttons on the 3D Model plot controller have an automatic update feature: Color (Spectrum, Neon, etc.), Axes, Legend, Auto Light, and Fixed Light.

It is not necessary to click the Update button after making these plot controller changes.

**Auto Size** – When on, the plot is fit to the size of the window if possible. Proper aspect ratio is preserved.

**Color Fit** – When on, plot colors are adjusted to display a greater range of colors for surfaces that are predominately one color. This affects the plot display only and not numeric results.

**Axes** - When on, the plot display includes an x and y axis dimensioned label.

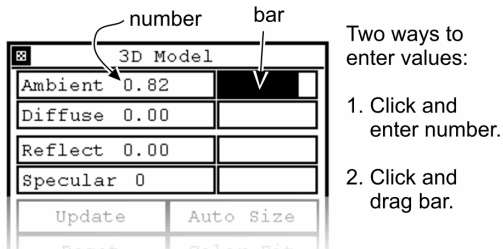
**Legend** – When on, displays a color key and scale to the right of the plot. The scale denotes magnitude.

**Auto Light** – When on, light is available everywhere. There are no shadows. When Auto Light is disabled, the secondary compass plot controller panel may be displayed.

**Fixed Light** – When on, light(s) shine at the same spot on the 3D model. When disabled, light shines on the model from the specified Azimuth and Elevation, no matter which part of the model is viewed. Azimuth and Elevation are part of the secondary plot controller panel.

**Compass** – When on, and Auto Light is disabled, a secondary controller panel opens. When disabled, the secondary controller panel is hidden.

### 3D Model Plot Controller- Light Controls



Two ways to enter values:

1. Click and enter number.
2. Click and drag bar.



These controls are used together for better lighting effect:

- Ambient and Diffuse
- Reflect and Specular

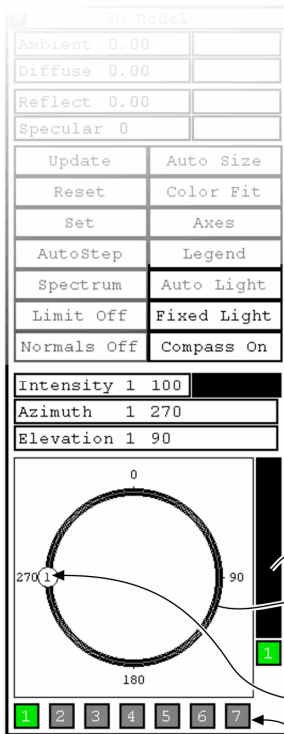
**Ambient** – Amount of ambient light that is visible. Settings: 0.00 to 1.

**Diffuse** – Amount of light reflected off the surface that is visible. Settings: 0.00 to 1.

**Reflect** – The intensity of the shininess of the model. Settings: 0.00 to 1.

**Specular** – The sharpness of the shine. The greater the value, the more the surface appears as polished. Settings: 0-100.

### 3D Model Plot Controller- Secondary Panel



Disable Auto Light so the secondary plot controller panel can be opened with the Compass button

Up to 7 light sources can be defined. Active lights are green. Grey lights are off.

Elevation Bar  
Azimuth Tool  
Light Locator (right click to select color)  
Light Buttons

**Compass** – When on, and Auto Light is disabled, a secondary controller panel opens. When disabled, the secondary controller panel is hidden.

**Intensity** – The brightness of the active light source. Settings: 0 to 100. To change the value, either click and enter a number, or click and drag the indicator bar.

**Azimuth** – The direction where the light is coming from. Settings: 0 to 360 (degrees). To change the value, click and enter a number, or click and drag the light locator on the azimuth tool.

**Elevation** – The height of the light above the horizon. Settings: 0 to 90 (degrees). To change the value, click and enter a number, or click and drag the elevation bar.

**Light Buttons** – Up to 7 light sources can be defined. Left click on a light button updates the Intensity, Azimuth, and Elevation properties. Right click on the light locator to select the color of the light source.



### Selecting 3D Model Plot Resolution

1. Click the left mouse button on the plot Controller's Step button until the desired step is displayed. When set to Auto Step, the number of data points used in the plot is automatically selected so the plot displays with optimum detail and speed.



Full data resolution is not shown when rotating, moving, or zooming. Full resolution is displayed once the plot action is complete.

2. To activate your changes, click the plot Controller's Update button.

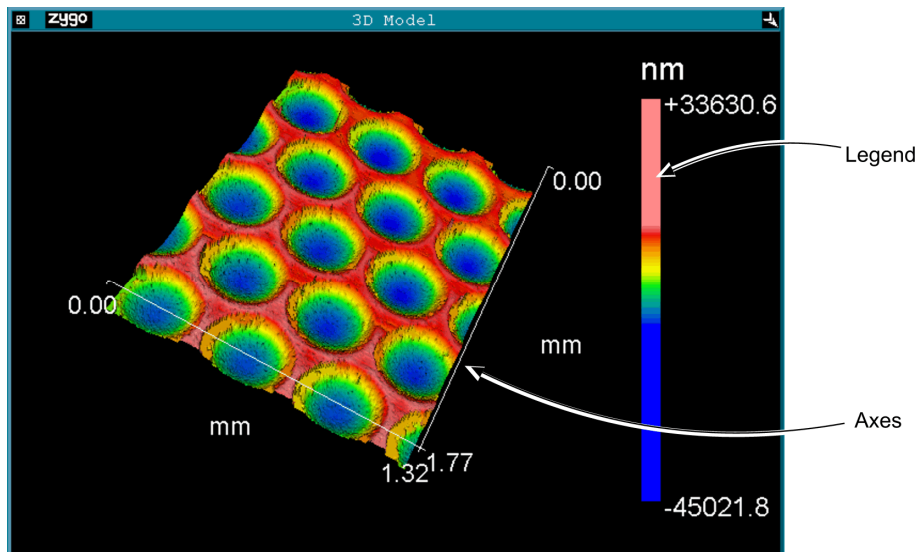
### Resizing the 3D Model Plot

The plot can be resized to any proportions allowed to by the data window it resides in.

1. Click the plot window Resize box or select the Plot menu's Resize command.
2. Press and hold the left mouse button, drag the lower right corner bracket of the window outline until it is the desired size, then release the mouse button.

### Displaying Axes and Legend in the 3D Model Plot

1. Click the plot Controller's Axes button so it is on. Click the Legend button.
2. Save your setting with the Set button.

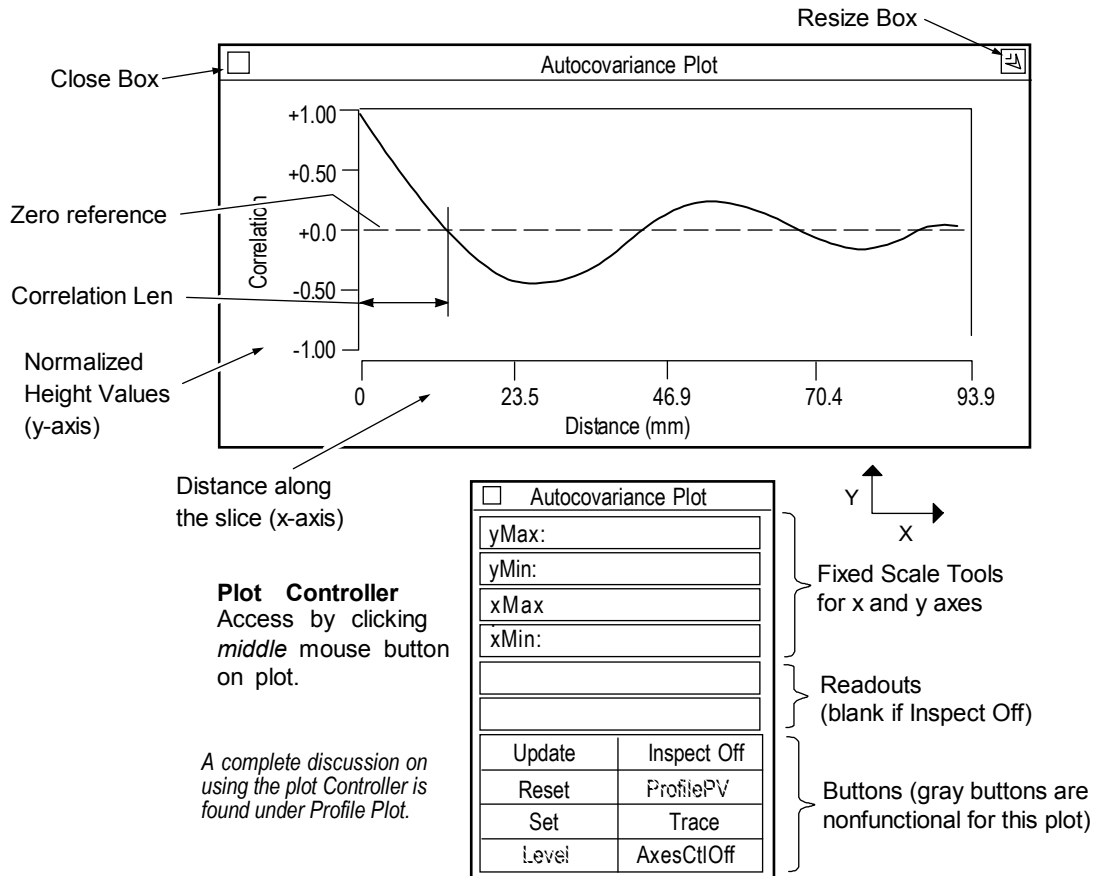


### Known Hardware Limitations for the 3D Model Plot

The computer's video card must have at least 8 MB RAM to display the 3D model when there is more than one active light source.

## Autocovariance Plot

The Autocovariance plot is an indicator of the randomness of a profile of the test surface. Autocovariance is used to determine the periodicity of a surface. The Autocovariance plot is available in phase profile data windows and is created using the New Plot command. To open the plot Controller, click on the plot with the middle mouse button.



For periodic surfaces, the plot has a characteristic sinusoidal shape that is related to the period of the dominant spatial frequencies of the surface. For random surfaces the first zero crossing point indicates the distance along the surface at which the surface becomes uncorrelated. Autocovariance is also known as Autocorrelation Function or ACF.

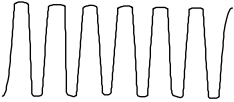
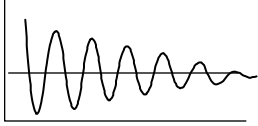

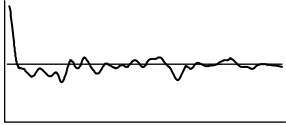
$$\text{Autocovariance} = \sum_{i=1}^{N-m} Y_i \cdot Y_{i+m}$$

Where: m is the shift position, an integer that ranges from zero to some fraction of N, and N is the number of discrete elements  $Y_i$  in the profile.

Autocovariance is a measure of similarity between two identical but laterally shifted profiles. Autocovariance is useful to distinguish the repetitive irregularities from random irregularities. Repetitive features may indicate tool wear or machine deficiencies. When examining the Autocovariance plot, look at the general shape, when the plot first crosses zero, and the distance to the first peak.

If the surface is random, having no repetitive waveforms, the Autocovariance plot rapidly drops to zero and then stays near zero. If the plot oscillates around zero in a periodic manner, then the surface has a dominant spatial frequency; by measuring the distance to the first peak (second maximum) its period is determined. If there are smaller ripples on the overall Autocovariance plot, then the surface has some periodic features.

The Correlation Len result shows the length along the x-axis where the autocovariance function first crosses zero. It can be thought of as the minimum distance along the profile where one point has no relation to the next. In a perfectly random surface, the correlation length is zero because no points have any relationship to other points. In a part with a non-random surface, correlation length is one quarter of the period of the dominant pattern.

<i>Description</i>	<i>Profile</i>	<i>Autocovariance Plot</i>
Surface with dominant waveform.		
Surface with random waveform.		



The Autocovariance is calculated for *profiles*; thus, the results are indicative of the slice location and may not accurately reflect the entire part. For this reason the slice should be as long as possible; the longer the slice length, the greater the accuracy.

### **Displaying the Autocovariance plot**

1. In a corresponding phase map data window, define a linear slice through the data within the Filled plot.
2. If the Autocovariance plot is blank make sure that you are using a linear slice and not a circular slice; that you are using corresponding data; and that the slice is drawn over an image area in the Filled plot.



No profile data is calculated or displayed until a linear slice is defined by the user within a Filled plot made in a corresponding phase map Data window. Slicing is covered in Section 7.

### **Changing the Autocovariance Plot**

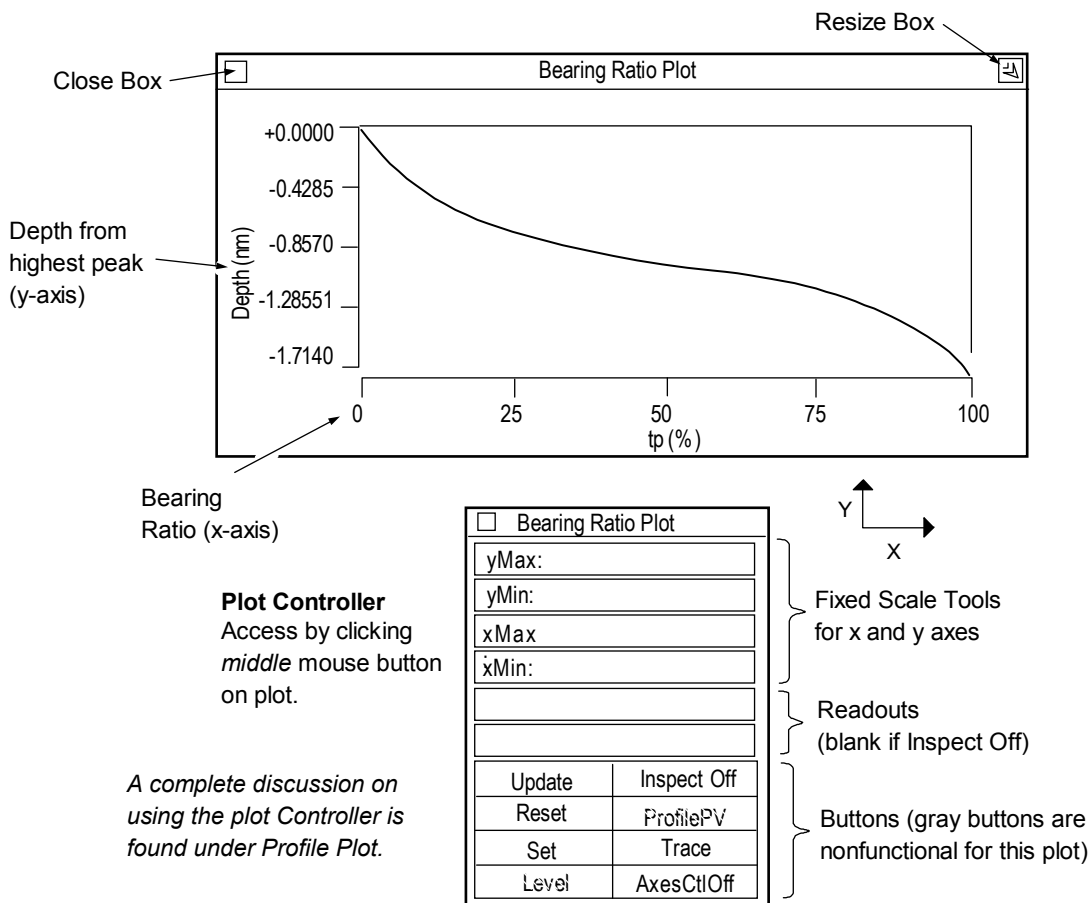
The plot display is adjusted and modified with the plot Controller. The Autocovariance plot Controller works the same way as standard profile plot Controller.

## Bearing Ratio Plot

The Bearing Ratio plot displays the bearing ratio at a range of depths for the entire data matrix. The Bearing Ratio plot is available in a Phase map Test/Default Data window and is created using the New Plot command. To open the plot Controller click on the plot with the middle mouse button.

The bearing ratio analysis includes both 2D profile data and 3D surface area data. Controls and results for profile data include the letters, “tp.” Controls and results for surface data include the letters “Stp.”

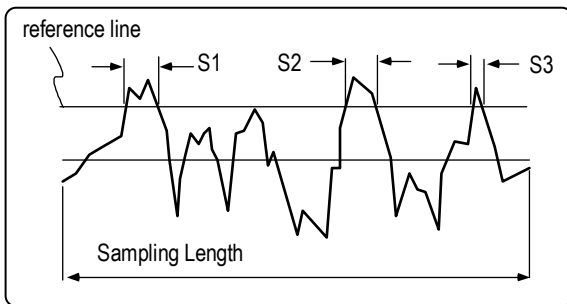
These controls are provided to specify locations along the curve based on either a percentage or height value. Portions of the curve can be isolated with offset controls, and the plot’s height reference location is selectable.



To state it differently, the Bearing Ratio plot is a set of bearing ratio values on the horizontal axis plotted against depths on the vertical axis. The Bearing Ratio plot simulates the effect of wear on a bearing surface. The Bearing Ratio plot is also known as the Abbott and Firestone curve (AFC), or the material ratio curve.

Bearing ratio, or tp, is the ratio (expressed as a percentage) of the length of the bearing surface at a specified depth below the highest peak. To simplify this discussion, bearing ratio is described here in relation to a slice of data, even though the Bearing Ratio plot

represents the entire surface. A reference line is drawn parallel to the center to intersect the data; the bearing ratio is the ratio of the sum of these subtended lengths to the sampling length.



$$\text{Bearing Ratio} = \frac{S1 + S2 + S3}{L} \times 100\%$$

Where L is the sampling length and Sx is the subtended length.

<i>Description</i>	<i>Profile</i>	<i>Bearing Ratio Plot</i>
Ground surface with random heights		
Honed surface with peaks removed		
Turned surface with dominating peaks		

The Bearing Ratio plot, although simulating the effect of wear, can never take the place of actual tests, as there are known limitations:

- It tends to ignore the geometric form and waviness of the test surface, which may have much more to do with the bearing contact of two surfaces than does a roughness profile.
- In practice two contacting surfaces are involved and the surface features of each contribute towards wear.

### **Changing the Bearing Ratio Plot**

The plot display is adjusted and modified with the plot Controller. The Bearing Ratio plot Controller works similar to the profile plot Controller.

## Bearing Ratio Reference Material

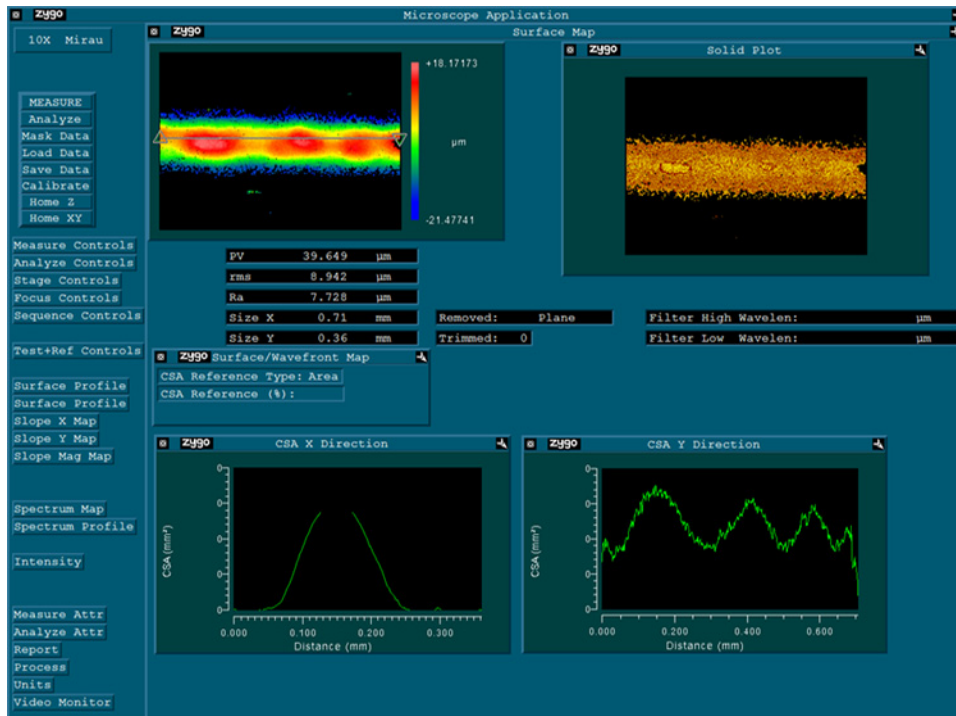
William Drews and Werner Weniger, “Rediscovering the Abbott-Firestone Curve,” *Quality*, September 1989, pp. 50-53.

E.J. Abbott and F.A. Firestone, “Specifying Surface Quality,” *Journal of Mechanical Engineering*, 55 1933: 569.

## Cross Sectional Area (CSA) Direction Plots

CSA analysis includes two new plots—CSA X Direction and CSA Y Direction. To create either one of these plots, in a Surface/Wavefront Map Window, select New Plot → CSA X Direction or CSA Y Direction.

CSA analysis finds the area under a curve by taking slices in the X and Y direction of a data set. Area is calculated by multiplying the total height times the width of each pixel. For each slice, the area under the curve and above the reference point set by the user is calculated. If no reference point is established, the default setting is the valley of the data set.

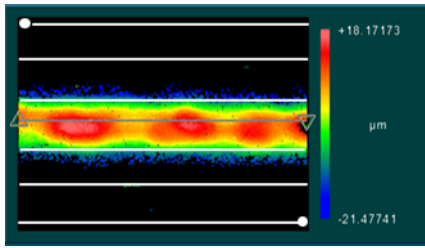


CSA X Direction	
yMax:	mm <sup>2</sup>
yMin:	mm <sup>2</sup>
xMax:	mm
xMin:	mm
	mm <sup>2</sup>
	mm
	degs
Update	Inspect Off
Reset	Prof PV
Set	Trace
Level	AxesCtloff

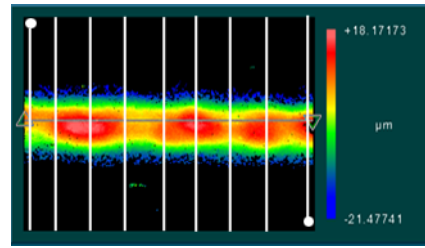
### Plot Controller

Select by clicking the middle mouse button on the plot. (Grayed out buttons represent non-functional items for this plot type.) This plot controller operates like the standard profile plot controller.

Note that the Y-axis is in units of area. If slices are made in the X direction, they are taken starting from the top row of the data and going from left to right, with the last slice taken at the last row of data. If slices are made in the Y direction, they are taken starting from the left-most column going from top to bottom with the last column on the right being the last slice. (See the following illustration.)



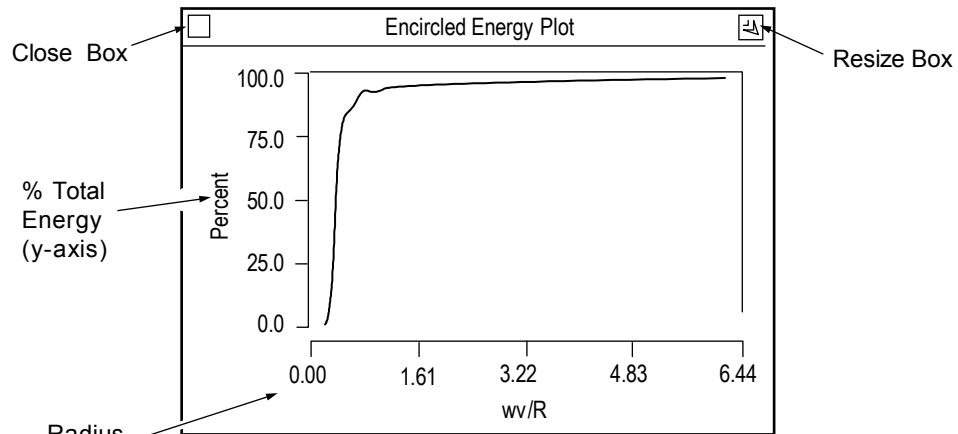
X Direction



Y Direction

## Encircled Energy Plot

The Encircled Energy plot shows the distribution of energy within the PSF plot; it is obtained from the PSF. The Encircled Energy plot is available in the PSF Data window and is created using the New Plot command. To open the plot Controller click on the plot with the middle mouse button.



**Plot Controller**  
Access by clicking *middle* mouse button on plot.

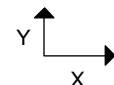
*A complete discussion on using the plot Controller is found under Profile Plot.*

Encircled Energy Plot	
yMax:	
yMin:	
xMax:	
xMin:	
Update	Inspect Off
Reset	ProfilePV
Set	Trace
Level	AxesCtlOff

} Fixed Scale Tools for x and y axes

} Readouts (blank if Inspect Off)

} Buttons (gray buttons are nonfunctional for this plot)



Think of the Encircled Energy plot as a drawing of circles with increasing radii centered at the center of the PSF spot. For each circle, the amount of energy it encloses is measured. This value is normalized by the total energy in the spot and plotted on the y-axis as a percentage. The plot illustrates how focused the energy is. A well corrected lens system will have a plot similar to the one shown above. Poorer quality lenses will not rise as quickly.



The Encircled Energy Plot requires an entry in the f-number control.

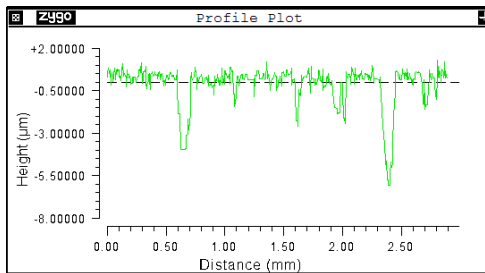
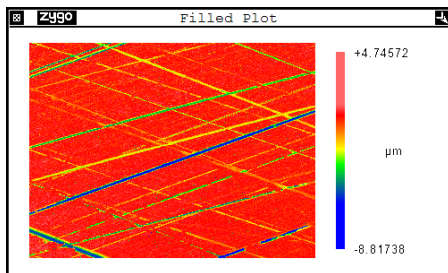
### Changing the Encircled Energy Plot

The plot display is adjusted and modified with the plot Controller. The Encircled Energy plot Controller works similar to the profile plot Controller.

## Material Probability Plot

The Material Probability Plot is an evaluation tool for predicting how well a material will function as a bearing surface. It is possible to look at data from a surface which was created using two different processes, such as plateau honing. It produces a surface which has components of both coarse and fine texture. The Material Probability Plot enables characterization of surface textures independently of one another. This is accomplished by determining the material ratio at the intersection of the peak (plateau) and valley line.

Suitable data for the Material Probability Plot should have smooth plateau regions separated by deep valley regions. Most often, this type of surface texture is found in critical sealing applications. A sample data set, suitable for Material Probability analysis, is shown below.



### Creating a Material Probability Plot

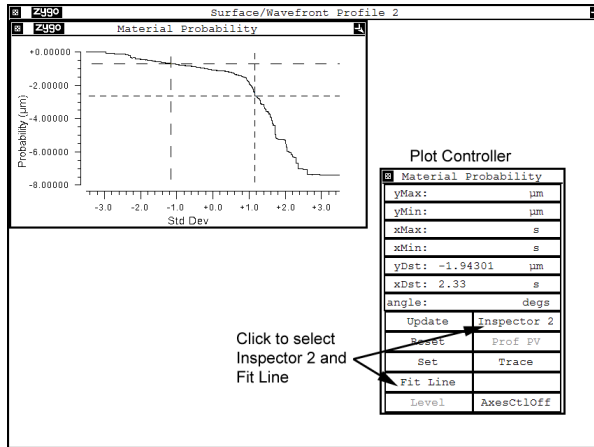
In a Surface/Wavefront Map Window, select New Plot → Material Probability. Open the Plot Controller. Click the Inspectors button and select Inspectors 2. If Fit Line is not active, click on the button to turn it on. Fit Line performs an automatic best-fit of the line to the curve.

Use the Inspectors to manually set the upper peak and lower valley limits. Inspector 1—light blue—establishes the upper peak limit; Inspector 2—orange—establishes the lower valley limit. And then press F2 or click the Analyze button to display results.





If you press F2, or load a new data set, you will have to redefine the limits.

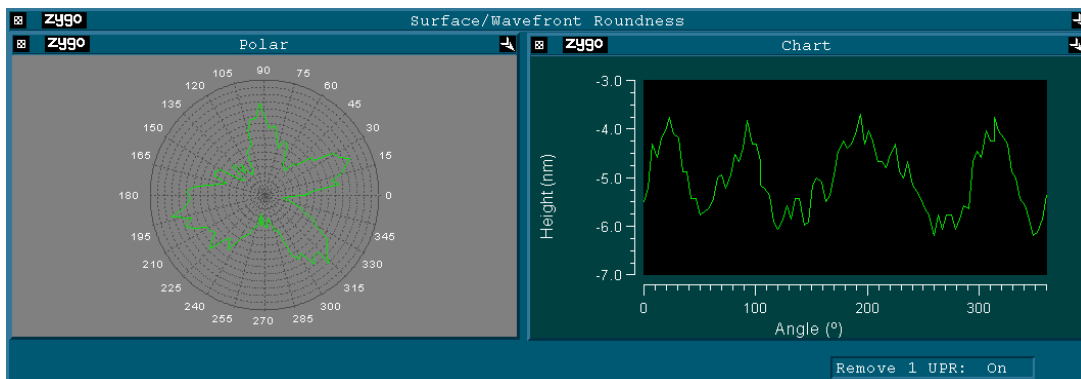


Grayed-out buttons represent nonfunctional items for this plot.

## Polar and Chart Plots—Roundness

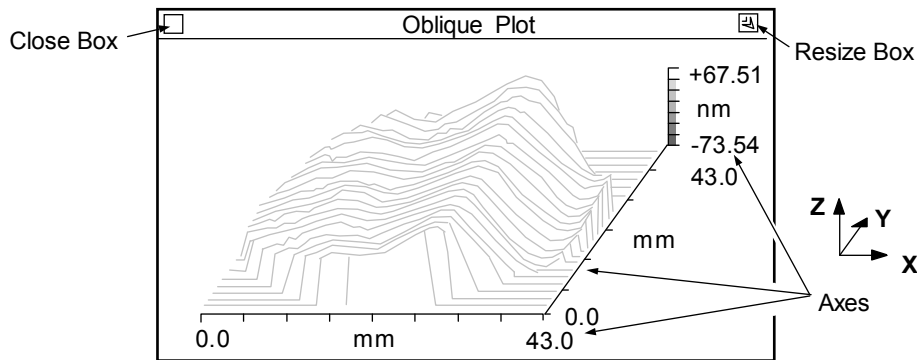
As a measurement result, ideal roundness is described as the condition in which all parts of the circle are identical from the center point out based on a polar coordinate system. Characterizing roundness for a circular part makes it possible to identify form deviation from the ideal roundness specification. It is often used in the control of certain manufacturing processes, such as grinding.

In the Surface/Wavefront Roundness window, click on New Plot to create the Polar and Chart plots shown below. The Polar plot shows the locations of peaks in the data. The Chart plot is a profile of the surface as represented by the selected slice.



## Oblique Plot

An Oblique plot is a three dimensional display of the data with the x-axis horizontal, the y-axis inclined from horizontal, and the z-axis vertical. All three axes of the plot typically include labeled scales. Areas with different magnitudes (height) are represented by different colors, or in a one color plot as different shades. The Oblique plot is available in map data windows and is created using the New Plot command. To open the Controller, click on the plot with the middle mouse button.



### Plot Controller

Access by clicking *middle* mouse button on plot.

Oblique Plot	
zMax:	nm
zMin:	nm
Update	Limit Off
Reset	Baseline
Set	Major Axes
Bands	Color Fit

**Fixed Scale Tool** - Use to control the z-axis scale of the plot. (see "Scaling the Oblique Plot's Z-axis")

### Buttons

To activate a button, position the pointer over the button and click the left mouse button.

**Update** - Redraws the plot to match the current Controller settings.

**Reset** - Restores button settings to match the "set" Controller settings.

**Set** - Makes the current Controller settings the master or "set" display.

**Color** - Selects the color of the plot. Choices: Bands (16 colors), Golds, Greys, CMYK (cyan, magenta, yellow, and black), Spectrum, and Neon (a variation of Spectrum). All colors except Band use 2000 colors.

**Limit** - Determines if and how the PV (peak-to-valley) limits are highlighted in red in the plot. Limit Off displays no limits in the plot.



To display limits in the plot, high limits must be set in a PV Result box in the same data window. For more information, see "Displaying Limits in the Oblique Plot".

**Display** - Selects how the plot is displayed. Baseline displays data with droplines and baselines. Stack F displays data as a floating oblique with a filled contour plot. Stack B displays data as a baseline oblique with a filled contour plot. Floating displays data without droplines or baselines.

**Axes** - Selects how the axes are displayed. Major Axes shows x, y, and z axes. Box 1 shows x, y, and z axes surrounding the data. Box 2 is a variation of Box 1. No Axes displays the data with no axes.

**Color Fit** - When on, plot colors are adjusted to display a greater range of colors for surfaces that are predominately one color. This affects the plot display only and not numeric results.

## Resizing the Oblique Plot

The plot can be resized to any proportions allowed by the data window in which it resides. The Oblique plot is designed to display in a 2:1 rectangular format. If you resize the plot, the width and height aspect ratio can be distorted so much that the plot does not even resemble the test part.

1. Click the window Resize box or select the Plot menu's Resize command.
2. Press the left mouse button and drag the lower right corner bracket of the window outline until it is the desired size; then release the mouse button.

## Using Colors in the Oblique Plot

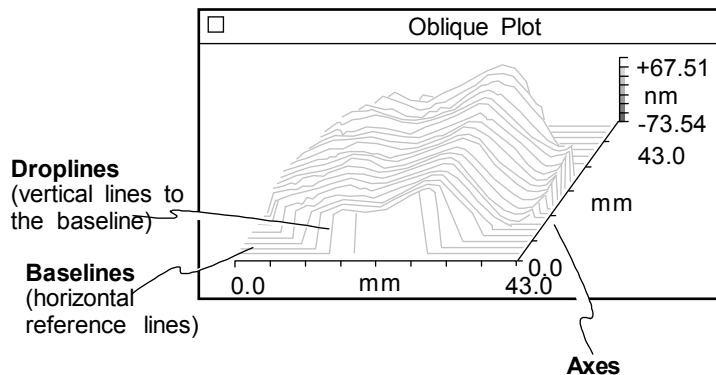
Click the plot Controller's Color button to change the color of the plot.

- Spectrum shows the greatest detail in the center of plotted height values.
- Neon shows the greatest detail near the top and bottom of plotted height values.
- Greys to display limits.

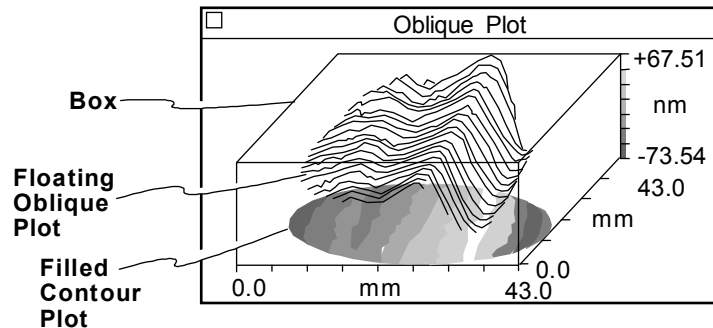
## Changing the Oblique Plot's Display Options

1. Click the Display button to select the way data is displayed.
2. Click the Axes button to select how the plot axes are displayed.
3. Click the plot Controller's Update button.

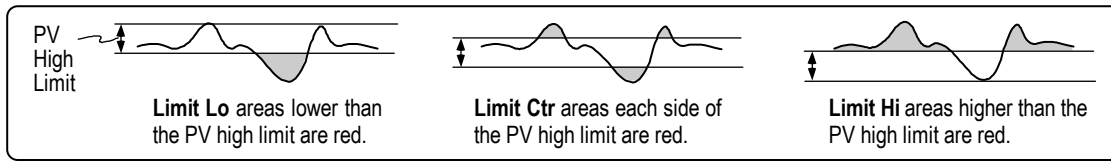
<input type="checkbox"/> Oblique Plot	
zMax:	nm
zMin:	nm
Update	Limit Off
Reset	Baseline
Set	Major Axes
Bands	Color Fit



<input type="checkbox"/> Oblique Plot	
zMax:	nm
zMin:	nm
Update	Limit Off
Reset	Stack F
Set	Box 1
Bands	Color Fit



## Displaying Limits in the Oblique Plot

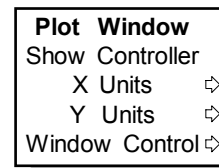


1. Click the plot color to Greys. Click the Limits button to select the limit mode. Then click the Controller's Update button.
2. In the PV result in the same data window, select the Limits → High command from the result's menu. Enter a high limit for the PV result and press [Enter].

## The Oblique Plot's Menu

**Show Controller** opens the plot controller.

**X-Y Units** select measurement units for the horizontal or x-axis and the inclined or y-axis. The x and y axes scales are dependent on the field of view of the instrument. If x and y axes are pixels, instrument calibration is required.

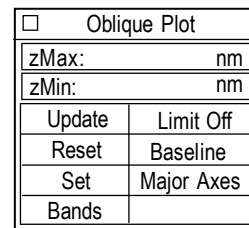


**Z Units** select measurement units for the vertical or z-axis. The z-axis scale is determined automatically by the data or the Z-axis Fixed Scale Tool if it is used.

**Window Control** use to move, resize and delete the window, and to rename or hide the window's title bar.

## Scaling the Oblique Plot's Z-axis

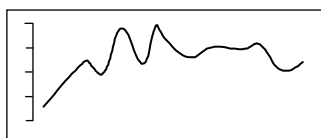
The Z-axis Fixed Scale Tool is useful when comparing the results of many similar parts; the z-axis scale does not change every time a measurement is made.



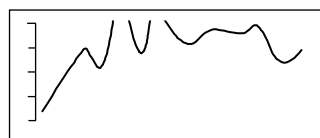
**Z-Axis Fixed Scale Tool**

Fixed scaling should be used with caution; data can be obscured if you input inappropriate values.

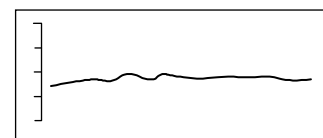
Data is clipped when the z-axis is too small; data is compressed by making the z-axis too big; and the plot may be blank because the data does not fall within the range of the z-axis.



Data within the y-axis



Clipped data



Compressed data

## Changing the Z-axis Fixed Scale Mode

1. Position the pointer over the Z-axis Fixed Scale Tool. Click the right mouse button to change modes.



There must be values entered in the fixed scale tool for it to function. Note that 0 (zero) is an entry.

## Entering Values in the Z-axis Fixed Scale Tool

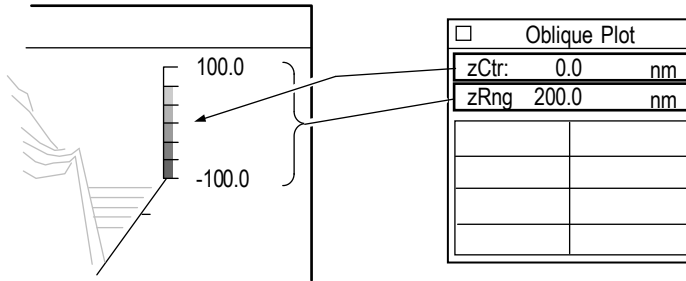
1. Position the pointer over one of the two boxes in the Z-axis Fixed Scale Tool.
2. Click the left mouse button, enter a numeric value, then press [Enter]. To erase values, click the left mouse button, delete all characters, then press [Enter].
3. Click the plot Controller's Update button to redraw the plot.
4. To preserve your changes, click the plot Controller's Set button.

## Example Use of the Z-axis Fixed Scale Tool

<i>Fixed Scale Modes</i>	<i>Example</i>
<p><b>zMax</b> specifies the upper value. If left blank, zMax defaults to the peak of the data.</p> <p><b>zMin</b> specifies the lower value. If left blank, zMin defaults to the valley of the data.</p>	
<p><b>zMax</b> specifies the upper value. If left blank, zMax defaults to the peak of the data.</p> <p><b>zRng</b> specifies the range of the scale. If left blank, the scale expands downward to show the data.</p>	
<p><b>zMin</b> specifies the lower value. If left blank, zMin defaults to the valley of the data.</p> <p><b>zRng</b> specifies the range of the scale. If left blank, the scale expands upward to show the data.</p>	

**zCtr** specifies the center of the scale. If left blank, zCtr defaults to the mean of the data.

**zRng** specifies the range of the scale. If left blank, the scale expands to show the data.



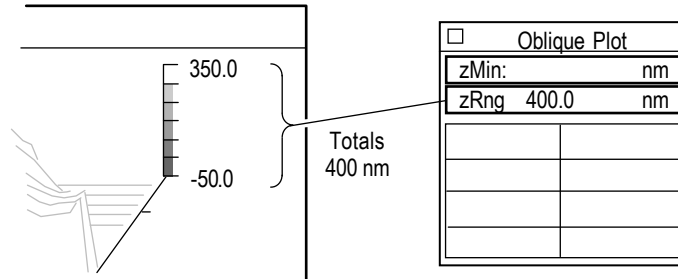
***The Z-axis Fixed Scale Tool's zRng Function***

The Z-axis Fixed Scale Tool zRng setting has dual functions. When a positive number is entered it specifies the overall size of the axis. When a negative number is entered, it invokes an exclude option; which works only with the zMax and zMin settings.

**zRng Function**

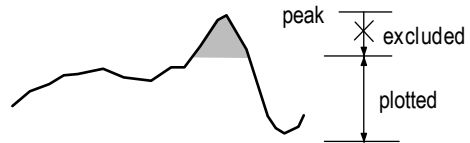
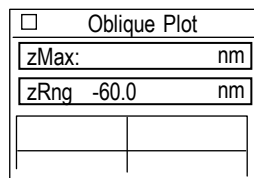
**Example**

**zRng (positive)**  
Specifies the overall size of z-axis.



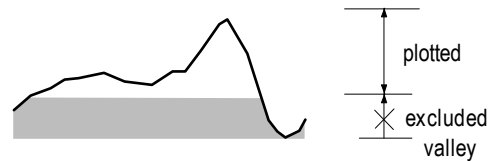
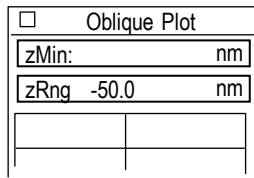
**zMax** specifies the upper value. zMax (blank) defaults to the peak.

**zRng (negative)** specifies the upper data range to exclude from the plot. (When used with zMax.)



**zMin** specifies the lower value. zMin (blank) defaults to the valley.

**zRng (negative)** specifies the lower data range to exclude from the plot. (When used with zMin.)



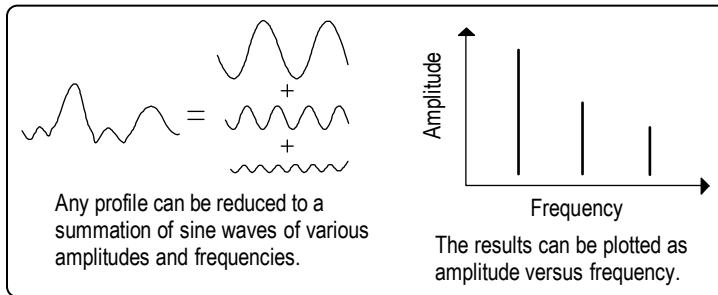
## Profile Spectrum Plots

This discussion covers four plots, all based on profile data. These plots are available in phase profile data windows and are created with the New Plot command.

- Amplitude Spectrum Plot
- Peak Amplitude Spectrum Plot
- Power Spectral Density Plot
- Power Spectrum Plot

Any profile can be reduced to a summation of sine waves of various amplitudes and frequencies. This spatial frequency data is obtained from a Fourier analysis of the profile. The profile spectrum plots are used to display the spatial frequency data.

Picture any given test surface as being made up of a combination of sine waves. When displayed as bars, every sine wave component of the test surface appears as a vertical line. Its height represents



the amplitude or power and its position represents its frequency. For all three plots, logarithmic scaling is often used for the y-axis to compress large amplitudes and expand small ones.

The profile spectrum plots help to characterize the surface features in terms other than roughness. Examine the general shape of the plot. Look at the slope of the plot and the height. Many surfaces tend to have spectrum plots that fall off quickly at the low frequencies and then level out; if this is the case, the surface is dominated by lower spatial frequencies (waviness). When the spectrum plot falls off more evenly over the horizontal axis the surface is dominated by high spatial frequencies (roughness). Spikes usually appear when the surface has distinct spatial frequencies due to a machining process. The spike occurs at the spatial frequency associated with the machining method.

<i>Description</i>	<i>Power Spectrum Plot</i>
Surface with little waviness and very high spatial frequencies (microroughness).	
Surface with low spatial frequencies dominant (waviness).	

Note that most surfaces tend to look smoother when examined over increasingly smaller regions, such as when using higher power microscope objectives. The lower power objectives tend to show much more waviness than high power objectives (10X and up). Changing objectives filters the spatial frequencies due to the different magnifications.





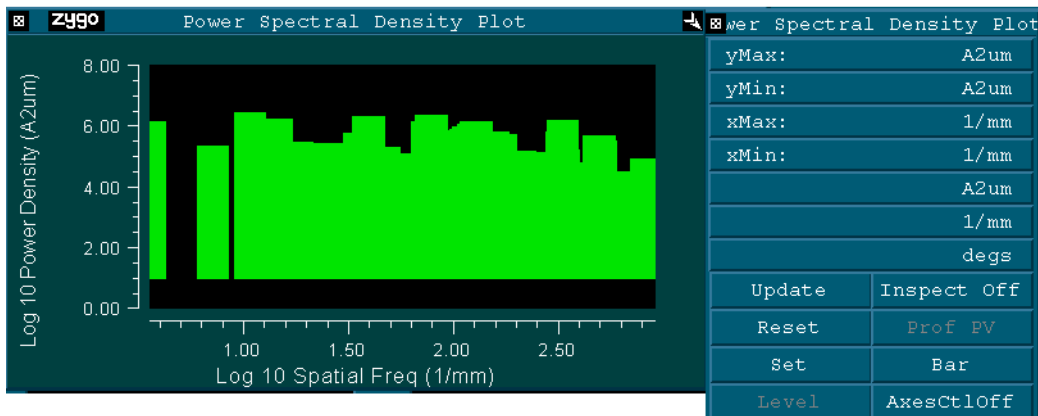
The use of the filtering controls can drastically affect the spectrum plots, as filtering changes the relative frequency content of the data.

### ***The Amplitude Spectrum Plot***

Displays spatial frequency data as amplitude versus frequency. The height of a bar (y-axis) indicates the amplitude of a component sine wave. The position of the bar (x-axis) indicates the frequency. Y-axis units are selectable and are linked to the Height Units control. X-axis units are selectable in cycles per lateral unit and are linked to the Lateral Units control. This plot is also called the Peak Amplitude Spectrum Plot.

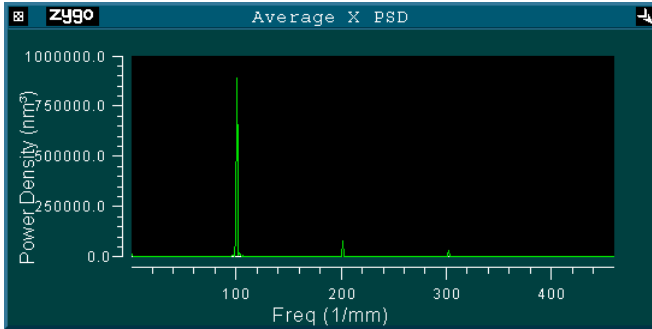
### ***The Power Spectral Density Plot***

Displays spatial frequency data as power density versus frequency. Power density is calculated as the square of the amplitude of a sine wave multiplied by the length of the profile. The height of a bar (y-axis) indicates the power density of a component sine wave. The position of the bar (x-axis) indicates the frequency. Y-axis units are always angstroms squared microns ( $\text{\AA}^2\mu\text{m}$ ). X-axis units are selectable, in cycles per lateral unit and are linked to the Lateral Units control.



### Power Spectral Density—Average X PSD Plot

Each frequency in the X-axis is taken as a slice and PSD is calculated for each one. All of the PSD data is then averaged. This provides information for locating the peak spike frequency. This plot is available in a Surface/Wavefront Map Window. Select New Plot → Average X PSD.



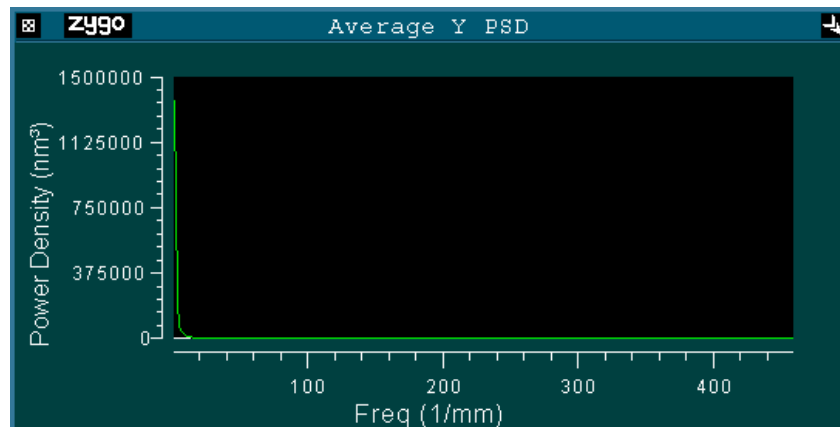
Average Y PSD	
yMax:	A²um
yMin:	A²um
xMax:	1/mm
xMin:	1/mm
	A²um
	1/mm
	degs
Update	Inspect Off
Reset	Prof EV
Set	Trace
Level	AxesCtlOff

#### Plot Controller

Select by clicking the middle mouse button on the plot. (Grayed out buttons represent non-functional items for this plot type.) This plot controller operates similar to the standard profile plot controller.

### Power Spectral Density—Average Y PSD Plot

Each power density value in the Y axis is taken as a slice, and the PSD is calculated for each one. All of the PSD data is then averaged. This provides information for locating the peak spike frequency. This plot is available in a Surface/Wavefront Map Window. Select New Plot → Average Y PSD. The Plot Controller has the same functionality as shown above. Click the middle mouse button on the plot to open the plot controller.

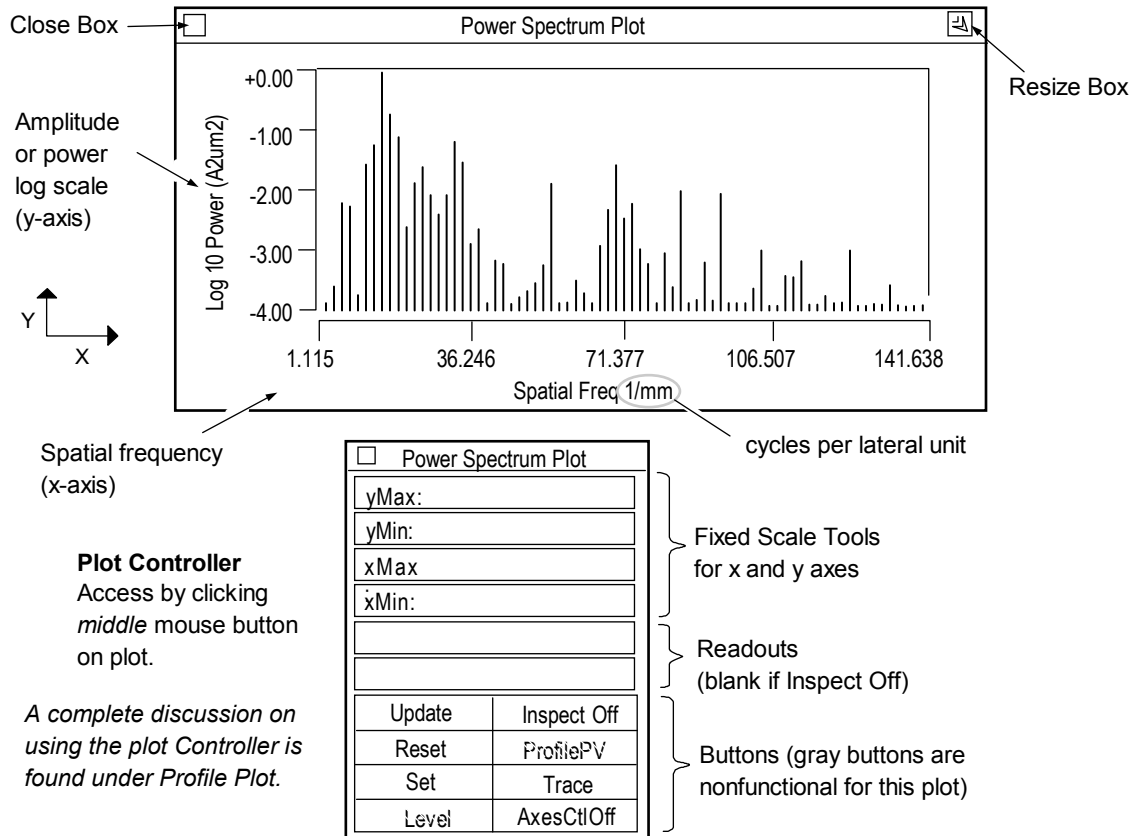


### The Power Spectrum Plot

Displays spatial frequency data as power versus frequency. Power is calculated as the square of the amplitude of a sine wave multiplied by the square of the length of the profile. The height of a bar (y-axis) indicates the power of a component sine wave. The position of the bar (x-axis) indicates the frequency. Y-axis units are always angstroms squared microns squared ( $A^2\mu m^2$ ). X-axis units are selectable in cycles per lateral unit and are linked to the Lateral Units control.

### Changing the Profile Spectrum Plots

The plot display is adjusted and modified with the plot Controller. To open the plot Controller, click on the plot with the middle mouse button. The profile spectrum plot Controllers work similar to the profile plot Controller. A secondary button panel for control over the axes is accessed by clicking on the AxesCtl button.



The spectrum plots are calculated for *profiles*; thus, results are indicative of the slice location and orientation and may not accurately reflect the entire part. The longer the profile length, the greater the accuracy.

## Displaying the Profile Spectrum Plots

1. In a corresponding map phase data window, define a linear slice through the data within the Filled plot. Slicing is described in Section 4.
2. If the profile spectrum plot is blank make sure that you are using a linear slice and not a circular slice; that you are using corresponding data windows; and that the slice is drawn over an image area in the Filled plot.



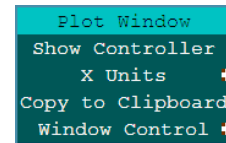
No profile data is calculated or displayed until a linear slice is defined by the user within a Filled plot made in a corresponding phase map data window.

## The Profile Spectrum Plot's Menu

**Show Controller** open the plot controller.

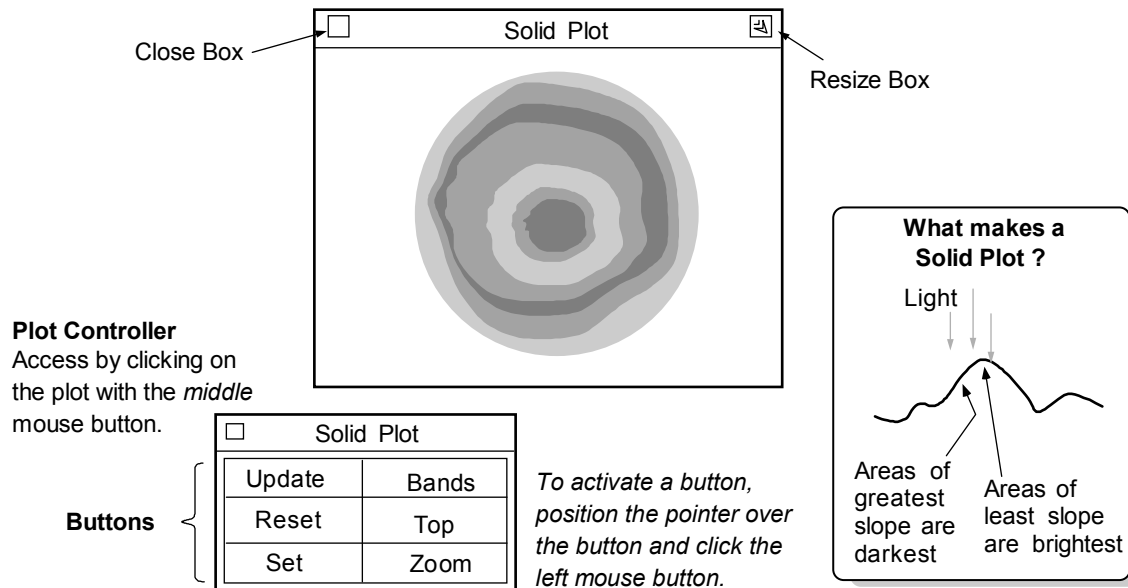
**X Units** select measurement units for the horizontal or x-axis. If x-axis units are pixels, instrument calibration is required.

**Window Control** use to move, resize and delete the window, and to rename or hide the window's title bar.



## Solid Plot

A Solid plot displays surface data as a function of slope as viewed along the instrument z-axis. Areas with different slopes are represented by different shades. The Solid plot displays high frequency irregularities better than the Filled plot. A Solid plot is available in map data windows and is created using the New Plot command. To open the plot Controller, click on the plot with the middle mouse button.



**Update** - Redraws the plot to match the current Controller settings.

**Reset** - Restores button settings to match the “set” Controller settings.

**Set** - Makes the current Controller settings the master or “set” display.

**Color** - Selects the color of the plot. Choices: Bands (16 colors), Golds, Greys, CMYK (cyan, magenta, yellow, and black), Spectrum, and Neon (a variation of Spectrum). All colors, except Bands are 2000 colors.

**View** - Selects the view of the data. Top displays a view from above. Oblique displays an inclined view.

**Zoom** – When on, the plot fills as much of the window as possible.

### Resizing the Solid plot

When resizing the window, the plot will automatically resize if the size of the window allows the next incremental plot size to fit and the Zoom button is on.

1. Click the Zoom button so the zoom function is on.
2. Position the pointer on the window Resize box and press the left mouse button; or, if the title bar is hidden, select the Plot menu’s Resize command. Then drag the mouse to resize the window and release the mouse button.



# Results and Attributes

## Section 9

*MetroPro provides countless results to characterize your test part. They are listed here alphabetically by name.*

This section provides an alphabetical listing of MetroPro results and attributes. Where applicable, specific applications are listed. Refer to the result or attribute of interest by name in this section.

### Results

Result boxes display calculated numeric values. If a limit has not been set, result boxes are normally black with white characters. If limits are set with the Limits command, the box will be red when an output exceeds the limit, or green when the value is within the limits. Results are created with the New Result command from the data window menu.

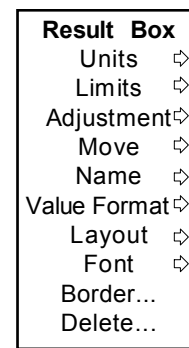


If the software cannot calculate a result, the result box remains blank. Usually, this occurs because the instrument is not calibrated.

If a result displays a series of asterisks (\*\*\*\*\*), it means the box is not large enough to display all the digits. To correct this, increase the number of decimal places with the result's menu Value Format → Decimal Places command, or increase the width of the result with the Value Format → Width command.

*Use the Result's menu to modify the box.*

- Units** select the measurement unit.
- Limits** set high and/or low limits for the result.
- Adjustment** adjust the final numeric result.
- Move** relocate the result.
- Name** change the result name and get information.
- Value Format** select the result width and decimals.
- Layout** select the way information is displayed.
- Font** select the type style.
- Border** change the line width around the result.
- Delete** erase the result from the screen.



*actual menus will vary*

## Layout Command

The Layout command enables you to specify the format for displaying result data. There are some formats that display results on two or three lines. The chart below shows the format for each layout type. It may be necessary to move the result box to completely display a two or three line result format.

**Sample Layout Command Options**

<i>Menu Choice</i>	<i>Example</i>
Name Value Units	PV 7.570 um
Name Value Units P/F	PV 7.570 um P*
Name Value Units [lo, hi]	PV 7.570 um [7.550, 7.588]**
Name / Value Units	PV 7.570 um
Name / Value / Units	PV 7.570 um
Name Value	PV 7.570
Name Value P/F	PV 7.570 P*
Name Value [lo, hi]	PV 7.570 [7.550, 7.588]**
Name / Value	PV 7.570
Value / Units	7.570 um
Value	7.570

\* This format is useful for immediate feedback on pass/fail status for a result when reviewing a report offline.

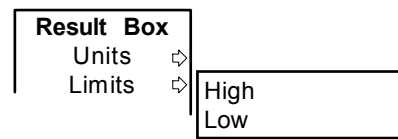
\*\* Lo represents the low limit for the result, and hi represents the high limit for the result. If this format has been selected, and a high or low limit has not been set, a – (dash) is displayed.

## Limits Command

The Limits command allows you to specify what is an acceptable value for a result. If limits are specified, the result is green if the value is acceptable and red if the value exceeds a limit.

The command is accessed with the result's menu. To enter a value, select the command, type in a value, and press [Enter].

Refer to Section 11 for additional information.

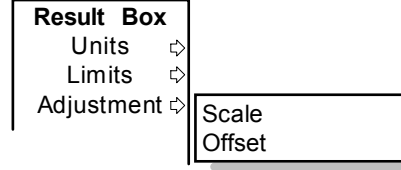




## Adjustment Command

The Adjustment command allows you to change or adjust numbers displayed within most results with a scale (multiplier) factor and an offset (add or subtract) value.

The command is accessed with the result's menu. To enter a value, select the command, type in a value and press [Enter].

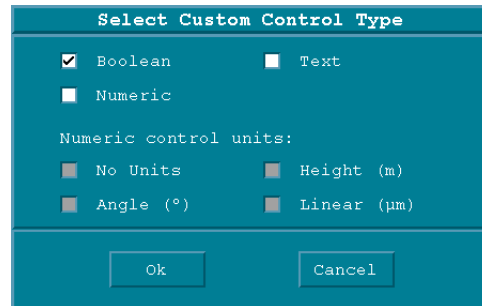


Because the numeric result is modified, it is denoted by the result name being highlighted in yellow. Both scale and offset values can be used in combination. Entering a scale of 0 (zero) will make the result 0. After an adjustment value is entered, the effect may be seen by clicking the Analyze button. Note that adjusting a numeric result does not change original or saved data.

## Custom Command

The Custom command together with MetroScript, can create a customized measurement result. A custom result can be Boolean (on/off), numeric, or text. The value of a custom result is derived from a user-created MetroScript. A custom result must use the Auto Run Script control to tell the system to run the script, and the Script File control to identify the location of the script file.

To create a custom result, from a Control window, select the New Control → Custom → Create New command and then choose the applicable options in the dialog box.



## Attributes

Attribute boxes display information about the measurement, such as: what a control was set to, what time the measurement was taken, and the current status of the measurement. Attribute boxes are black. Attributes are created with the New Attribute command. The menus for attributes are similar to those for results.



Only *unique* attributes are described in this section. Most attributes are simply an image of the control when the measurement was made; for more information on these attributes, refer to control name as listed in Section 3.

## 3/A(B/C)

The SAG, IRR, and RSI results in ISO form. Part of the ISO figure specification (ISO 10110-5).

## Alignment Err

Displays the fiducial actual alignment error in pixels. Attribute only.

## Aperture

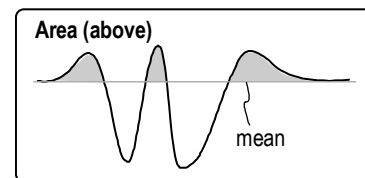
This is a read-only result for large aperture systems. It reflects the aperture selected with the Aperture control, which is located in the upper left hand corner of the application.

## Aperture

Outputs the setting of the Aperture button at the time the measurement was taken. Attribute only. Applies to microscope applications only.

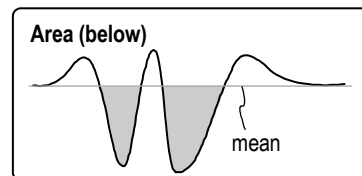
## Area (above)

Area (above) is the area of the profile data above the mean. Instrument calibration is required for this result. The mean is the best fit surface to the data.



## Area (below)

Area (below) is the area of the profile data below the mean. Instrument calibration is required for this result. The mean is the best fit surface to the data.

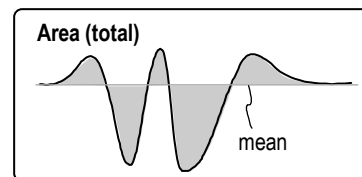


## Area (net)

Area (net) is the overall area of the profile data. It is equal to the Area (above) minus the Area (below). Instrument calibration is required for this result.

## Area (total)

Area (total) is the sum of the Area (above) and the Area (below) the mean of the profile data. Instrument calibration is required for this result. The mean is the best fit surface to the data.



## AstAng (Z)

AstAng (Z) (Astigmatism Angle based on Zernikes) is the angle in the instrument coordinate system at which astigmatism occurs. The range of values for AstAng (Z) is  $\pm 90^\circ$ . For an explanation of astigmatism, see AstMag (Z). Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display this result.

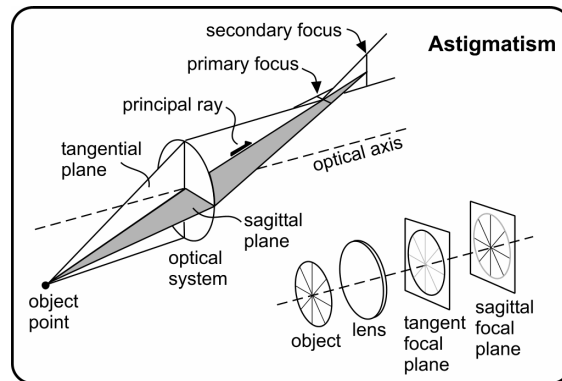
$$\text{AstAng} = 0.5 \arctan\left(\frac{z5}{z4}\right) \quad \text{Where } z4 \text{ is the 4th Zernike term and } z5 \text{ is the 5th term.}$$

## AstMag (Z)

AstMag (Z) (Astigmatism Magnitude based on Zernikes) is a third order wavefront aberration where the rays in two orthogonal axes do not come to focus on the same plane.

A schematic view of an optical system imaging an off axis point is shown to illustrate astigmatism.

There are two planes: the tangential plane and the sagittal plane. Rays in the tangential plane come to focus closer to the lens (primary focus) than rays in the sagittal plane (secondary focus). The overall affect of astigmatism is illustrated by the wagon wheel, where the rim and spokes do not come to focus at the same point.



In a perfectly aligned and fabricated optical system, astigmatism is only found at image points off the optical axis. In real optical systems, astigmatism can be found anywhere in the image plane. If aberrations are found on axis they are an indication of fabrication or alignment errors.

$$\text{AstMag} = 2 \sqrt{z4^2 + z5^2} \quad \text{Where } z4 \text{ is the 4th Zernike term and } z5 \text{ is the 5th term.}$$

Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display this result.

## Auto Save Data Dir

This attribute displays the directory path in which the last auto-saved data file was written. It will only show a value if the Auto Save Data control was On at the time the measurement was made. This attribute is especially helpful if a special code was entered in the Auto Save Data Dir control. Attribute only.

## Auto Save Data File

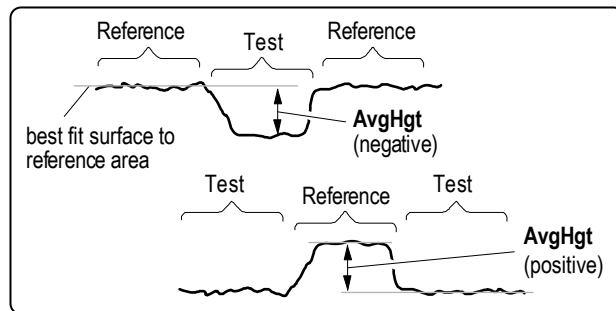
This attribute displays the file name in which the last auto-saved data file was written. It will only show a value after a measurement is made with the Auto Save Data Control set to On. This attribute is helpful if a special code was entered in the Auto Save Data File control. Attribute only.

## Auto Seq Count

Auto Seq Count (Auto Sequence Count) outputs the actual number of auto sequences performed. Attribute only.

## AvgHgt (Test)

AvgHgt (Average Height) is the average height of a test data area in relation to a reference data area in the instrument's z-axis. It compares an area defined by a Test mask to an area defined by a Reference mask and determines the vertical offset between them. Height refers to direction along the instrument's z-axis.



AvgHgt requires Test and Reference masks to be defined with the Mask Editor. If possible, use a Reference mask on both sides of the test area in order to accurately define the reference plane. When only one reference area is used, the result is generally less reliable. If masks are not used, AvgHgt equals the arithmetic average of the data set.

Ensure that the Remove control is set to remove at least piston or plane; otherwise offset and tilt of the overall surface are reflected in the result.

## AWM Vacuum Wavelength (nm)

Shows the vacuum wavelength for the last acquired data set, or for the data set loaded.

Available in a Control Window under New Attribute.

VeriFire instruments only. Attribute only.

## AWM Air Wavelength (nm)

Shows the air wavelength for the last acquired data set, or for the data set loaded.

Available in a Control Window under New Attribute.

VeriFire instruments only. Attribute only.

## **AWM Air Temperature (deg C)**

Shows air temperature for the last acquired data set, or for the data set being loaded.

Available in a Control Window under New Attribute.

VeriFire instruments only. Attribute only.

## **AWM Air Pressure (mmHg)**

Shows air pressure for the last acquired data set, or for the data set loaded.

Available in a Control Window under New Attribute.

VeriFire instruments only. Attribute only.

## **AWM Air Relative Humidity (%)**

Shows relative humidity for the last acquired data set, or for the data set loaded.

Available in a Control Window under New Attribute.

VeriFire instruments only. Attribute only.

## **AWM Air Quality**

Shows air quality for the last acquired data set, or for the data set loaded.

Available in a Control Window under New Attribute.

VeriFire instruments only. Attribute only.

## **AWM Input Power (mW)**

Shows AWM input power for the last acquired data set, or for the data set loaded.

Available in a Control Window under New Attribute.

VeriFire instruments only. Attribute only.

## **Calibration f-number**

Displays the f-number value of the calibration standard used when calibrating for spherical distortion. Attribute only.

## **Calibration NA**

Displays the numerical aperture value for the calibration standard used when calibrating for spherical distortion. Attribute only.

## Calibration Radius

Displays the radius of curvature value for the calibration standard used when calibrating for spherical distortion. Attribute only.

## Camera Res

It displays the lateral resolving power of each camera pixel with a given calibrated objective or calibrated transmission element. The value is the smallest detail that can be measured laterally. If the objective or transmission element is not calibrated, the output box is blank. Attribute only.

## Centroid X

*See Weighted Centroid X.*

## Centroid Y

*See Weighted Centroid Y.*

## Coherence Mode

Displays the orientation of the MESA Coherence Mode knob when the measurement was made. Attribute only.

Obsolete. For backwards compatibility.

## Clip Data Height

The average height of the data after clipping is performed. The result is calculated immediately after clipping is performed within the data processing sequence. If no clipping is performed the result is blank.

## Coef (0 to 36)

Displays the value for Zernike polynomial coefficients created when a Zernike data set was generated.

## ComAng (Z)

ComAng (Z) (Coma Angle based on Zernikes) is the angle in the instrument coordinate system at which coma occurs. The range of values for ComAng (z) is  $\pm 180^\circ$ . For an explanation of coma, see ComMag (z).

ComAng(Z) =  $\arctan\left(\frac{z7}{z6}\right)$       Where z6 is the 6th Zernike term and z7 is the 7th term.

Zernike polynomials are used to calculate Seidels, and at least 9 Zernike terms must be analyzed to display the result.

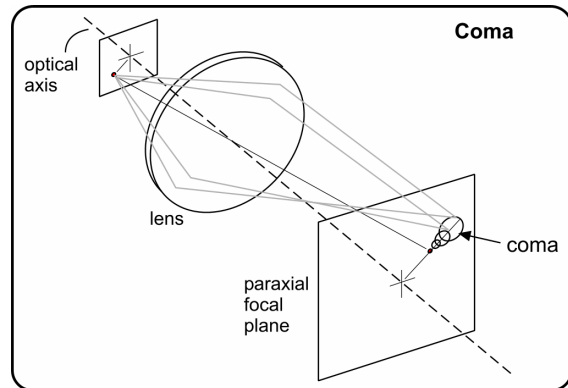
## ComMag (Z)

ComMag (Z) (Coma Magnitude based on Zernikes) is a third order wavefront aberration that appears when light is brought to a focus at points off the optical axis. The name coma is Latin for comet, which is the shape of the aberrated image of an off-axis point.

$$\text{ComMag} = 3 \sqrt{(z6^2 + z7^2)} \quad \text{Where } z6 \text{ is the 6th Zernike term and } z7 \text{ is the 7th term.}$$

Zernike polynomials are used to calculate Seidels, and at least 9 Zernike terms must be analyzed to display the result.

The imaging of an off-axis point source by a lens with positive transverse coma is shown here. Each cone of rays passing through a circle of the lens surface is imaged as a comatic circle and not a point. The overall image is shaped like a comet. Rays passing through the center of the lens form a point image at the vertex of the cone.



In a perfectly aligned and fabricated optical system, coma is only found at image points off the optical axis. In real optical systems, coma can be found anywhere in the image plane. If aberrations are found on axis they are an indication of fabrication or alignment errors.

In third order aberration theory, coma may be positive or negative. For negative coma, the tail points away from the optical axis and for positive coma, the tail points toward the axis. ComMag as computed in MetroPro is always positive. Its orientation is given by ComAng. This modification of the definition was necessary because the location of the optical axis is unknown to the interferometer.

## Cone Angle

Represents the value of the cone angle that was removed from the data set. For fixed angle cone removal, this result will be the value entered in the Cone Angle control. For variable angle cone removal, this result will be the angle of the cone determined during the measurement and removed during analysis.

## Cone Origin X

The location of the cone's vertex in the X axis.

## Cone Origin Y

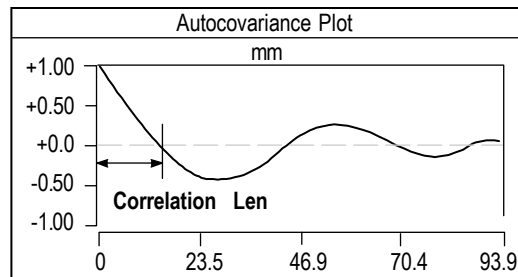
The location of the cone's vertex in the Y axis.

## Cone Origin Z

The location of the cone's vertex in the Z axis.

## Correlation Len

Correlation Len (Length) is the distance or length along the x-axis of the Autocovariance plot where the autocovariance function first crosses zero. It can be thought of as the minimum distance along the cross section of the surface where one point has no relation to the next. In a perfectly random surface, the Correlation Len is zero because no points have any relationship to other points. In a part with a non-random surface, Correlation Len is one-quarter of the period of the dominant pattern.



The Correlation Len result is blank if a Filled plot in a corresponding data window does not have a linear slice defined. The instrument must be calibrated for the Correlation Len result to display in units other than pixels. For Zygo microscopes, objectives are factory calibrated; unless they are replaced or switched later. For ZYGO interferometers, calibration is required every time the zoom setting is changed.

## CSA X Mean

An average of all the data points in the X direction.

## CSA X Peak

The value of the highest data point in the X direction.

## CSA X Peak Loc X

In the X direction, this result is the x value at the peak (or highest value) of the profile.

## CSA X Pts in PV Spec (%)

This is the percentage in the X direction of valid data points within the user specified limit for PV. See CSA Reference Type.

## CSA X PV

The peak-to-valley distance between the highest and lowest points in the X direction.



## **CSA X Valley Peak Loc X**

In the X direction, this result is the x value at the valley (or lowest) value of the profile.

## **CSA Y Mean**

An average of all the data points in the Y direction.

## **CSA Y Peak**

The value of the highest data point in the Y direction.

## **CSA Y Peak Loc X**

In the Y direction, this result is the x value at the peak (or highest value) of the profile.

## **CSA Y Pts in PV Spec (%)**

This is the percentage in the Y direction of valid data points within the user specified limit for PV. See CSA Reference Type.

## **CSA Y PV**

The peak-to-valley distance between the highest and lowest points in the Y direction.

## **CSA Y Valley Peak Loc X**

In the Y direction, this result is the x value at the valley (or lowest) value of the profile.

## **Current Sweep Measurement**

Displays the current position within the measurement sweep. Used with dynamic stroboscopic measurements. Attribute only.

## **Custom**

This result allows for creation of a new, numeric result not offered through standard MetroPro. Custom is available in a Test or Surface/Wavefront window in Microscope or GPI applications. The value of a custom result is derived from a user-created MetroScript. A unit of measure must be selected and named. None is a selection for unit of measure if there isn't one that applies to the custom result. The Auto Run Script control tells the system to run the script, and the Script File control identifies its location.

## Cutoff Freq

Cutoff Freq (frequency) is the maximum spatial frequency that can be resolved by a lens; it is where the theoretical unaberrated MTF goes to zero. The Cutoff Freq result requires an entry in the f-number control. With an optic with a focused wavefront, or an f-number greater than zero, the units are shown in cycles per millimeter (1/mm).

$$\text{Cutoff Freq} = \frac{2 \text{ NA}}{\text{Wavelength} - \text{ln}} \quad \text{Where: NA} = \frac{1}{(2) \text{ f - number}}$$

## Cutoff Freq (afocal)

The maximum angular frequency that can be resolved by a lens; it is where the theoretical unaberrated MTF goes to zero. For afocal wavefronts, set the f-number control to 0 (zero) and enter a dimension in the Exit Pupil Diam control. The units are shown in cycles per arc sec (1/sec).

$$\text{Cutoff Freq (afocal)} = \frac{\text{Exit Pupil Diam}}{\text{Wavelength} - \text{ln}}$$

## Data File

Displays the name of the last saved or loaded data file. Attribute only.

## Delta tp (%)

The difference in the profile bearing ratio (expressed as a percentage) between the Upper and Lower tp (%) values.

## Delta Stp (%)

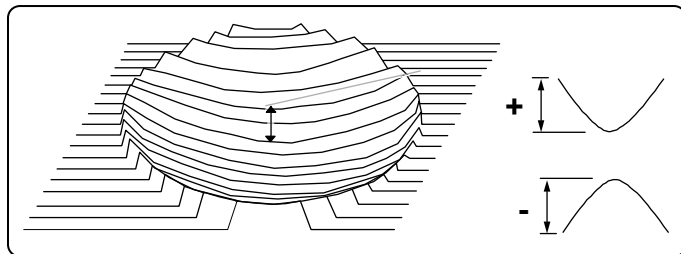
The difference in the areal bearing ratio (expressed as a percentage) between the Upper and Lower Stp (%) values.

## Distance Moved

The actual distance traveled by the z-stage between the confocal and catseye positions. This result is only applicable to instruments with a programmable motorized z-axis.

## FocMag (Z)

FocMag (Z) (Focus Magnitude based on Zernikes) is a first order wavefront aberration; it is a measure of the sag of the surface or wavefront without distinguishing between the X and Y dimensions. It is the height difference between the center point and the point farthest from the center. FocMag (z) is positive for a concave surface and negative for a convex surface.



$$\text{FocMag} = 2(z_3) - 6(z_8)$$
 Where  $z_3$  is the 3rd Zernike term and  $z_8$  is the 8th term.

Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display the result.

## Focus Adjust

This attribute stores the amount to move the z stage. Once data is loaded or a measurement is done, this value is cleared.

## Focus Error

The null error value based on FocMag (Z) for the catseye wavefront of a radius of curvature measurement.

## Focus Pitch Adjust

This attribute stores the amount to move the pitch (tilt) stage. Once data is loaded or a measurement is done, this value is cleared.

## Focus Roll Adjust

This attribute stores the amount to move the roll (tip) stage. Once data is loaded or a measurement is done, this value is cleared.

## Fringe Contrast (Ref)

A number representing the contrast between the light and dark fringes at the time of acquisition. The result can range from 0 to 100, with 0 depicting no contrast and 100 depicting the perfect contrast. Fringe Contrast (Ref) is the contrast in the area of the test part defined as the Reference mask.

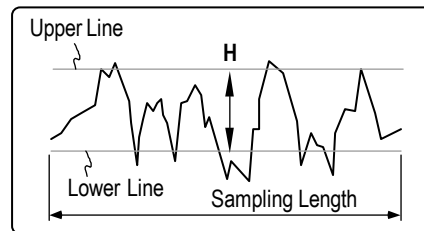
## Fringe Contrast (Test)

A number representing the contrast between the light and dark fringes at the time of acquisition. The result can range from 0 to 100, with 0 depicting no contrast and 100 depicting the perfect contrast. Fringe Contrast (Test) is the contrast in the area of the test part defined as the Test mask or the entire part if masks are not used.

The Fringe Contrast (Test) and Fringe Contrast (Ref) results serve together as a focus indicator for the microscope Step Height Application. When both display somewhat equal values it means the objective is properly focused on the step. Values will not be equal if there are dissimilar materials on the top and bottom of the step.

## H

H or Swedish height is the distance between two reference lines inside the profile. The upper reference line is positioned at a depth which exposes 5% of the data and the lower reference line exposes 90%. Swedish height is less sensitive to data spikes than PV.



## Height LPL

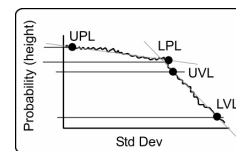
The height of the lower plateau or peak limit, as located by the software in the Material Probability analysis.

## Height LVL

The height of the lower valley limit of the Material Probability plot, as defined by the user using the orange Inspector tool.

## Height UPL

The height of the upper plateau (peak) limit of the Material Probability plot, as defined by the user using the light blue Inspector tool.



## Height UVL

The height of the upper valley limit of the Material Probability plot, as defined by the user using the orange Inspector tool.

## Hi Clip Height

The height at which high clipping is performed. All points above the high clip height are removed from the data set. The result is calculated at the time clipping is performed within the data processing sequence. If no clipping is performed the result is blank.

## Homogeneity

A measure of the uniformity or purity of an optical material. The lower the Homogeneity, the better the uniformity.

Homogeneity is given by:  $\Delta n = [n (T - C) - (n-1) (S2 - S1)] / t$

Where  $n$  is the refractive index,  $t$  is the part thickness, and  $T$ ,  $C$ ,  $S1$ , and  $S2$  are the measurements.

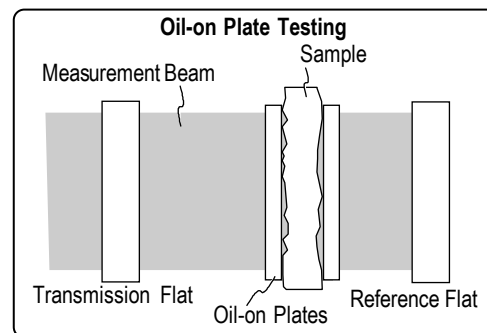
It is typically used with large aperture interferometer systems to evaluate material quality before expending time and resources on fabrication. Prior to making a measurement, the thickness of the optical material being tested must be entered in a Part Thickness control. Homogeneity is equal to the PV divided by the part thickness.

The Homogeneity result is commonly used with the oil-on plate testing technique for testing material samples that do not have polished surfaces. Oil-on plate testing is shown here and described below.

Oil-on plates are nominally plane-parallel plates, of which one surface is very flat, and the other surface is corrected to provide good transmitted wavefront quality. The

flat surface of the oil-on plate is index matched to the sample under test using an index matching oil with the same index of refraction as the material being tested. The index matching oil serves the dual function of “wetting” the ground surface of the sample to make it transparent, and “filling” the voids in the sample surface.

First, a reference measurement is taken of the cavity consisting of the transmission flat, reference flat, and both oil-on plates oiled together; this measurement is stored as a system error file. The sample is then inserted in the cavity, using the index matching oil between the sample and the plates, and a second measurement is made. The reference measurement is then subtracted from the second measurement to provide corrected data on the sample only.



## Homogeneity RMS

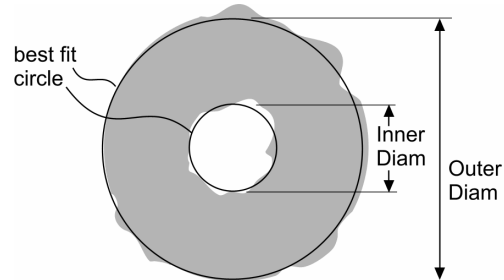
The root-mean-square deviation of all points from a plane fit to the test part surface.

## Htp

Height between two points on the profile bearing ratio curve as specified by the Upper tp (%) and Lower tp (%) control settings.

## Inner Diam

The diameter of a best fit circle to the points surrounding a no data area within the center of the data set. The result is only valid when there is a no data area within the center of the data set.

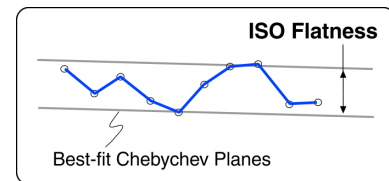


## IRR

Irregularity (IRR) is the tolerance of the surface form error which remains after the sagitta error is removed. It is the PV with respect to the best fit reference sphere. Part of the ISO figure specification (ISO 10110-5).

## ISO Flatness

This is a measure of how much a surface deviates from perfectly flat. It is the distance between two parallel planes obtained by applying a Chebychev fit to the surface data. The Chebychev fit is a mathematical technique that effectively uses two parallel planes to “squeeze” the surface data points from both inside and outside, adjusting the angle to minimize the distance between the planes.



## L (Prof Len Size)

The profile length size or horizontal evaluation length is the total horizontal distance between point centers of valid adjacent points starting from the left most valid point and moving horizontally toward the right most valid point in a profile plot. For linear type slices, the Linear Interpolate Slice control must be On or the result is blank. This result is available in a Surface/Wavefront Profile window.

## Last Reading

Displays the position of the z-axis stage when one of the following buttons has been clicked: Home, Read, Reset, Track, Set Pos X, or Goto Pos X.

This result is available in the Micro LYNX window; and works only with applicable hardware.

## Length/Circum

Length/Circum is the dimension of the slice drawn on a Filled plot. For a linear slice, Length is the distance from one end point to the other. For a circular slice, Circum is the circumference of the circle. The Length/Circum result is inappropriate if there is not a slice drawn on a Filled plot. For units other than pixels the instrument must be calibrated.

## Limits

Indicates if any result has exceeded a user-set limit. Use the attribute's menu Display As command to change the output from Pass/Fail to Accept/Reject. Copy this box to the Video Monitor window to display it on the video monitor screen. Attribute only.

## Limits Status

Displays the status of results with user set limits. Indicates Pass or Fail. If there are one or more results out of range, Fail is displayed. Attribute only.

## Lo (Prof Len Actual)

The profile length actual or actual profile length is the distances between point centers over the entire length of the profile contour. Point distance is only determined when there exist two valid adjacent points. For linear type slices, the Linear Interpolate Slice control must be On or the result is blank. This result is available in a Surface/Wavefront Profile window.

Lo is calculated as the square root of the square of dx (difference in lateral distance between the current valid point the adjacent valid point) plus the square of dz (difference in height between the current valid point the adjacent valid point) over the entire profile. In short, Lo is the total point distance of the profile starting from the left most valid point and ending at the right most valid point as you move along the line that makes up the profile.

## Lo Clip Height

The height at which low clipping is performed. All points below the low clip height are removed from the data set. The result is calculated at the time clipping is performed within the data processing sequence. If no clipping is performed the result is blank.

## Log Dir

This attribute displays the directory path in which the report file was written. It is useful in that it shows the actual directory path when the Log Dir control contains special codes. If Log Dir is displayed, it will also be written to the report file. Attribute only.

## Log File

This attribute now displays up to 80 columns in width. It is useful in showing the actual log file name when the Log File control contains special codes. If the Log File attribute is displayed, it will also be written to the report file. Attribute only.

## Lower Stp Height

The height of the areal bearing ratio curve where it intersects the percentage specified by the Lower Stp (%) control, relative to the selected Stp Reference location.

## Lower Stp (%)

The areal bearing ratio (expressed as a percentage) at the location specified by the Lower Stp Height control, relative to the selected Stp Reference location.

## Lower tp Height

The height of the profile bearing ratio curve where it intersects the percentage specified by the Lower tp (%) control, relative to the selected tp Reference location.

## Lower tp (%)

The profile bearing ratio (expressed as a percentage) at the location specified by the Lower tp Height control, relative to the selected tp Reference location.

## Lr (Prof Len Ratio)

The profile length ratio or actual profile ratio is the profile length normalized by the evaluation length, or the ratio of the Lo to L. Lr indicates crispness or sharpness of the surface profile. The greater the contrast in roughness between points, the higher Lr will get. For a relatively smooth profile, Lr is slightly greater than 1. For linear type slices, the Linear Interpolate Slice control must be On or the result is blank. This result is available in a Surface/Wavefront Profile window.

## Mean

This is an average of all the data points.



## Mean Min Encl Rect Maj Dim

The mean length of a part analyzed along the direction of the Major Dimension in the Minimum Enclosing Rectangle. The mean length is derived by placing slices inside the Minimum Enclosing Rectangle with the same angle as the Major Dimensions and finding the distance from the first valid point to the last valid point for each slice and then calculating the average. This is available in a data window with the New Results → Min Encl Rect menu.

## Mean Min Encl Rect Min Dim

The mean length of a part analyzed along the direction of the Minor Dimension in the Minimum Enclosing Rectangle. The mean length is derived by placing slices inside the Minimum Enclosing Rectangle with the same angle as the Minor Dimensions and finding the distance from the first valid point to the last valid point for each slice and then calculating the average. This is available in a Surface/Wavefront Test/Default data window with the New Results → Min Encl Rect menu.

## Mean Htp

The average of all the height values between the two points on the profile bearing ratio curve specified by the Upper tp (%) and Lower tp (%) controls.

## Mean SHtp

The average of all the height values between the two points on the areal bearing ratio curve specified by the Upper Stp (%) and Lower Stp (%) controls.

## Mean Size X

This is the mean dimension of the data set in the x-axis of the video monitor screen. This result is the average width based on every row of data in the data set. In the Test & Reference window, it applies only to the dimension in the test mask area.



For this result to be accurate, calibration is required whenever a new objective is installed on a microscope. Calibration is also required on an interferometer whenever a zoom setting is changed.

## Mean Size X (All)

This is the mean dimension of the data set in the x-axis of the video monitor screen. This is a special case result available only in Test & Reference data windows. Usually in this data window, just the defined test area is used for results; but in this case the result applies to the entire data set, including both the test and reference areas.



For this result to be accurate, calibration is required whenever a new objective is installed on a microscope. Calibration is also required on an interferometer whenever a zoom setting is changed.

## Mean Size Y

This is the mean dimension of the data set in the y-axis of the video monitor. This result is the average height based on every column of data in the data set. In the Test & Reference window, it applies only to the dimension in the test mask area.



For this result to be accurate, calibration is required whenever a new objective is installed on a microscope. Calibration is also required on an interferometer whenever a zoom setting is changed.

## Mean Size Y (All)

This is the mean dimension of the data set in the y-axis of the video monitor screen. This is a special case result available only in Test & Reference data windows. Usually in this data window, just the defined test area is used for results; but in this case the result applies to the entire data set, including both the test and reference areas.



For this result to be accurate, calibration is required whenever a new objective is installed on a microscope. Calibration is also required on an interferometer whenever a zoom setting is changed.

## Measurement

Three Zone Radius Scale Application, Three Flat Application, and Two Sphere Application. Shows what measurement in a multi-measurement sequence is currently displayed on the screen. Attribute only.

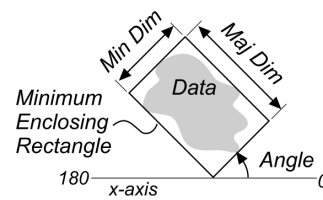
## Measurement Status

Displays the measurement number and total number of measurements during a stitching sequence. Attribute only.

## Min Encl Rect Angle

The angle between the major or long side of the minimum enclosing rectangle and the x-axis.

Minimum Enclosing Rectangle



## Min Encl Rect Ctr X

The X coordinate of the center of the Minimum Enclosing Rectangle relative to the data dimension. This is available in a Surface/Wavefront/Test/Default data window with the New Results → Min Encl Rect menu.

## Min Encl Rect Ctr Y

The Y coordinate of the center of the Minimum Enclosing Rectangle relative to the data dimension. This is available in a Surface/Wavefront/Test/Default data window with the New Results → Min Encl Rect menu.

## Min Encl Rect Maj Dim

The dimension of the minimum enclosing rectangle along the major or longer side of the rectangle. See Min Encl Rect Angle for an illustration.

## Min Encl Rect Min Dim

The dimension of the minimum enclosing rectangle along the minor or shorter side of the rectangle. See Min Encl Rect Angle for an illustration.

## Movie File Name

Displays the data file name for the current frame. Used with dynamic stroboscopic measurements. This control is available in the Control window with the New Attribute → Dynamic → Movie menu. Attribute only.

## Mr1

Material component relative to peaks - The material ratio at which Rpk and Rk meet. It represents the upper limit of the core roughness profile. Part of the Bearing Ratio analysis. See also Rk.

## Mr2

Material component relative to valleys - The material ratio at which Rvk and Rk meet. It represents the lower limit of the core roughness profile. Part of the Bearing Ratio analysis. See also Rk.

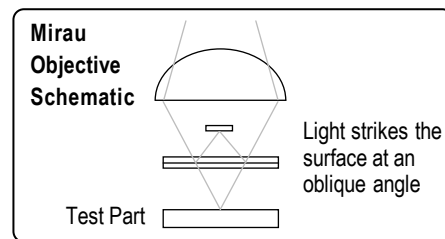
## Objective

Displays what objective was selected for the measurement or indicates the objective chosen with the Objective button at the time of measurement. Attribute only.

## Obliquity Factor

Displays the system calibration factor when using Mirau objectives. MetroPro automatically corrects the height results with an obliquity factor when using Mirau objectives. The Obliquity Factor Attribute box lets you see the scale factor that was used. Fizeau objectives do not require a correction factor because they illuminate normal to the surface. Attribute only.

When using Mirau objectives the test part is illuminated with light oblique (not perpendicular) to the surface. Surface heights measured this way must be multiplied by an appropriate Obliquity Factor to give true surface height. The magnitude of the obliquity factor is a function of the microscope objective numerical aperture and the intensity distribution of the illumination across the pupil of the microscope objective.



The relationship between fringe spacing and the optical path difference when using a Mirau objective is:  $1 \text{ fringe spacing} = \lambda/2 [1/\cos(\alpha)]$  Where the term  $1/\cos(\alpha)$  is the obliquity factor.

## Outer Diam

The diameter of a best fit circle to the outer points of the data set. See also Inner Diam.

## Part f-number

Displays the f-number entered for the test part. Attribute only.

## Part NA

Displays the numerical aperture of the test part. Attribute only.

## Part Radius

Displays the nominal radius value of the test part. Attribute only.

## Pattern Col

Displays the column number position of the current running pattern. Attribute only.

## Pattern Coords

Displays the current coordinates of a motorized programmable stage. Attribute only.

## Pattern Failed (%)

Displays the percentage of the pattern locations that fail a user set limit on a result.

## Pattern Passed (%)

Displays the percentage of the pattern locations that pass a user set limit on a result.

## Pattern Position

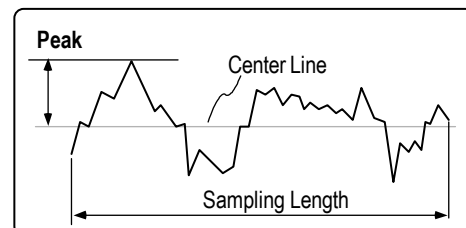
Displays the current ordinal number occupied by a motorized programmable stage in an ordered sequence. Attribute only.

## Pattern Row

Displays the row number position of the current running pattern. Attribute only.

## Peak

Peak is the maximum distance between the center line and the highest peak point within the sample. The center line is defined as the best fit surface selected with the Remove Control box. Peak is the value of the highest data point. It is also known as Rp.



## Peak (All)

Peak (All) is available only in Test+Reference data windows. It is the highest point in both the test and reference areas. Test and reference areas are defined with the Mask Editor.

## Peak (Ref)

Peak (Ref) is available only in Test+Reference data windows. It is the highest point in the area defined by the Reference mask.

## Peak (Test)

Peak (Test) is available only in Test+Reference data windows. It is the highest point in the area defined by the Test mask.

## Peak Loc X

The x-axis location in camera coordinates of the highest point in a profile. For Profile data only.

## Peak Loc Y

The y-axis location in camera coordinates of the highest point in a profile. For Profile data only.

## Points

Displays the number of valid data points in a particular data set. Also known as pixels, or the number of camera pixels used in the measurement and/or analysis. The number of data points can vary due to the use of masks, data dropout, and the instrument components.

## Points (All)

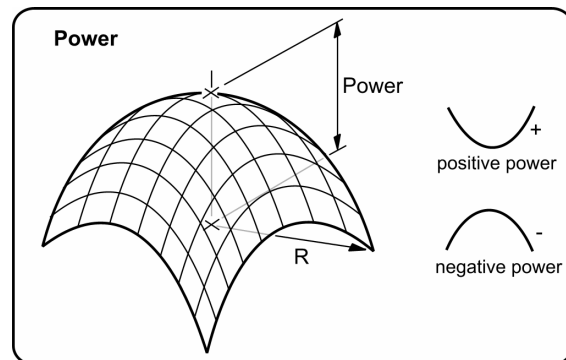
Points (All) is available only in Test+Reference data windows. It is the number of valid data points or pixels in the area defined by the Reference mask and Test mask.

## Points (Test)

Points (Test) is available only in Test+Reference data windows. It is the number of valid data points or pixels in the area defined by the Test mask.

## Power

A measure of the curvature of the surface or wavefront without distinguishing between the X and Y dimensions. It is equivalent to the height difference between the center point and the point farthest from the center. The Power result is derived from a best fit spherical surface (see equation). Power is positive for a concave surface and negative for a convex surface.



The equations used to calculate Power are:

$$Z(X, Y) = C_0 + C_1X + C_2Y + C_3(X^2 + Y^2)$$

$$\text{Power} = C_3R^2$$

Where  $C_x$  are coefficients derived by fitting the surface, and  $R$  is the radius or the distance between the center point and the point farthest from the center.

## Power Error

The null error value based on Power, for the catseye wavefront of a radius of curvature measurement.

## Pts in PV Spec (%)

Percentage of Points within the Peak-to-Valley specification is the percentage of valid data points within a user specified high limit for the PV result. It is linked to the PV result and displays a percentage result only if a high limit is set on the PV result. When a percentage is displayed, it represents the percentage of data points within the set limit.

## Pts in PV Spec (All) (%)

Pts in PV Spec (All) (%) is available only in Test+Reference data windows. It is the percentage of valid data points within a user specified high limit for the PV (All) result; it applies to both the reference and test areas. The test and reference areas are defined with the Mask Editor. It is linked to the PV (All) result and displays a percentage only if a high limit is set on the PV result. It represents the percentage of data points within the set limit.

## Pts in PV Spec (Ref) (%)

Pts in PV Spec (Ref) (%) is available only in Test+Reference data windows. It is the percentage of valid data points within a user specified high limit for the PV (Ref) result; it applies to the area defined by the Reference mask. It is linked to the PV (Ref) result and displays a percentage only if a high limit is set on the PV result. It represents the percentage of data points within the set limit.

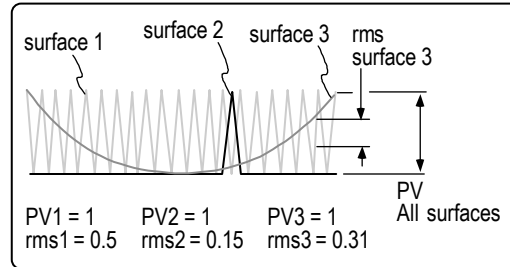
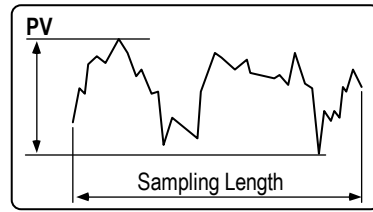
## Pts in PV Spec (Test) (%)

Pts in PV Spec (Test) (%) is available only in Test+Reference data windows. It is the percentage of valid data points within a user specified high limit for the PV (Test) result; it applies to the area defined by the Test mask. It is linked to the PV (Test) result and displays a percentage only if a high limit is set on the PV result. It represents the percentage of data points within the set limit.

## PV

PV (Peak-to-Valley) is the distance between the highest and lowest points within the sample. PV is also known as  $R_t$ .

When used to quantify roughness, PV is the maximum roughness height. PV is the worst case point-to-point error in the data set. PV compares the two most extreme points on the surface; thus, it is possible for two very different surfaces to have the same PV value. This figure illustrates that different surfaces can have the same PV; three surfaces are superimposed over the top of each other.



When a high limit is set in the PV result, it has a special display function with Filled, Oblique, and 3D plots in the same data window. When the set high limit is exceeded, red areas are displayed in the plots.

## PV (All)

PV (All) is available only in Test+Reference data windows. It is the greatest distance between the highest and lowest points in with both the test and reference areas. The test and reference areas are defined with the Mask Editor.

## PV (Ref)

PV (Ref) is available only in Test+Reference data windows. It refers to the distance between the highest and lowest points within the area defined by the Reference mask.

## PV (Test)

PV (Test) is available only in Test+Reference data windows. It refers to the distance between the highest and lowest points within the area defined by the Test mask.

## Pwr X

Pwr X or Power X, is a measure of the curvature of the surface or wavefront in the x-axis. Used when measuring cylindrical surfaces to indicate the amount of power in the measurement, regardless of the setting of the Remove control. Instrument calibration is required. The equations used are:

$$Z(X, Y) = C_0 + C_1X + C_2Y + C_3X^2 + C_4Y^2 + C_5XY$$

$$\text{Pwr X} = C_3X^2$$

Where:  $C_x$  are coefficients derived by fitting the surface.



## Pwr Y

Pwr Y or Power Y, is a measure of the curvature of the surface or wavefront in the y-axis. Used when measuring cylindrical surfaces to indicate the amount of power in the measurement, regardless of the setting of the Remove control. Instrument calibration is required. The equations used are:

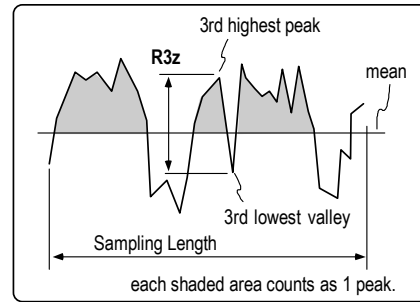
$$Z(X, Y) = C_0 + C_1X + C_2Y + C_3X^2 + C_4Y^2 + C_5XY$$

$$Pwr Y = C_4Y^2$$

Where: Cx are coefficients derived by fitting the surface.

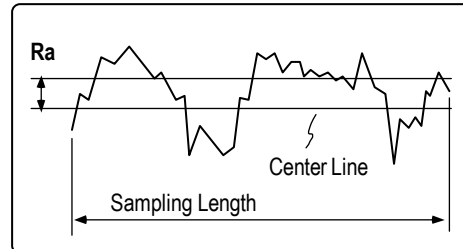
## R3z

R3z is the distance between the third highest peak and the third lowest valley within the sampling length. For profile data, a peak is defined as the portion of a surface above the mean line and between center line crossings. For map data, a peak is defined as any island of data protruding up through a plane at the mean of the data. If there are not enough peaks in the data to calculate R3z, the result is blank.



## Ra

Ra is the arithmetic average deviation from the center line. The centerline is defined as the best fit surface selected with the Remove control. Since Ra is a roughness parameter, surface figure should be removed from the data with the Remove control for this result to be meaningful.



$$Ra = \frac{y_1 + y_2 + y_3 \dots + y_N}{N}$$

Where  $y_x$  is the absolute value of each point and N is the number of discrete elements.

## Ra (Ref)

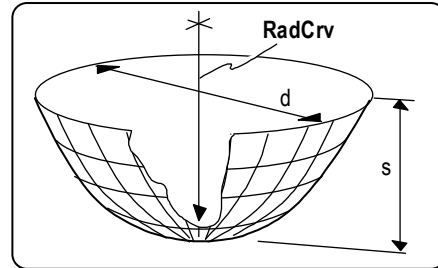
Ra (Ref) is available only in Test+Reference data windows. It is the arithmetic average deviation of all data points from the shape fit to the area defined by the Reference mask.

## Ra (Test)

Ra (Test) is available only in Test+Reference data windows. It is the arithmetic average deviation of all data points from the shape fit to the area defined as the Test mask referenced to the shape fit to the reference area.

## RadCrv

RadCrv (Radius of Curvature) is the distance from the part being measured to the center of the curvature of the surface. Radius of curvature is for a sphere. It is typically represented in millimeters or inches. A positive value corresponds to a convex surface or wavefront; a negative value corresponds to a concave surface or wavefront.



$$\text{RadCrv} = (D / 2)^2 / 2S \quad \text{Where } d \text{ is the diameter and } s \text{ is the sag.}$$

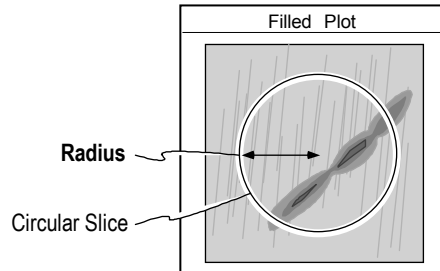
The instrument must be calibrated for this result to be accurate. Objectives supplied with an original microscope system are factory calibrated; calibration is required when other objectives are used. For interferometers, calibration is required every time the zoom setting is changed.

## RadCrv X

RadCrv X is a measure of the radius of curvature of the surface in the x-axis. For additional information refer to RadCrv.

## Radius

Radius is the length from the center of a circular slice to its circumference. The Radius result is inappropriate, unless there is a circular slice drawn on a Filled plot.



The instrument must be calibrated for this result to be accurate. Objectives supplied with an original microscope system are factory calibrated; calibration is required when other objectives are used. For interferometers, calibration is required every time the zoom setting is changed.

## Radius of Curvature (Focus)

The measured radius of curvature using FocMag (Z) to determine null error.

## Radius of Curvature (Power)

The measured radius of curvature using Power to determine null error.

## Ref MTF 0 deg

The modulation value at 0 degrees, at the frequency specified with the Ref Freq control. Part of the modulation transfer function analysis.

## Ref MTF 45 deg

The modulation value at 45 degrees, at the frequency specified with the Ref Freq control. Part of the modulation transfer function analysis.

## Ref MTF -45 deg

The modulation value at -45 degrees, at the frequency specified with the Ref Freq control. Part of the modulation transfer function analysis.

## Ref MTF 90 deg

The modulation value at 90 degrees, at the frequency specified with the Ref Freq control. Part of the modulation transfer function analysis.

## Ref MTF Mean

The average modulation value of the MTF values at 0, 45, 0, and -45 degrees, at the frequency specified with the Ref Freq control. Part of the modulation transfer function analysis.

## Ref Piston

The piston value of the reference region obtained by calculating a best-fit plane.

## Removed

Displays the shape(s) or surface(s) removed with the Remove control at the time of the measurement or analysis. The Removed attribute varies per instrument, though the function is identical.

## Ring/Spot Mode

This attribute indicates the light source used when the measurement was made. For additional information see Ring/Spot Mode button in Section 3.

## Rk

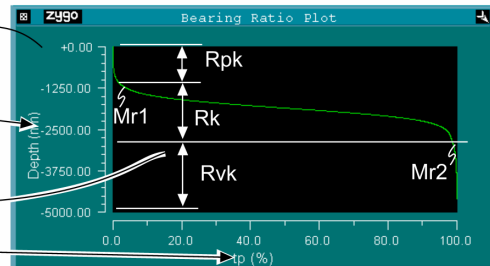
Core roughness depth. The long term running surface which influences the performance and life of the bearing. Part of the Bearing Ratio analysis.

The Bearing Ratio Plot displays the bearing ratio at a range of depths for the entire surface.

Depth from the highest peak (y-axis)

These results are labeled to illustrate the concepts; they do not appear in the plot.

tp or Bearing Ratio (x-axis)



## Rk Midpoint

The midpoint of the Rk region, it is an absolute height. Part of the Bearing Ratio analysis. See also Rk.

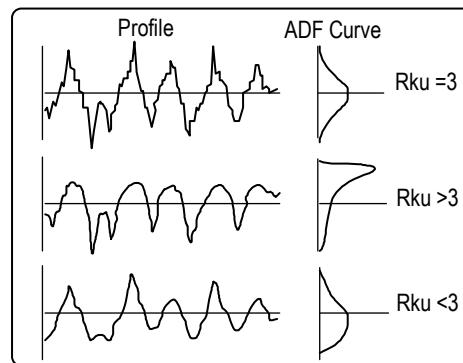
## Rku

Rku or Kurtosis is the measure of the sharpness of the ADF (Amplitude Density Function) curve and of the "spikiness" of a surface. Spikiness does not necessarily mean the sharpness of individual peaks and valleys. The sharper the ADF curve, the greater the value. Kurtosis values can range from 0 to 8.

$$Rku = \frac{1}{n(R_q)^4} \sum_{i=1}^{i=n} (Y_i)^4$$

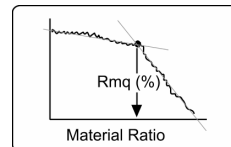
Where n is the number of elements  $Y_i$  in the profile and  $R_q$  is the root-mean-square roughness.

Kurtosis is also a measure of the randomness of profile heights: a perfectly random surface has a kurtosis of 3; the less random and more repetitive the surface, the further the kurtosis value is from 3. Kurtosis is sometimes specified for the control of stress fracture.



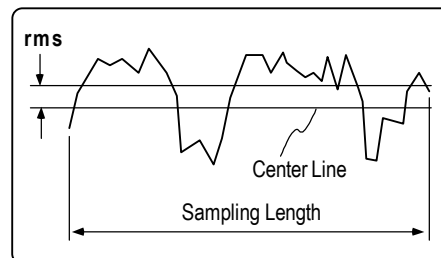
## Rmq (%)

Material ratio (expressed as a percentage) at the plateau to valley transition.



## rms

Root-Mean-Square or rms is the root-mean-square deviation from the center line. This is a method of calculating an average by squaring each value and then taking the square root of the mean. The center line is defined as the best fit surface selected with the Remove control. It is also known as  $R_q$ .



$$rms = \left( \frac{y_1^2 + y_2^2 + y_3^2 \dots + y_N^2}{N} \right)^{1/2}$$

Where:  $Y_x$  are the height elements along the profile and N is the number of discrete elements.

The rms result is calculated as the standard deviation of the height (or depth) of the test surface relative to the reference at all data points in the data set. Since rms is a roughness parameter, surface figure should be removed from the data with the Remove control for this result to be meaningful.

The rms result is the root-mean-square of surface figure error or transmitted error relative to a reference surface. The rms result is an area weighted statistic; when used for optical components, it more accurately depicts the optical performance of the surface being measured than the PV statistic because it uses all the data in the calculation.

## rms (Ref)

rms (Ref) is available only in Test+Reference data windows. It is the root mean-square deviation of all data points from the shape fit to the area defined by the Reference mask.

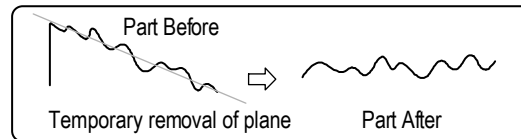
## rms (Test)

rms (Test) is available only in Test+Reference data windows. It is the root mean-square deviation of all data points from the area defined as the Test mask referenced to the shape fit to the reference area.

## rms Cyl Residual

rms Cyl Residual (root-mean-square Cylinder Residual) is the residual rms of the test part after cylinder is removed. This result provides a variation of the

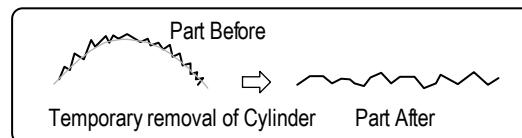
rms result without changing the Remove control. It is the rms of the test part that is left once the designated surface is removed. The rms Cyl Residual result should match the rms result if cylinder is already removed with the Remove control.



## rms Pln Residual

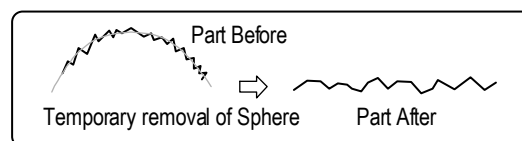
rms Pln Residual (root-mean-square Plane Residual) is the residual rms of the test part after Plane is removed. This result provides a variation of the rms result without

changing the Remove control. It's the rms of the test part that is left once the designated surface is removed. The rms Pln Residual result should match the rms result if plane is already removed with the Remove control.



## rms Sph Residual

rms Sph Residual (root-mean-square Sphere Residual) is the residual rms of the test part after Sphere is removed. This result provides a variation of the rms result



without changing the Remove control. It's the rms of the test part that is left once the designated surface is removed. The rms Sph Residual result should match the rms result if sphere is already removed with the Remove control.

## RMSa

Residual rms from the best fit AAS (Approximating Aspheric Surface) after best fit plane and sphere are subtracted. A version of rms error. Part of the ISO figure specification (ISO 10110-5).

## RMSi

Residual rms from the best fit sphere after best fit plane is subtracted. A version of RMS error. Part of the ISO figure specification (ISO 10110-5).

## RMSt

Residual rms from the best fit plane. A version of RMS error. Part of the ISO figure specification (ISO 10110-5).

## Roundness

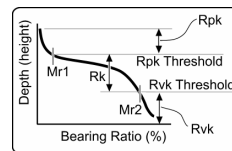
See *Section 8*, "Other Plots", for information on the Roundness Polar and Chart plots.

## Rpk

Reduced peak height - The top portion of the surface that is worn away during the run-in period. Part of the Bearing Ratio analysis. See also Rk.

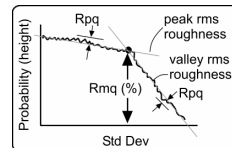
## Rpk Threshold

The threshold between the Rpk and Rk regions, it is an absolute height. Part of the Bearing Ratio analysis. See also Rk.



## Rpq

The root-mean-square average of the height deviations in the peak or plateau portion of the Material Probability plot.



## Rvq

The root-mean-square average of the height deviations in the valley portion of the Material Probability plot. Rvq is useful as a predictor of the surface roughness prior to any secondary material removal process.

## Rvk Threshold

The threshold between the Rk and Rvk regions; it is an absolute height.

## RSI

Rotationally Symmetric Irregularity (RSI) is the tolerance on the rotationally symmetric component of the surface form error after the best fit sphere is subtracted. It is the PV of the Approximating Aspheric Surface (AAS). Part of the ISO figure specification (ISO 10110-5).

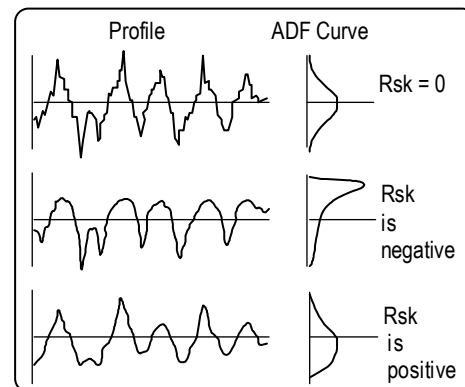
## Rsk

Rsk or skewness is a measure of the symmetry of the profile about the center line. It will distinguish between asymmetrical profiles of the same Ra and rms.

$$Rsk = \frac{1}{n(R_q)^3} \sum_{i=1}^{i=n} (Y_i)^3$$

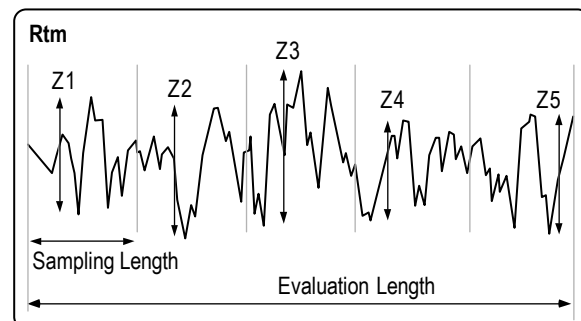
Where n is the number of data points  $Y_i$  in the profile and  $R_q$  is the root-mean-square roughness.

Negative skew, often specified from -1.6 to -2.0, is used as a criterion for a good bearing surface. Positive skew is sometimes specified for electrical contacts.



## Rtm

Rtm is the average peak-to-valley roughness determined by the difference between the highest peak and the lowest valley within multiple samples in the evaluation area. In profile data, as shown here, Rtm is based on 5 sampling lengths within the evaluation length. In map data, Rtm is based on 9



sampling areas within the three dimensional evaluation area.

$$R_{tm} = \frac{(Z_1 + Z_2 \dots Z_n)}{n}$$

Where  $Z_x$  is the difference between the highest peak and lowest valley within one sample and  $n$  is the number of samples (5 or 9).

## Rvk

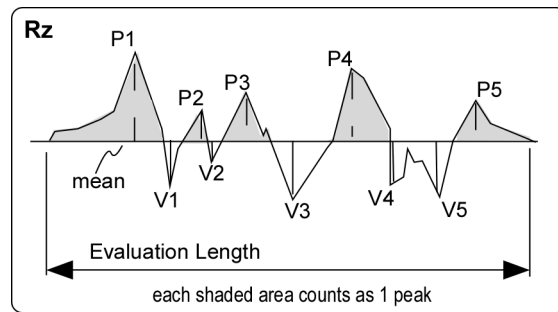
Reduced valley depth - The lowest part of the surface that retains the lubricant. Part of the Bearing Ratio analysis. See also  $R_k$ .

## Rvk Threshold

The threshold between the  $R_k$  and  $Rvk$  regions, it is an absolute height. Part of the Bearing Ratio analysis. See also  $R_k$ .

## Rz

$R_z$  is the average distance between the five highest peaks and the five deepest valleys within the evaluation length measured from a line parallel to the center line.  $R_z$  is also known as the 10 point height parameter.



$$R_z = \frac{(P_1 + P_2 + P_3 + P_4 + P_5) - (V_1 + V_2 + V_3 + V_4 + V_5)}{5}$$

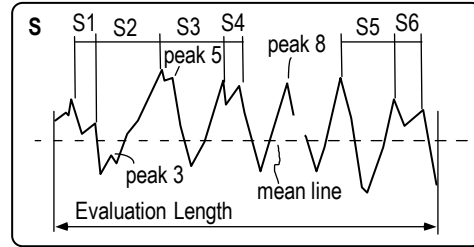
Where:  $P_x$  is the peak distance and  $V_x$  is the valley distance.

For profile data, a peak is defined as the portion of a surface above the mean line and between center line crossings. For map data, a peak is defined as any island of data protruding up through a plane at the mean of the data. The result is blank if there are not enough peaks and valleys in the data to calculate  $R_z$ .



**S**

S is the average spacing between local peaks over the evaluation length. A local peak is the highest point between two adjacent minima. A peak is included only if the vertical distance between the peak and its preceding minima is at least 1% of the Rt (the vertical distance from the highest peak to the lowest valley).



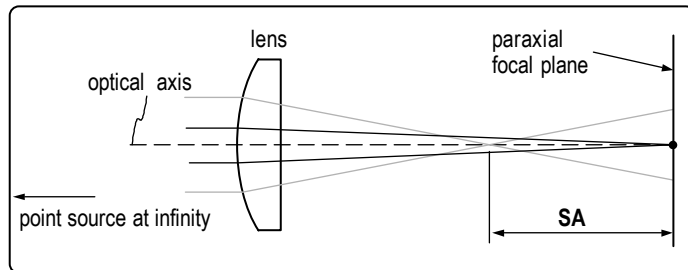
S is calculated by summing the peak spacings (horizontal distances between the adjacent local peaks) and dividing by the number of peak spacings. If there are three or more consecutive bad data points, the peak spacing is not included.

In the example above, S is calculated from six peak spacings. Note that peak 3 and peak 5 are not used in the peak spacing because the vertical distance from their preceding minima are less than 1% Rt. Peak 8 is neglected because of bad data points before its preceding peak. S for the above example is calculated by:

$$S = \frac{S_1 + S_2 + S_3 + S_4 + S_5 + S_6}{6}$$

**SA (Z)**

SA (Z) (Spherical Aberration based on Zernikes) is a third order wavefront aberration; it is the failure of a lens or lens system to form a perfect image of a point source axial object. When rays from a point on the axis passing through the outer



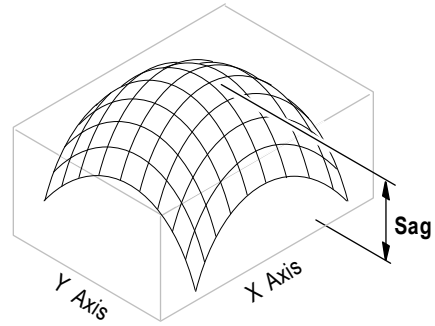
lens zones are focused closer to the lens than rays passing the central zones, the lens has negative spherical aberration; if the outer zones have a longer focal length than the inner zones, the lens has positive spherical aberration.

SA = 6.0(z8)      Where z8 is the 8th Zernike term.

Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display this result.

## Sag

Sag is a measure of the curvature of the surface or wavefront without distinguishing between the X and Y dimensions. It is equivalent to the height difference between the center point and the point farthest from the center. The Sag result is derived from a best fit cylindrical surface.



The equations used are:

$$Z(X, Y) = C0 + (C1 \times X) + (C2 \times Y) + (C3 \times X \times Y) + (C4 \times X^2) + (C5 \times Y^2)$$

$$\text{Sag} = -\frac{(C4 + C5)}{2} \times R^2$$

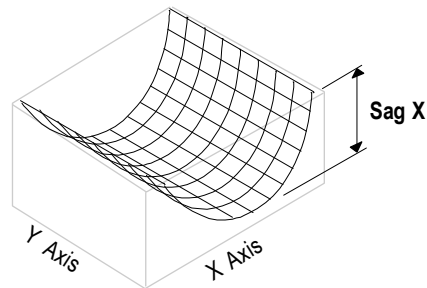
Where: Cx are coefficients derived by fitting the surface, and R is the radius or the distance between the center point and the point farthest from the center.

Sag is negative for a concave surface and positive for a convex surface. The Sag result is intended for measuring circular regions (normally optical components). It may also be used to measure square regions. The Sag result is incorrect when measuring regions of other outlines. Sag is not very meaningful for a surface of arbitrary outline or orientation.

Sagitta error (SAG) is the tolerance on the power or focus of the surface with respect to a reference sphere with the nominal radius of curvature. Part of the ISO figure specification (ISO 10110-5).

## Sag X

Sag X is a measure of the curvature of the surface or wavefront in the X dimension only. The Sag X result is derived from a best fit cylindrical surface. Sag X is negative for a concave surface and positive for a convex surface.



The equations used are:

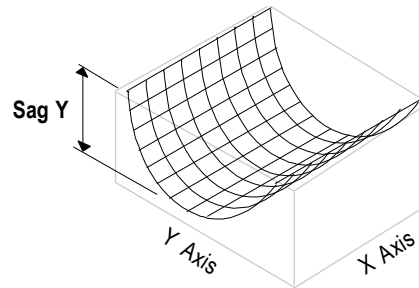
$$Z(X, Y) = C0 + (C1 \times X) + (C2 \times Y) + (C3 \times X \times Y) + (C4 \times X^2) + (C5 \times Y^2)$$

$$\text{Sag X} = -C4 \times R^2$$

Where: Cx are coefficients derived by fitting the surface, and R is the radius of the region in the X dimension (it is not the same R used for Sag).

## Sag Y

Sag Y is a measure of the curvature of the surface or wavefront in the Y dimension only. The Sag Y result is derived from a best fit cylindrical surface. Sag Y is negative for a concave surface and positive for a convex surface.



The equations used are:

$$Z(X, Y) = C0 + (C1 \times X) + (C2 \times Y) + (C3 \times X \times Y) + (C4 \times X^2) + (C5 \times Y^2)$$

$$\text{Sag Y} = -C5 \times R^2$$

Where:  $C_x$  are coefficients derived by fitting the surface, and  $R$  is the radius of the region in the Y dimension (it is not the same  $R$  used for Sag).

## Scale Range

This attribute displays the setting of the Scale Range control, which is either Off or 1023.

## Scan

Displays the length and type of scan used during the measurement. Applies only to a scanning microscope. Attribute only.

## Scan Focus Camera Res

Displays the effective pixel spacing of data obtained during a scanning auto focus or tilt operation. Attribute only.

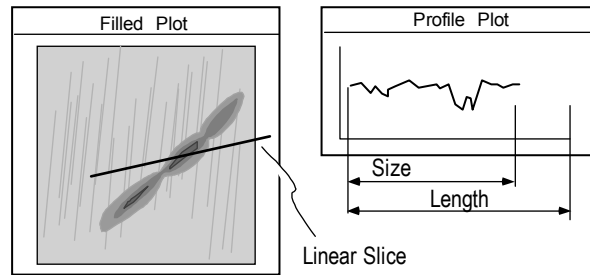
## SHtp

Height between two points on the areal bearing ratio curve as specified by the Upper Stp (%) and Lower Stp (%) control settings

## Size

Size is the extent or length of the valid data points of a linear slice. The Size result is similar to Length, however, Length is the dimension of the slice, which can be larger than the dimension of the actual data.

Size is applicable to only profile data



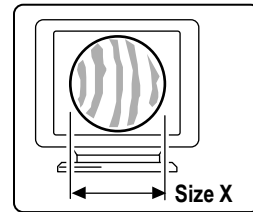
For rectangular windows, it should not be confused with Size X and Size Y, which are applicable to map data windows and have nothing to do with slicing. The Size result is inappropriate, unless there is a linear slice drawn on a Filled plot. If you ask for the Size of a circular slice, the result is blank.

The instrument must be calibrated for this result to be accurate. Objectives supplied with an original microscope system are factory calibrated; calibration is required when other objectives are used. For interferometers, calibration is required every time the zoom setting is changed.

## Size X

Size X is the dimension of the data set in the x-axis of the Video Monitor screen.

The instrument must be calibrated for this result to be accurate. Objectives supplied with an original microscope system are factory calibrated; calibration is required when other objectives are used. For interferometers, calibration is required every time the zoom setting is changed.



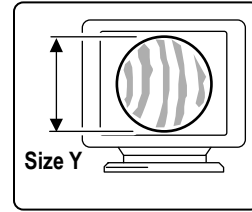
## Size X (All)

Size X (All) is a special case result available only in Test+Reference data windows. Usually in this data window, just the defined test area is used for results; but in this case, the result applies to the whole data set, both to the test and reference areas. In the Test+Reference data window, Size X (without All) applies to only the test area. The test and reference areas are defined with the Mask Editor.

## Size Y

Size Y is the dimension of the data set in the y-axis of the Video Monitor screen.

The instrument must be calibrated for this result to be accurate. Objectives supplied with an original microscope system are factory calibrated; calibration is required when other objectives are used. For interferometers, calibration is required every time the zoom setting is changed.

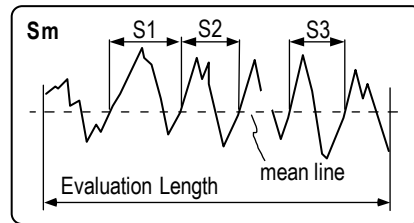


## Size Y (All)

Size Y (All) is a special case result available only in Test+Reference data windows. Usually in this data window, just the defined test area is used for results; but in this case, the result applies to the whole data set, both to the test and reference areas. In the Test+Reference data window, Size Y (without All) applies to only the test area. The test and reference areas are defined with the Mask Editor.

## Sm

Sm is the average spacing between peaks at the mean line over the evaluation length. A peak is the highest point between an upwards and downwards crossing of a mean line. Sm is calculated by summing the peak spacings (horizontal distances between the upward mean crossings) and dividing by the number of peak spacings. If there are two or more consecutive bad data points before the downward mean line crossing, the peak spacing is not included.



In the example here, Sm is calculated from three peak spacings. The first and last peaks are not included because they don't include complete mean line crossings; the fourth peak is not included because it has missing data points. Sm for the above example is calculated by:

$$S_m = \frac{S_1 + S_2 + S_3}{6}$$

## Spherical Distortion Correction

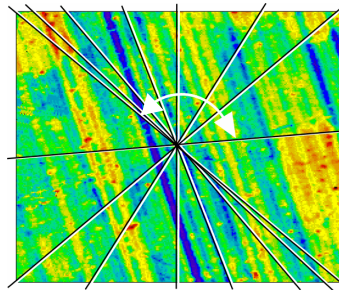
GPI Application. Identifies whether spherical distortion correction was turned on or off. Attribute only.

## Sphere Radius

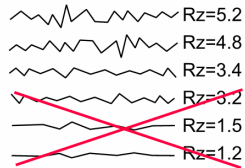
Displays the value of the radius of the sphere that was removed. A convex surface has a positive radius. A concave surface has a negative radius. Attribute only.

## SRz

This result is an average of the largest half of many Rz results. The data is sliced in a pinwheel fashion through 360 degrees. The Rz results are sorted by magnitude, and SRz is calculated by averaging the largest 50% of the values. A line-generation algorithm is used to determine the actual pixel-to-pixel path of each slice. SRz is based on the entire data set.



The data array is sliced in a radial fashion to generate many Rz results; only the largest half are averaged.

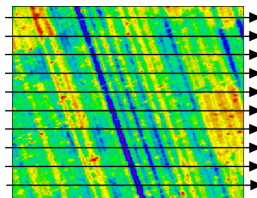


The lines shown are representative of numerous slices through the entire data set. The line does not appear in the data.

SRz expands and improves upon standard Rz analysis by averaging hundreds of radially-generated Rz results. SRz provides measurement results that are representative of the surface regardless of the orientation of the test part. The averaging calculation is independent of lay (or direction) because only the data that are running across the lay are averaged, therefore optimizing gage repeatability and reproducibility (GR&R).

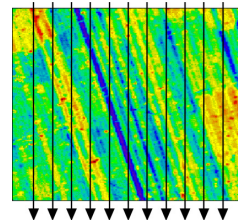
## SRzX

This result is the average of many individual Rz results, which are determined by slicing the data in the X-axis. The individual Rz results are based on a profile slice one pixel wide. SRzX is based on the entire data set. See also SRz.



## SRzY

This result is the average of many individual Rz results, which are determined by slicing the data in the X-axis. The individual Rz results are based on a profile slice one pixel wide. SRzY is based on the entire data set. See also SRz.



## Status Msg

Status Message displays the status of the current analysis process. The Status Msg Attribute box is empty if a measurement has not been taken, or if the analysis is complete. Use the Width command in the item's menu to change the size of the Status Msg. Attribute only.

## Std LPL

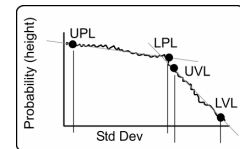
The standard deviation at the lower plateau or peak limit, as located by the software in the Material Probability analysis.

## Std LVL

The standard deviation at the lower valley limit, as located by the software in the Material Probability analysis.

## Std UPL

The standard deviation at the upper plateau (peak) limit of the Material Probability plot, as defined by the user using the light blue Inspector tool.



## Std UVL

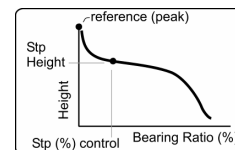
The standard deviation at the upper valley limit, as located by the software in the Material Probability analysis.

## Step Height

Step Height is the height or peak-to-valley measurement of the “current” slice in a corresponding data window Filled plot.

## Stp1 Height

The height of the areal bearing ratio curve where it intersects the percentage specified by the Stp1 (%) control, relative to the selected Stp Reference location.



## Stp2 Height

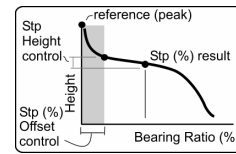
The height of the areal bearing ratio curve where it intersects the percentage specified by the Stp2 (%) control, relative to the selected Stp Reference location.

## Stp3 Height

The height of the areal bearing ratio curve where it intersects the percentage specified by the Stp3 (%) control, relative to the selected Stp Reference location.

## Stp1 (%)

The areal bearing ratio (expressed as a percentage) at the height specified by the Stp1 Height control, relative to the selected Stp Reference location and the Stp1 (%) Offset control value.



## Stp2 (%)

The areal bearing ratio (expressed as a percentage) at the height specified by the Stp2 Height control, relative to the selected Stp Reference location and the Stp2 (%) Offset control value.

## Stp3 (%)

The areal bearing ratio (expressed as a percentage) at the height specified by the Stp3 Height control, relative to the selected Stp Reference location and the Stp3 (%) Offset control value.

## Strehl

Strehl is the ratio of the peak intensity of light in an aberrated point image to the peak intensity of light in an unaberrated point image from an aperture of the same size and shape. It is also known as Strehl Ratio.

## Subtracted

Subtracted is an Attribute box, which displays the setting of the Subtract control when the measurement or analysis was made.

## Surface Filter

Displays the orientation of the MESA Surface Filter knob when the measurement was made. Attribute only.

Obsolete. For backwards compatibility.

## Surface Type

Displays the type of surface the ISO results are based on. Part of the ISO 10110-5 window. Attribute only.

## Sweep

Displays the current state of a measurement sweep as either On or Off. Used with dynamic stroboscopic measurements. This attribute is available in the Control window with the New Attribute → Dynamic → Sweep menu. Attribute only.

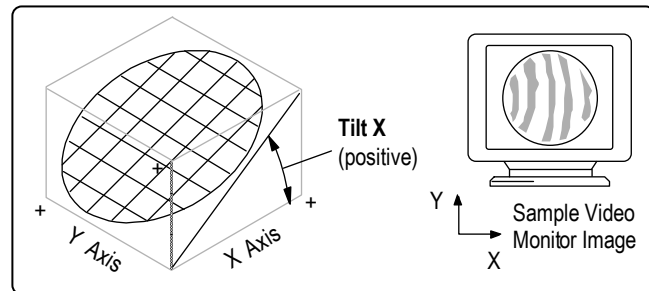


## Sweep Measurement Count

Displays the total number of measurements in the sweep. Used with dynamic stroboscopic measurements. This attribute is available in the Control window with the New Attribute → Dynamic → Sweep menu.

## Tilt X

Tilt X is the tilt of the part relative to the reference surface in the X direction. Instrument calibration is required for this result.



## Tilt X (Ref)

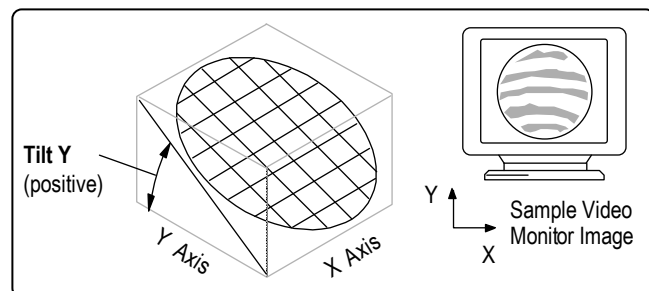
Tilt X (Ref) is the tilt of the part in the X direction of an area defined by a Reference mask. Instrument calibration is required for this result. Used with the Tilt Y (Ref) result as an indicator of instrument null. See Tilt X.

## Tilt X (Tst)

Tilt X (Tst) is the tilt of the part relative to the test surface in the X direction. Instrument calibration is required for this result. See Tilt X.

## Tilt Y

Tilt Y is the tilt of the part relative to the reference surface in the Y direction. Instrument calibration is required for this result.



## Tilt Y (Ref)

Tilt Y (Ref) is the tilt of the part in the Y direction of an area defined by a Reference mask. Instrument calibration is required for this result. See Tilt Y.

## Tilt Y (Tst)

Tilt Y (Tst) is the tilt of the part relative to the test surface in the Y direction. Instrument calibration is required for this result. See Tilt Y.

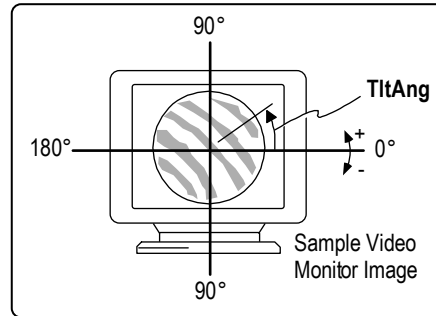
## Time

Displays the date and time of the measurement. The Time Attribute box is empty if a measurement has not yet been taken. When a data file is loaded, the Time box will indicate the date and time of the measurement. Attribute only.

## TltAng

TltAng (Tilt Angle) is the direction of tilt. Visually, this can be seen on the Video Monitor as the direction perpendicular to the fringes. The wavefront is highest at the specified angle. Instrument calibration is required for this result.

$$\text{TltAng} = \text{Tan}^{-1} \left( \frac{\text{Tilt Y}}{\text{Tilt X}} \right)$$



## TltAng (Ref)

TltAng (Ref) (Tilt Angle Reference) is the direction of tilt in an area defined by a Reference mask. Instrument calibration is required for this result. See TltAng.

## TltAng (Z)

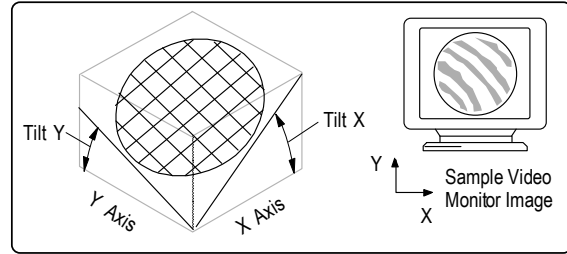
TltAng (Z) (Tilt Angle based on Zernikes) is the direction of tilt. Visually, this can be seen on the Video Monitor as the direction perpendicular to the fringes. TltAng (Z) is typically expressed in degrees and is defined over  $\pm 180^\circ$ . The wavefront is highest at the specified angle. See TltAng.

$$\text{TltAng (Z)} = \arctan \left( \frac{y \text{ tilt}}{x \text{ tilt}} \right) \quad \text{Where: } x \text{ tilt} = z1 - 2.0 (z6) \text{ and } y \text{ tilt} = z2 - 2.0 (z7). \text{ } z6 \text{ and } z7 \text{ are the corresponding Zernike terms.}$$

Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display the result.

## TltMag

Tilt refers to the angle of inclination between the reference and test beams of the interferometer. If measuring a surface, tilt is the angle between the reference and test surface. If measuring a transmitted wavefront, tilt is the angle of the beam deviated by the optic. It can be thought of as lying in the plane of the reference surface, or the Video Monitor.



$$\text{TltMag} = \sqrt{\text{Tilt X}^2 + \text{Tilt Y}^2}$$

Instrument calibration is required for this result.

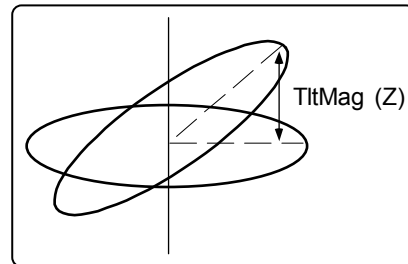
Typically, Tilt X, Tilt Y, TltAng, and TltMag results compare data within a Test mask to data within a Reference mask and determine the relative tilt between these two areas on the same part. When using masks, the reference area becomes a zero point, the tilt of the test area is compared to it. Without using masks, the tilt results provide the relative tilt of the interferometer cavity, or the incline of the test part to the reference surface. (As long as tilt is not removed with the Remove control.)

## TltMag (Ref)

TltAng (Ref) (Tilt Magnitude Reference) is the overall tilt of the part in both x and y axes in an area defined by a Reference mask. Instrument calibration is required for this result. See TltMag.

## TltMag (Z)

TltMag (Z) (Tilt Magnitude based on Zernikes) is the overall tilt of the part in both x and y axes. TltMag (Z) is expressed in height units and is always positive. Tilt refers to the angle of inclination between the reference and test beams of the interferometer. If measuring a surface, tilt is the angle between the reference and test surface. If measuring a transmitted wavefront, tilt is the angle of the beam deviated by the optic.

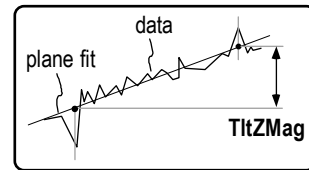


$$\text{TltMag (Z)} = \sqrt{\text{xtilt}^2 + \text{ytilt}^2} \quad \text{Where } \text{xtilt} = z1 - 2.0 (z6) \text{ and } \text{ytilt} = z2 - 2.0 (z7). \text{ } z6 \text{ and } z7 \text{ are the corresponding Zernike terms.}$$

Zernike polynomials are used to calculate Seidel results; at least 9 Zernike terms must be analyzed to display the result.

## TltZMag

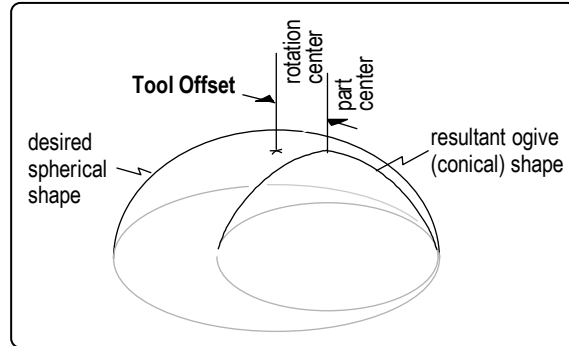
The PV of the plane, fit to the data in the direction of the tilt angle, using the furthest X and Y extent of the data. It is similar to the maximum difference in the Z axis of the data with the noise eliminated. TltZMag is a special case result only available in Test+Reference Data windows; it refers to the whole data set, both the test and reference areas.



## Tool Offset

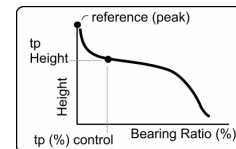
The lateral distance from the physical center of the part to the center of the curve of the arc of the cutting tool, along the horizontal axis of the part. Also known as “ogive”.

Tool Offset is the horizontal decentration, which will actually alter the overall figure of the part. When there is vertical decentration, the tool is denied access to the central region of the spherical part; it does not affect the surface figure significantly. Tool Offset is concerned only with horizontal decentration.



## tp1 Height

The height of the profile bearing ratio curve where it intersects the percentage specified by the tp1 (%) control, relative to the selected tp Reference location.



## tp2 Height

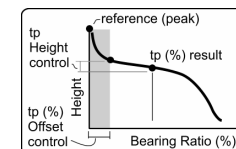
The height of the profile bearing ratio curve where it intersects the percentage specified by the tp2 (%) control, relative to the selected tp Reference location.

## tp3 Height

The height of the profile bearing ratio curve where it intersects the percentage specified by the tp3 (%) control, relative to the selected tp Reference location.

## tp1 (%)

The profile bearing ratio (expressed as a percentage) at the height specified by the tp1 Height control, relative to the selected tp Reference location and the tp1 (%) Offset control value.



**tp2 (%)**

The profile bearing ratio (expressed as a percentage) at the height specified by the tp2 Height control, relative to the selected tp Reference location and the tp2 (%) Offset control value.

**tp3 (%)**

The profile bearing ratio (expressed as a percentage) at the height specified by the tp3 Height control, relative to the selected tp Reference location and the tp3 (%) Offset control value.

**Trimmed**

Displays the number of pixel layers removed from the data set during analysis. The number in the black Trimmed attribute box should match the number in the Trim control, except when saved data sets are loaded or when the Trim value has been changed but the data set not reanalyzed. Attribute only.

**Twist**

The amount that a cylindrical part is not aligned in the x and y axes. It is also called “fan” by opticians because of the characteristic fan-shaped fringes. Used when measuring cylindrical parts. The equations used are:

$$Z(X, Y) = C_0 + C_1X + C_2Y + C_3X^2 + C_4Y^2 + C_5XY$$

$$\text{Twist} = C_5R^2$$

Where Cx are coefficients derived by fitting the surface and R is the radius.

**Upper Stp Height**

The height of the areal bearing ratio curve where it intersects the percentage specified by the Upper Stp (%) control, relative to the selected Stp Reference location.

**Upper Stp (%)**

The areal bearing ratio (expressed as a percentage) at the location specified by the Upper Stp Height control, relative to the selected Stp Reference location.

**Upper tp Height**

The height of the profile bearing ratio curve where it intersects the percentage specified by the Upper tp (%) control, relative to the selected tp Reference location.

**Upper tp (%)**

The profile bearing ratio (expressed as a percentage) at the location specified by the Upper tp Height control, relative to the selected tp Reference location.

## V1

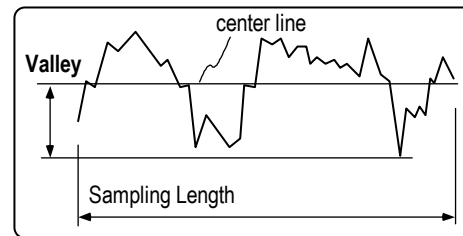
Volume 1 - The volume of material that is removed during the run-in period. V1 is an estimate of the volume of the friable, wearable surface. Part of the Bearing Ratio analysis.

## V2

Volume 2 - The potential volume of retained lubricant. V2 is the estimated lube volume in the surface set by the Mr2 intercept. It is a prediction of the volume of liquid that this surface region can hold. Part of the Bearing Ratio analysis.

## Valley

Valley is the maximum depth between the center line and the lowest valley within the sample. The center line is defined as the best fit surface selected with the Remove Control box. Valley is the value of the lowest data point. It is also known as  $R_v$ .



## Valley (All)

Valley (All) is available only in Phase Test+Reference Data windows. It is the lowest point in the area defined by the both the reference and test areas. The test and reference areas are defined with the Mask Editor.

## Valley (Ref)

Valley (Ref) is available only in Test+Reference data windows. It is the lowest point in the area defined by the Reference mask.

## Valley (Test)

Valley (Test) is available only in Test+Reference data windows. It is the lowest point in the area defined by the Test mask.

## Valley Loc X

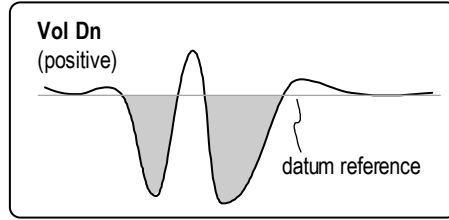
The x-axis location in camera coordinates of the lowest point in a profile. Profile data only.

## Valley Loc Y

The y-axis location in camera coordinates of the lowest point in a profile. Profile data only.

## Vol Dn

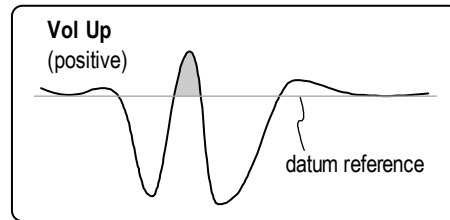
Volume Down is the volume of the test area which is lower than the reference area. Positive Vol Dn can be thought of as the space occupied by pits on the test area; a negative Vol Dn result would protrude above the reference area. See VolNet.



For proper results, Test and Reference masks must be previously defined with the Mask Editor. Instrument calibration is required for this result.

## Vol Up

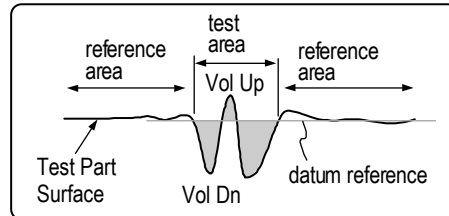
Volume Up is the volume of the test area which is higher than the reference area. Positive Vol Up can be thought of as the space occupied by bumps on the test area; a negative Vol Up result would extend below the reference area. See VolNet.



For proper results, Test and Reference masks must be previously defined with the Mask Editor. Instrument calibration is required for this result.

## VolNet

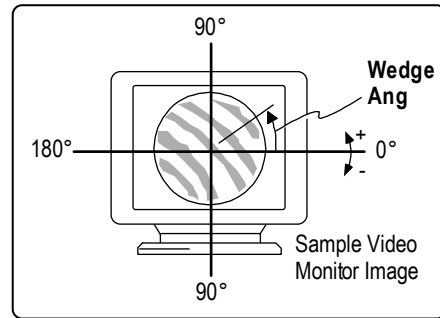
VolNet is the overall volume of the test area. It is equal to the Vol Up minus the Vol Dn. For proper results, Test and Reference masks must be previously defined with the Mask Editor. Instrument calibration is required for this result.



The Vol Up, Vol Dn, and VolNet results require Test and Reference masks to be defined. The reference area defined by the Reference mask establishes a datum reference from which the volume is calculated. The datum reference is derived from a best fit surface to the Reference mask. Volume is the amount of space occupied by the data in the three dimensional test area defined by the Test mask. Volume is calculated by finding the height of each data point multiplied by the area of the pixel.

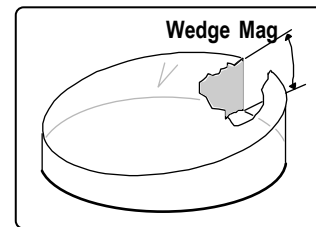
## Wedge Ang

Wedge Ang (Angle) is the direction of the wedge. Visually, this can be seen on the Video Monitor as the direction perpendicular to the fringes. The part is thickest at the specified angle. Wedge Ang is typically expressed in degrees and is defined over  $\pm 180^\circ$ . Instrument calibration and an entry in the Refractive Index control are required for this result. See Wedge Mag.



## Wedge Mag

Wedge Mag (Magnitude) is the overall wedge or non-parallelism in the optic. Wedge Mag is a positive number expressed in angle units (degrees or radians). A wedge optical component is an optical element having plane-inclined surfaces. Usually the angle between the faces are inclined toward one another at a very small angle. Instrument calibration and an entry in the Refractive Index control are required for this result.



Wedge X, Wedge Y, Wedge Ang, and Wedge Mag results require the use of Test, Reference, and Acquisition masks. The Test mask is defined as the fringe area of the part; the Reference mask is defined as the surrounding fringe area of the reference flat; and the Acquisition mask is defined as the areas incorporated by the Test and Reference masks. To derive the wedge results, data within the Test mask is compared to data within the Reference mask.

$$\text{Wedge Mag} = \frac{\text{TiltMag}}{n - 1} \quad \text{Where } n \text{ is the refractive index.}$$

## Wedge X

Wedge X is the wedge in the part in the X direction; it is a component of Wedge Mag. Wedge X is expressed in angle units (degrees or radians) and can be either positive or negative. Instrument calibration and an entry in the Refractive Index control are required for this result.

$$\text{Wedge X} = \frac{\text{Tilt X}}{n - 1} \quad \text{Where } n \text{ is the refractive index.}$$



## Wedge Y

Wedge Y is the wedge in the part in the Y direction; it is a component of Wedge Mag. Wedge Y is expressed in angle units (degrees or radians) and can be either positive or negative. Instrument calibration and an entry in the Refractive Index control are required for this result.

$$\text{Wedge Y} = \frac{\text{Tilt Y}}{n - 1} \quad \text{Where } n \text{ is the refractive index.}$$

## Weighted Centroid X

The location in the x-axis of the center of the data, as based on a weighted average. Calculated using the height of each point (relative to the valley) to weight the coordinates.

## Weighted Centroid Y

The location in the y-axis of the center of the data, as based on a weighted average. Calculated using the height of each point (relative to the valley) to weight the coordinates.

## Within Field Pattern Position

This attribute shows the current within field pattern position in the format “1 of N”. Only applicable to instruments with programmable stages.

## Within Field Pattern Position

Displays a position within a pattern sequence. Attribute only.

## Within Field Pattern X

This attribute shows the current within field pattern X coordinate in millimeters, relative to the origin of the field. Only applicable to instruments with programmable stages.

## Within Field Pattern Y

This attribute shows the current within field pattern Y coordinate in millimeters, relative to the origin of the field. Only applicable to instruments with programmable stages.

## Zernike Sampled

Displays the number selected in the Zernike Sample control during the analysis. Attribute only.



# Special Results

Section

# 10

*MetroPro provides countless results. Specialized result plots, tables, and windows are covered in this section.*

## This Section Includes ...

This section describes various specialized results which are listed in alphabetical order. These results reside in data windows and are created by selecting the New Result (or New Plot) command from the data window's or the Result box's menu. The availability of these results varies depending on the application and data window.

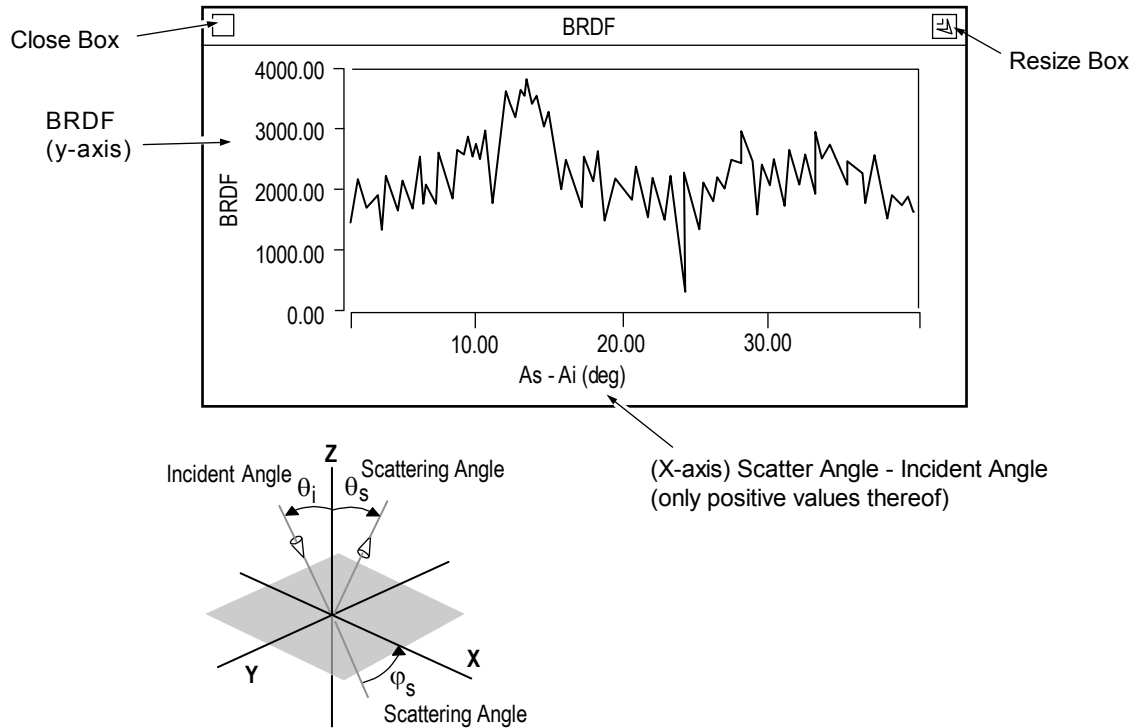
<b>Result</b>	<b>Quick Overview</b>
<i>BRDF</i>	Bidirectional Reflective Scatter Distribution Function is used to describe scattered light patterns.
<i>Control Chart</i>	A two-dimensional display showing the historical record of one result over multiple measurements.
<i>Histogram Plot</i>	A two-dimensional display representing the spread or distribution of data.
<i>ISO 10110-5 Window</i>	Provides results specified by the ISO figure specification.
<i>MTF</i>	Modulation Transfer Function of an optical system indicates the ability of the system to resolve detail as a function of the spatial frequencies present in the object.
<i>Process Stats</i>	Displays statistics about results over multiple measurements.
<i>Profile Stats</i>	Displays various statistics about profile data.
<i>PSF</i>	Point Spread Function is a mathematical representation of the energy distribution in the output of an optic.
<i>Seidel Coefficients</i>	First and third order wavefront aberrations.
<i>Slope Data</i>	Data about the slope of the wavefront.
<i>Spectrum Data</i>	Spatial frequency spectrum data obtained by applying a two-dimensional FFT transform to test/default data.
<i>Tool Offset</i>	The tool decentration or offset of turned spherical parts.
<i>Zernike Polynomials</i>	Wavefront data in polynomial form.

## BRDF

BRDF or Bidirectional Reflective Scatter Distribution Function is used to describe scattered light patterns. It is obtained by applying a two-dimensional FFT transform to the input data. The BRDF calculation is only valid for s-polarized in and s-polarized out. It is used to detect component defects and to analyze polished surfaces.



The numerical FFT on the data is a model of the theoretical BRDF analysis and limits the output to the angle entered in the Scattering Angle control.



The BRDF plot displays the BRDF of a surface on the y-axis and the scattering angle minus the incident angle on the x-axis, and only positive values thereof. BRDF analysis requires entries in the Wavelength, Refractive Index, Incident Angle, and Scattering Angle controls. These controls are summarized in the following table and are created with the data window menu's New Control command.

<i>Control</i>	<i>Function</i>
<i>Wavelength</i>	Specifies the wavelength of the output data. It is used to display results as if the measurement was performed at a wavelength other than the instrument's wavelength.
<i>Refractive Index</i>	Specifies the refractive index of the part being measured.
<i>Incident Angle</i>	Specifies the angle of the incoming light from the z-axis. It is the polar angle of s-polarized in.
<i>Scattering Angle</i>	Specifies the angle ( $\varphi_s$ ) of the outgoing light relative to the plane of incidence; results are calculated based on this angle. It is the polar angle of s-polarized out.

### ***BRDF Reference Material***

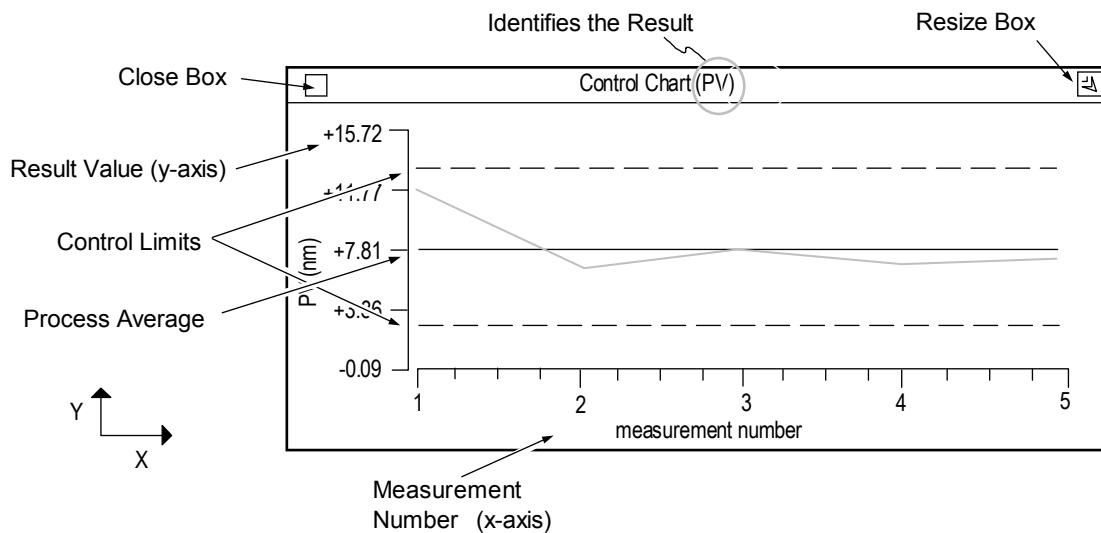
E. L. Church, P. Z. Takacs, and T. A. Leonard, *The Prediction of BRDFs from Surface Profile Measurements* (SPIE Vol. 1165 Scatter from Optical Components, 1989)

## Control Chart

A Control Chart is a two dimensional display showing the historical record of one result over multiple measurements. The horizontal or x-axis represents the number of measurements, while the vertical or y-axis represents the absolute result value. Control Charts are available for all results.

The Control Chart is used to shows the variation of one result over a series of measurements. It can be used to compare one result over multiple measurements on similar parts. The Control Chart is for “display” purposes; its contents cannot be saved. To save or output the results of numerous measurements use the Report window.

Control Charts are available in all data windows where there are results; they are also available in the Process window. It is created using the Result menu’s Plots command.



### Creating a Control Chart

A Control Chart can be made for any displayed result. However, it must reside within the same Data window as the result.

1. Determine which result(s) you want to track. If the result does not exist within the data window use the New Result command to create it.
2. Position the pointer over the result and select the Plots → Control Chart command. An outline of the chart appears.
3. Move the mouse to position the window. Click the left mouse for the Control Chart to appear.



When first created the chart is blank. It is updated as measurements are made or as existing data is loaded.

## Using the Control Chart

The Control Chart is blank until measurements are made. As measurements are completed the chart is automatically updated with measurement data, control limits, and the mean average line. The settings of the controls in the Process window affect the use of the Control Chart.

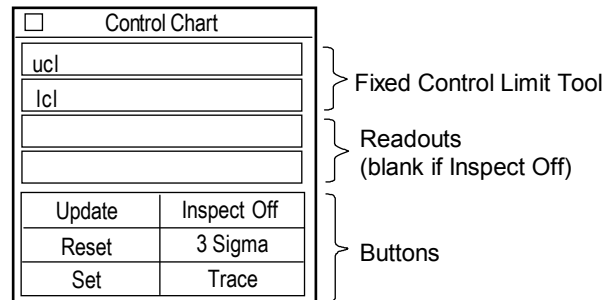
<i>Process Window Control</i>	<i>Function in Control Chart</i>
<i>Window Size</i>	Determines the number of measurements displayed on the chart.
<i>Auto Store</i>	If On, the chart is updated as measurements are made.
<i>Store button</i>	When clicked the existing data is entered into the chart.
<i>Clear button</i>	Erases all data from the chart.
<i>Undo button</i>	Removes the last data entered into the chart.

## Changing the Control Chart

Most changes for the Control Chart are made with the plot Controller. The Control Chart plot Controller generally works similar to the profile plot Controller. To open the plot Controller for the Control Chart, click on the chart with the middle mouse button.

**Plot Controller**  
Access by clicking on the plot with the middle mouse button

*A complete discussion on using the plot Controller is found under Profile Plot.*



**Update** - Redraws the plot to match the current Controller settings.

**Reset** - Restores button settings to match the “set” Controller settings.

**Set** - Makes the current Controller settings the master or “set” display.

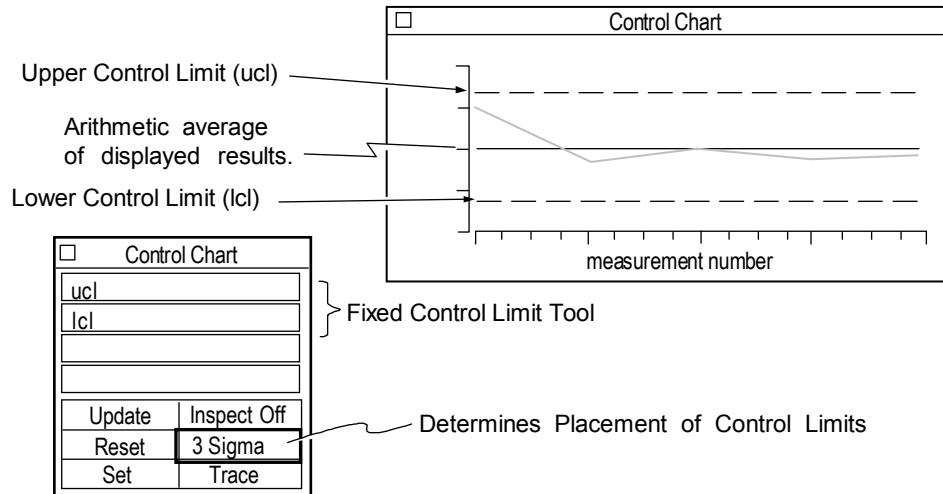
**Inspect** - Turns inspect features on and off. When Inspect Off the readouts and the plot crosshairs are non-functional. For other selections see Section 4.

**Sigma** - Selects the position of control limits. 3 Sigma places the limits at three times the standard deviation. 2 Sigma places the limits at two times the standard deviation. 1 Sigma places control limits at the standard deviation. No CLs removes the limits from the chart.

**Display** - Selects how data is displayed. Trace displays data as a line graph. Bar displays data as a series of vertical bars. Scatter displays data as points.

## Working With Automatic Control Limits

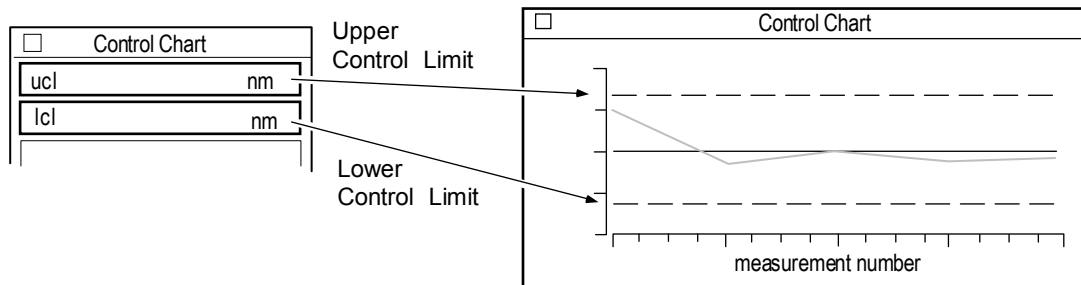
In the default mode, the control limits are automatically calculated based on the displayed results and the setting of the Sigma button. Control limits provide a guide to analysis. They are not specification limits, but are reflections of the natural variability.



1. Click the Sigma button with the left mouse button to select the placement of the limits.
2. Click the plot Controller's Update button to redraw the chart.

## Working With Fixed Control Limits

Control limits may also be turned into specification limits if the Fixed Control Limit Tool is used. If the Fixed Control Limit Tool is used, limits do not change every time a measurement is made and the setting of the Sigma button is ignored.



1. Position the pointer over one of the two boxes in the Fixed Control Limit Tool.
2. Click the left mouse button, enter a numeric value and press [Enter]. To erase values, click the left mouse button, delete all characters, then press [Enter].
3. Click the plot Controller's Update button to redraw the chart.
4. To preserve your changes, click the plot Controller's Set button.

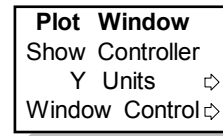


### The Control Chart Menu

**Show Controller** opens the plot controller.

**Y Units** select measurement units for the vertical or y-axis. If y-axis units are pixels, instrument calibration is required.

**Window Control** use to move, resize and delete the window, and to rename or hide the window's title bar.



### Bringing Existing Data into the Control Chart

In its default setting, the Chart shows data as measurements are made, but it can also graph existing data.

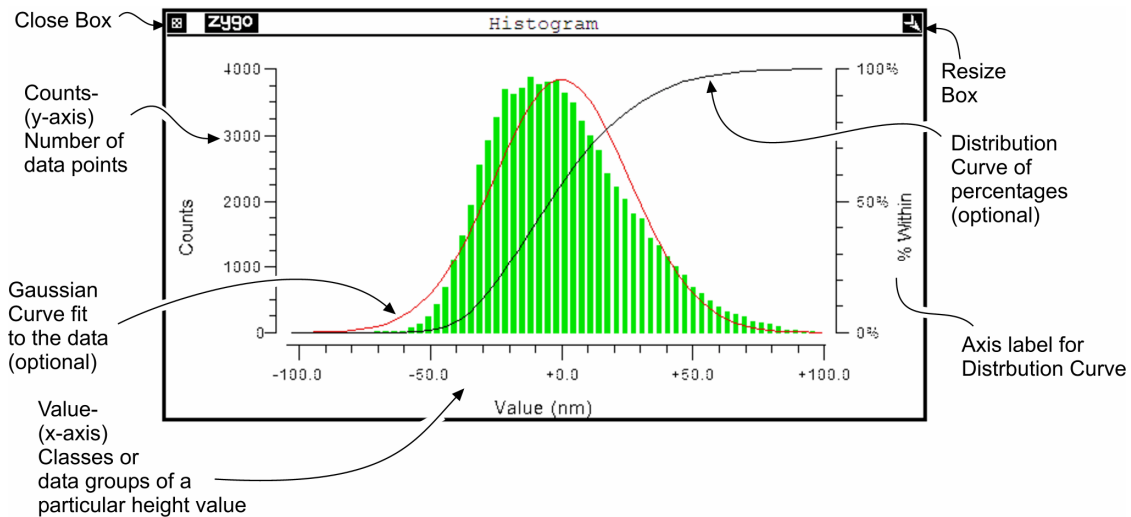
1. Load an existing data set into MetroPro using the Load Data button.
2. Click the Store button in the Process window.
3. Repeat the above steps for additional data sets.

### Reading Control Charts

<i>Control Chart</i>	<i>Feature of Data</i>
	<p><b>Point Outside of Limit</b> Control limits are calculated to measure the natural variability of a process. Any point outside the limit is considered abnormal and requires investigation.</p>
	<p><b>Run</b> A series of seven points on one side of the center line is considered abnormal.</p>
	<p><b>Trending</b> Seven points in a continuous upward or downward direction.</p>
	<p><b>Grouping</b> A majority of points on one side of the center line is considered abnormal. A majority is defined as: 10 out of 11, 12 of 14, or 16 of 20.</p>
	<p><b>Cycling</b> Any repetitious up and down trend is abnormal and requires investigation.</p>

## Histogram Plot

A Histogram plot is a two dimensional display representing the spread or distribution of data. The horizontal, or x-axis, represents values, while the vertical, or y-axis, represents the occurrences or frequency of the values. A map Histogram plot is based on all acquired data, where the profile Histogram is based on along a cross section or slice of the test surface. The profile Histogram requires a defined slice in a corresponding Filled plot. The Histogram plot is created using the New Plot command.



The Histogram plot shows the dispersion or spread of the entire data set, if it is used in a map Data window; or the distribution of the data defined by the slice(s), if it is used in a profile Data window. There are a discrete number of data groups used for the x-axis of the Histogram plot. Each data point is categorized to the nearest group; then the frequency of these groups at each interval is plotted. Some Histograms will show a Gaussian curve fit to the data. It is displayed in red. The peak of the Gaussian curve is the average of all classes; it is the sum of all the measured data divided by the total number of data points.

The distributions in the Histogram plot show a pattern of variation of the test surface. A surface with random features has a height distribution that fits the Gaussian curve. A surface with a dominant shape has a non-Gaussian height distribution.

The formula for the Gaussian curve is:

$$ae^{-\frac{t^2}{2}}$$

Where a is a normalization factor, e is equal to 2.71828, and t is equal to  $\frac{x - \bar{x}}{sd}$ ; and where x is each value on x-axis of histogram,  $\bar{x}$  is the mean of the data, and sd is the standard deviation of the data.

## Displaying the Histogram Plot

If the Histogram plot is used in a map data window, it displays data soon after the measurement.

If the Histogram plot is used in a profile data window, a slice must be defined in a corresponding map data window Filled plot before any data is displayed.

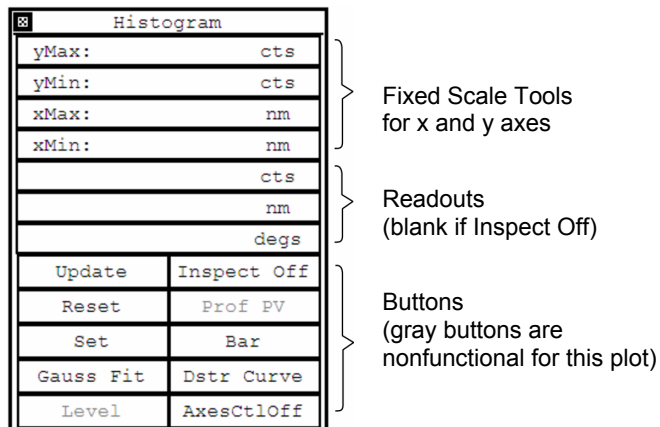
## Changing the Histogram Plot

The plot display is adjusted and modified with the plot Controller. The Histogram plot Controller works similar to the profile plot Controller. To open the Histogram plot Controller click on the plot with the middle mouse button.

### Plot Controller

Access by clicking middle mouse button on plot.

*A complete discussion on using the plot Controller is found under Profile Plot.*



**Update** - Redraws the plot to match the current Controller settings.

**Reset** - Restores button settings to match the “set” Controller settings.

**Set** - Makes the current Controller settings the master or “set” display.

**Gauss Fit** - Applies a Gaussian fit to the data and displays the result in red over the data.

**Inspect** - Turns inspect features on and off. When Inspect Off the readouts and the plot crosshairs are non-functional. For other selections see Section 4.

**Display** - Selects how data is displayed. Trace displays data as a line graph. Bar displays data as a series of vertical bars. Scatter displays data as points.

**Dstr Curve** - Calculates a data distribution curve of percentages and displays the result in white over the data. This is performed by adding the counts of each bin with the sum of all previous bins and dividing by the overall number of counts.

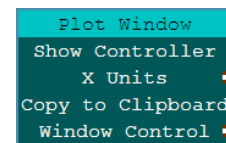
**Axes CtlOff** - Selects options for the axes scales; opens a secondary button panel. Details in using this feature are found in section 7.

## The Histogram Plot's Menu

**Show Controller** open the plot controller.

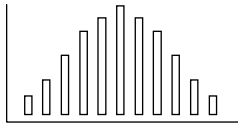
**X Units** select measurement units for the horizontal (x) axis. If the units are pixels, instrument calibration is required.

**Window Control** use to move, resize and delete the window, and to rename or hide the window's title bar.

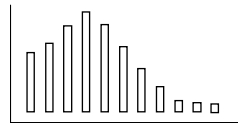


## Understanding Histograms

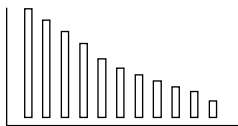
A histogram is a tool to recognize patterns; they provide information on the degree of variation of the data as well as indicate a distribution pattern. Dispersion of the data can produce a wide variety of shapes depending upon the data we are viewing.



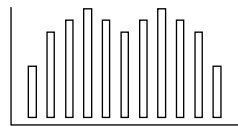
**Normal**  
Most values fall toward the center of the distribution and the variation on both sides of the center is balanced.



**Skewed**  
A skewed histogram has a long tail on one side. This can indicate a shift of some variable.



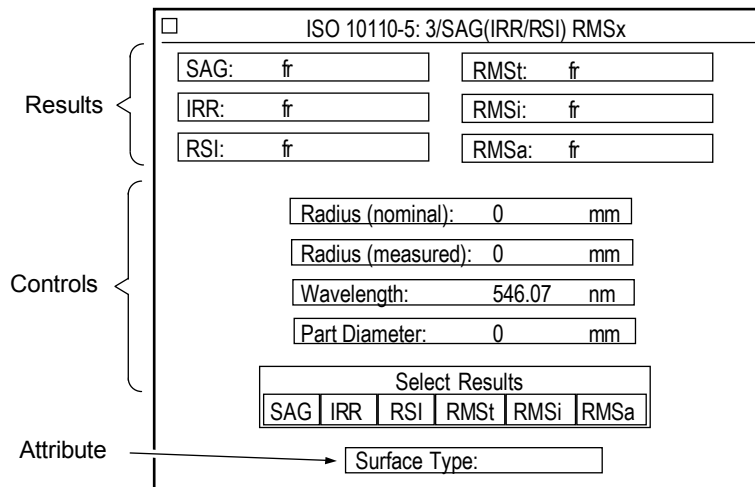
**Precipiced**  
Most values appear shifted to one of the sides. This could occur when the data has been sorted or when there is some natural barrier.



**Bi-Modal**  
There appear to be two peaks. This usually occurs when two different data groups are mixed.

## ISO 10110-5 Window

The ISO 10110-5 Window is specialized window that provides results specified by the ISO figure specification (ISO 10110-5). The window is preconfigured with results and controls when created. It typically is used with a GPI XP or Mark IV<sub>XP</sub> interferometer system. Additional information is available in the SPIE (Society of Photo-Optical Instrumentation Engineers) Proceeding Reprint Volume 1776, Interferometry: Surface Characterization and Testing (1992).



Example of ISO 10110-5 Window

## ISO Controls and Results

<b><i>Controls</i></b>	<b><i>Description</i></b>
<i>Select Results</i>	Selects which ISO results are calculated. They can be selected in any combination. Choices are SAG, IRR, RSI, RMSt, RMSi, and RMSa.
<i>Wavelength</i>	Selects the wavelength of the output results. This defaults to 546.07 nm by ISO 10110-5 and corresponds to the green emission line of mercury.
<i>Radius (measured)</i>	Specifies the actual measured radius of curvature of the part being measured. This radius is supplied from some other means, such as the Radius Scale Application.
<i>Radius (nominal)</i>	Specifies the nominal radius of curvature of the part being measured. Either Radius entry is required, but not both.
<i>Part Diameter</i>	Specifies the nominal part diameter of the part being measured. Required entry.
<b><i>Results</i></b>	<b><i>Description</i></b>
<i>3/A(B/C)</i>	SAG, IRR, and RSI in ISO form.
<i>IRR</i>	Irregularity (IRR) is the tolerance of the surface form error which remains after the sagitta error is removed. It is the PV with respect to the best fit reference sphere.
<i>RMSa</i>	Residual RMS from the best fit AAS (Approximating Aspheric Surface) after best fit plane and sphere are subtracted. A version of RMS error.
<i>RMSi</i>	Residual RMS from the best fit sphere after best fit plane is subtracted. A version of RMS error.
<i>RMSt</i>	Residual RMS from the best fit plane. A version of RMS error.
<i>RSI</i>	Rotationally Symmetric Irregularity (RSI) is the tolerance on the rotationally symmetric component of the surface form error after the best fit sphere is subtracted. It is the PV of the Approximating Aspheric Surface (AAS).
<i>SAG</i>	Sagitta error (SAG) is the tolerance on the power or focus of the surface with respect to a reference sphere with the nominal radius of curvature.
<i>Surface Type</i>	Displays the type of surface the ISO results are based on. This is an Attribute only.

## MTF

The MTF (Modulation Transfer Function) of an optical system indicates the ability of the system to resolve detail as a function of the spatial frequencies present in the object. Perfect resolution is indicated by an MTF value of 1; at the cutoff frequency of the lens the value of the MTF decreases to 0.

In MetroPro, MTF is available as a map and a profile data window; these data windows are created with the New Data Window → Phase Test/ Default → MTF command. Plots and results inside of these windows represent the ability of a lens or optical system to resolve object detail.

The Filled plot and 3D plot available inside the MTF map data window provide a qualitative indication of the performance of the lens system. A symmetric cone shape 3D plot indicates a well assembled, centered lens system performing near the diffraction limit. An asymmetric shape indicates a lens system where the rotational symmetry has been affected either inadvertently through improper fabrication or deliberately as a result of the design.

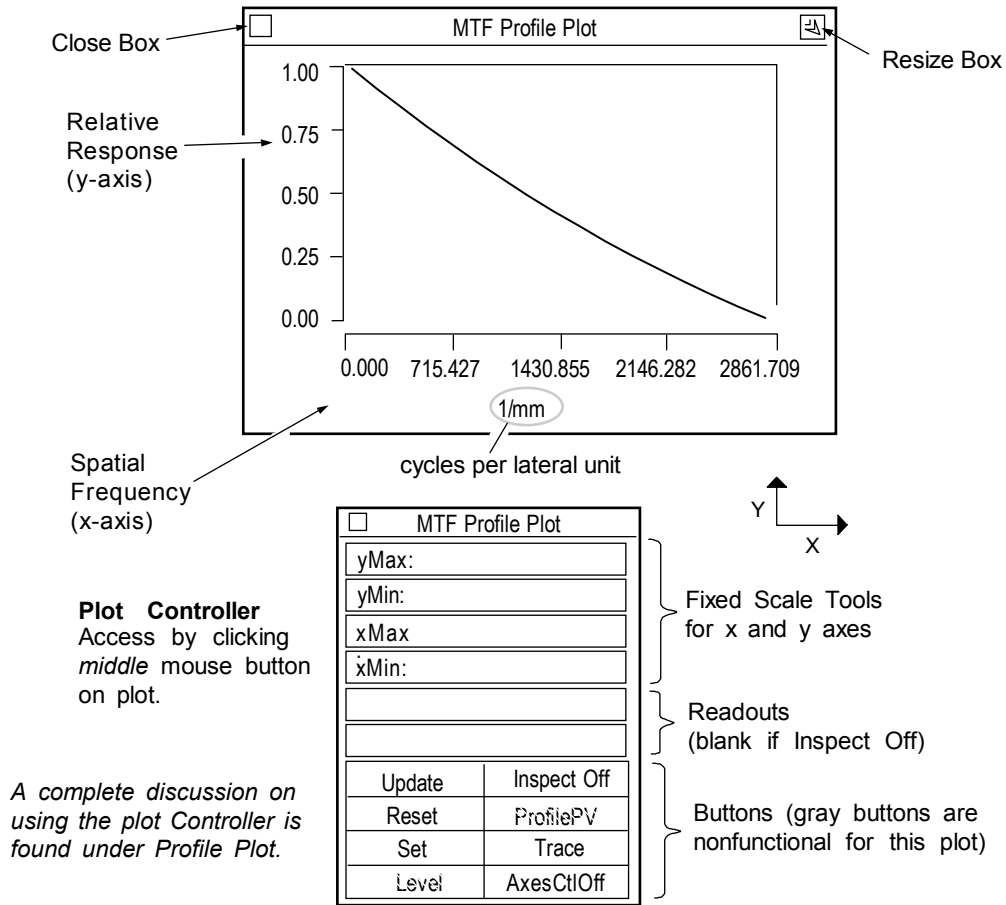
If quantitative information concerning the MTF data is desired, you have two options: the MTF Profile plot and the MTF table. The MTF Profile plot allows you to view a profile of the MTF data in any angular orientation. This makes it possible to quantitatively observe the variation in a lens response with object orientation. Where the MTF Profile plot reaches zero is the maximum spatial frequency that can be resolved by the lens; this frequency is called the cutoff frequency. The cutoff frequency is displayed in a Cutoff Freq result. The number entered in the f-number control is used for the calculation of the Cutoff Freq result.

The MTF Profile plot makes it possible to quantitatively observe the variation in a lens response at any object orientation. The functional form of the MTF curve is dependent on the wavefront quality, the wavelength of the light, and the size and shape of the aperture. If precise MTF versus spatial frequency data is required, the inspectors can be used to obtain the x and y values for any location on the MTF curve. The cutoff frequency is the maximum spatial frequency that can be resolved by the lens; it is where the MTF curve goes to zero.

The MTF table provides tabulated values of the MTF in four orientations: 90°, 45°, 0°, and -45°. This is equivalent to creating profiles in four directions from the center of the MTF Filled plot to the edge and listing the modulation values for various spatial frequencies.

### MTF Profile Plot

The MTF Profile plot allows the user to view a profile of the MTF data in any angular orientation. The MTF Profile plot is available in a MTF profile Data window and is created using the New Plot command. To open the plot Controller click on the plot with the middle mouse button.



### Displaying the MTF Profile Plot

1. In a corresponding map MTF Data window, define a Radial Ctr slice through the data within the Filled plot. Slicing is described in Section 4.
2. If the plot is blank make sure that you are using corresponding MTF data windows; and that the slice is drawn over an image area in the Filled plot.



No profile data is calculated or displayed until a Radial Ctr slice is defined by the user within a Filled plot made in a corresponding map MTF Data window.

### MTF Profile Plot X-axis Units

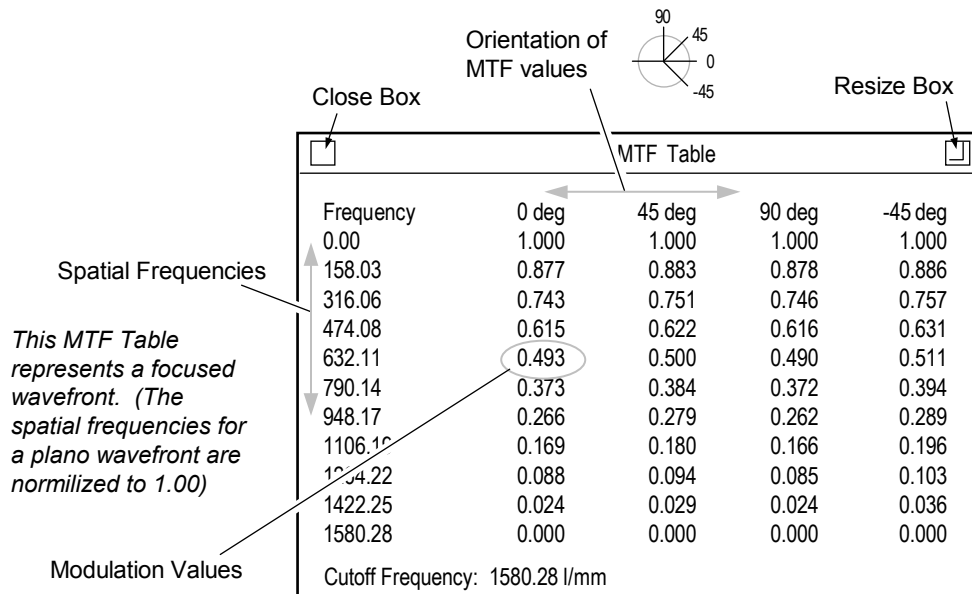
The x-axis units on the MTF Profile plot vary depending upon the wavefront of the optic being tested. With an optic that has a focused wavefront, or an f-number greater than zero, the x-axis is shown in cycles per millimeter (1/mm). With an optic that has a plano or afocal wavefront, or an f-number equal to zero, the x-axis units are normalized to one.

### Changing the MTF Profile Plot

The plot display is adjusted and modified with the plot Controller. The MTF plot Controller works similar to the profile plot Controller.

### MTF Table

The MTF table is a specialized window that lists the MTF results in numerical form. It is available in the MTF map data window; and it is created with the New Result command. To print a copy of the MTF table, select the Window Control → Print command.



### MTF Reference Material

Joseph W. Goodman, *Introduction to Fourier Optics* (New York: McGraw Hill, 1968).



## Process Stats

Process Stats (Statistics) is a specialized result window which displays statistics about results for multiple measurements. It is useful when comparing the results of multiple measurements on similar parts. It serves as a statistical process tool. It is created using the New Result → Process Stats command.

The information displayed inside the Process Stats window is determined by the results within the same data window when the Stats result is created. Only results are displayed in the Stats window, Annotations and Attribute boxes are not.

The Process Stats result window is available in all data windows that have results, including both profile and map data. Process Stats are also available in the Process window. The Process Stats result window is similar to Profile Stats window, except the Process Stats is for multiple measurements, where Profile Stats is for multiple profiles on a single measurement.

Any result in the data window, when the Process Stats window is created, is automatically part of the stats.

Process Stats allows you to track results over multiple measurements.

Each row pertains to one measurement.

	rms nm	Ra nm	PV nm
1	1.48	1.09	10.39
2	1.38	1.18	4.99
3	1.81	1.58	6.41
4	1.96	1.52	8.54
5			
N	4	4	4
Mean	1.66	1.34	7.58
SD	0.24	0.21	2.05
Range	0.58	0.49	5.39

### Creating the Process Stats Window

1. Ensure that the results you want to appear in the Stats window are displayed in the same data window. Otherwise, create the desired Result boxes.
2. Use the New Result → Process Stats command to create the Process Stats window. When the window outline appears, press and hold a mouse button, move the mouse to relocate the window; then release the button.



When first created the Stats window is blank. The Stats window is updated as measurements are made or as existing data is loaded. The column order is determined by the creation order of the results. The total number of measurements displayed is determined by the Window Size control in the Process window.

## Using Process Stats

Process Stats are blank until measurements are made. As measurements are completed the chart is automatically updated with measurement data and statistics. The settings of the controls in the Process window affect the use of the Process Stats.

<i>Process Window Control</i>	<i>Function in Process Stats</i>
<i>Window Size</i>	Determines the number of measurements displayed in the stats.
<i>Auto Store</i>	If On, the chart is updated as measurements are made.
<i>Store button</i>	When clicked the existing data is entered into the Process Stats.
<i>Clear button</i>	Erases all data.
<i>Undo button</i>	Removes the last data entered into the stats.

## The Process Stats Window

The Process Stats window lists the results for multiple measurements and provides combined statistical information on each result. Depending upon the state of the controls in the Process window, results can be dynamically updated as measurements are made, or existing data sets can be opened and added.

Each row of results in the Process Stats window corresponds to one measurement. The measurements are listed in reverse order, with the current measurement listed last. Results in the window are listed in order of creation.

The Process Stats window is a “display” window, its contents cannot be saved. To save or output the results of numerous measurements use the Report window.

	rms nm	Ra nm	PV nm
1	1.48	1.09	10.39
2	1.38	1.18	4.99
3	1.81	1.58	6.41
4	1.96	1.52	8.54
5			
N	4	4	4
Mean	1.66	1.34	7.58
SD	0.24	0.21	2.05
Range	0.58	0.49	5.39

Close Box

zygo Process Stats

Resize Box

Scroll Control up down

Click left mouse button to move one row. Click with right button to move all rows.

Measurement number; the current measurement is listed last.

Statistics

Select with Process Stats menu's Statistics command.

row

Each row shows results for one measurement.

column

Shows combined statistics for a column.

## Displaying the Statistics in the Process Stats

Select Statistics		
Max	Mean	LLimit
Min	StdDev	NValid
Range	Cv %	Passed
Total	ULimit	Failed
<input type="button" value="Done"/>		<input type="button" value="Cancel"/>

**Max** The maximum value of all results in the column.

**Min** The minimum value of all results in the column.

**Range** The maximum result value minus the minimum value.

**Total** The sum of the values in the column.

**Mean** The arithmetical average of the values in the column.

**StdDev** The standard deviation of all values in the column.

**Cv %** Coefficient of variation times 100. CV is equal to StdDev divided by Mean.

**ULimit** Shows the setting of the high limit in the result.

**LLimit** Shows the setting of the low limit in the result.

**NValid** The number of valid measurements.

**Passed** The number of measurements within set limits for the result.

**Failed** The number of measurements outside set limits for the result.

1. Position the pointer over the window and press the right mouse button.
2. Select the Statistics command. A Select Statistics dialog opens.
3. Click the buttons in the dialog box to select the statistics to display, then click the Done button.

## Changing the Height of the Process Stats

The height or y-direction can be resized with the Resize box or the Resize command. The center portion of the Process Stats window is the only resizable section, the top and bottom sections are fixed. Any number of rows may be displayed, even more or less rows of data than exist. Blank rows indicate no data. Click the left or right mouse button on the Scroll control to move rows up or down.

1. Press and hold the left mouse button on the Resize box, a central resize outline appears.
2. Move the mouse to change the height of the window and then release the mouse button.

## Changing the Width of the Process Stats

The width or x-direction is determined by the number of results displayed and their individual specified widths. To change the width of one column:

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Value Format → Width command. Input a new width value with the keyboard and press [Enter].
3. Repeat these steps for other results.

### ***Bringing Existing Data into the Process Stats***

In its default setting, the Process Stats window shows data as measurements are made, but it can also display statistics on existing data.

1. Load an existing data set into MetroPro using the Load Data button.
2. Click the Store button in the Process window.
3. Repeat the above steps for additional data sets.

### ***Adding or Removing the Results Displayed in the Process Stats***

1. Delete the current Stats window with the Window Control → Delete command. Confirm your action by clicking the Yes button in the Dialog box.
2. Add or delete Result boxes in the same data window.
3. Select the New Result → Process Stats command. When the window outline appears, press and hold a mouse button, move the mouse to relocate the window, then release the mouse button. A new Process Stats window appears.

### ***Changing Result Units in the Process Stats***

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Units command and choose a measurement unit.

### ***Displaying Limits in the Process Stats***

Limits can be set for each result column so that individual results in the column are displayed in red or green depending on the numeric result.

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Limits command, enter a value with the keyboard, then press [Enter]. Limits → High specifies the high limit; any result in the result column above this value turns red. Limits → Low specifies the low limit; any result in the result column under this value turns red.

### ***Process Stats (Limits)***

The Process Stats (Limits) window is a variation of the Process Stats window. They both display statistics about results, tracking them over multiple measurements. With standard Process Stats all measurements are displayed. In the case of Process Stats (Limits) only those measurements that pass all user set limits on results are displayed.

If user set limits for even one result in the window are exceeded, the measurement is not displayed in the statistics. If there are no limits set for results with the result menu's Limits command, then the Process Stats (Limits) window will have the same function as the standard Process Stats window.

## Profile Stats

Profile Stats is a specialized result window that displays various statistics about profile data. The information displayed inside the Profile Stats window is determined by the slice(s) in a corresponding Filled plot. The results that show up in the Profile Stats result are copies of those found in the same data window when the Stats result is created. Only results are displayed in the Stats window, Annotations and Attribute boxes are not.

Profile Stats relate to profile data; it is different from Process Stats, which can relate to any results. The Profile Stats window is created using the New Result → Profile Stats command.

Any result in the Profile Data window, when the Profile Stats window is created, is automatically part of the stats.

Profile Stats allows you to track results for multiple slices.

Each row pertains to one slice. The number of slices determines the number of rows.

Slices are defined in a Filled plot in a corresponding map data window.

	rms nm	Ra nm	PV nm
1	1.48	1.09	10.39
2	1.38	1.18	4.99
3	1.81	1.58	6.41
4	1.96	1.52	8.54
N	4	4	4
Mean	1.66	1.34	7.58
SD	0.24	0.21	2.05
Range	0.58	0.49	5.39

### Creating the Profile Stats Window

1. Ensure that the slices you want to appear in the Stats windows are created in the Filled plot of the corresponding map data window. Otherwise, create the desired slices.
2. Ensure that the results you want to appear in the Stats window are displayed in the profile data window. Otherwise, create the desired Result boxes.
3. In the profile data window, select the New Result → Profile Stats command to create the Profile Stats window. When the window outline appears, press and hold a mouse button, move the mouse to relocate the window, then release the button.



If there are no valid slices the Stats window is blank. The Stats window is updated as measurements are made or as the slices are modified or moved through the existing data. The row order is determined by the creation order of the slices. The column order is determined by the creation order of the results.

## The Profile Stats Window

The Profile Stats window lists the results for one or more slices and provides combined statistical information on each result. When the slices in the corresponding Filled plot are modified, the Stats results are automatically updated. Each row of results in the Stats window corresponds to one slice. The first 10 slice numbers are color coded to match the slice colors in the profile. The top row lists the results of the “current” slice, which is the last created or modified slice. The underlying rows list the results in consecutive order.

The order that the results appear in the Stats window is determined by the row order of the slices in the profile data window at the time the Stats result is created. To change the order, you must delete the Stats window, change the order of the slices in the data window, and recreate the Stats result. Stats cannot be part of a Report window.

Close Box

Scroll Control  
up  
down  
Click left mouse button to move one row. Click with right button to move all rows.

Slice number; the current slice is 1.

Slice	Profile Color	Slice Label
1	green	Triangle
2	cyan	Square
3	blue	Diamond
4	red	none

Statistics  
Select with Profile Stats menu's Statistics command.

Resize Box

row

Each row shows results for one slice. The number of rows is based on the slices.

column

Shows combined statistics for a column.

## Displaying the Statistics in the Profile Stats

Select Statistics		
Max	Mean	LLimit
Min	StdDev	NValid
Range	Cv %	Passed
Total	ULimit	Failed
Done		Cancel

**Max** The maximum value of all results in the column.

**Min** The minimum value of all results in the column.

**Range** The maximum result value minus the minimum value.

**Total** The sum of the values in the column.

**Mean** The arithmetical average of the values in the column.

**StdDev** The standard deviation of all values in the column.

**Cv %** Coefficient of variation times 100. CV is equal to StdDev divided by Mean.

**ULimit** Shows the setting of the high limit in the result.

**LLimit** Shows the setting of the low limit in the result.

**NValid** The number of valid measurements.

**Passed** The number of measurements within set limits for the result.

**Failed** The number of measurements outside set limits for the result.

1. Position the pointer over the window and press the right mouse button.
2. Select the Statistics command. A Select Statistics dialog opens.
3. Click the buttons in the dialog box to select the statistics to display, then click the Done button.

### ***Changing the Height of the Profile Stats***

The height or y-direction can be resized with the Resize box or the Resize command. The center portion of the Profile Stats window is the only resizable section, the top and bottom sections are fixed. Any number of rows may be displayed, even more or less rows of data than exist. Blank rows indicate no data. Click the left or right mouse button on the Scroll control to move rows up or down.

1. Press and hold the left mouse button on the Resize box, a central resize outline appears.
2. Move the mouse to change the height of the window and then release the mouse button.

### ***Changing the Width of the Profile Stats***

The width or x-direction is determined by the number of results displayed and their individual specified widths. To change the width of one column:

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Value Format → Width command. Input a new width value with the keyboard and press [Enter].
3. Repeat these steps for other results.

### ***Bringing Existing Data into the Profile Stats***

In its default setting, the Process Stats window shows data as measurements are made, but it can also display statistics on existing data.

1. Load an existing data set into MetroPro using the Load Data button.
2. Click the Store button in the Process window.
3. Repeat the above steps for additional data sets.

### ***Adding or Removing the Results Displayed in the Profile Stats***

1. Delete the current Stats window with the Window Control → Delete command. Confirm your action by clicking the Yes button in the Dialog box.
2. Add or delete Result boxes in the same profile data window until the results you want are displayed.
3. Use the New Result → Profile Stats command to create a new Profile Stats window. When the window outline appears, press any mouse button, move the mouse to relocate the window, and release the button.

### ***Changing Result Units in the Profile Stats***

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Units command and choose a measurement unit.

## Displaying Limits in the Profile Stats

Limits can be set for each result column so that the slice results within the set limits display green and those out of specification display red.

1. Position the pointer over a result in the Stats window and press the right mouse button.
2. Select the Limits command, enter a value with the keyboard and press [Enter]. Limits → High specifies the high limit; any result in the result column above this value turns red. Limits → Low specifies the low limit; any result in the result column under this value turns red.

## PSF

The PSF (Point Spread Function) is a mathematical representation of the energy distribution in the output of a lens or optical system. The PSF plots display the absolute value of the light amplitude at the focus of the wavefront. The form of the PSF function is dependent on the wavefront quality, the wavelength of the light, and the size and shape of the aperture.

Plots and results inside of the PSF data window represent the energy intensity distribution around the image of a point source. The Filled plot and 3D plot available inside the PSF Data window provide a qualitative indication of the performance of the lens system. The Filled plot display for a perfect lens system would be represented by a bright central spot surrounded by rings of decreasing brightness. This pattern is commonly referred to as an Airy disk. The Encircled Energy Plot displays quantitative information of the distribution of energy within the PSF plot.



If the PSF data does not fall to zero at the edge of the Filled or 3D plot due to a large amount of aberration, the data displayed in the plot is incorrect due to aliasing. In other words, the data that falls off one edge is added to the data on the opposite edge.

You may control the resolution of the array used in the computation of PSF analysis with the PSF Size control. A Strehl result displays the ratio of the peak intensity of light in an aberrated point image to that of unaberrated point image. The number entered in the f-number control is used for the calculation of PSF.

## PSF Reference Material

Joseph W. Goodman, *Introduction to Fourier Optics* (New York: McGraw Hill, 1968).

## Seidel Coefficients

Seidel aberrations are the first and third order wavefront aberrations of an optical system. They are also known as primary, or third-order aberrations. There are nine Seidel results:

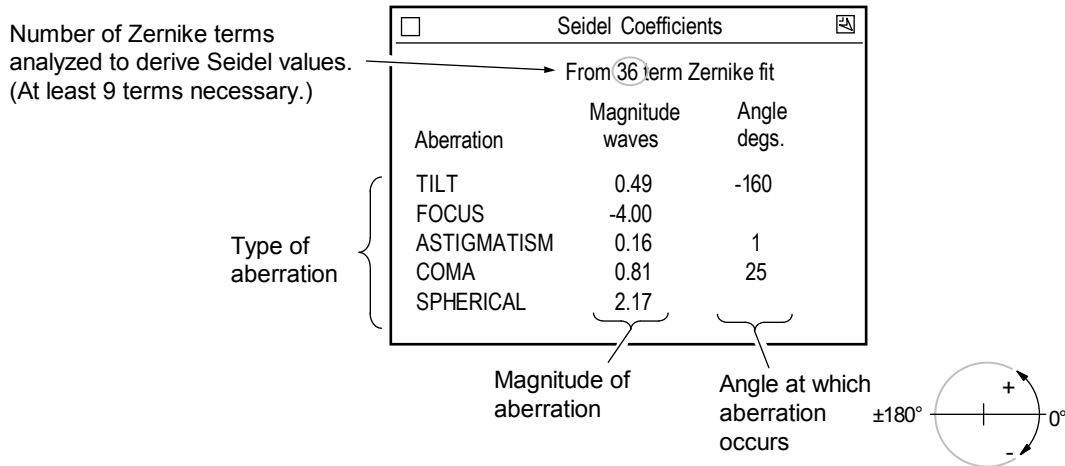


All (described below), TltMag, TltAng, FocMag, AstMag, AstAng, ComMag, ComAng, and SA.



Seidels are designed for circular data sets. Seidels of noncircular data sets may be erroneous.

Seidel “All” results are listed in a specialized window which may be created in a phase data window using the New Result → Seidels → All command. Each aberration listed in this window may be displayed as individual Result boxes.



The wavefront aberration coefficients for the first order include tilt and focus. The wavefront aberration coefficients for the third order include astigmatism, coma, and spherical aberration. In the result window, the magnitude of each aberration is shown in waves. For tilt, astigmatism, and coma, the angle of the aberration is shown in degrees. Values for both tilt and coma vary ±180°, while the values for astigmatism vary ±90°.

Zernike polynomials are used to calculate Seidel results, and at least 9 Zernike terms must be analyzed for Seidel results to be displayed.

### Seidel Formulas

Where z(number) represent Zernike terms, z4 is the 4th term, z5 is the 5th term, etc...

<b>Result</b>	<b>Formula</b>
<i>AstAng</i> (Z)	$0.5 \arctan\left(\frac{z5}{z4}\right)$
<i>AstMag</i> (Z)	$2 \sqrt{z4^2 + z5^2}$
<i>ComAng</i> (Z)	$\arctan\left(\frac{z7}{z6}\right)$
<i>ComMag</i> (Z)	$3 \sqrt{z6^2 + z7^2}$

$$FocMag (Z) = 2 (z3) - 6 (z8)$$

$$SA (Z) = 6.0 (z8)$$

$$TltAng (Z) = \arctan\left(\frac{y \text{ tilt}}{x \text{ tilt}}\right)$$

$$TltMag (Z) = \sqrt{x \text{ tilt}^2 + y \text{ tilt}^2}$$

## Slope Data

Slope data windows present data about the slope of the wavefront. Plots created in the Slope X window shows slope information occurring the x-axis, the Slope Y window shows the y-axis.

Slope data displayed as a Filled plot provides a good visual representation of the relative slopes present in the surface, or the transmitted wavefront, of the item being tested. The plots are useful for spotting small defects that may be hidden by overall surface, or transmitted wavefront, errors in other types of plots. The Slope X Filled plot appears as a solid surface with x-axis slopes highlighted by what appears to be a light source to the left of the plot. The Slope Y Filled plot is similar, except that only slopes occurring in the y-axis are shown, and the apparent light source is below the plot.

X and Y slopes of each data point are determined by comparing the values of the data points surrounding it.

For Data Point E:

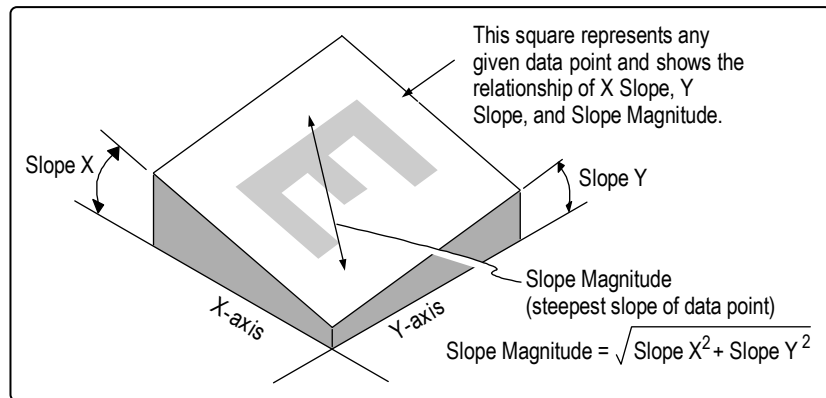
$$\text{Slope X} = \frac{F - D}{2}$$

$$\text{Slope Y} = \frac{B - H}{2}$$

A	B	C
D	<b>E</b>	F
G	H	I

This block represents any given group of nine adjacent data points.

Plots created in a Slope Mag Data window shows information about slopes occurring in between the X and Y axes. In a Slope Mag Filled plot, areas of steepest slope appear brightest (regardless



of whether the slope is positive or negative), while areas of least slope appear darkest (the inverse of the way a standard Solid plot is displayed). Therefore, only the rising and falling edges (areas of steepest slope) of wavefront features are clearly shown in the Slope Mag Data window.

If testing a part with a slope specification, create a Peak Result box in the Slope Mag Data window. Change the measurement units for the Peak result with the PV menu's Units command.

## Spectrum Data

The Spectrum Data window shows spatial frequency spectrum data obtained by applying a two-dimensional FFT transform to test/default data. The use of the Spectrum Data window increases the time required for analysis.

The Spectrum Data window breaks data into frequency components. The plots can be used to determine if a surface is anisotropic and for viewing surface characteristics, such as machining marks and other repetitive structures. Z-axis scaling for plots is the log of the magnitude of the 2D FFT.

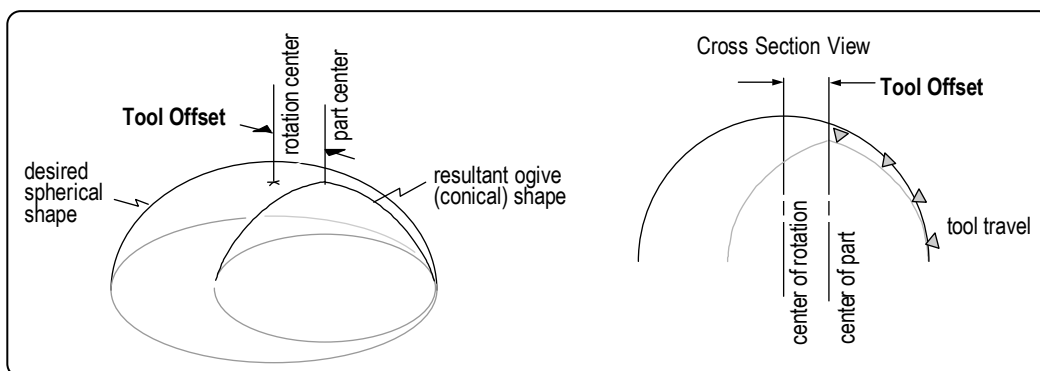
The data displayed in the Spectrum Data window is controlled by the Remove, Shape, and Window controls. These controls are created with the data window menu's New Control command.

## Tool Offset

MetroPro can be configured to calculate the tool decentration or offset of turned spherical parts. Calculation of tool offset is usually done so the cutting tool can be reset closer to the axis of rotation. Measuring the tool offset of spherical parts is best performed using a GPI XP interferometer. This entry describes measuring tool offset, and covers the Nominal RadCrv and Tool Offset Sign controls, and the Tool Offset result.

In the case of a diamond-turned optical component, the optical figure is generated as the tool is moved over the surface to create a circular arc. The Tool Offset result establishes to what extent the center of this circular tool arc lies on the spindle axis or axis of rotation. If the tool's center is misaligned with respect to the spindle axis, an aberration known as ogive error is generated. The term "ogive" is so named because of its resemblance to a pointed gothic archway.

Tool Offset is the horizontal decentration, which will actually alter the overall figure of the part. When there is vertical decentration, the tool is denied access to the central region of the spherical part; it does not affect the surface figure significantly. Tool Offset is concerned only with horizontal decentration.

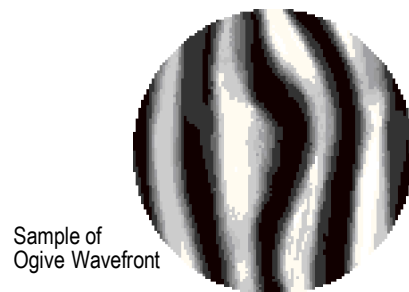


<i>Item</i>	<i>Description</i>
-------------	--------------------

<i>Nominal RadCrv</i> control	Specifies the nominal or planned radius of curvature of the spherical part. This value must be entered before making a measurement. Use a negative sign for concave surfaces, convex surfaces are positive.
<i>Tool Offset Sign</i> control	Changes the sign of the Tool Offset result to accommodate different test setups or lathe polarity. Settings are Unchanged or Changed.
<i>Tool Offset</i> result	The lateral distance from the physical center of the part to the center of the curve of the arc of the cutting tool, along the horizontal axis of the part.

### Measuring Tool Offset

1. Open the standard GPI application.
2. In the phase map data window, create Nominal RadCrv and Tool Offset Sign controls with the New Control command. Then use the New Result command to create the Tool Offset result.
3. Click on the Nominal RadCrv control and enter the nominal or planned radius of curvature of the test part.
4. Set up the interferometer as instructed in the operator’s manual for measuring a spherical part.
5. Before making a measurement, you must perform lateral calibration. An overview of lateral calibration is: Click the Calibrate button. Press and hold the left mouse button, move the mouse to draw a line across the image area, then release the mouse button. The line should match up to some portion of the image for which you know the dimension. Enter the dimension of the line in millimeters and press [Enter]. Close the Calibrator window.
6. Press F1 or click the MEASURE button. When the analysis is complete, the Tool Offset result is displayed. A sample ogive wavefront is shown.
7. To preserve changes made to the application, access the Application Window menu and select the Save Application command. In the File Handler, click the Current Selection box, enter a name for the file, ending with “.app”, then press [Enter]. Click the Done button to close the File Handler.



## Zernike Polynomials

To aid in the interpretation of optical test results, it is often convenient to express wavefront data in polynomial form. Zernike polynomials are frequently used for this purpose since they are made up of terms that are of the same form as the types of aberrations often observed in optical tests.

- Zernikes are designed for circular data sets. Zernikes of noncircular data sets may be erroneous.
- Zernikes have little value when air turbulence is present.
- Fabrication errors present in the single-point diamond turning process cannot be represented using a reasonable number of terms in the Zernike polynomial.
- The blind use of Zernike polynomials can lead to erroneous results.

Zernike polynomial terms are displayed in a specialized window. Use the New Result → Zernikes command to create this window in a Phase Data window. The number of terms analyzed and displayed in the Zernike Polynomials are determined by the Zernike Terms control. The number of data points used in the Zernike result are selected with the Zernike Sample control.

A typical Zernike result is shown below; 37 terms were used.

Zernike Coefficients from 39711 data points

```
Order:12th      Terms:37      rms:0.012
 1.844  1.305 -2.509  2.833
-5.871 -0.204  0.233 -2.296  0.792
-0.689  2.152 -1.656 -0.115  0.074 -0.768 -0.186
 2.131  0.156 -0.220  0.660  0.332 -0.020 -0.004 -0.078 -0.029
 0.318 -0.563 -0.063  0.060 -0.005  0.042  0.083  0.014 -0.003 -0.003 0.017
 0.007

Order: 10th      Terms:36      rms:0.012
 1.843  1.306 -2.512  2.834
-5.868 -0.205  0.235 -2.297  0.802
-0.692  2.155 -1.667 -0.116  0.075 -0.766 -0.170
 2.123  0.156 -0.221  0.659  0.309 -0.021 -0.003 -0.077 -0.023
 0.319 -0.564 -0.067  0.060 -0.005  0.042  0.069  0.014 -0.002 -0.003 0.011

Order:8th       Terms:25      rms:0.013
 1.901  1.057 -0.098  3.021
-6.109 -0.092  0.014 -0.103  1.052
-0.034  0.092 -2.028 -0.006  0.007 -0.010 -0.005
 2.198  0.054 -0.021  0.002  0.060  0.012 -0.004 -0.001  0.017

Order:6th       Terms:16      rms:0.021
 0.119  1.050 -0.065  0.219
-0.428 -0.025  0.001 -0.080  0.052
-0.015  0.073  0.027  0.011  0.001 -0.004  0.024

Order: 4th      Terms:9      rms:0.023
 0.144  1.043  0.064  0.257
-0.497 -0.033 -0.004 -0.002  0.054

Order: Sphere   Terms:4      rms:0.043
-0.072  1.045  0.066 -0.013

Center X: 321      Center Y: 244      Radius: 179.6
```

### ***Labeling used in Zernike Results***

<b><i>Label</i></b>	<b><i>Definition</i></b>
Order	The power of the radial symmetrical term.
Terms	The number of terms subtracted in the order group. For each grouping, term 0 is the first term at top left; term numbering is from left to right.
rms	The residual rms value of the wavefront.
Center X	The number of pixels to the center of the test wavefront in the x axis.
Center Y	The number of pixels to the center of the test wavefront in the y axis.
Radius	Number of pixels from the center point to the edge of the test data.

The more terms specified for analysis, the longer the analysis will take. Also, when a given number of terms are specified for analysis, all lower-order terms (except for 3-term) are analyzed and displayed as well. For example, if you specify an analysis of 16 terms, analyses for 9 terms and 4 terms are performed at the same time. You must select a Zernike fit of at least 9 terms if you want to display Seidel coefficient results.

### ***Zernike Files***

Zernike results may be saved as compatible CODE V Zernike data files. Select the type of CODE V file with the Code V Type control. To save a Zernike file click the Save Zernike button. In the File Handler, click the Current Selection box, enter a name for the file, ending with “.zfr”, and press [Enter]. Then click the File Handler’s Done button.

### ***Zernike Reference Material***

Max Born and Emil Wolf, *Principles of Optics* (New York: Pergamon Press, 1980).

Daniel Malacara, *Optical Shop Testing* (New York: John Wiley and Sons, 1978)  
Appendix 2.

## Zernike Polynomials Table

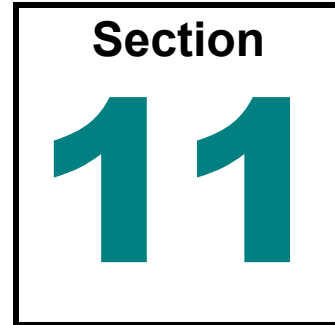
In this table,  $\phi$  = polar coordinate angle, and  $\rho$  = radius (normalized to 1 at the edge of the aperture). The numbers in columns  $m$  and  $n$  are the indices for Zernike polynomials.

$n$	$m$	Term #	Polynomial	Meaning
0	0	0	1	Piston or Bias
1	+1	1	$\rho \cos \phi$	Tilt X
	-1	2	$\rho \sin \phi$	Tilt Y
	0	3	$2\rho^2-1$	Power
2	+2	4	$\rho^2 \cos 2 \phi$	Astigmatism X
	-2	5	$\rho^2 \sin 2 \phi$	Astigmatism Y
	+1	6	$(3\rho^2-2)\rho \cos \phi$	Coma X
	-1	7	$(3\rho^2-2)\rho \sin \phi$	Coma Y
	0	8	$6\rho^4-6\rho^2+1$	Primary Spherical
3	+3	9	$\rho^3 \cos 3 \phi$	Trefoil X
	-3	10	$\rho^3 \sin 3 \phi$	Trefoil Y
	+2	11	$(4\rho^2-3)\rho^2 \cos 2 \phi$	Secondary Astigmatism X
	-2	12	$(4\rho^2-3)\rho^2 \sin 2 \phi$	Secondary Astigmatism Y
	+1	13	$(10\rho^4-12\rho^2+3)\rho \cos \phi$	Secondary Coma X
	-1	14	$(10\rho^4-12\rho^2+3)\rho \sin \phi$	Secondary Coma Y
	0	15	$20\rho^6-30\rho^4+12\rho^2-1$	Secondary Spherical
4	+4	16	$\rho^4 \cos 4 \phi$	Tetrafoil X
	-4	17	$\rho^4 \sin 4 \phi$	Tetrafoil Y
	+3	18	$(5\rho^2-4)\rho^3 \cos 3 \phi$	Secondary Trefoil X
	-3	19	$(5\rho^2-4)\rho^3 \sin 3 \phi$	Secondary Trefoil Y
	+2	20	$(15\rho^4-20\rho^2+6)\rho^2 \cos 2 \phi$	Tertiary Astigmatism X
	-2	21	$(15\rho^4-20\rho^2+6)\rho^2 \sin 2 \phi$	Tertiary Astigmatism Y
	+1	22	$(35\rho^6-60\rho^4+30\rho^2-4)\rho \cos \phi$	Tertiary Coma X
	-1	23	$(35\rho^6-60\rho^4+30\rho^2-4)\rho \sin \phi$	Tertiary Coma Y
	0	24	$70\rho^8-140\rho^6+90\rho^4-20\rho^2+1$	Tertiary Spherical
5	+5	25	$\rho^5 \cos 5 \phi$	Pentafoil X
	-5	26	$\rho^5 \sin 5 \phi$	Pentafoil Y
	+4	27	$(6\rho^2-5)\rho^4 \cos 4 \phi$	Secondary Tetrafoil X
	-4	28	$(6\rho^2-5)\rho^4 \sin 4 \phi$	Secondary Tetrafoil Y
	+3	29	$(21\rho^4-30\rho^2+10)\rho^3 \cos 3 \phi$	Tertiary Trefoil X
	-3	30	$(21\rho^4-30\rho^2+10)\rho^3 \sin 3 \phi$	Tertiary Trefoil Y
	+2	31	$(56\rho^6-105\rho^4+60\rho^2-10)\rho^2 \cos 2 \phi$	Quaternary Astigmatism X
	-2	32	$(56\rho^6-105\rho^4+60\rho^2-10)\rho^2 \sin 2 \phi$	Quaternary Astigmatism Y
	+1	33	$(126\rho^8-280\rho^6+210\rho^4-60\rho^2+5)\rho \cos \phi$	Quaternary Coma X
	-1	34	$(126\rho^8-280\rho^6+210\rho^4-60\rho^2+5)\rho \sin \phi$	Quaternary Coma Y
	0	35	$252\rho^{10}-630\rho^8+560\rho^6-210\rho^4+30\rho^2-1$	Quaternary Spherical
0	36	$924\rho^{12}-2772\rho^{10}+3150\rho^8-1680\rho^6+420\rho^4-42\rho^2+1$		





# Special Functions



*Have you ever wanted to add your own text or image to a MetroPro application, perform data filtering or statistical processing of your measurements? MetroPro provides these tools and more.*

## This Section Includes ...

This section provides an alphabetical listing of specialized features found in MetroPro. Some features may include a special control panel designed to perform a specific function, or it may be a group of controls used together to execute a larger task.

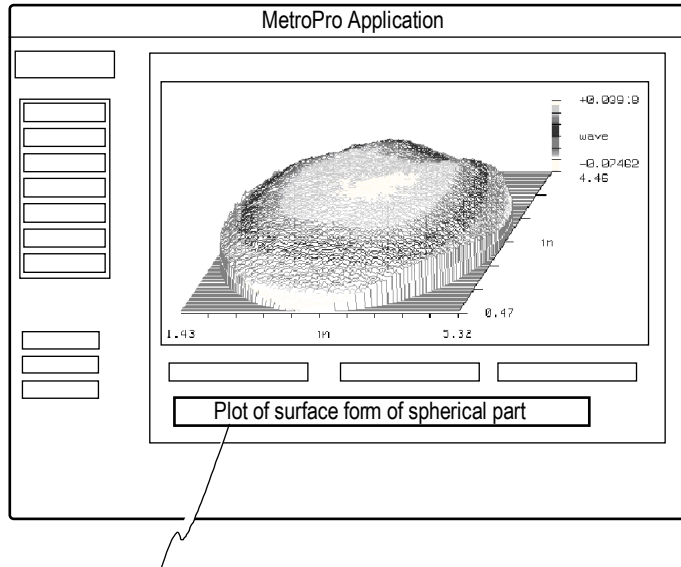
<b><i>Function</i></b>	<b><i>Quick Overview</i></b>
<i>Annotation</i>	Used to label and add text within a window.
<i>Absolute Wavelength Meter(AWM)</i>	An AWM provides an absolute measurement of the wavelength of the light source in order to increase the accuracy of interferometric measurements. <i>(For use only with VeriFire MST instruments.)</i>
<i>Bitmap Window</i>	Used to display a bitmap file.
<i>Filtering Data</i>	Filtering data breaks the surface characteristics into waviness, roughness, and high frequency results.
<i>Generate Function</i>	Used to create and manipulate Zernike polynomials.
<i>Limit Function</i>	Display visual feedback of user-specified limits
<i>Linked Control Settings</i>	Derives a control's value from another control or attribute.
<i>Process Window</i>	Used to gather and organize result boxes from different windows.
<i>Q-DAS Report Window</i>	Used to output measurement data in Q-DAS compatible format.
<i>Report Window</i>	Used to compile Result boxes and Attribute boxes from data and control windows into one window for the purpose of creating a text-based report file.
<i>Synthetic Fringes</i>	Used to create virtual fringes from the phase data.

## Annotation

An Annotation box is used to enter display text in a window. Any entry in the Annotation box is not saved with the data file. Annotations are used for display and printing purposes only. To have text saved with the data file use the Comment control instead. To create an Annotation box, access the window's menu and select the New Annotation command.

To enter text, click on the Annotation box with the left mouse button. An entry field appears, in which you may type whatever you want; press [Enter] to complete the entry.

The width of the Annotation automatically adjusts as text is entered. To change the type style of the text, select the Annotation menu's Font command.



Annotation used to add textual comment to a window.

## Absolute Wavelength Meter (AWM)

This function makes it possible to add an AWM to a VeriFire MST system. It enables measurement of the wavelength of the light source in order to increase the accuracy of measurements. The following attributes provide feedback on system function when using an AWM. Refer to *Section 9*, "Results and Attributes" for a description of each attribute.

- AWM Vacuum Wavelength (nm)
- AWM Air Wavelength (nm)
- AWM Air Temperature (deg C)
- AWM Air Pressure (mmHg)
- AWM Air Relative Humidity (%)
- AWM Air Quality
- AWM Input Power (mW)

## Bitmap Window

This function makes it possible to load and display a bitmap file into a special MetroPro Bitmap Window. This ability is particularly useful if you want to display a part drawing company logo, or other graphic on the screen while acquiring and analyzing data. It can also be used to customize the look of a MetroPro button or icon.

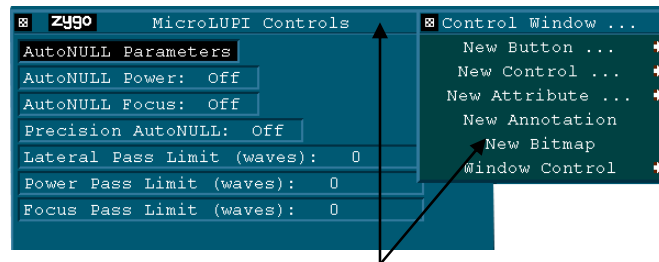
Like other MetroPro windows, it will have a border whose width can be specified.

### Bitmap Size

It is important to size the bitmap *before* loading it into MetroPro. The Bitmap Window will be the size of the bitmap image. Once loaded, it cannot be edited for size, contrast, or color adjustments. This must be done in an external image editing program. MetroPro will import the bitmap at whatever pixel size it was saved at. If the bitmap is edited in another program and size is adjusted by changing resolution (dpi), MetroPro will still import it according to its pixel size.

### Loading the Bitmap

Access New Bitmap by right-clicking in the title bar of a Control, Data, or Process Window. Click on New Bitmap in the pull-down menu. When prompted, enter the title of the bitmap. The bitmap must reside in the MetroPro working directory, typically C:\users\zygo..



Right click in the window.  
Then left click New Bitmap.

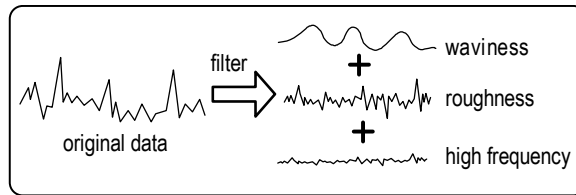
Once a Bitmap Window is added to a MetroPro application, you may load a different bitmap by right clicking the Bitmap Window title bar and selecting File... and specifying a new file name.

### Bitmaps on Buttons and Icons

A bitmap may be displayed on a MetroPro button (e.g. Measure, Analyze, Load Data) or an icon (Measure Cntrl, Analyze Cntrl, Pattern Cntrl). Right click the button or icon and select Bitmap → File...

## Filtering Data

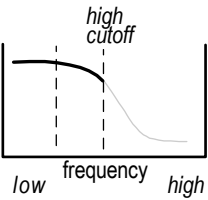
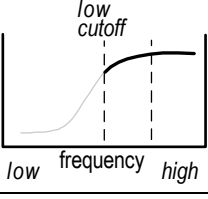
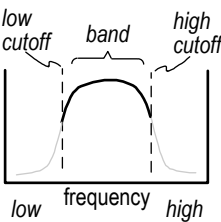
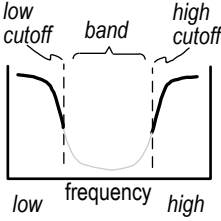
By digital filtering of the test data, the surface characteristics of the test part are broken down into waviness, roughness, and high frequency results. Both map and profile data can be filtered. Use



caution when filtering data, as it modifies the original data and can drastically alter the test results. To observe the effects of filtering, make the first measurement with the Filter control Off; then change the filter controls, press the Analyze button, and observe the outcome. For many applications, click the Analyze Cntrl icon to find the filter controls. The terms frequency and wavelength as they relate to filtering are shown here:

Waviness	Roughness	High Frequency
<i>low</i>	← frequency →	<i>high</i>
<i>long</i>	← wavelength →	<i>short</i>

### Summary of Filtering Functions

Filter	Chart	Description
<i>Off</i>	-	All data is unfiltered.
<i>Low Pass</i>		Low frequency or waviness data is highlighted. The effect varies based on the Filter Type control. Average, Median, and 2 Sigma work in conjunction with the Window Size control; the larger the size the greater the effect. FFT Fixed lets you set the cutoff.
<i>High Pass</i>		High frequency or roughness data is emphasized. The effect varies based on the Filter Type control. Average, Median, and 2 Sigma work in conjunction with the Window Size control; the larger the size the greater the effect. FFT Fixed lets you set the cutoff.
<i>Band Pass</i>		Data in the center of the band is analyzed. The Filter Type control must be set to FFT Fixed or FFT Auto. FFT Fixed lets you set the cutoff locations with the Filter High/Low Wavelen (or Freq) controls. In FFT Auto, the software arbitrarily sets the cutoffs as a starting point; you should switch to FFT Fixed and enter your own cutoffs. The exact filter values to enter vary due to the test part, the instrument's optics, and your testing criteria.
<i>Band Reject</i>		Data in the center of the band is rejected. The Filter Type control must be set to FFT Fixed or FFT Auto. FFT Fixed lets you set the cutoff locations with the Filter High/Low Wavelen (or Freq) controls.

## The Filtering Controls

<i>Item</i>	<i>Function</i>
<i>Filter</i>	Activates data filtering options. Settings are Off, Low Pass, High Pass, Band Pass, and Band Reject.
<i>Filter Type</i>	Selects the filtering algorithm when the Filter control is active. The settings are Average, Median, 2 Sigma, FFT Auto, and FFT Fixed.
<i>Filter Window Size</i>	Specifies the number of data points used to generate a new filtered data point when the Filter Type control is set to Average, Median or 2 Sigma. The larger the window size the greater the filtering effect.
<i>Filter Cutoff</i>	Selects the method of frequency attenuation when the Filter Type control is set FFT Auto or FFT Fixed. Settings are Sinusoid and Gaussian.
<i>Filter Trim</i>	When On, edge data is lost or trimmed due to filtering. When Off, edge data is preserved.
<i>Filter High Freq / Wavelen</i>	Specifies the upper cutoff for the filter either in wavelength or frequency when the Filter Type control is set to FFT Fixed and the applicable Filter is selected.
<i>Filter Low Freq / Wavelen</i>	Specifies the lower cutoff for the filter either in wavelength or frequency when the Filter Type control is set to FFT Fixed and the applicable Filter is selected.

### Interaction of Filter Controls

<i>Filter Type</i>	<i>Filter</i>	<i>Filter Low Frequency Filter Low Wavelength</i>	<i>Filter High Frequency Filter High Wavelength</i>	<i>Filter Window Size</i>	<i>Filter Cutoff</i>	<i>Filter Trim</i>
Average	Low Pass	NA	NA	Yes	NA	Yes
Average	High Pass	NA	NA	Yes	NA	Yes
Median	Low Pass	NA	NA	Yes	NA	Yes
Median	High Pass	NA	NA	Yes	NA	Yes
2 Sigma	Low Pass	NA	NA	Yes	NA	Yes
2 Sigma	High Pass	NA	NA	Yes	NA	Yes
FFT Auto	Low Pass	NA	NA	NA	Yes	Yes
FFT Auto	High Pass	NA	NA	NA	Yes	Yes
FFT Auto	Band Pass	NA	NA	NA	Yes	Yes
FFT Auto	Band Reject	NA	NA	NA	Yes	Yes
FFT Fixed	Low Pass	NA	Yes	NA	Yes	Yes
FFT Fixed	High Pass	Yes	NA	NA	Yes	Yes
FFT Fixed	Band Pass	Yes	Yes	NA	Yes	Yes
FFT Fixed	Band Reject	Yes	Yes	NA	Yes	Yes

NA means not applicable.

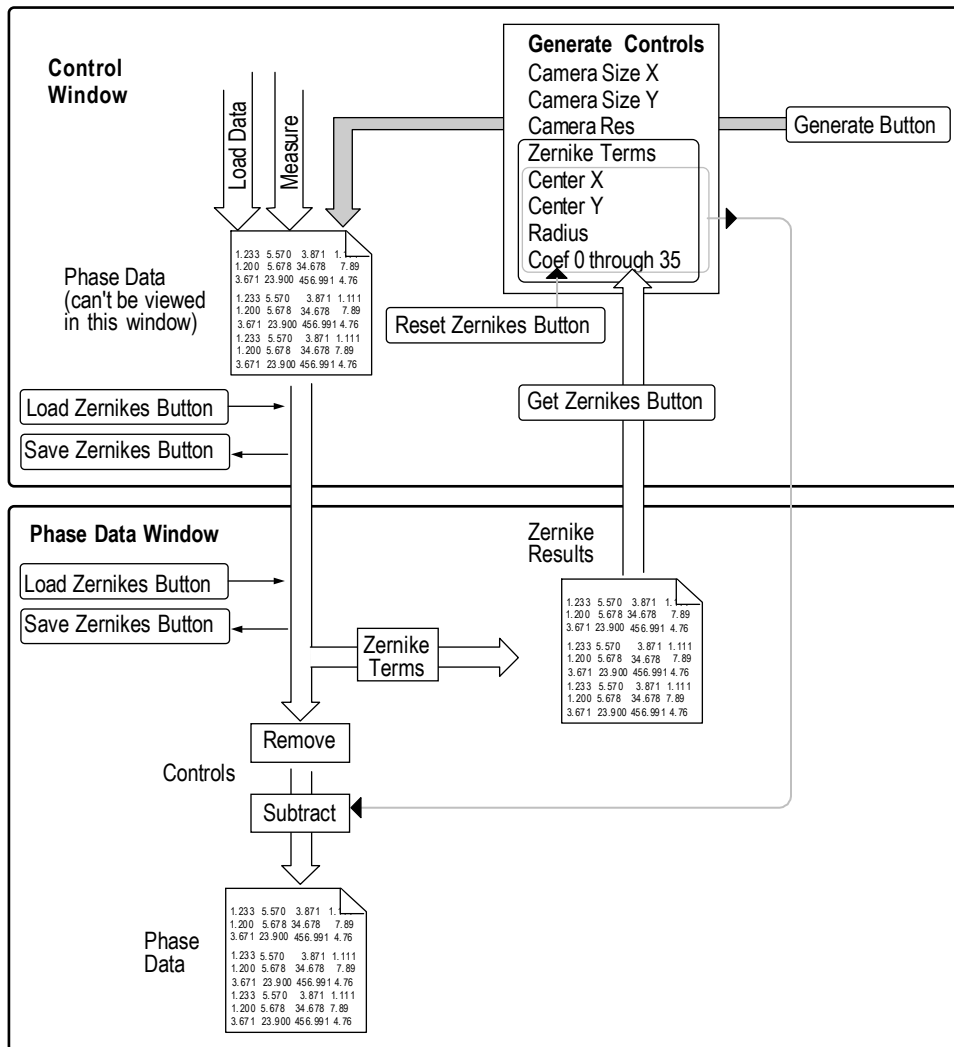
## Generate Function

A group of controls and buttons are used together to create and manipulate Zernike polynomials. Most of the controls and buttons are available in the Control window and created with the New Control → Generate command.

The generate features can be used to:

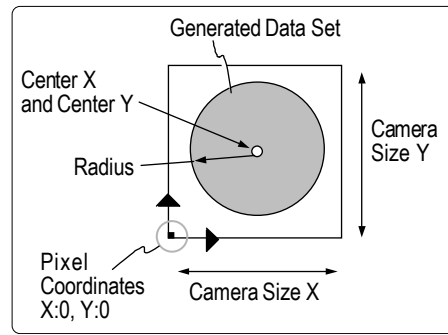
- create or generate a theoretical wavefront without an actual test part.
- subtract specific aberrations from an existing data set.
- compare a measured wavefront with a design wavefront.

### Generate Overview



## The Generate Controls

<i>Item</i>	<i>Function</i>
<i>Generate button</i>	Creates a data set based on the settings of the generate controls.
<i>Save Zernikes button</i>	Opens the File Handler, which is used to specify a file name and save the file.
<i>Load Zernikes button</i>	Opens the File Handler, which is used to select the Zernike file to load.
<i>Get Zernikes button</i>	Obtains Zernike terms and characteristics from a current data file in the default data window.
<i>Reset Zernikes button</i>	Resets the Center X, Center Y, and Radius controls to -1, and Coef controls to 0.
<i>Camera Size X</i>	Specifies the number of camera pixels in the x-dimension.
<i>Camera Size Y</i>	Specifies the number of camera pixels in the y-dimension.
<i>Camera Res</i>	Specifies the lateral dimension between camera pixels.
<i>Center X</i>	Specifies the location in the x-axis of the center of generated data; -1 places it at the center of the camera size.
<i>Center Y</i>	Specifies the location in the y-axis of the center of generated data; -1 places it at the center of the camera size.
<i>Coef 0 through Coef 36</i>	Specify the coefficients that comprise the Zernike data.
<i>Radius</i>	Specifies the size of the generated data as the number of pixels from the center; -1 fills the camera size.
<i>Subtract</i>	When set to Gen Zern, the current generated Zernike data is subtracted from the current wavefront data when the Analyze button is clicked..
<i>Zernike Terms</i>	Specifies the number of Zernike terms used when data is generated.



## Using the Generate Function to Subtract Aberrations

1. Measure the test part as usual.
2. Click the Get Zernikes button to capture the Zernikes from the data.
3. Note the significant shape you want to subtract from the data. Zero out the Coef controls that are insignificant. To do this, position the cursor over the Coef control, click the left mouse button; enter all zeroes with the keyboard, then press [Enter].
4. Click the Generate button to create a generated Zernike data set.
5. Set the Subtract Control box to Gen Zern.
6. Click the Analyze button, so the data is reanalyzed with the generated data subtracted from the current data.
7. To save the generated data, click the Save Zernikes button. Click the Current Selection box, type in a name for the file, ending with “.zfr”, then press [Enter]. Click Done to close the File Handler. Note that the settings of the Radius or Center controls are not preserved with Zernike data.

## Limit Function

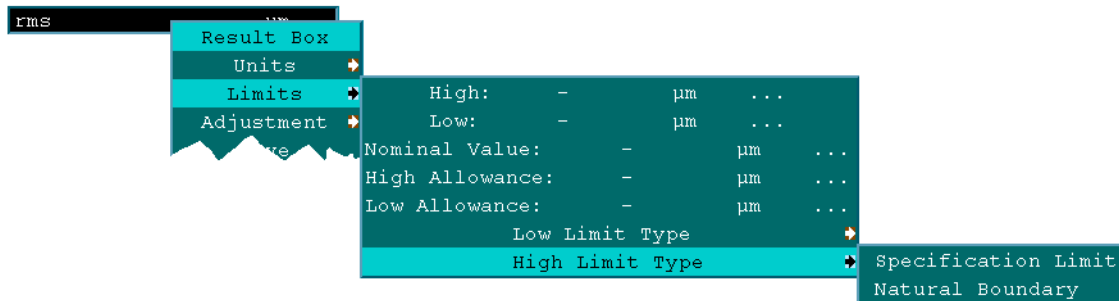
MetroPro can be configured to display visual feedback of user-specified limits for:

- Results (display green for within limits or red for outside of limits)
- Filled Plot, Oblique Plot, 3D Plot, and 3D Model Plot (display red areas outside of PV result high limit)

## Using Limits in a Result

The Limits sub-menu is used to specify what is an acceptable value for a numeric result box. If limits are specified for a result, the result box is green when the value is acceptable, and red when the value is not acceptable. This serves as a visual indicator that the value has passed or failed a set limit.

The Limits Sub-menu for a Result





1. Position the pointer over the Result box and press the right mouse button to access its menu. Access the Limits sub-menu, select the desired option, and enter a numeric value with the keyboard and press [Enter]. Depending on how you want limits to display, additional entries may be required. Note that zero (0) is an acceptable value.
2. To turn the limit function off, access the Limits sub-menu and delete all characters from a defined limit option and press [Enter].

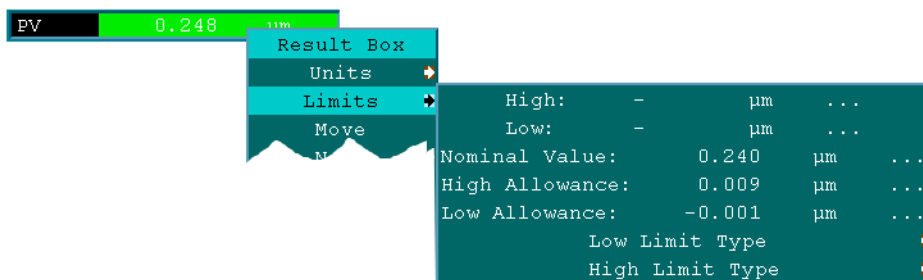
**Two General Approaches for Using Result Limits**

<i>Approach</i>	<i>How Limits are Defined</i>	<i>Limits Sub-menu to use</i>
Range	Limits are based on absolute values.	Enter values in High and/or Low.
Tolerance	Limits are based tolerances (plus and minus values) or allowances.	Enter values in Nominal Value and/or High Allowance and Low Allowance.

**Examples of Using Result Limits**

<i>Indicate if</i>	<i>Use Limits Sub-menu to</i>	<i>How the Result Displays</i>
<i>Value is large</i>	Enter value at High	Result is <i>green</i> when the value is less than the entered value, and <i>red</i> when the value is equal to or greater than the entered value.
<i>Value is small</i>	Enter value at Low	Result is <i>green</i> when the value is equal to or greater than the entered value, and <i>red</i> when the value is less.
<i>Value is outside of range</i>	Enter value at High and Low	Result is <i>green</i> when the value is between the values entered for High and Low, and <i>red</i> when it is outside.
<i>Value is outside of allowance</i>	Enter value at Nominal Value, and/or High Allowance and Low Allowance	Result is <i>green</i> when the value is within the tolerance range (specified with High and Low Allowance) from the Nominal (or base) value.

**Example Showing Use of Tolerance Limits on a Result**



### Notes on Using Result Limits

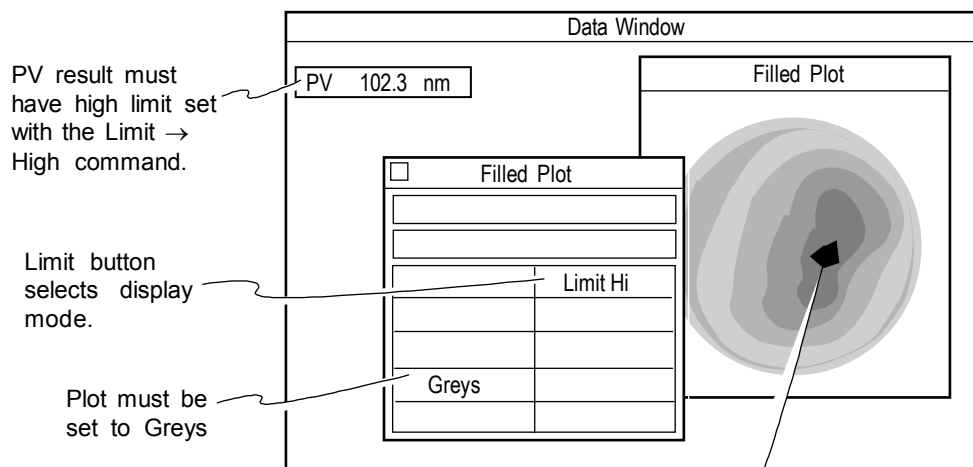
If values are entered for both High and High Allowance, the smaller of the two is used to check for the high limit. If values are entered for both Low and Low Allowance, the larger of the two is used to check for the low limit.

The Low Limit Type and High Limit Type menu selections are information fields to support the Q-DAS report function. They specify whether the applicable limit is a Specification Limit or a Natural Boundary.

### Using Limits in a Plot

The limit function for plots displays areas outside of user-specified limits as red. Limits may be displayed in the Filled Plot, Oblique Plot and 3D Plot if the following conditions are met:

- 1) The plot color is set to Greys with the Plot Controller.
- 2) The limit function is activated with the Plot Controller. The setting of the Limit button determines how limits are displayed.
- 3) The PV result, in the same data window, must have limits set with the Limits → High command.

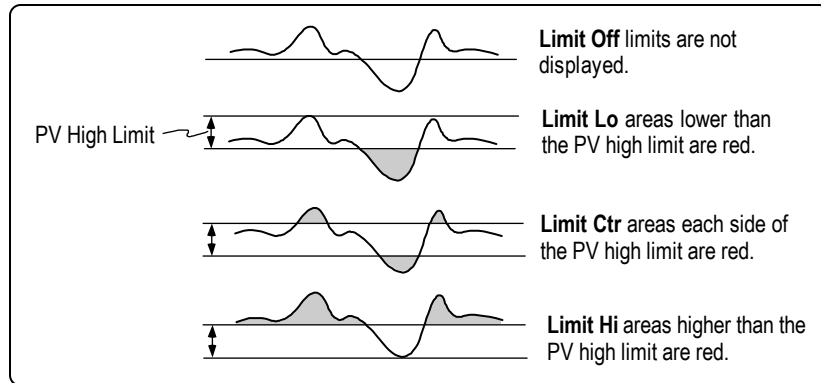


*The Filled plot and PV result must be in the same data window.*

In this example, the area above the PV high limit is displayed in red.

### How Limits are Highlighted in the Plot

The plot Controller Limit button has four choices: Limit Off, Limit Lo, Limit Ctr (center), or Limit Hi. Depending upon the limit value entered in the PV result and the Limit button setting, red areas may be shown in the plot.



### ***Displaying Limits in a Filled, Oblique, 3D, or 3D Model Plot***

1. If the data window does not contain a PV result, create one using the New Result command.
2. Using the PV result box menu, select the Limits → High command and enter a value.
3. Open the plot Controller by clicking on the plot with the middle mouse button.
4. Click the plot Controller Limit button, with the left mouse button, to select the way limits are displayed.
5. To update the plot, click the Controller's Update button.
6. To preserve the plot settings, click the Controller's Set button.
7. To preserve your changes, save the application with the Application Window menu Re-save Application command.

## Linked Control Settings

In certain measurement situations, it is desirable to have a control's value be derived from another control or attribute. For example, Lot Number, Part Number, Part Serial Number, Pattern File and Within Field Pattern File information may be included in one or more of the following MetroPro controls: Auto Save Data File, Auto Save Data Dir, Log File (in a Report Window), and Log Dir (in a Report Window).

Most control values are set by the operator (or scripts) and are preserved when the application is saved. Controls affect the operation of the next measurement or pattern run. The following table identifies the special codes, which can be used to embed values of other controls into certain file and directory name controls.

**Special Codes to Embed Values from Controls**

<i>Control Name</i>	<i>Type of Entry</i>	<i>Code</i>
Lot Num	Text	@LN
Lot Num	Text	@L <sup>1</sup>
Part Num	Text	@PN
Part Num	Text	@P <sup>1</sup>
Part Ser Num	Text	@SN
Part Ser Num	Text	@S <sup>1</sup>
Pattern File	Text	@PF <sup>2</sup>
Within Field Pattern File	Text	@WF <sup>2</sup>

1 These single character codes were available in previous releases

(Log File Control only) and are supported for backward compatibility.

2 The @PF and @WF codes strip the ".pat" extension from the filename.



Special codes for embedding values are case sensitive. Codes for controls are uppercase, whereas codes for attributes are lowercase.

## Embedding Values from Attributes

An attribute's value is not set by the operator, but is cleared and set during certain operations. In many cases, an attribute is simply set at the end of an operation with the value of the control of the same name. Attributes show information about the previous measurement or pattern run.

The following table lists the special codes, which can be used to embed values of attributes into certain file and directory name controls.

## Special Codes to Embed Values from Attributes

<i>Attribute Name</i>	<i>Type of Entry</i>	<i>Code</i>	<i>When Cleared &amp; Set</i>
Lot Num	Text	@ln	Cleared at start of data acquisition. Set at end of data acquisition before analysis.
Part Num	Text	@pn	Cleared at start of data acquisition. Set at end of data acquisition before analysis.
Part Ser Num	Text	@sn	Cleared at start of data acquisition. Set at end of data acquisition before analysis.
Pattern File	Text	@pf <sup>1</sup>	Set by pattern run before first stage movement.
Within Field Pattern File	Text	@wf <sup>1</sup>	Set by a script.
Pattern Row	Integer	@pr <sup>2</sup>	Set during pattern run.
Pattern Col	Integer	@pc <sup>2</sup>	Set during pattern run.

1. The @pf and @wf codes strip the “.pat” extension from the file name.
2. The @pr and @pc codes can be immediately followed by a format specification enclosed by two ‘!’ characters.

**Examples from the Above Table**

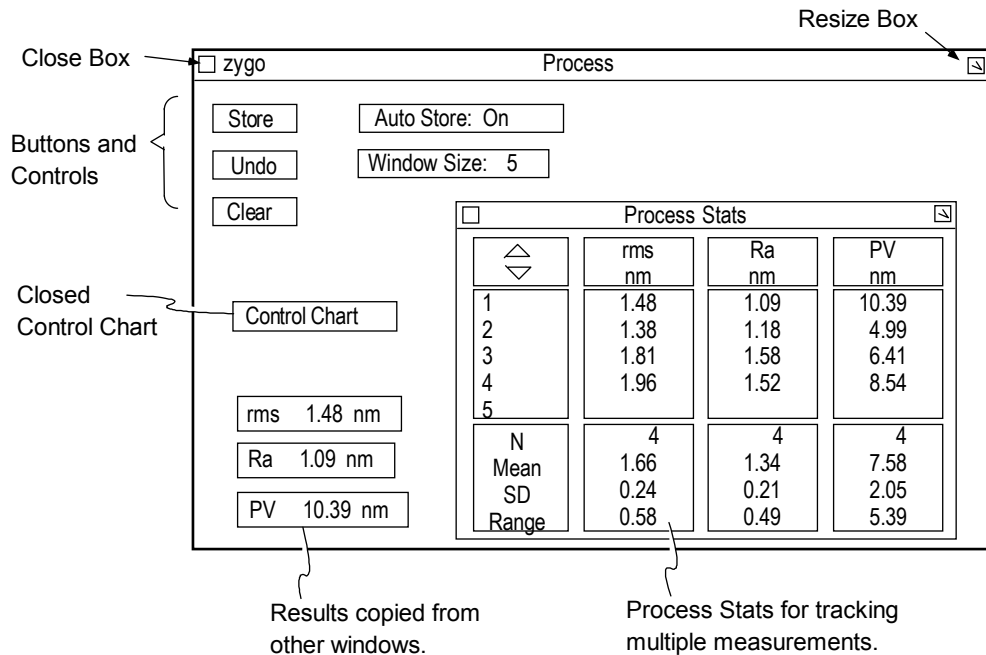
@pr!%4d! embeds the pattern row number with a minimum field width of four, left-padded with blanks.

@pc!%03d! embeds the pattern column number with a minimum field width of three left-padded with zeroes.

## Process Window

The Process window is used to gather and organize result boxes from different data windows into one window for display. The Process window also contains buttons and controls that interact with Control Charts and Process Stats. The Process window can display Control Charts and Process Stats made from results from different data windows.

The Process window is created with the Application window menu New Process Window command. You can use more than one Process window. The Process window is a “display” window, its contents cannot be saved. To save or output the results of numerous measurements, use the Report window.

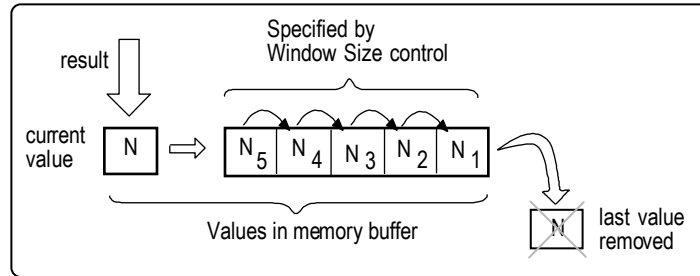


### Controls in the Process Window

<i>Item</i>	<i>Function</i>
<i>Store button</i>	Places the current displayed result value into buffer memory; adds value to Process Stats and Control Charts.
<i>Undo button</i>	Removes the last entered result values from buffer memory; removes value from Process Stats and Control Charts.
<i>Clear button</i>	Erases all values from buffer memory; clears all values from Process Stats and Controls Charts.
<i>Auto Store</i>	When On, values are stored in buffer memory as measurements are made; Process Stats and Controls Charts are updated with each measurement. When Off, values are not placed in memory.
<i>Window Size</i>	Specifies the size of the buffer memory or the number of values for each result. Controls the number of measurements on Control Charts and the number of values used in Process Stats.



## How Result Information is Handled in the Process Window

Multiple measurement result values are stored in temporary memory. The temporary memory buffer for a result is activated when it is created. The number of values stored for one result is determined by the Window Size control. As new values are added at the front, older results drop out.



## Creating a Process Window

When first created, the Process window contains three buttons and two controls; it does not contain any results, Control Charts, or Process Stats.

1. Create the Process Window by selecting the Application Window menu New Process Window command.
2. Select the Copy Output Box from the window's menu. The cursor turns to an arrow with an asterisk .
3. Point to the result that you want to copy and press and hold the left mouse button. An outline of the box appears.
4. Move the mouse to position the box inside the Process window and release the mouse button. The box appears at this location.
5. The cursor remains  for further copying. To copy additional results repeat steps 3 and 4.
6. When done copying output boxes, click the right mouse button.



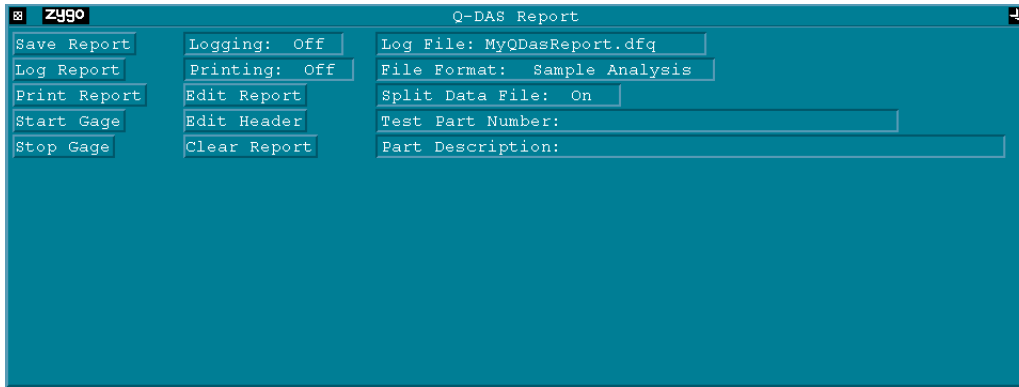
Since you can mix results from different data windows you must be careful not to confuse results with the same names from different windows. You can change the name of a result with the result menu's Name command.

7. To display statistical information about the all the results gathered into the window select the New Result → Process Stats command.
8. To save your work, select the Re-save Application command from the Application Window menu.

## Q-DAS Report Window

The Q-DAS Report window is used to output measurement data in Q-DAS compatible format. Numeric results from other windows can be copied into the window and become part of the Q-DAS report. Functionality is similar to the standard Report window. The Q-DAS report file can be saved, logged (appended) after each measurement, and output to a printer or another computer.

The Q-DAS Report window is created with the Application Window menu New Q-DAS Report Window command. You can have more than one report window.



### Controls in the Q-DAS Report Window

<i>Item</i>	<i>Function</i>
<i>Save Report button</i>	When clicked, opens the file handler, which is used to save the contents of one report window under a user-supplied name. For information about file extensions, see the Split Data File control.
<i>Log Report button</i>	When clicked, adds the contents of the report window to the report file specified by the Log File control.
<i>Print Report button</i>	When clicked, outputs the contents of the report window to a printer.
<i>Start Gage button</i>	When clicked, clears existing data and starts the gage test. The File Format control must be set to Gage-Type 1 or Gage-Type 3. All gage studies are started by clicking this button.
<i>Stop Gage button</i>	When clicked, stops a running gage test. This button is used to end a “manual” gage sequence or to abort an active gage study.
<i>Logging</i>	When On, the contents of the report window is saved (appended) to the file, named by the Log File control, after each measurement.
<i>Printing</i>	When On, the contents of the report window is output to a printer after each measurement.
<i>Edit Report button</i>	When clicked, opens a file for editing in a text window. If the Split Data File is Off, the file specified in the Log File control is opened. If the Split Data File is On, the .dfx file is opened.





## Controls in the Q-DAS Report Window (continued)

<i>Item</i>	<i>Function</i>
<i>Edit Header button</i>	When clicked, opens a file for editing in a text window. If the Split Data File is Off, the file specified in the Log File control is opened. If the Split Data File is On, the .dfd file is opened.
<i>Clear Report button</i>	When clicked, the file specified by the Log File control is cleared of values.
<i>Log File</i>	Specifies the name of the report file. For information about file extensions, see the Split Data File control.
<i>File Format</i>	Selects the format of the Q-DAS report. The settings are: Sample Analysis, Gage-Type 1, or Gage-Type 3. Sample Analysis is a standard test measurement. Gage-Type 1 is a gage study using one operator measuring a known reference standard a number of times. Gage-Type 3 is a gage study using one operator measuring a number of parts in a series of measurement trials.
<i>Split Data File</i>	Selects whether the report is saved as one file or two. When Off, the file is saved as one, with the extension as .dfq. When On, the file is split into a header file, with the extension .dfd, and a data file, with the extension .dfx. The files will have the base name specified in the Log File control.
<i>Test Part Number</i>	Required text entry. A user-supplied number for identification of the part being tested.
<i>Part Description</i>	Required text entry. A user-supplied description or name of the part being tested.

## Creating a Q-DAS Report Window

When first created, the Report window comes equipped with buttons and controls.

1. Create the Q-DAS Report Window by selecting the Application Window menu New Q-DAS Report Window command.
2. Select the Copy Output Box from the window's menu. The cursor turns to an arrow with an asterisk .
3. Point to the result that you want to copy and press and hold the left mouse button. An outline of the box appears.
4. Move the mouse to position the box inside the Report window and release the mouse button. The box appears at this location. Copied Result and Attribute boxes "snap" to an invisible grid. The grid helps keep boxes aligned without overlapping.
5. The cursor remains  for further copying. To copy additional results repeat steps 3 and 4.

- When done copying output boxes, click the right mouse button.



Since you can mix results from different data windows you must be careful not confuse results with the same names from different windows. You can change the name of a result with the result menu's Name command.

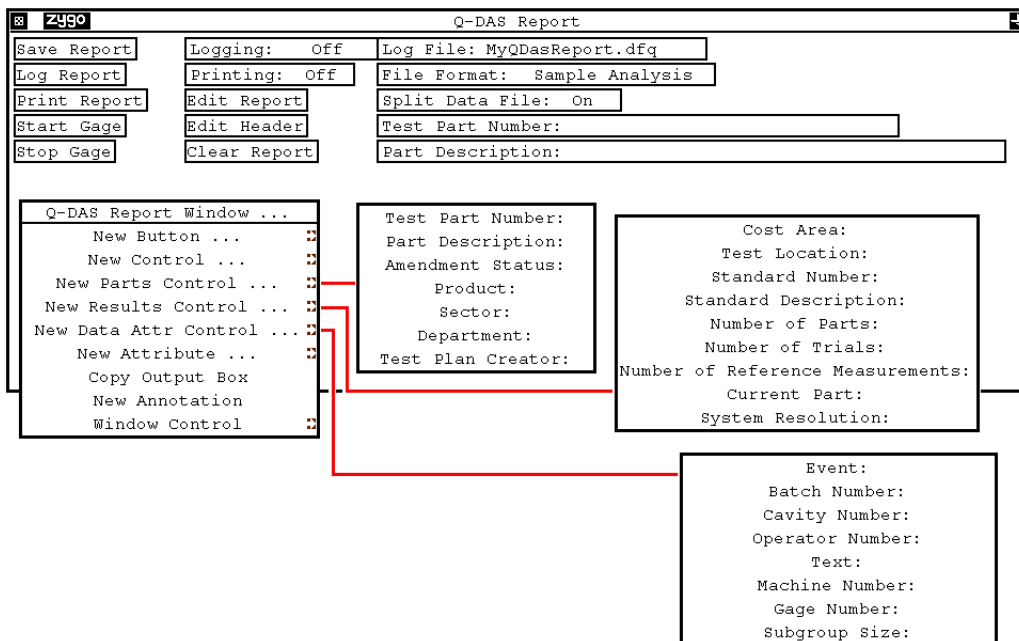
- Customize the boxes in the Report window with their respective menus. You can move the boxes, rename them, or change their layout. You should arrange the order and placement of the boxes into a pleasing arrangement. Use blank Annotation boxes as line spacers.
- To save your work, select the Re-save Application command from the Application Window menu.

### Generating a Q-DAS Report

- Enter text in the Test Part Number and Part Description controls. Set the Logging control to On.
- (Optional) Enter a file name in the Log File control. Select appropriate settings in the File Format and Split Data File controls.
- Begin making measurements. Report information is automatically logged to a file as measurements are made. The Q-DAS report is created and stored in the current directory.

### Additional Q-DAS Controls

The following controls are available through the Q-DAS Report Window menu.



**Additional Q-DAS Controls (continued)**

<b>Item</b>	<b>Function</b>
<i>Amendment Status</i>	Text entry for the date and time of the last change to the part drawing. (Parts Control)
<i>Batch Number</i>	An alphanumeric entry in the Q-DAS Report window, which identifies the batch number. This entry is saved with the data. (Data Attr Control)
<i>Cavity Number</i>	A numeric entry in the Q-DAS Report window, which specifies either the cavity, nest, or spindle number. This entry is saved with the data. (Data Attr Control)
<i>Cost Area</i>	Text entry for entering cost information. (Results Control)
<i>Current Part</i>	Specifies the number of the part being currently measured in a type 3 manual gage study.
<i>Department</i>	Text entry for entering department information. (Parts Control)
<i>Event</i>	A numeric entry for entering event codes in the Q-DAS Report window. Enter a list of numbers in the range of 0 to 255, separated by spaces. This entry is saved with the data. (Data Attr Control)
<i>Gage Number</i>	A numeric entry in the Q-DAS Report window for identifying the gage number. This entry is saved with the data. (Data Attr Control)
<i>Gage Sequence</i>	<p>Selects the sequence during a gage study when the File Format control is set to Gage-Type 3. The settings are: Manual, All Parts Per Trial, or All Trials Per Part.</p> <p>When set to <i>Manual</i>, you track the measurement sequence. For each measurement, you must specify the current part in the Current Part control. The “Current” attributes provide feedback on the sequence. The manual study is started with the Start Gage button and ends by clicking the Stop Gage button.</p> <p>When set to <i>All Parts Per Trial</i>, every part is measured once in an ordered sequence and then this sequence is repeated. The Number of Trials control determines the number of sequences.</p> <p>When set to <i>All Trials Per Part</i>, each part is measured multiple times in succession, then the next part is measured and so on. The Number of Trials control determines how many times each part is measured.</p> <p>For both All Parts Per Trial and All Trials Per Part settings, the study is started with the Start Gage button, but ends automatically. Also, the part number is automatically incremented after the data is logged and the “Current” and “Next” attributes show the status of the gage study. .</p>
<i>Machine Number</i>	A numeric entry in the Q-DAS Report window for identifying the machine number. This entry is saved with the data. (Data Attr Control)

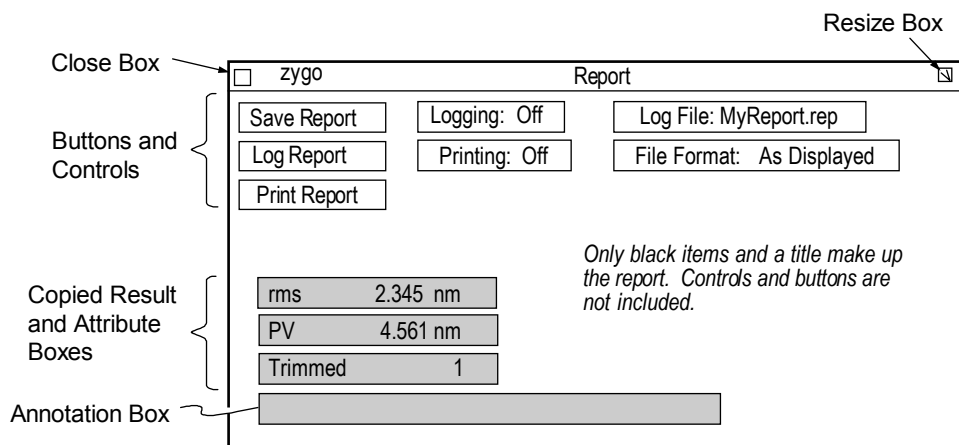
**Additional Q-DAS Controls (continued)**

<i>Item</i>	<i>Function</i>
<i>Number of Parts</i>	Numeric entry for specifying the number of parts being measured during a Type-3 gage study. The default setting is 25.
<i>Number of Reference Measurements</i>	Numeric entry for specifying the number of times the reference standard is measured during a Type-1 gage study. The default setting is 25.
<i>Number of Trials</i>	Numeric entry for specifying the number of times each part is measured during a Type-3 gage study. The default setting is 25.
<i>Operator Number</i>	A numeric entry in the Q-DAS Report window, which identifies the number of the operator of the machine. This entry is saved with the data. (Data Attr Control)
<i>Product</i>	Text entry for entering product information. (Parts Control)
<i>Sector</i>	Text entry for entering sector information. (Parts Control)
<i>Standard Description</i>	Text entry for entering a description of the reference standard used on a Type-1 gage study.
<i>Standard Number</i>	Text entry for the part number of the reference standard used on a Type-1 gage study.
<i>Subgroup Size</i>	A numeric entry in the Q-DAS Report window for the subgroup or sample size. This entry is saved with the data. (Data Attr Control)
<i>System Resolution</i>	Numeric entry for entering the vertical resolution of the instrument. (Results Control)
<i>Test Location</i>	Text entry for entering the location of the test. (Results Control)
<i>Test Plan Creator</i>	Text entry for entering a person's name. (Parts Control)
<i>Text</i>	A text entry in the Q-DAS Report window for adding additional textual information. This entry is saved with the data. (Data Attr Control)

## Report Window

The Report window is used to compile Result boxes and Attribute boxes from data and control windows into one window for the purpose of creating a report file. The report file can be saved, logged (appended) after each measurement, and output to a printer or another computer. The Report window is useful when you want to consolidate many results together from different data windows.

The Report window is created with the Application Window menu New Report Window command. You can have more than one Report window.





**Controls in the Report Window**

<i>Item</i>	<i>Function</i>
<i>Save Report button</i>	Click to open the File Handler, which is used to save the contents of one report window under a specified name.
<i>Log Report button</i>	Adds the contents of the report window to the report file specified by the Log File control.
<i>Print Report button</i>	Outputs the contents of the report window to a printer.
<i>Logging</i>	When On, the contents of the report window is saved (appended) to the file, named by the Log File control, after each measurement.
<i>Log File</i>	Specifies the name of the report file to which measurement results are appended to; it should end with “.rep”.
<i>File Format</i>	Selects the format of the report file. Choices are: As Displayed, Comma Separated, or Tab Separated.
<i>Printing</i>	When On, the contents of the report window is output to a printer after each measurement.
<i>Post-Log Command</i>	Specifies a command for post processing.

## Creating a Report Window

When first created, the Report window comes equipped with three buttons and four controls, and is exactly 80 characters wide. If you make the Report window wider, you may lose information when printed.

1. Create the Report Window by selecting the Application Window menu New Report Window command.
2. Select the Copy Output Box from the window's menu. The cursor turns to an arrow with an asterisk .
3. Point to the result that you want to copy and press and hold the left mouse button. An outline of the box appears.
4. Move the mouse to position the box inside the Report window and release the mouse button. The box appears at this location. Copied Result and Attribute boxes "snap" to an invisible grid. The grid helps keep boxes aligned without overlapping.
5. The cursor remains  for further copying. To copy additional results repeat steps 3 and 4.
6. When done copying output boxes, click the right mouse button.

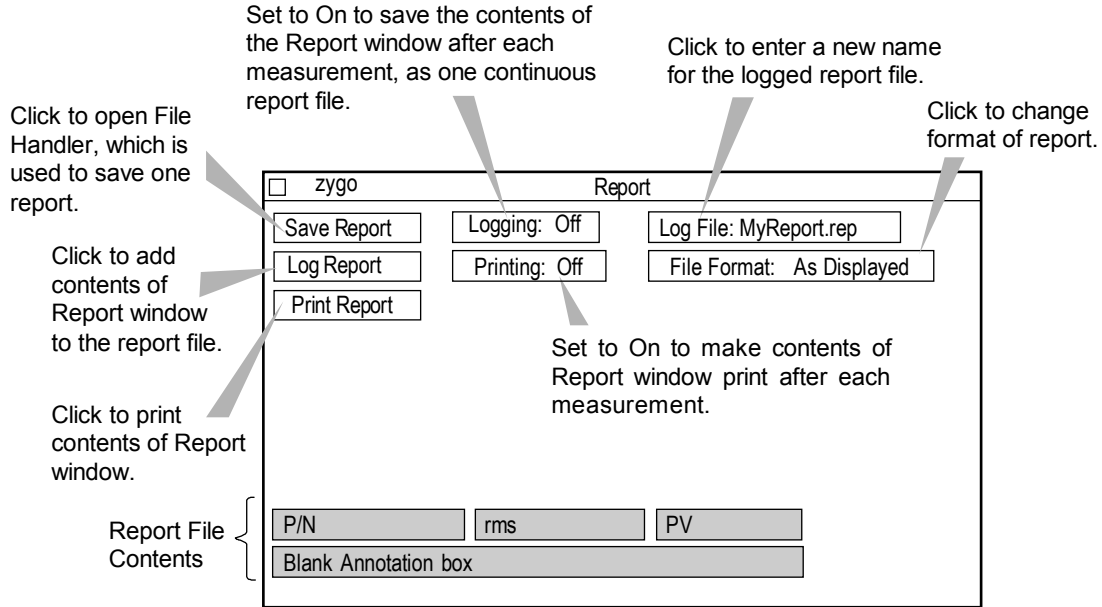


Since you can mix results from different data windows you must be careful not to confuse results with the same names from different windows. You can change the name of a result with the result menu's Name command.

7. Customize the boxes in the Report window with their respective menus. You can move the boxes, rename them, or change their layout. You should arrange the order and placement of the boxes into a pleasing arrangement. Use blank Annotation boxes as line spacers.
8. To save your work, select the Re-save Application command from the Application Window menu.

## Using the Report Window

The Report window may be used in a number of ways, including: saving individual reports, logging selected reports, logging a series of reports, and logging reports and sending the reports to a printer at the same time.



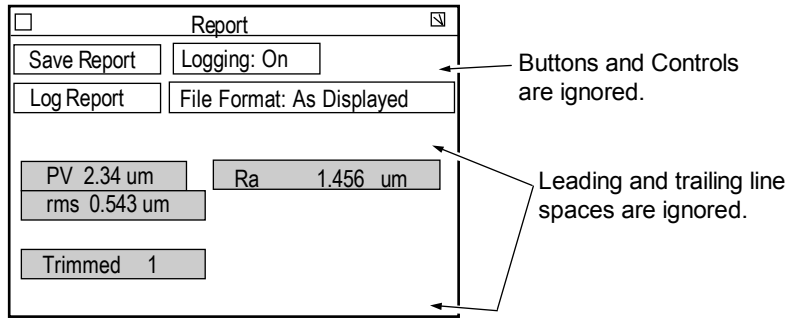
## Saving a Report File

1. Click the Save Report button. In the File Handler, click the Current Selection box, enter a name for the report, ending with “.rep”, then press [Enter]. Click the Done button to close the File Handler.

## The Report File

A report file contains Result and Attribute boxes with their contents along with a one line title. Buttons and control within the Report window are not part of the report file. The report file does not contain font or type style information on the boxes; it only contains the information inside the boxes in plain ASCII text.

The contents of the report file depend upon a number of factors, including: what Result and Attribute boxes are in the window, their placement within the window, and the setting of the File Format control.



<i>File Format</i>	<i>Sample Output</i>
<i>As Displayed</i>	Zygo MetroPro Report PV 2.34 um Ra 1.456 um rms 0.543 um  Trimmed 1
<i>Comma Separated</i>	"Zygo MetroPro Report" "PV",2.34," um ","Ra",1.456," um " "rms",0.543," um " " "Trimmed",1
<i>Tab Separated</i>	"Zygo MetroPro Report" "PV" 2.34 " um " "Ra" 1.456 " um " "rms" 0.543 " um " " "Trimmed" 1

## Specialized Report Functions

Add the contents of a window to the report by entering **@W (string)** in an Annotation box within the Report window. Where (string) refers to the name of an existing Stats or Zernike window in MetroPro.



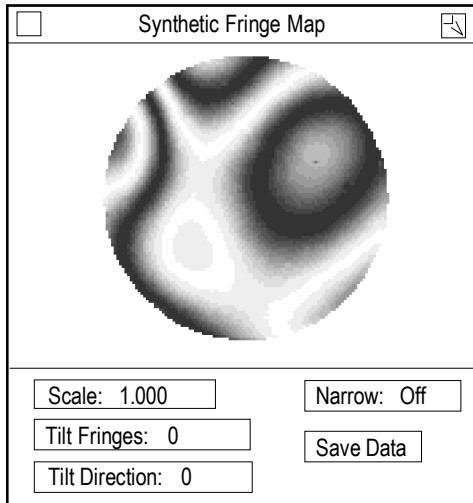
The Stats or Zernike window must be open for @W to function correctly.



## Synthetic Fringes

MetroPro can create synthetic or virtual fringes from the phase data. Fringes are only created when there is valid phase data. The number of fringes, the orientation, and the density are selectable. Synthetic fringes can be used as an aid in viewing surface detail of a smooth part by increasing the scale.

The Synthetic Fringe window is created with the Application Window menu New Data Window command. To display the fringes, use the window's menu to create a Filled Plot.



**Scale** Multiplies or divides the number of fringes per wave. Less than 1 divides, greater than 1 multiplies.

**Tilt Fringes** Adds the number of fringes to the cavity.

**Tilt Direction** Specifies the orientation of the tilt fringes. Numeric entry in degrees.

**Narrow** Reduces the width of the dark fringes. On or Off.

**Save Data** Click to open the File Handler so manipulated fringe data can be saved.

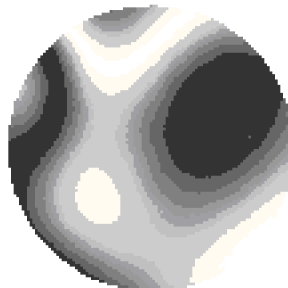
Click the Analyze button to update the plot when settings are changed.

### Examples of Synthetic Fringes

The examples shown below are derivatives of the above original.



Scale: 1.000  
Tilt Fringes: 5  
Tilt Direction: 0



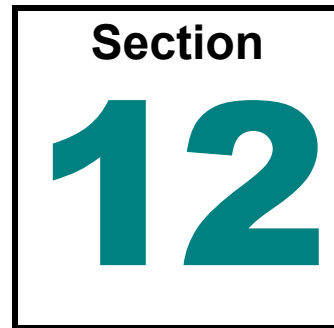
Scale: 0.5  
Tilt Fringes: 0  
Tilt Direction: 0



Scale: 5  
Tilt Fringes: 0  
Tilt Direction: 0



# ***Data Format and Conversion***



*If you need to import or export data with MetroPro, the details are covered here.*

## **Supported Data Formats**

- Binary Data File (MetroPro “.dat” format)
- HDP Data File (Zygo Corporation’s data format before MetroPro)
- ASCII Data File
- Raw ASCII Data File
- CODE V Data File
- OSLO Spreadsheet Data File - Zernike Information
- ZEMAX Grid Sag Data File
- SDF Data File
- XYZ Data File

CODE V is a registered trademark of Optical Research Associates.

OSLO is a registered trademark of Sinclair Optics, Inc.

ZEMAX is a registered trademark of Focus Software, Inc.

All of the above-mentioned file formats are described in greater detail in this section. MetroPro’s native data file format is binary (.dat). Click the Save Data button to create a binary data file. MetroPro also outputs CODE V Zernike compatible data files (.zfr). Click the Save Zernikes button to create this file format.

To export data, MetroPro binary data must be converted to the selected format using the appropriate conversion utility included with MetroPro.

To import data, the file must be converted to a binary data file using the appropriate conversion utility included with MetroPro.



Use the Report Window if all you want to do is output results and measurement attributes to a spreadsheet program or another computer. The use of this window is described in Section 11.

Cabling and/or network requirements for transferring data into and out of MetroPro are the responsibility of the end-user.

## MetroPro Binary Data File Format

MetroPro supports filing measurement data using several different types of files. The Binary Data File is the *native* format. It is the most efficient in terms of disk space and time required to save or load data. It is called “binary” because the values are stored in low-level machine representations (e.g. bytes and words instead of lines of text). The files cannot be read or written with an ordinary text editor.

The following information about the binary data file format is provided so that a programmer can develop:

- Reader software to read and correctly interpret files that were created by MetroPro.
- Writer software to create files that can be read and correctly interpreted by MetroPro.

There are three versions of the binary format. MetroPro is always backward compatible with older versions of the file format. That is, newer versions of MetroPro can always load data that was saved by older versions of MetroPro.

### File Structure

**The general file structure is as follows:**

Data Set 1 (required)

Data Set 2...N (optional)

Most binary data files contain just one Data Set. Only a few of the various types of MetroPro applications create binary data files containing multiple Data Sets (e.g. MST applications).

**A Data Set is structured as follows:**

Header (required)

Intensity Data Matrix (optional)

Phase Data Matrix (optional)

A Data Set will always contain *at least one*, often *both* of the two types of matrices: Intensity and Phase.

Every binary data file begins with a Header (the one associated with the first Data Set).

The Header contains many data items or *fields*. Only a few of these values are essential to properly access and interpret the Intensity and Phase data matrices. Most of the other fields may be considered non-essential attributes (e.g. ancillary information about the measurement setup).

The Header fields have various data types and byte orders indicated by the key letters in the following table:

Key Letter	Meaning
I	Integer numeric field
F	Floating point numeric field (IEEE standard format)
B	Numeric field stored in big-endian byte order
L	Numeric field stored in little-endian byte order
S	String field, null terminated
C	Character field

The first 10 bytes of the Header contain three fields that serve as a “signature” for a MetroPro binary data file. These fields are described in the following table:

Key	Bytes	Length	Field Name
IB	0001-0004	4	magic number
IB	0005-0006	2	header format
IB	0007-0010	4	header size

As of this writing, there are only three recognized combinations of these values as shown in the following table:

magic_number (hex)	header_format	header_size (bytes)
0x881B036F	1	834
0x881B0370	2	834
0x881B0371	3	4096

Reader software that is rigorous should read all three values and validate them per the above table.

Complete maps of the header formats can be obtained by running the **dat\_test.exe** program that is included with MetroPro in folder C:\MetroPro\Bin. Type the following at a command prompt:

```
dat_test -maps > maps.txt
```

File maps.txt will contain the output.

### Intensity Data Matrix

The Intensity Data Matrix is typically a matrix of pixel intensity values grabbed from the instrument camera. (In MetroPro, this is normally displayed in an Intensity Map data window.) This matrix may contain multiple camera frames or “buckets”. Or, it may contain a single frame that is the result of a transform applied to multiple frames (e.g. Remove Fringes).

The essential Header fields required to access and properly interpret the Intensity Data Matrix are described below

Key	Bytes	Length	Field Name
IB	0049-0050	2	ac_org_x
IB	0051-0052	2	ac_org_y
IB	0053-0054	2	ac_width
IB	0055-0056	2	ac_height
IB	0057-0058	2	ac_n_buckets
IB	0059-0060	2	ac_range
IB	0061-0064	4	ac_n_bytes

(The prefix ac\_ stands for acquired.)

The **ac\_org\_x** and **ac\_org\_y** values are the coordinates of the origin (upper left) of the intensity data matrix relative to the origin of the camera (upper left).

The **ac\_width** and **ac\_height** values are the X and Y dimensions of the matrix, respectively.

The **ac\_n\_buckets** value is the number of frames in the matrix.

The **ac\_range** value is the maximum expected intensity value (e.g. 255 for an 8-bit frame grabber).

The **ac\_n\_bytes** value is the total number of bytes occupied by the intensity matrix in the file.

If the Intensity Data Matrix is present in the Data Set, then it begins immediately after the Header.

Each data point is an unsigned 16-bit (2-byte) integer stored in big-endian byte order. The points are in row-major order, beginning at the upper left.

The total number of points is:  $ac\_width \cdot ac\_height \cdot ac\_n\_buckets$ .

Valid points are in the range [0,ac\_range]. Invalid points (dropouts) have value 65535 (hex 0xFFFF).

## Phase Data Matrix

The Phase Data Matrix typically represents a surface or wavefront map (e.g. this matrix would normally be displayed in a MetroPro Surface/Wavefront Map data window). It was named “phase data” because when it was conceived, the data was obtained using phase modulating interferometry.

The essential Header fields required to access and properly interpret the Phase Data Matrix are described in the following table:

Key	Bytes	Length	Field Name
IB	0065-0066	2	cn_org_x
IB	0067-0068	2	cn_org_y
IB	0069-0070	2	cn_width
IB	0071-0072	2	cn_height
IB	0073-0076	4	cn_n_bytes
FB	0165-0168	4	intf_scale_factor
FB	0169-0172	4	wavelength_in
FB	0177-0180	4	obliquity_factor
IB	0219-0220	2	phase_res

(The prefix **cn\_** stands for connected.)

The **cn\_org\_x** and **cn\_org\_y** values are the coordinates of the origin (upper left) of the phase data matrix relative to the camera origin (upper left).

The **cn\_width** and **cn\_height** values are the X and Y dimensions of the matrix, respectively.

The **cn\_n\_bytes** value is the total number of bytes occupied by the matrix in the file.

If the Phase Data Matrix exists in the Data Set, then it begins immediately after the Intensity Data Matrix, if that exists. If the Intensity Data Matrix does not exist, then the Phase Data matrix begins immediately after the Header.

Each phase data point is a signed 32-bit (4-byte) integer stored big-endian byte order. The points are in row-major order, beginning at the upper left.

The total number of points is:  $cn\_width \cdot cn\_height$ .

Valid points are normally in the range  $[-2097152, 2097151]$ . Invalid points (dropouts) have values greater than or equal to 2147483640 (hex 0x7FFFFFF8).

The phase data values are in units of “zygos”. A zygo is a fraction of a fringe of interference.

To convert a phase data value to waves, meters or some other standard unit, it is necessary to utilize four other values obtained from the Header.

The **intf\_scale\_factor** value is a unit-less positive number. It is a scale factor corresponding to the interferometric setup (e.g. 0.5 for double-pass). (This value is set by the MetroPro Intf Scale Factor control.)

The **wavelength\_in** value is a positive number in meters specifying the wavelength of the interferometer light source (e.g.  $6.328e-7$  m for a HeNe laser). (This value is set by the MetroPro Wavelength-In control.)

The **obliquity\_factor** value is a unit-less positive number. It is a scale factor, usually close to 1, that corrects for a non-normal mean angle of incidence in interferometric microscopes.

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The **phase\_res** value is an integer indirectly specifying the resolution of a zygo. (This is set by the MetroPro Phase Res control.) Note that the interpretation of the **phase\_res** value changed when the **header\_format** was changed from 1 to 2. The following table shows how to determine the resolution value (R) based on the **header\_format** and **phase\_res** values:

header_format	phase_res	R
1	0	4096
1	1	32768
2 or 3	0	4096
2 or 3	1	32768
2 or 3	2	131072

The resolution of a zygo is (1/R) fringe.

To convert a phase data value from zygos to a height, use these formulas:

S = intf\_scale\_factor

W = wavelength\_in

O = obliquity\_factor

R = resolution from above table

To convert to a height in **waves**, multiply by (S • O / R).

To convert to a height in **meters**, multiply by (W • S • O / R).



## ASCII Data File Format

This section describes the format of a MetroPro ASCII data file. The file is made up of three parts: header, intensity data, and phase data. Each part is followed by a line containing a sharp (#) character. At least one of the data sets must be present. A MetroPro ASCII data file is created by using the `dat_to_asc` conversion utility.

### ASCII Data File Header Information

The header consists of 14 required lines of information. Line 1 is a string constant (not enclosed in quotes). The remaining lines contain named fields.

<i>Line</i>	<i>Field Name</i>
1	Zygo ASCII Data File - Format 2
2	SoftwareType MajorVers MinorVers BugVers SoftwareDate
3	IntensOriginX IntensOriginY IntensWidth IntensHeight NBuckets IntensRange
4	PhaseOriginX PhaseOriginY PhaseWidth PhaseHeight
5	Comment
6	PartSerNum
7	PartNum
8	Source IntfScaleFactor WavelengthIn NumericAperture ObliquityFactor Magnification CameraRes TimeStamp
9	CameraWidth CameraHeight SystemType SystemBoard SystemSerial InstrumentId ObjectiveName
10	AcquireMode IntensAvg PZTCal PZTGain PZTGainTolerance AGC TargetRange LightLevel MinMod MinModPts
11	PhaseRes PhaseAvg MinimumAreaSize DisconAction DisconFilter ConnectionOrder RemoveTiltBias DataSign CodeVType
12	SubtractSysErr SysErrFile
13	RefractiveIndex PartThickness
14	ZoomDesc

## ASCII Data File Header Field Descriptions

Each header field in an ASCII data file is described below. The types of fields are: integer, real, and string. The integer fields are always whole numbers. The real fields may be whole numbers, decimal, or exponential notation. The string fields are fixed-length (blank padded) and enclosed in double-quotes (“ ”).

**SoftwareType** This integer indicates what program created the data file. The programs are: unknown (0), MetroPro (1), MetroBASIC (2), and d2bug (3).

**MajorVers, MinorVers, BugVers** These integers contain the version numbers of the program that created the data file.

**SoftwareDate** This 30-character string contains the time and date that the program was created.

**IntensOriginX, IntensOriginY** These integers are the coordinates of the origin of the intensity data matrix. They refer to positions in the camera coordinate system. The origin of the camera coordinate system (0,0) is located in the upper left corner of the video monitor.

**IntensWidth, IntensHeight** These integers are the width (columns) and height (rows) of the intensity data matrix. If no intensity data is present, this value is zero.

**NBuckets** This integer is the number of buckets of intensity data that are stored. Currently, MetroPro stores one bucket of intensity data. If no intensity data matrix is present, this value is zero.

**IntensRange** This unsigned integer is the maximum possible value of an intensity data point.

**PhaseOriginX, PhaseOriginY** These integers are the coordinates of the origin of the connected phase data matrix. They refer to positions in the camera coordinate system. The origin of the camera coordinate system (0,0) is located in the upper left corner of the video monitor.

**PhaseWidth, PhaseHeight** These integers are the width (columns) and height (rows) of the connected phase data matrix. If no phase data is present, these values are zero.

**Comment** This 81-character string is a user-entered remark line.

**PartSerNum** This 39-character string is a user-entered serial number for the part measured.

**PartNum** This 39-character string is a user-entered identifier of the part measured.

**Source** This integer indicates the source of the data. A value of 0 indicates the data is from an instrument; 1 indicates that the data was generated.

**IntfScaleFactor** This real number is the interferometric scale factor. It is the number of waves per fringe as specified by the user.

**WavelengthIn** This real number is the wavelength, in meters, at which the interferogram was measured.

**NumericAperture** This real number is  $1 / (2 * f\text{-number})$ .

**ObliquityFactor** This real number is a phase correction factor required when using a Mirau objective on a microscope. A value of 1.0 indicates no correction factor was required.

**Magnification** This real number is reserved for future use.

**CameraRes** This real number is the lateral resolving power of a camera pixel in meters/pixel. A value of 0 means that the value is unknown.

**TimeStamp** This integer is the system representation of the date and time the data was measured or generated. It is the number of seconds since 0:00:00 January 1, 1970.

**CameraWidth, CameraHeight** These integers are the width (columns) and height (rows) of the usable camera field in pixels.

**SystemType** This integer indicates the type of system used to make the measurement. The system may be: Mark IVxp (1), Maxim•3D (2), Maxim•NT (3), GPI-XP (4), NewView (5), Maxim•GP (6), NewView/GP (7), Mark to GPI conversion (8), or none (0), if the data was software generated.

**SystemBoard** This integer indicates which system board was in use when the data measurement was taken. Valid values range from 0 to 7.

**SystemSerial** This integer indicates the serial number of the instrument.

**InstrumentId** This integer indicates the instrument unit number. Valid values range from 0 to 7.

**ObjectiveName** This is an 11-character string. For the microscopes, this field indicates the objective in use when the measurement was taken. For the GPI, this field indicates the aperture in use when the measurement was taken. If the data was generated, this field is blank.

**AcquireMode** This integer indicates the setting of the Acquisition Mode control. The settings are: phase (0), fringe (1), or scan (2).

**IntensAvgs** This integer is the number of intensity averages performed. Values of 0 or 1 indicate no averaging.

**PZTCal** This integer indicates whether or not the modulation amplitude was automatically adjusted during acquisition. A value of 1 indicates adjustment; a value of 0 indicates no adjustment.

**PZTGain** This integer specifies the modulation amplitude value used during data acquisition.

**PZTGainTolerance** This integer specifies a PZT error range if PZT calibration was adjusted.

**AGC** This integer indicates whether or not automatic gain control was performed during data acquisition. A value of 1 indicates AGC was used; a value of 0 indicates AGC was not used.

**TargetRange** This real number is the acceptable tolerance limits of the light intensity used during AGC.

**LightLevel** This integer is the light level setting used during data acquisition.

**MinMod** This integer is the minimum value of modulation needed to calculate a phase value. MinMod is equal to  $10.23 * \text{MinMod}(\%)$ . MinMod(%) is a user setting indicating a percentage of full modulation each camera pixel must have in order to be accepted as a valid data point.

**MinModPts** This integer is the minimum number of data points required to pass MinMod criteria during AGC.

**PhaseRes** This integer indicates the resolution of the phase data points. A value of 0 indicates normal resolution, with each fringe represented by 4096 counts. A value of 1 indicates high resolution, with each fringe represented by 32768 counts.

**PhaseAvgs** This integer is the number of phase averages performed.

**MinimumAreaSize** This integer is the minimum number of contiguous data points required for a valid data region. Any smaller regions are deleted.

**DisconAction** This integer indicates the action taken when the system encountered discontinuities in phase data. The discontinuity actions are: delete regions (0), filter regions (1), and ignore (2).

**DisconFilter** This real number specifies the degree to which discontinuities were removed when DisconAction was filter. Valid values range from 0 (none) to 100 (all).

**ConnectionOrder** This integer specifies the order in which separate regions of phase data were processed. The order may be by location (0) or by size (1).

**RemoveTiltBias** This integer indicates whether or not the tilt bias was removed from the phase data. A value of 1 indicates it was removed; a value of 0 indicates it was not removed.

**DataSign** This integer indicates the sign of the data. The data sign may be normal (0) or inverted (1).

**CodeVType** This integer indicates whether the phase data represents a wavefront (0) or a surface (1). This information is used by the CODE V program.

**SubtractSysErr** This integer indicates whether or not the system error was subtracted from the phase data. A value of 1 indicates that it was subtracted; a value of 0 indicates it was not subtracted.

**SysErrFile** This 14-character string is a user-entered name of the file containing the system error data.

**RefractiveIndex** This real number is the index of refraction as specified by the user. Currently, this value is used only in the calculation of corner cube dihedral angles.

**PartThickness** This real number is the thickness, in meters, of the part measured. Currently, this value is only relevant to the calculation of homogeneity.

**ZoomDescr** This 7-character string is the value of the image zoom used during data acquisition.

## ASCII Data File Intensity Data

Each data point is an integer. The data is written 10 data points per line in row-major order. Acceptable values are from 0 to the value specified in IntensRange. An invalid point is indicated by a value  $\geq 65535$ . A line containing only a sharp character (#) is output after the data. The number of intensity data points is:

$$\text{IntensWidth} * \text{IntensHeight} * \text{NBuckets}$$

## ASCII Data File Connected Phase Data

Each data point is an integer. The data is written 10 data points per line in row-major order. Acceptable values are in the range from -2097152 to +2097151. An invalid point is indicated by a value  $\geq 2147483640$ . A line containing only a sharp character (#) is output after the data. The number of connected phase data points is:

$$\text{PhaseWidth} * \text{PhaseHeight}$$

The phase data points are in internal units representing a scaled number of fringes. To convert a value to waves, multiple by  $(S * O)/R$ .

Where: S = IntfScaleFactor, O = ObliquityFactor, and R = 4096 for normal PhaseRes or 32768 for high PhaseRes.

## ASCII Data File Programming Notes

This section provides notes for persons writing programs to create MetroPro compatible ASCII data files.

- The string fields must be blank-padded to the indicated fixed length.
- If a data set is not present, its concluding line containing a sharp character must still be present.
- Many of the fields in the header can be assigned null values since they are not used in calculations. Null values are zero for numeric fields or blanks for string fields. The following paragraphs indicate which fields must have true values.
- The IntensOriginX, IntensOriginY and PhaseOriginX, PhaseOriginY coordinates must be non-negative.
- The IntensWidth, Height and NBuckets values must correctly indicate the number of points in the intensity data matrix.
- The PhaseWidth, PhaseHeight values must correctly indicate the number of points in the phase data matrix.
- The CameraWidth, CameraHeight fields must describe a camera coordinate system that encloses the intensity and phase data matrices. The maximum values are (512,512).
- In order that phase values be correctly analyzed, the IntfScaleFactor, ObliquityFactor, WavelengthIn, and PhaseRes fields must have true values.

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- In order that intensity values be correctly analyzed, the IntensRange field must have a true value.
- If lateral dimensions are to be reported in units other than pixels, the CameraRes field must have a true value.
- In order to obtain correct encircled energy and MTF cutoff frequency results, the NumericAperture field must have a true value.

### ASCII Data File Example

Following is an example data file containing tiny 6x6 intensity and phase data matrices. Note that line 5 containing the Comment field is truncated.

```
Zygo ASCII Data File - Format 1
1 1 6 6 "Thu May 23 15:36:21 EDT 1991 "
122 118 6 6 1 1023
122 118 6 6
"
"      "
"      "
0 0.5 6.328e-07 0 1 0 0 671819076
262 235 1 0 5555 0 "Sm Aperture"
0 0 1 1686 3 1 0.1 40 71 50
0 0 20 1 0 0 0 0 0
0 "  "
0 0
0
#
404 414 414 423 434 448 422 431 435 442
452 459 459 460 456 458 465 470 464 453
449 445 456 474 459 462 457 450 444 457
453 444 440 425 421 430
#
2530 2566 2606 2649 2698 2751 2693 2731 2773 2812
2868 2913 2860 2905 2944 2990 3036 3094 3030 3072
3121 3161 3207 3261 3206 3255 3298 3337 3381 3423
3356 3410 3452 3503 3548 3592
#
```

**Header Fields**

**Intensity Data Matrix**

**Phase Data Matrix**

## Raw ASCII Data File Format

This section describes the format of a MetroPro Raw ASCII data file. This format contains no header information and bare measurement data in row order of the data matrix. A raw ASCII data file is created by using the `dat_to_raw_asc` conversion utility.

### Composition of a Raw ASCII File

<i>First Line</i>	The total number of data points.
<i>Subsequent Lines</i>	The matrix data is listed as: column number (x), row number (y), and data value (z). These numbers are separated by a space. The number of lines is equal to the number of data points. The data is presented in row-major order. The data value (z) is the connected phase data value from the binary file.
<i>Second Last Line</i>	Minimum value of all data points.
<i>Last Line</i>	Range of the data; the maximum data value minus the minimum data value.

### Raw ASCII Data File Example

Following is an example raw ASCII data file. Note that the data entry is truncated.

```
60268
0 0 0.732558
1 0 0.728682
2 0 0.722868
3 0 0.722868
4 0 0.717054
5 0 0.717054
6 0 0.718992
7 0 0.717054
8 0 0.715116
9 0 0.717054
10 0 0.715116
...
...
283 209 0.697674
284 209 0.695736
285 209 0.697674
286 209 0.697674
-4360
4128
```

**First line is the number of data points followed by data.  
Data: column number, row number, data value.  
The number of data lines is equal to number of data points.**

**2nd to last line is the minimum data value.  
Last line is the data range.**

## CODE V Data File Format

This section describes the format of a MetroPro CODE V .INT data file. The data file is made of two parts: a header and the appropriate phase or Zernike data. The CODE V file format presented is described on page 10-25 in the July 2009, *CODE V Reference Manual*, version 10.1. Intensity apodization filter data is *not* handled.

CODE V phase data is created using the `dat_to_grd` conversion utility. The CODE V data files are ASCII files, which means that they are readable and printable.

### CODE V Data File Header Information

Because of the limited amount of data stored in the CODE V file, header lines have been developed so that files can be created outside of the MetroPro environment and then read into the system. The header lines *must* appear at the beginning of the file and begin with an exclamation point (!). Imbedded blank lines are *not* allowed. Each header line has a three character identifying label, similar to the CODE V labeling scheme.

There are 2 required lines in the header. The first line of the file *must* be:

! ZYGGRD *or* ! ZYGOZR

If this line is not the first line in the file, the file will be considered invalid by MetroPro. All other header lines may appear in any order. The second required header line, which may appear anywhere after the ZYGO line in the header, is the REQ line. The REQ line must be present and complete for the file to be considered valid. All other header lines, if included, must have all data elements present and in the specified order. The header line formats are listed in the following table.



**CODE V Data File Header Information**

<i>Label</i>	<i>Field Name</i>
REQ	CameraWidth CameraHeight NumericAperture ObliquityFactor CameraRes
SWI	SoftwareType MajorVers MinorVers BugVers SoftwareDate
ACQ	AcquireType
COM	Comment
CON	MinimumAreaSize DisconAction DisconFilter ConnectionOrder
ERR	SubtractSysErr SysErrFile
IAC	IntensAvg
LLV	AGC TargetRange LightLevel
MAG	Magnification PartThickness RefractiveIndex RemoveTiltBias
MOD	MinMod MinModPts
ONM	ObjectiveName
PAC	PhaseAvg
SCF	phaseRes scaleFactor
PNM	PartNum
PSN	PartSerNum
RMP	PZTCal PZTGainTolerance PZTGain
SGN	DataSign
SRC	Source PhaseWidth PhaseHeight
SYS	SystemType SystemBoard SystemSerial InstrumentId
TMS	TimeStamp

**CODE V Data File Header Field Descriptions**

Descriptions of each header field in the CODE V data file are identical to those found in the ASCII Data File Header Field Descriptions.

**CODE V File Formats**

After the header lines, the first line of a CODE V file is an 80-character description. This line will contain the comment text, if any was provided. Otherwise, it will contain 'ZYGO' followed by the software type that stored the data followed by the date and time the data was stored. The second line contains CODE V parameters. The appropriate data is then listed.

## CODE V Phase (Grid ) Data

When a CODE V file contains grid data, its parameter line must contain the following elements:

GRD x\_size y\_size SUR/WFR WVL val SSZ val [NDA val]

While the entries on the line are order independent, the values associated with each element *must* appear in the order shown. For each label it is assumed that all of the parameters exist and are in the correct order. All of the elements must be present (with the exception of the NDA term, which is optional) for the file to be considered valid. Each element indicates the following data:

- 1) GRD x\_size y\_size  
X\_size and y\_size are integers and represent the number of horizontal (x) and vertical (y) grid points. The total number of data points is x\_size \* y\_size.
- 2) SUR/WFR  
SUR indicates that the data to follow represents surface data as opposed to WFR, which indicates wavefront data. (FIL is used to indicate intensity apodization filter data, which is *not* supported.) SUR or WFR are selected with the Code V Type control; which is created with the New Control → Miscellaneous → Code V Type command.
- 3) WVL val  
This real number is used to specify the wavelength, in microns, at which the interferogram was measured.
- 4) SSZ val  
This real number is the value of the data corresponding to one wave of deformation.
- 5) NDA val  
This integer is the value of data that is to be interpreted as missing data. This is an optional parameter element. The default value is 32767.

The data points are integers and are output 10 per line with a field width of 7.

## CODE V Zernike Data

When a CODE V file contains Zernike polynomial coefficients, its parameter line must contain the following elements:

ZFR num\_terms SUR/WFR WVL val SSZ val

While entries on the line are order independent, the values associated with each element *must* appear in the order shown. For each label it is assumed that all of the parameters exist and are in the correct order. All of the elements must be present for the file to be considered valid. Each element indicates the following data:

1) ZFR num\_terms

ZFR indicates that the coefficients represent a *Fringe* Zernike polynomial. (ZRN would indicate that the coefficients represent a standard Zernike polynomial; however, regular polynomials are *not* supported.) The number of terms represents the number of coefficients present in the data. While up to 37 terms are supported by CODE V for the *Fringe* Zernike polynomial, only 3, 4, 9, 16, 25, 36, and 37 terms are valid for MetroPro. This is an integer value.

2) SUR/WFR

SUR indicates that the data to follow represents surface data as opposed to WFR, which indicates wavefront data. (FIL is used to indicate intensity apodization filter data, which is *not* supported.) SUR or WFR are selected with the Code V Type control; which is created with the New Control → Miscellaneous → Code V Type command.

3) WVL val

This real number is used to specify the wavelength, in microns, at which the interferogram was measured.

4) SSZ val

This real number is the value of the data corresponding to one wave of deformation.

The coefficients are real numbers and are output 6 per line with a field width of 12 and a precision of 4.

## Scaling MetroPro Data to CODE V Data

Because CODE V uses 16 bits and MetroPro uses 24 of 32 bits to represent phase data, there is a possibility that MetroPro data may represent a value that is outside of the CODE V range of valid values. To deal with this, when converting MetroPro data to Code V data, data is scaled down before being written if any of the values in the data set fall outside of the -32767 through +32767 CODE V valid range.

The scaleFactor in the SCF header line is the scale shift factor used for scaling. If the SCF header line is present, when converting data from Code V to MetroPro, the data will be shifted using the scaleFactor, and the ZYGOCIRCLE will be calculated based on the phaseRes. If the SCF header line is not present, no scaling will be done and MetroPro will assume the Phase Resolution is low.

When MetroPro scales its data, the following algorithm is used:

- 1) The appropriate ZYGOCIRCLE value is selected based on the Phase Res.
- 2) The initial scale size (SSZ) is calculated by dividing the ZYGOCIRCLE value by the IntfScaleFactor. The initial shift factor (scaleFactor) is set to 0.
- 3) Establish whether or not any data values fall outside of the CODE V value range.
- 4) If no data falls outside of the CODE V range, do nothing special and write out the data.
- 5) If data does fall outside of the CODE V range, divide the scale size (SSZ) by 2 and increment the shift factor (scaleFactor) by 1 repeatedly until the data falls within the CODEV range. The data is shifted down by scaleFactor before writing.

## Converting CODE V Files to MetroPro Files

The following are a few notes to be aware of when converting CODE V files to MetroPro files:

- 1) If no comment line (COM) is included in the header, the 80-character description line will be placed in the comment field.
- 2) If no source line (SRC) is included in the header, the source field will be set to generated (1).
- 3) Header fields of unknown or unnecessary values should be set to 0.
- 4) Apodization filter data files (FIL) are not handled by MetroPro.
- 5) If there is no SCF line in the header, Low Resolution is assumed, IntfScaleFactor is calculated by dividing the ZYGOCIRCLE by the scale size (SSZ), and nothing is done to the data values.

If the SCF header line exists, phaseRes determines the ZYGOCIRCLE, and IntfScaleFactor is calculated by dividing the ZYGOCIRCLE by the scale size (SSZ) multiplied by  $2^{\text{scaleFactor}}$ . The data is shifted up by scaleFactor before writing.

## CODE V Data File Examples

Two examples of MetroPro CODE V .INT data files shown below. The grid file contains a tiny 6x6 phase data matrix. The Zernike file shows the format for 36 terms. Note that the COM lines are truncated.

```

! ZYGGRD
! REQ 262 235 0 1
! TMS 671819076
! SWI 1 1 6 6 "Thu May 23 15:36:21 EDT 1991 "
! COM "
! SRC 0 6 6
! MAG 0 0 0 0
! ACQ 0
! IAC 0
! RMP 1 3 1686
! LLV 1 0.1 40
! MOD 71 50
! CON 20 1 0 0
! SGN 0
! SYS 1 0 5555 0
! ONM "Sm Aperture"
! PNM "
! PAC 0
! ERR 0 "
! PSN "
Zygo MetroPro Wed May 1 11:35:27 1991
GRD 6 6 SUR WVL 0.6328 SSZ 8192.000000 NDA -32768
  2530 2566 2606 2649 2698 2751 2693 2731 2773 2812
  2868 2913 2860 2905 2944 2990 3036 3094 3030 3072
  3121 3161 3207 3261 3206 3255 3298 3337 3381 3423
  3356 3410 3452 3503 3548 3592

```

**First line denotes Code V grid data**

**followed by header lines**

**and then data**

```

! ZYGOZFR
! REQ 262 235 0 1 0
! TMS 671819076
! SWI 1 1 6 6 "Thu May 23 15:36:21 EDT 1991 "
! COM "
! SRC 0 6 6
! MAG 0 0 0 0
! ACQ 0
! IAC 0
! RMP 1 3 1686
! LLV 1 0.1 40
! MOD 71 50
! CON 20 1 0 0
! SGN 0
! SYS 1 0 5555 0
! ONM "Sm Aperture"
! PNM "
! PAC 0
! ERR 0 "
! PSN "
Zygo MetroPro Wed May 1 11:35:27 1991
ZFR 36 SUR WVL 0.6328 SSZ 8192.000000
  0.0000 3.0000 6.0000 9.0000 12.0000 15.0000
  18.0000 21.0000 24.0000 27.0000 30.0000
  33.0000
  36.0000 39.0000 42.0000 45.0000 48.0000
  51.0000
  54.0000 57.0000 60.0000 63.0000 66.0000 69.0000
  72.0000 75.0000 78.0000 81.0000 84.0000 87.0000
  90.0000 93.0000 96.0000 99.0000 102.0000 105.0000

```

**First line denotes Code V Zernike data**

**followed by header lines**

**and then data**

## OSLO Compatible File

OSLO software supports interferogram (.INT) files. From MetroPro, a compatible .INT file can be created with the grid conversion utility or with the Save Zernikes button.

### Creating an .INT File from Grid Data

Use these steps to create an .INT file based on grid data from a MetroPro data file for use with OSLO.

1. Use the `dat_to_grd` conversion utility to create an .INT file
2. Open a command prompt window.
3. Change to the directory in which the MetroPro data file is located.
4. Type- `dat_to_grd Input Output` and press Enter.

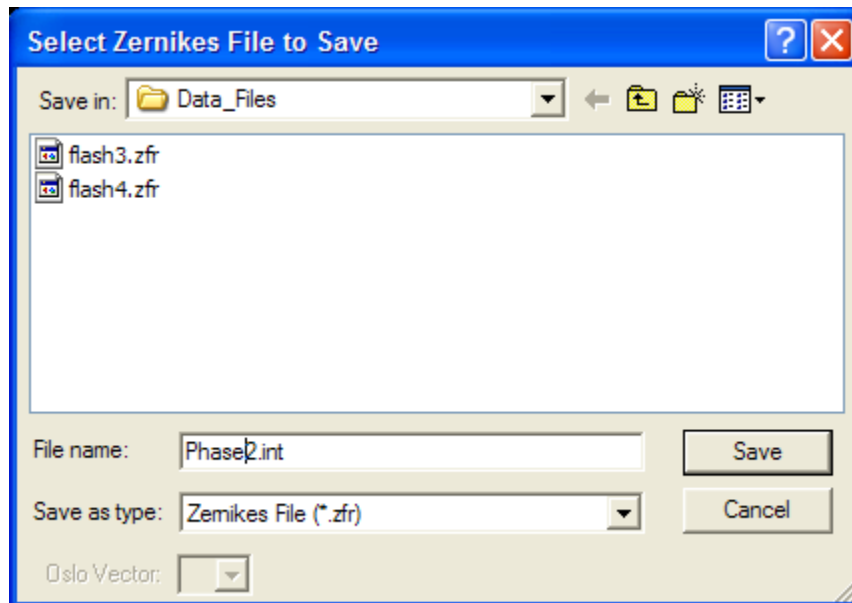
### Creating an .INT File from Zernike Coefficients

Use these steps to create an .INT file based on Zernike coefficients from MetroPro Zernikes for use with OSLO.

1. Click the Save Zernike button in MetroPro.
2. If you are using the standard MetroPro File Handler, name the file using the extension .INT instead of .zfr.

**Or,**

If you are using Windows Dialog Boxes (`-windowsDialog` command line option) as shown below, name the file using .INT as the file extension. Do not select .zrs as the Save As Type or select an Oslo Vector.



**Note:** The MetroPro `zfr_to_zrs` conversion utility does not output an OSLO compatible file.

## ZEMAX Grid Sag Data File Format

This section describes the format of a MetroPro ZEMAX grid sag surface data file. The file has two parts: a header line and the sag data. ZEMAX files are ASCII files, which means that they are readable and printable. MetroPro data files are converted to ZEMAX grid sag files by using the `dat_to_zxgrd` conversion utility.

### ZEMAX Data File Header Information

The first line of the file contains 5 values and has the following format:

`x_size y_size x_spacing y_spacing unit_flag`

`X_size` and `y_size` are integers that indicate the number of data points in the sag grid surface in the x (width) and y (height) direction. `X_spacing` and `y_spacing` are real numbers that indicate the spacing between points in the x and y directions. `Unit_flag` indicates the units of the data; MetroPro data is stored in millimeters (`unit_flag = 0`)

### ZEMAX Data File Format

The remaining `x_size * y_size` lines of the data file contain 4 real numbers and an integer flag in the following format:

`z dz/dx dz/dy d2z/dxdy flag`

`Z` indicates the sag (or height) value. `dz/dx` and `dz/dy` are the x and y derivatives of the sag. `d2z/dxdy` is the cross derivative of the point. `Flag` indicates the validity of the data in the line; 0 = valid data, 1 = invalid data.

The values for `dx`, `dy`, and `dxdy` are slope calculations, which mean the current `z` value is compared or subtracted from adjacent `z` values. The data flag is invalid (1) when there are not adjacent data points to determine the slope. This occurs when there is data dropout and on the edge of data.

## SDF Data File Format

This section describes the format of a MetroPro SDF data file. The file is made up of three parts: header, phase data, and trailer. All sections are followed by a line consisting of an asterisk (\*). A semi-colon (;) is used to comment the remaining line. A MetroPro SDF data file is created by using the `dat_to_sdf` conversion utility.

### SDF Data File Header Information

The header consists of 13 required lines of information. Line 1 is a string constant (not enclosed in quotes). The remaining lines contain information about the measurement system and data file. They have the following format: *record\_name* “ = “ *value*. A list of *record\_names* is shown in the table below.

<i>Information</i>	<i>ASCII Record Name</i>	<i>Binary Data Type</i>	<i>Binary Length (bytes)</i>
Version Number		unsigned char	8
Manufacture’s ID	ManufacID	unsigned char	10
Creation Time and Date	CreateDate	unsigned char	12
Last Modification Time and Date	ModDate	unsigned char	12
Number of Points per Profile	NumPoints	unsigned int	2
Number of Profiles	NumProfiles	unsigned int	2
X-Scale	Xscale	double	8
Y-Scale	Yscale	double	8
Z-Scale	Zscale	double	8
Z-Resolution	Zresolution	double	8
Compression Type	Compression	unsigned char	1
Data Type	DataType	unsigned char	1
Check Sum Type	CheckType	unsigned char	1



## SDF Data File Header Field Descriptions

Each header field in a SDF data file is described below. The types of the fields are noted in the above table.

**Version Number** This field must be the first line of the data file. It indicates what version of SDF format was used to generate the data file. The only valid value for this field is “aBCR-1.0”.

**Z-Scale** This is the lateral resolution of the z-axis. Value is in meters.

**Manufacture’s ID** This field specifies what version of MetroPro was used to create the data. The first two characters are MP for MetroPro and the remaining characters are the version number of MetroPro.

**Creation Time and Date** This is the time and date the original data file was created. It is in the format DDMMYYYYHHMM and zero padding is required (i.e. 0307 for July 3<sup>rd</sup> versus 37). The hour is in 24 hour format. Therefore, 120719971421 is July 12, 1997 at 2:21PM.

**Last Modification Time and Date** This field is similar to the *Creation Time and Date* except it represents the last time the SDF file was changed.

**Number of Points per Profile** This is the number of columns in the data set. This number is stored in a word cannot exceed 65535.

**Number of Profiles** This is the number of rows in the data set. This number is stored in a word cannot exceed 65535.

**X-Scale** This is the lateral resolution between data points along the x-axis. Value is in meters.

**Y-Scale** This is the lateral resolution between data points along the y-axis. Value is in meters.

**Z-Scale** This is the lateral resolution of the z-axis. Value is in meters.

**Z-Resolution** This is the lateral resolution of the z-axis. Value is in meters.

**Compression Type** This field specifies what type of compression is used on the data. Since no compression is used, this field is zero (0).

**Data Type** This field what format the data is in. MetroPro SDF data file stores its data as unsigned long so this value is always two (2). Any data values equal to maximum value of an unsigned long (4,294,967,295) represent an invalid data point which should not be used in calculations.

**Check Sum Type** This field is always zero (0).

## SDF Data File Data

Each data point is an unsigned long integer. The data is written 10 data points per line in row-major order. Acceptable values are less than 4,294,967,295. The data points values are scaled; to convert to meters, multiply valid the data point value by Z-Scale. A line consisting of only an asterisk (\*) is output after the data. The number of data points is:

$$NumPoints * NumProfiles$$

## SDF Data File Trailer

The trailer section is used to store additional information not stored in the header. This information consists of every field in the Binary Data File header and is used to ensure proper conversion back to Binary format. Although most fields are optional, the following are required to convert from SDF to Binary: camera\_width, camera\_height, obliquity\_factor, num\_aperture, lateral\_res, intf\_scale\_factor, wavelength\_in and phase\_res. The format of this information if the same as in the header.

## SDF Data File Programming Notes

This section provides notes for persons writing programs to read MetroPro SDF data files.

- The data file format consists of series of records terminated with CR (#13), LF (#10) or CR+LF.
- Additional “white space” characters (#9, #10, #13, #32) are ignored including those in the data section.
- All real numbers are composed of the following characters ‘0’ ... ‘9’, ‘.’, ‘e’, ‘E’, ‘+’, ‘-’.
- All three sections are of the file (header, data, and trailer) are terminated with a single record containing the character ‘\*’ (#42). Thus the final ‘\*’ record identifies the end of the data file.
- All three sections are of variable length.
- Any record information following a ‘;’ (#59) character is considered a comment and is ignored.
- Elements of the header are given as separate records for readability and ease of file I/O.
- The first record of the data file is always the version number.
- All other records pertaining to the header may be placed in any order in the header section.
- Each record in the header contains three (3) parts: the record ID, a separator (=), and the value.

## Sample SDF Data File

```

aBCR-1.0                ; This is always the first line
ManufacID = MP6.5.6    ; the following records
;                       ; can be presented in
;                       ; any order
CreateDate = 210819971517 ; Aug 21, 1997 @ 3:17PM
ModDate = 020219981407  ; Feb 2, 1998 @ 2:07PM
NumPoints = 132
NumProfiles = 169
Xscale = 1.19246e-05
Yscale = 1.19246e-05
Zscale = 9.67234e-12
Zresolution = 9.67234e-12
Compression = 0        ; NONE
DataType = 2           ; UNSIGNED LONG
CheckType = 0          ; NONE
*
201658 201855 202180 202237 201903
201983 202030 202194 201937 202100
202365 202366 202260 202583 202624
202904 202322 202875 202645 202927
202991 203169 203354 203555 204347
205257 206923 4294967295 ; last point is a bad data point
1241499 1241611 1241771 1241923 1242201
...
1242252 1242104 1242048 1242157 1242029
*
; Additional Information
operator = Tom Jones
shift = 1
* ; End Of File

```

## XYZ Data File Format

This section describes the format of a MetroPro XYZ data file. The file is made up of two parts: header and measurement data. The parts are separated by a line containing a sharp (#) character. Using the `dat_to_xyz` conversion utility creates a MetroPro XYZ data file from a MetroPro binary data file. Using the `xyz_to_dat` conversion utility creates a MetroPro binary data file from a XYZ data file.

### XYZ Data File Header Information

This section is identical to the MetroPro ASCII data file header. See the section in the ASCII Data File Format for more information.

### XYZ Data File Connected Phase Data

The data in this section is organized by phase origin. Each line contains three pieces of data. The first two columns contain the column (y) and row (x) location of the data, beginning at the phase origin. The third number on the line can be either the character string "No Data" or a floating-point number corresponding to the measurement in microns. To convert these measurements to 'zygos', use the following formula. (The names in parenthesis refer to the Binary Data Format field names)

The data in the file is in microns. To convert to meters:

For Low resolution (0) phase data:

Multiply third column data in by:

$$(4096 / (\text{IntfScaleFactor} * \text{ObliquityFactor} * \text{WavelengthIn} * 1000000))$$

For High resolution (1) phase data:

Multiply third column data by:

$$(32768 / (\text{IntfScaleFactor} * \text{ObliquityFactor} * \text{WavelengthIn} * 1000000))$$

The PhaseRes is the first value of the eleventh line of the header. Convert the result to an integer to be stored in the binary file. This will cause round-off error, but amounts to a less than one Angstrom variance from the original data.

### XYZ Pixel Resolution

The camera resolution is found on the eighth line of the header (CameraRes) (in meters/pixel). Multiply this number by the appropriate factor to obtain the resolution needed. The horizontal and vertical pixel resolution can be calculated as follows:

$$\text{CameraRes} = 1.81512e-005$$

$$\text{To get microns } (10^{-6} \text{ meters}): (.000018512) * (1000000) = 18.512 \text{ microns.}$$

The horizontal and vertical pixel resolutions are the same.

### Sample XYZ Data File

```

Zygo XYZ Data File - Format 1
1 7 3 2 "Thu May 27 10:05:01 1999      "
0 0 560 420 1 255
130 5 413 412
"XXXXXX Engine Company, Inc.          "
"                                       "
"4001896- Armature & Plunger          "
0 0.5 6.48e-007 0 1 0 1.81512e-005 908907731
560 420 11 0 -15531 0 "2.5X Mich "
2 0 0 0 0 0 0 28.7912 10 0
0 0 7 1 60 0 0 0 0
0 "                                     "
1 0
#
130 5 No Data
131 5 No Data
132 5 No Data
133 5 No Data
134 5 No Data
...
330 5 No Data
331 5 2.434588
332 5 2.459188
333 5 2.447323
334 5 2.434904
...
537 417 No Data
538 417 No Data
539 417 No Data
540 417 No Data
541 417 No Data
#

```

### XYZ Data File Notes

Be aware that the resultant file will be larger than the original file due to it being ASCII, not binary, and requiring three fields (x, y, z) for the original phase data. Intensity data will be lost when the file is converted back to binary (.dat) format, since it is not maintained in the .xyz file.

## Exporting Data

To export data, MetroPro binary data must be converted to the selected format using the appropriate conversion utility included with MetroPro.

Supported file types (export):

- ASCII data
- Raw ASCII data
- BMP bitmap image data (.bmp)
- Interferogram Data (.int) for CODEV and OSLO
- ZEMAX ASCII data (.zxgrd)
- SDF data (.sdf)
- XYZ data (.xyz)
- Zernike Coefficient File (.zrs)



Binary files (.dat) are made with the Save Data button. CODE V Data files (.zfr) are made with the Save Zernikes button.

## Converting Data files for Exporting

To use a Conversion utility, open a command prompt window, change to the directory where the files are located, and type the conversion utility name (include underscores), existing filename (input), and converted filename (output), and then press [Enter].

<i>Utility (Export)</i>	<i>Description</i>
<i>dat_to_asc Input Output</i>	Binary data to ASCII.
<i>dat_to_bmp Input Output options</i>	Binary data to BMP file.
<i>dat_to_raw_asc Input Output</i>	Binary data to raw ASCII.
<i>dat_to_grd Input Output</i>	Binary data to .INT interferogram data file.
<i>dat_to_zxgrd Input Output width</i>	Binary data to ASCII ZEMAX data file. The width indicates the width of the desired sag grid. <b>Notes:</b> Because of the size of MetroPro data files, it is recommended that the ZEMAX file be of a smaller dimension. Width must be an odd number and smaller than the width of the data in the binary data file. MetroPro cannot convert data files that have dropouts or do not fill the entire aperture.
<i>dat_to_sdf Input Output</i>	Binary data to sdf data.
<i>dat_to_xyz Input Output</i>	Binary data to xyz data.
<i>zfr_to_zrs Input Output vector</i>	Zernike (.zfr) data to OSLO spreadsheet data . The vector specifies the vector (or column) in the OSLO spreadsheet where the data will be stored. Valid vector values range from 'a' through 'f' and 'u' through 'z'.

## Converting MetroPro Data to a Bitmap File

The `dat_to_bmp` export conversion utility converts a binary data file (height or intensity) to a bitmap output file.

There are optional parameters to this conversion:

<i>Parameter</i>	<i>Description</i>
-f	Specifies the format of the data used to create the bitmap. 0 converts intensity data to a bitmap. Bad pixels are set to zero (0). Data is scaled to the range 0 to 250. The minimum intensity is set to 0, and the maximum intensity to 250. 1 converts height data. Points with no data are set to 0. The data is scaled to the range of 0 to 250. The minimum height is set to zero (0), and the maximum to 250. 2 converts height data to a mask-type bitmap. Data points are set to 128 if the data is valid, and 0 if it is not. The result is the creation of a mask based on the presence of height data.
-t	Specifies the percentage of the height data to use to define the top limit. This parameter is only valid when the format parameter is set to 1 or 2. The default value is 1%.
-b	Specifies the percentage of the height data to use to define the bottom limit. This parameter is only valid when the format parameter is set to 1 or 2. The default value is 1%.
-c	The data is placed relative to camera coordinates and not relative to (0, 0).

## Importing Data

Data types created by other systems can be imported into MetroPro by copying the file to the MetroPro computer and converting the file to a binary data (.dat) file with a converter utility included with MetroPro.

Supported file types (Import):

- ZYGO data format (HDP) before MetroPro
- ASCII data
- CODE V grid data format
- SDF data
- XYZ data (contains ASCII xyz coordinates)

## Converting Files for Importing

To use a Converter utility, open a command prompt window, change to the directory where the files are located, and type the conversion utility name (include underscores), existing filename (Input), and converted filename (Output), and then press [Enter].



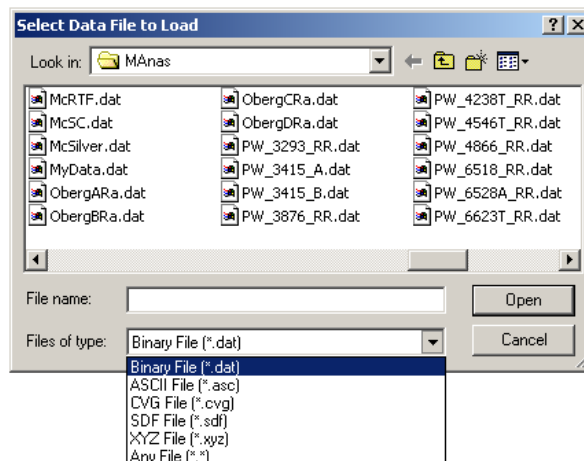
When converting files into the MetroPro binary data file format the extension “.dat” must be used for MetroPro to recognize the file in the Load Data dialog box.

<i>Utility (Import)</i>	<i>Description</i>
hdp_to_dat <i>Input Output</i>	Zygo HDP data file to binary data.
asc_to_dat <i>Input Output</i>	ASCII data to binary data.
grd_to_dat <i>Input Output</i>	CODE V .INT grid data to binary data.
sdf_to_dat <i>Input Output</i>	SDF data to binary data.
xyz_to_dat <i>Input Output</i>	XYZ data to binary data.

## An Easier Method for Converting Data Files

Standard Windows file handling dialog boxes can be used in MetroPro. To activate them, right click on the MetroPro shortcut, select Properties, and type –windowsDialog after file name in the Target line. Include the dash. Then click okay.

The Windows file dialog box makes it easier to make file conversions. With the load data dialog box open, look at the available file types. You can now save and load directly to other file types. You no longer have to use the DOS-based Command Prompt window and type the name of the conversion utility.





## **Responding to Error Messages**

Some of the conditions that cause errors can be corrected by finding the error message in the listing provided in this appendix and following the recommendations.

If you experience serious problems that cause MetroPro to quit, refer to the last page of this appendix. If you continue to experience problems or if you are not sure about the error message you are getting, contact Zygo Corporation. Additional information can also be found by checking the MetroPro log file MetroLog.txt.

## **Error Message Listing**

The following is an alphabetical list of MetroPro error messages. This list is not meant to be a complete error message listing. This listing is meant to provide help in understanding common errors and messages. Sometimes the action required to fix the error is provided in the message itself, in which case the error is not listed here. Error messages are displayed in Dialog boxes. Click the OK button to acknowledge the message.

### ***Acquisition mask is required.***

The application requires that you define an Acquisition mask. See the appropriate application documentation for more information.

### ***Acquisition Mode not set to Scan.***

The application requires Scan acquisition, not Phase, Fringe, or Intensity.

### ***Active instrument is not an interferometer.***

Occurs when the selected instrument is not an interferometer and the user initiates an operation that is only appropriate for an interferometer. Example: auto-focus on a scanner. Select instrument with Instrument control.

### ***Application is incompatible with this version of MetroPro.***

This is likely to occur when you have loaded a new version of MetroPro but have not converted your existing applications.

### ***Application license is invalid.***

Occurs when the user attempts to measure or load data using an application which requires a license.

### ***Auto aperture error: Aperture Mode: Mask Editor Controlled and test mask cannot be used together.***

These features are mutually exclusive. Either use the auto aperture mask or your own Test mask.

***Auto focus and tilt not implemented.***

Call Zygo Corporation if you have a new automation requirement.

***Auto mask and test mask cannot be used together.***

These features are mutually exclusive. Either use the auto loaded mask or your own Test mask.

***Auto mask radius value is unreasonable.***

The auto mask radius is either too large or too small.

***Auto mask requires lateral calibration.***

The instrument must be calibrated for the auto mask feature to work. Use the Calibrator as described under “Calibration” in the reference section.

***Auto save data failed.***

Data was not saved during an auto save operation. This may have happen because the disk is full or the destination directory has permissions set to disallow writing.

***Automatic tilt adjustment failed.***

The system is unable to find the correct tilt position. Reset Tilt Zero parameter.

***Calibration aborted.***

The Esc(ape) key was pressed during the measurement. Measure the part again.

***Cannot access DMI.***

The distance measuring interferometer is not connected or is not working. This message applies to the MetroPro Radius Scale Application.

***Camera resolution not specified.***

Lateral calibration needs to be performed.

***Cannot access ramp data files.***

Ramp files in directory C:\Metropro\cfg\ramps do not exist or are not compatible with the instrument serial number.

***Cannot adjust light for acquire.***

When the Acquisition Mode is Phase, this error is unlikely. It could occur if the AGC algorithm is unable to converge. When the Acquisition Mode is Fringe, this error occurs if there is insufficient light.

***Cannot attenuate light for acquire.***

Can occur if a part is highly reflective and the AGC algorithm is confused by camera over-saturation. This error is unlikely.

There is not enough data for the calculation. Filtering, trimming, masking, or the remove option selected may reduce available data.

***Cannot calibrate.***

The following is list of possible problems: invalid length entered, invalid magnification entered, invalid resolution entered, line too short, magnification must be within 50% of nominal, magnification is unreasonable, fringe or phase data from the instrument is required (not loaded or generated data.), there is no active instrument or it is incompatible with this application, no instrument aperture is selected, no objective in current turret position, and no objective selected.

***Cannot create file.***

Occurs when MetroPro cannot create a new file or over-write an existing file. The destination directory or file has permissions set to disallow writing.

***Cannot open file.***

Occurs when MetroPro cannot find a file in the expected directory or the user does not have permission to read the file

***Cannot find cube sectors.***

This message applies to the MetroPro Corner Cube Application if an incorrect number of regions of phase data are found. Six regions are required for single-pass, three for double-pass.

This error may be caused if the Auto Mask figures do not align well with the sector images. To fix this problem- correct alignment of part, increase Mask Spacing control value, and or consider using manual masking.

This error may also be caused if dropouts divide a sector into multiple regions of phase data. Increase Min Area Size control value. Increase Trim control values. Use manual masking to isolate one region of phase data per sector.

***Cannot find stage home position.***

Stage is incorrectly configured (i.e., the config file does not a match the stage), the limits have not been defined, the system could not locate the home position, or there is a mechanical problem. Reset MetroPro application and re-home the stage.

***Cannot focus.***

Part is too far from Focus Range control value.

***Cannot goto focus zero position.***

Zero position has not been set.

***Cannot goto stage tilt zero position.***

Zero position has not been set.

***Cannot initialize motion controller.***

Emergency Stop button may be depressed or power is not applied to Motion Controller.

***Cannot read file.***

You do not have proper permission to read the file or the file type is not MetroPro compatible.

***Cannot write file.***

Disk is full or you do not have proper write permission for this directory.

***Data file corrupted.***

Occurs when MetroPro attempts to read a file recognized as a data file but the file is missing essential information.

***Error initializing motion controller.***

***Error in communication with motion controller.***

Incorrect or no response from motion controller to the host. Items to check include: power to the motion controller, and the firmware version of the motion controller and the host for compatibility. Reset power to the motion controller, perform a hard reset on the motion controller (the red stop button on the front panel), reset MetroPro, and re-home the stage.

***Error in license file <filename>.***

Information in named file does not agree with issued license parameters. Check parameters or call Zygo Corporation for new license.

***Error initializing instrument.***

There is a hardware error on the instrument board. Reset power to the Electronic Enclosure and check the cables. This could be a possible communications error. Also, there could be a conflict in the config file. Check the version numbers between MetroPro and Electronic Enclosure firmware.

***Error. Invalid Parameter.***

Unexpected internal condition. Note conditions and call Zygo Corporation.

***Fringe contrast is too low.***

Occurs when the Acquisition Mode is Fringe and the fringe contrast is low. On the GPI xp, low contrast fringes may be caused by mismatched reflectance test and reference surfaces.

***Fringes too closely spaced.***

Occurs when the Acquisition Mode is Fringe and the fringes are too closely spaced. Try readjusting (nulling) the instrument. This message applies to the Static Fringe Application.

***Hardware Problem.***

***Hardware Warning.***

Occurs when there is some problem accessing the interferometer hardware, either when MetroPro is started or when a measurement is attempted. Call Zygo Corporation.

***ID Module required.***

Older versions of MetroPro required an HP ID Module to measure or to use applications.

***Improper default mask.***

Occurs if the default mask does not intersect with the phase data. Redefine the mask with the Mask Editor.

***Improper mask.***

Occurs if a mask does not intersect with the phase data. Redefine the mask with the Mask Editor.

***Improper test mask.***

Occurs if the test mask does not intersect with the phase data. Redefine the mask with the Mask Editor.

***Improper reference mask.***

Occurs if the reference mask does not intersect with the phase data. Redefine the mask with the Mask Editor.

***Incorrect stage configuration.***

The motorized stage is not a Zygo Corporation supported stage.

***Intensity data is not available.***

Occurs when intensity data is required for processing of phase data but intensity data is not available. The error could occur when analyzing phase data that was created by some other program.

***Intensity data must have fringes removed.***

The analysis required that the Fringe Remove control be set to On. Change control and re-measure.

***Internal error.***

Severe unexpected internal error. Note conditions and call Zygo Corporation.

***Lateral calibration required.***

One of the features you are trying to use requires lateral calibration; units other than pixels are needed. Perform calibration.

***License number ... is inconsistent.***

You have entered an invalid license key code in the Edit/View License window. Try entering the key code again or call Zygo Corporation.

***MetroPro license is invalid.***

Occurs when the user attempts to measure or to load data using a version of MetroPro which requires a license. You must enter a valid license key code obtained from Zygo Corporation in the Edit/View License window.

***No valid data points.***

Occurs when masking, trimming, and/or filtering deletes all phase data points.

***Not a data file.***

Occurs when MetroPro attempts to read a file expected to be a data file but the file contents are unrecognized.

***Not an application file.***

The file is not recognized as an application or it is an older application not compatible with the current version of MetroPro.

***Not enough data.***

Occurs when masking, trimming, and/or filtering leaves too few phase data points.

***Not enough fringes.***

Occurs when the Acquisition Mode is Fringe and there are too few fringes. Readjust the instrument.

***Option license is invalid.***

Occurs when the user attempts to measure or to load data using an optional MetroPro application that requires a license. You must enter a valid license key code obtained from Zygo Corporation in the Edit/View License window.

***Out of memory.***

Not enough available memory in computer for processing needs. It is also possible to have a programming error. Note the conditions and call Zygo Corporation.

***Overflow.***

Internal software number representation overflow. Note conditions and call Zygo Corporation.

***Premature end-of-file.***

Occurs when MetroPro attempts to read a file that is missing essential information. The file is corrupted and is not readable.

***PZT power supply trip.***

Occurs during a phase measurement if the current to the piezoelectric transducers exceeds a limit. Click the Reset button and retry. If this error occurs often, call Zygo Corporation.

***Region too complicated.***

May occur if a region of phase data consists of a maze of twisty threads of points.

***Scan too short.***

Select a longer scan range and re-measure.

***Stage home position is unknown.***

Stage has not been set to home position since starting MetroPro. A reference (home) is required after a hard reset. Home stage.

***Stage movement is out of range.***

The pattern, based on its origin position, extends beyond the travel range of the stage.

***System error data file <filename> read from directory <directory> has mismatched phase resolution.***

The system error data file must be created using the same phase resolution as the current data set. See Phase Res control and System Error Function in this manual.

***Test and reference masks are required.***

The analysis to be performed requires test and reference mask definition. Load or create a test and reference mask.

***Test and reference masks intersect.***

Occurs in certain applications that require that the Test and Reference masks do not intersect. Adjust the masks so that the figures do not intersect.

***There are no results to show in a Stats Window.***

There must be results present in the window before opening a Stats window. The Stats window uses the results to determine what result columns to create.

***There is no active instrument.***

Occurs if a measurement is attempted when the Instrument control is set to None. It is usually caused by a problem accessing the interferometer hardware. MetroPro only recognizes hardware that is accessible at startup time. Make sure the instrument is properly connected and turned on. Then restart MetroPro.

***There is no active motion controller.***

Motion controller setup is missing from the configuration file or there is no motion controller present.

***There is no large aperture PZT drive.***

Occurs in a GPI xp application if a measurement is attempted with the Aperture control set to Lg Aperture and there is no large aperture piezoelectric transducer power supply.

***Too few modulating points for acquire.***

Occurs when the Acquisition Mode is Phase and too few points are modulating for the AGC algorithm to function. It is usually caused by poor quality fringes. The AGC algorithm samples points within the Acquisition mask and requires that the number of modulating points found be at least the value specified by the Min Mod Pts control. Increase light level if part is dim. Lower the Min Mod % control to allow weakly modulating points to pass. Use acquisition cursor on area of interest. If these fail, the part may not be reflective enough or too rough to measure.

### ***Too many regions to connect.***

This error occurs when there are too many separate regions of phase data, possibly caused by the filtering of discontinuities. Lower the Discon Filter control value. Change the Discon Action control setting. Increase the Min Area Size control value.

### ***Unknown Error.***

Unexpected internal condition. Note conditions and call Zygo Corporation.

### ***Other Messages***

You may encounter this error message:

```
Out of memory.  
  Attempting recovery.  
Too many graphic windows.  
  Attempting recovery.
```

These errors are self explanatory. Memory refers to RAM; a graphic window includes plots, the Mask Editor and the Calibrator window. When this happens, the system automatically starts a recovery sequence to restart MetroPro and return it to approximately the same state that existed before the error occurred. As the recovery sequence progresses, read the messages that appear on the screen, and press a mouse button when directed to do so.

Usually the following screen message appears:

```
MetroPro has restarted to recover from an error condition.  
The following information was not preserved:  
- Mask definitions.  
- The objective selection for Microscope applications.  
- The calibration for GPI xp applications.
```

If the application was newly created and was not saved to the hard drive, you will see a message indicting that it cannot be recovered. If the application has been saved, it will be reloaded in the configuration in which it was last saved. Also, an attempt is made to recover unsaved measurement data.

You should find out the exact cause of your problem and correct the situation. You may have to restart the computer to reclaim fragmented memory or close graphic windows in the application.



## Appendix B

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### MetroProDAT.dll for Access to MetroPro Data Files

#### Introduction

Zygo Corporation provides an ActiveX DLL to allow programmers to easily read and write MetroPro data files. It is called MetroProDAT.dll and can be used by any ActiveX enabled programming language. This document describes the interfaces exposed by the DLL and provides example code.

#### Overview

This DLL provides the facilities to perform the following operations:

- Read a standard MetroPro data file containing phase and/or intensity data.
- Obtain information about the data file from the header and attributes.
- Set information about the data file.
- Save a standard MetroPro data file containing phase and/or intensity data.
- Use ActiveX objects to manipulate data sets.
- Backward compatibility with the MPVB DLL.

The objects exposed by the DLL each support the manipulation of a single MetroPro data set at a time. However, multiple objects can be created to manipulate multiple data sets simultaneously.

#### Data Types

The following data types are used in this document. The Visual Basic equivalent data types follow each generic description. This document uses the Visual Basic names for the data types.

Generic Description	Visual Basic	C/C++
2-byte signed integer	Integer	short
4-byte signed integer	Long	long
4-byte floating point	Single	float
Length prefixed wide character string	String	BSTR
Boolean	Boolean	VARIANT_BOOL

#### Contents of the DLL

This section describes the enumerated types and objects exposed by the DLL.

##### ***Enumerated Types***

Enumerated types is a user-defined type consisting of named constants. They are used to make the code more readable when each integer value has a specific meaning.

##### ***ZygoSoftwareType***

Used by the *Type* property of ZygoSoftwareInfo.

swtUnknown	0
swtMetroPro	1
swtMetroBasic	2
swtDiagnostic	3

### **ZygoSourceAttr**

Used by the *Source* property of ZygoDataAttributes.

UnknownSource	-1
Measured	0
Generated	1
Scanned	2

### **ZygoAcquireType**

Used by the *AcquireType* property of ZygoDataAttributes.

AcqPhase	0
AcqFringe	1
AcqScan	2
AcqIntensity	3
AcqBright	4
AcqbrightDark	5
AcqFromFile	6

### **ZygoResolution**

Used by the *PhaseRes* property of ZygoDataAttributes.

UnknownRes	-1
LowRes	0
HighRes	1
SuperRes	2

### **ZygoDisconAction**

Used by the *DisconAction* property of ZygoDataAttributes.

DeleteRegionsWithDiscontinuities	0
DeleteDiscontinuities	1
IgnoreDiscontinuities	2
DeleteWithoutChecking	3
SuperDeleteDiscontinuities	4

### **ZygoConnectionOrder**

Used by the *ConnectionOrder* property of ZygoDataAttributes.

ConnectByLocation	0
ConnectBySize	1

### ZygoSystemType

Used by the *SystemType* property of ZygoDataAttributes.

sysUnknown	0
sysMark	1
sysMaxim	2
sysMaximNT	3
sysGPI	4
sysMaximXR	5
sysMaximGP	6
sysMaximXRGPI	7
sysMarkGPI	8
sysRVA	9
sysMaximVS	10
sysMaximXRICO	11
sysMaximGPICO	12
sysMaximXRGPIICO	13
sysMesa	14
sysNIF	15
sysFTP	16
sysMicroLupi	17
sysDVD	18
sysFTPSI	19
sysMaximDelta	20
sysSAI	21
sysNewview6000	22
sysGpiCan	23
sysMarkFP	24

### ZygoCodeVType

Used by the *CodeVType* property of ZygoDataAttributes.

codeVWavefront	0
codeVSurface	1

### ZygoFdaRes

Used by the *FDARes* property of ZygoDataAttributes.

fdaResTest1	-100
fdaResTest2	-101
fdaResSmooth	-4
fdaResCentroid	-3
fdaResNone	-2
fdaResFineOld	-1
fdaResMedium	0
fdaResFine	1
fdaResHigh2g	3
fdaResDissMin	8
fdaResDissMax	9
fdaResPhase1	20
fdaResPhase2	21
fdaResPhase3	22

**ZygoCoherenceMode**

Used by the *CoherenceMode* property of ZygoDataAttributes.

cohModeNone	0
cohModeStandard	1
cohModeShort	2

**ZygoSurfaceFilter**

Used by the *CoherenceMode* property of ZygoDataAttributes.

surfFilterNone	0
surfFilterStandard	1
surfFilterRough	2

**ZygoOrientation**

Used by the *RcOrientation* property of ZygoDataAttributes2.

zoUnknown	32 (' ')
zoNorth	78 ('N')
zoSouth	83 ('S')
zoEast	69 ('E')
zoWest	87 ('W')

**ZygoFtpsiPhaseRes**

Used by the *FtpsiPhaseResolution* property of ZygoDataAttributes2.

zfprHigh	0
zfprMax	1
zfprCustom	2

**ZygoCavityType**

Used by the *CavityType* property of ZygoDataAttributes2.

zctThin	0
zctThick	1
zctMedium	2
zctAuto	3

**ZygoScanDirection**

Used by the *ScanDirection* property of ZygoDataAttributes2.

zsdNode	0
zsdUpward	1
zsdDownward	2

**Objects**

**ZygoSoftwareVersion (IZygoSoftwareVersion interface)**

Properties

<i>Major</i> as Integer	Major version number.
<i>Minor</i> as Integer	Minor version number.
<i>Bug</i> as Integer	Bug version number.

Methods

Copy( <i>Source</i> as ZygoSoftwareVersion)	Copies the values of <i>Source</i> .
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## ZygoSoftwareInfo (IZygoSoftwareInfo interface)

### Properties

<i>Type</i> as ZygoSoftwareType	Indicates which program created the data file.
<i>Date</i> as String	The date the data file was created in the format “Tue Apr 23 14:13:48 EDT 2002.” The value is truncated to 29 characters when the data file is saved.
<i>Version</i> as ZygoSoftwareVersion	The version number of the program that created the data file.

### Methods

<i>Copy</i> ( <i>Source</i> as ZygoSoftwareInfo)	Copies the values of <i>Source</i> .
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## ZygoDataLocation (IZygoDataLocation interface)

### Properties

<i>XPosition</i> as Single	The position of the X-axis when the data was measured in inches.
<i>YPosition</i> as Single	The position of the Y-axis when the data was measured in inches.
<i>ZPosition</i> as Single	The position of the Z-axis when the data was measured in inches.
<i>XRotation</i> as Single	The rotation of the X-axis (Roll) when the data was measured in degrees.
<i>YRotation</i> as Single	The rotation of the Y-axis (Pitch) when the data was measured in degrees.
<i>ZRotation</i> as Single	The rotation of the Z-axis (Theta) when the data was measured in degrees.

### Methods

<i>Copy</i> ( <i>Source</i> as ZygoDataLocation)	Copies the values of <i>Source</i> .
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## ZygoDataAttributes (IZygoDataAttributes interface)

### Properties

<i>TimeStamp</i> as Long	The date and time the data was measured.
<i>Comment</i> as String	User-entered remark line. The value is truncated to 81 characters when the data file is saved.
<i>Source</i> as ZygoSourceAttr	Indicates how the data was acquired or generated.
<i>IntfScaleFactor</i> as Single	The interferometric scale factor is the number of waves per fringe.
<i>WavelengthIn</i> as Single	The wavelength, in meters, at which the interferogram was measured.
<i>ObliquityFactor</i> as Single	Phase correction factor required when using a Mirau objective on a microscope. A value of 1.0 indicates no correction.
<i>NumericAperture</i> as Single	Equals $1 / (2 * f\text{-number})$ .
<i>Magnification</i> as Single	Reserved for future use.
<i>LateralResolution</i> as Single	Lateral resolving power of a camera pixel in meters/pixel. A value of 0 means that the value is unknown.
<i>AcquireType</i> as ZygoAcquireType	Indicates the setting of the Acquisition Mode control.
<i>IntensityAverageCount</i> as Integer	The number of intensity averages performed. Values of 0 or 1 indicate no averaging.
<i>PZTCal</i> as Boolean	Indicates whether or not the modulation amplitude was automatically adjusted during acquisition.
<i>PZTGainTolerance</i> as Integer	Specifies the PZT error range if PZT calibration was adjusted.

**ZygoDataAttributes (IZygoDataAttributes interface)-continued**

<i>PZTGain</i> as Integer	Specifies the modulation amplitude value used during data acquisition.
<i>PartThickness</i> as Single	The thickness, in meters, of the part measured.
<i>AGC</i> as Boolean	Indicates whether or not automatic gain control was performed during data acquisition.
<i>TargetRange</i> as Single	The acceptable tolerance limits of the light intensity used during AGC.
<i>RadCrvMeasSeq</i> as Integer	
<i>MinMod</i> as Long	Minimum value of modulation needed to calculate a phase value.
<i>MinModCount</i> as Long	Minimum number of data points required to pass <i>MinMod</i> criteria during AGC.
<i>PhaseRes</i> as ZygoResolution.	The resolution of the phase data points. LowRes means that each fringe is represented by 4096 counts. HighRes means that each fringe is represented by 32768 counts.
<i>MinAreaSize</i> as Long	Minimum number of contiguous data points required for a valid region.
<i>DisconAction</i> as ZygoDisconAction	Indicates the action taken when the system encounters discontinuities in phase data.
<i>DisconFilter</i> as Single	Specifies the degree to which discontinuities were removed when <i>DisconAction</i> was filtered.
<i>ConnectionOrder</i> as ZygoConnectionOrder	Order in which separate regions of phase data are processed.
<i>DataSign</i> as Integer	Sign of the data. 0 is normal, 1 is inverted.
<i>CameraWidth</i> as Integer	The width (columns) of the usable camera field in pixels.
<i>CameraHeight</i> as Integer	The height (rows) of the usable camera field in pixels.
<i>SystemType</i> as ZygoSystemType	Indicates the system used to make the measurement.
<i>SystemBoard</i> as Integer	Indicates which system board was used when the data measurement was taken. Valid values range from 0 to 7.
<i>SystemSerial</i> as Integer	The serial number of the instrument.
<i>InstrumentID</i> as Integer	The instrument unit number. Valid values range from 0 to 7.
<i>ObjectiveName</i> as String	For microscopes, this is the objective in use. For the GPI, this is the aperture in use. For generated data, this is blank. The value is truncated to 11 characters when the data file is saved.
<i>PartName</i> as String	User-entered identified for the part measured. The value is truncated to 39 characters when the data file is saved.
<i>CodeVType</i> as ZygoCodeVType	Indicates whether the phase data represents a wavefront or a surface. This is only used by the CODE V program.
<i>PhaseAverageCount</i> as Integer	The number of phase averages performed.
<i>SubtractSystemError</i> as Boolean	Indicates whether or not the system error was subtracted from the phase data.
<i>PartSerialNumber</i> as String	User-entered serial number for the part. The value is truncated to 39 characters when the data file is saved.
<i>RefractiveIndex</i> as Single	Index of refraction as specified by the user. This is used only in the calculation of corner cube dihedral angles.
<i>RemoveTiltBias</i> as Boolean	Indicates whether or not the tilt bias was removed from the phase data.
<i>RemoveFringes</i> as Boolean	Indicates whether or not fringes were removed from the intensity data.
<i>MaxAreaSize</i> as Long	Maximum number of contiguous data points required for a valid phase data region. Any larger regions are deleted.

**ZygoDataAttributes (IZygoDataAttributes interface) -continued**

<i>SetupType</i> as Integer	Identifies the different setup used by the Angle Measurement Application.
<i>Wrapped</i> as Boolean	
<i>PreConnectFilter</i> as Single	The amount of filtering done to wrapped phase data.
<i>WavelengthIn2</i> as Single	The value from the Wavelength-In 2 control, if relevant to the measurement.
<i>WavelengthFold</i> as Boolean	Indicates whether or not two wavelength folding is on.
<i>WavelengthIn1</i> as Single	The value from the Wavelength-In 1 control, if relevant to the measurement.
<i>WavelengthIn3</i> as Single	The value from the Wavelength-In 3 control, if relevant to the measurement.
<i>WavelengthIn4</i> as Single	The value from the Wavelength-In 4 control, if relevant to the measurement.
<i>WavelengthSelect</i> as String	The value of the Wavelength Select control, if relevant to the measurement. The value is truncated to 7 characters when the data file is saved.
<i>FDARes</i> as ZygoFdaRes	Indicates the setting of the FDA Res control for a measurement when the Acquisition Mode control is set to Scan.
<i>ScanDescription</i> as String	Description of the scan for a measurement when the Acquisition Mode control is set to Scan. The value is truncated to 19 characters when the data file is saved. A sample string is "5 um bipolar".
<i>NFiducials</i> as Integer	The number of fiducials defined.
<i>FiducialX(Index as Long)</i> as Single	The X component of the fiducial's coordinates specified by <i>Index</i> . <i>Index</i> can range from 1 to 7. The coordinate system is the camera's and (0,0) is in the upper left corner of the video monitor.
<i>FiducialY(Index as Long)</i> as Single	The Y component of the fiducial's coordinates specified by <i>Index</i> . <i>Index</i> can range from 1 to 7. The coordinate system is the camera's and (0,0) is in the upper left corner of the video monitor.
<i>PixelWidth</i> as Single	The effective camera pixel width (spacing) in meters. Affects the scaling of Mask Editor figures. If zero, default values are assumed. Not the same as <i>LateralResolution</i> .
<i>PixelHeight</i> as Single	The effective camera pixel height (spacing) in meters. Affects the scaling of Mask Editor figures. If zero, default values are assumed. Not the same as <i>LateralResolution</i> .
<i>ExitPupilDiameter</i> as Single	The exit pupil diameter setting used during data acquisition.
<i>LightLevelPercent</i> as Single	The light level percent used during data acquisition.
<i>CoordinateState</i> as Long	Indicates whether or not the coordinates in the <i>Coordinates</i> property are valid. 0 indicates invalid coordinates.
<i>Coordinates</i> as ZygoDataLocation	Coordinates of the stage during data acquisition.
<i>CoherenceMode</i> as ZygoCoherenceMode	The coherence mode setting used during data acquisition.
<i>SurfaceFilter</i> as ZygoSurfaceFilter	The surface filter setting used during data acquisition.
<i>SystemErrorFileName</i> as String	User-entered name of the file containing the system error data. The value is truncated to 27 characters when the data file is saved.
<i>ZoomDescription</i> as String	Value of the image zoom used during data acquisition. The value is truncated to 7 characters when the data file is saved.

**ZygoDataAttributes (IZygoDataAttributes interface)-continued**

<i>AplhaPart</i> as Single	
<i>BetaPart</i> as Single	
<i>DistancePart</i> as Single	
<i>CameraSplitLocationX</i> as Integer	
<i>CameraSplitLocationY</i> as Integer	
<i>CameraSplitTransX</i> as Integer	
<i>CameraSplitTransY</i> as Integer	
<i>MaterialA</i> as String	The value is truncated to 23 characters when the data file is saved.
<i>MaterialB</i> as String	The value is truncated to 23 characters when the data file is saved.
<i>CameraSplitUnused</i> as Integer	
<i>DMICenterX</i> as Single	
<i>DMICenterY</i> as Single	
<i>SphDistCorr</i> as Boolean	
<i>SphDistPartNa</i> as Single	
<i>SphDistPartRadius</i> as Single	
<i>SphDistCalNa</i> as Single	
<i>SphDistCalRadius</i> as Single	
<i>SurfaceType</i> as Integer	
<i>ZPosition</i> as Single	
<i>PowerMultiplier</i> as Single	
<i>FocusMultiplier</i> as Single	
<i>RadCrvFocusCalFactor</i> as Single	
<i>RadCrvPowerCalFactor</i> as Single	

Methods

Copy( <i>Source</i> as ZygoDataAttributes)	Copies the values of <i>Source</i> .
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**ZygoDataAttributes (IZygoDataAttributes2 interface)**

**Properties**

<i>AcSurfaceType</i> as Integer	
<i>CalPixelLocationX</i> as Integer	X coordinate of cal pixel in camera coordinates
<i>CalPixelLocationY</i> as Integer	Y coordinate of cal pixel in camera coordinates
<i>CameraFrameRate</i> as Single	
<i>CavityType</i> as ZygoZavityType	
<i>FilmsDataFormat</i> as Integer	
<i>FilmsMaxReflRatio</i> as Single	
<i>FilmsMaxThickness</i> as Single	
<i>FilmsMinMod</i> as Single	
<i>FilmsMinReflRatio</i> as Single	
<i>FilmsMinThickness</i> as Single	
<i>FilmsMode</i> as Integer	
<i>FilmsObliquityCorrection</i> as Single	
<i>FilmsReflectivityRatio</i> as Integer	
<i>FilmsRefractionIndex</i> as Single	
<i>FilmsSystemCharacterizationFileName</i> as String	



**ZygoDataAttributes (IZygoDataAttributes2 interface)-continued**

<i>FilmsTemp1</i> as Integer	
<i>FilmsTemp2</i> as Integer	
<i>FramesAcquired</i> as Integer	
<i>FtpLeftPosition</i> as Single	
<i>FtpPitchPosition</i> as Single	
<i>FtpRightPosition</i> as Single	
<i>FtpRollPosition</i> as Single	
<i>FtpsiPhaseResolution</i> as ZygoFtpsiPhaseRes	
<i>FtpsiResolutionFactor</i> as Single	
<i>MaxIntensity</i> as Long	Maximum intensity from frame grabber
<i>MinModPercent</i> as Single	Min Mod as a percent
<i>RcAngle</i> as Single	
<i>RcDiameter</i> as Single	
<i>RcDistance</i> as Single	
<i>RcOrientation</i> as ZygoOrientation	
<i>ReferenceCalPixelOpd</i> as Single	
<i>ReferenceCalPointCount</i> as Integer	
<i>ReferenceCalPointX</i> as Single	
<i>ReferenceCalPointY</i> as Single	
<i>RemoveFringesMode</i> as Boolean	
<i>RingOfFire</i> as Boolean	
<i>ScanDirection</i> as ZygoScanDirection	
<i>SystemSerial2</i> as Long	
<i>TestCalPixelOpd</i> as Single	
<i>TestCalPointCount</i> as Integer	
<i>TestCalPointX</i> as Single	
<i>TestCalPointY</i> as Single	
<i>TuneRange</i> as Single	Optical frequency excursion (Hz)

## Methods

Copy( <i>Source</i> as IZygoDataAttributes2)	Copies the values of <i>Source</i> .
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## ZygoDataFileHeader (IZygoDataFileHeader interface)

### Properties

<i>MagicNumber</i> as Long	Indicates whether or not the file is a valid MetroPro file. The file is valid only if the value is -2011495569 (881B036F hex).
<i>HeaderFormat</i> as Integer	Indicates the format of the header. This is always 1.
<i>HeaderSize</i> as Long	The size of the header in bytes. This should always be 834.
<i>SoftwareInfo</i> as ZygoSoftwareInfo	Software date, type and version.
<i>IntensOriginX</i> as Integer	The X component of the origin of the intensity data matrix. The coordinate system is the camera's and (0,0) is in the upper left corner of the video monitor.
<i>IntensOriginY</i> as Integer	The Y component of the origin of the intensity data matrix. The coordinate system is the camera's and (0,0) is in the upper left corner of the video monitor.
<i>IntensWidth</i> as Integer	The width (number of columns) of the intensity data matrix. If no intensity data matrix is present, then this value is zero.
<i>IntensHeight</i> as Integer	The height (number of rows) of the intensity data matrix. If no intensity data matrix is present, then this value is zero.
<i>IntensNumBuckets</i> as Integer	The number of buckets of intensity data that are stored. If no intensity data matrix is present, then this value is zero.
<i>IntensRange</i> as Integer	Maximum possible value of an intensity data point.
<i>IntensNumBytes</i> as Long	Number of bytes of intensity data stored. This value is equal to $IntensWidth * IntensHeight * IntensNumBuckets * 2$ .
<i>PhaseOriginX</i> as Integer	The X component of the origin of the phase data matrix. The coordinate system is the camera's and (0,0) is in the upper left corner of the video monitor.
<i>PhaseOriginY</i> as Integer	The Y component of the origin of the phase data matrix. The coordinate system is the camera's and (0,0) is in the upper left corner of the video monitor.
<i>PhaseWidth</i> as Integer	The width (number of columns) of the phase data matrix. If no phase data matrix is present, then this value is zero.
<i>PhaseHeight</i> as Integer	The height (number of rows) of the phase data matrix. If no phase data matrix is present, then this value is zero.
<i>PhaseNumBytes</i> as Long	Number of bytes of phase data stored. This value is equal to $PhaseWidth * PhaseHeight * 4$ .
<i>Attr</i> as ZygoDataAttributes	Attributes of the data.

### Methods

Copy( <i>Source</i> as ZygoDataFileHeader)	Copies the values of <i>Source</i> .
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## ZygoDataWindow (IZygoDataWindow interface)

### Properties

<i>X</i> as Integer	The X component of the origin of the data matrix.
<i>Y</i> as Integer	The Y component of the origin of the data matrix.
<i>Width</i> as Integer	The width (number of columns) of the data matrix.
<i>Height</i> as Integer	The height (number of rows) of the data matrix.

### Methods

Copy( <i>Source</i> as ZygoDataWindow)	Copies the values of <i>Source</i> .
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## ZygoDataMatrix (IZygoDataMatrix interface)

### Properties

<i>Window</i> as ZygoDataWindow	Specifies the origin and size of the data matrix. The <i>X</i> , <i>Y</i> , <i>Width</i> , and <i>Height</i> values are the same as <i>PhaseOriginX</i> , <i>PhaseOriginY</i> , <i>PhaseWidth</i> , and <i>PhaseHeight</i> in <i>ZygoDataFileHeader</i> .
<i>Matrix</i> as Variant	2D array of Longs representing the phase data. The first dimension is the columns, and the second is the rows. Matrix(column, row).

### Methods

Copy( <i>Source</i> as ZygoDataMatrix)	Copies the values of <i>Source</i> .
--	--------------------------------------

## ZygoIntensityMatrix (IZygoIntensityMatrix interface)

### Properties

<i>Window</i> as ZygoDataWindow	Specifies the origin and size of the data matrix. The <i>X</i> , <i>Y</i> , <i>Width</i> , and <i>Height</i> values are the same as <i>IntensOriginX</i> , <i>IntensOriginY</i> , <i>IntensWidth</i> , and <i>IntensHeight</i> in <i>ZygoDataFileHeader</i> .
<i>Matrix</i> as Variant	3D array of Integers representing the intensity data. The first dimension is the columns, the second is the rows and the third is the buckets. Matrix(column, row, bucket).
<i>Range</i> as Integer	Maximum possible value of an intensity data point. This value is the same as <i>IntensRange</i> in <i>ZygoDataFileHeader</i> .
<i>NumBuckets</i> as Integer	Read Only. The number of buckets of intensity data that are stored. This value is the same as <i>IntensNumBuckets</i> in <i>ZygoDataFileHeader</i> .

### Methods

Copy( <i>Source</i> as ZygoIntensityMatrix)	Copies the values of <i>Source</i> .
---	--------------------------------------

## ZygoDataFile (IZygoDataFile interface)

### Properties

<i>Header</i> as ZygoDataFileHeader	Data file header.
<i>Attribute</i> as ZygoDataAttributes	Data file attributes.
<i>PhaseData</i> as ZygoDataMatrix	Phase data.
<i>IntensityData</i> as ZygoIntensityMatrix	Intensity data.
<i>InvalidPhase</i> as Long	Read Only. Minimum value of phase data that indicates the data point is not valid.

### Methods

LoadData( <i>FileName</i> as String)	Loads the data file specified by <i>FileName</i> .
SaveData( <i>FileName</i> as String)	Saves the current information to the data file specified by <i>FileName</i> . When the data is saved, the values for the phase and intensity origin and dimensions in ZygoDataFileHeader are overwritten with the values from ZygoDataMatrix and ZygoIntensityMatrix.
Clear()	Removes phase and intensity data and resets all header and attribute values to their default values.

## Objects for Backward Compatibility

These objects are provided for the purpose of backward compatibility with the MPVB DLL. In the MPVB DLL, MetroProDataAttr was defined in a Visual Basic Module as a public structure using the Type keyword. That module also defined the calls into the MPVB DLL using the Declare keyword. The following objects provide the same functionality while requiring few code changes.

### MetroProDataAttr (IMetroProDataAttr interface)

### Properties

<i>CameraCols</i> as Integer	The number of columns (width) of the usable camera field in pixels.
<i>CameraRows</i> as Integer	The number of rows (height) of the usable camera field in pixels.
<i>CameraRes</i> as Single	Lateral resolving power of a camera pixel in meters/pixel. A value of 0 means that the value is unknown.
<i>IntensMatOrgX</i> as Integer	The X component of the origin of the intensity data matrix. The coordinate system is the camera's and (0,0) is in the upper left corner of the video monitor.
<i>IntensMatOrgY</i> as Integer	The Y component of the origin of the intensity data matrix. The coordinate system is the camera's and (0,0) is in the upper left corner of the video monitor.
<i>IntensMatCols</i> as Integer	The number of columns (width) of the intensity data matrix. If no intensity data matrix is present, then this value is zero.
<i>IntensMatRows</i> as Integer	The number of rows (height) of the intensity data matrix. If no intensity data matrix is present, then this value is zero.
<i>IntensMatBuckets</i> as Integer	The number of buckets of intensity data that are stored. If no intensity data matrix is present, then this value is zero.
<i>PhaseMatOrgX</i> as Integer	The X component of the origin of the phase data matrix. The coordinate system is the camera's and (0,0) is in the upper left corner of the video monitor.

**MetroProDataAttr (IMetroProDataAttr interface)-continued**

<i>PhaseMatOrgY</i> as Integer	The Y component of the origin of the phase data matrix. The coordinate system is the camera's and (0,0) is in the upper left corner of the video monitor.
<i>PhaseMatCols</i> as Integer	The number of columns (width) of the phase data matrix. If no phase data matrix is present, then this value is zero.
<i>PhaseMatRows</i> as Integer	The number of rows (height) of the phase data matrix. If no phase data matrix is present, then this value is zero.
<i>PhaseRes</i> as Integer	The resolution of the phase data points. 0 means that each fringe is represented by 4096 counts. 1 means that each fringe is represented by 32768 counts.
<i>IntfScaleFactor</i> as Single	The interferometric scale factor is the number of waves per fringe.
<i>WavelengthIn</i> as Single	The wavelength, in meters, at which the interferogram was measured.
<i>ObliquityFactor</i> as Single	Phase correction factor required when using a Mirau objective on a microscope. A value of 1.0 indicates no correction.
<i>NumAperture</i> as Single	Equals $1 / (2 * \text{f-number})$ .
<i>AcquireType</i> as Integer	Indicates the setting of the Acquisition Mode control. See <i>ZygoAcquireType</i> for values.
<i>IntensAvgCount</i> as Integer	The number of intensity averages performed. Values of 0 or 1 indicate no averaging.
<i>PztCal</i> as Integer	Indicates whether or not the modulation amplitude was automatically adjusted during acquisition. A value of 0 indicates that no adjustment was performed.
<i>PztGain</i> as Integer	Specifies the modulation amplitude value used during data acquisition.
<i>PartThickness</i> as Single	The thickness, in meters, of the part measured.
<i>AGC</i> as Integer	Indicates whether or not automatic gain control was performed during data acquisition. A value of 0 indicates no AGC was performed.
<i>Sign</i> as Integer	Sign of the data. 0 is normal, 1 is inverted.
<i>Comment</i> as String	User-entered remark line. The value is truncated to 81 characters when the data file is saved.
<i>PartName</i> as String	User-entered identified for the part measured. The value is truncated to 39 characters when the data file is saved.
<i>PartSerNum</i> as String	User-entered serial number for the part. The value is truncated to 39 characters when the data file is saved.

## Methods

<i>Copy</i> ( <i>Source</i> as MetroProDataAttr)	Copies the values of <i>Source</i> .
--	--------------------------------------

### **MetroProDataFile (IMetroProDataFile interface)**

Note: Multiple data files can be loaded by creating multiple MetroProDataFile objects and loading one data file with each object.

Methods

LoadMetroProDataFile( <i>FileName</i> as String, <i>pAttr</i> as MetroProDataAttr ) as Integer	Loads the data file specified by <i>FileName</i> . The data files attributes are returned in <i>pAttr</i> .  A return value of 0 indicates no error.
SaveMetroProDataFile( <i>FileName</i> as String, <i>pAttr</i> as MetroProDataAttr ) as Integer	Saves the attributes specified by <i>pAttr</i> and the current phase and intensity data to the data file specified by <i>FileName</i> .  A return value of 0 indicates no error.
ResetMetroProData()	Removes phase and intensity data and resets all header and attribute values to their default values.
GetMetroProPhaseData( <i>PhaseDataArray</i> as Variant ) as Integer	Returns the phase data in <i>PhaseDataArray</i> . <i>PhaseDataArray</i> must either be a properly dimensioned 2D array of Longs or and empty Variant.  A return value of 0 indicates no error.
SetMetroProPhaseData( <i>PhaseDataArray</i> as Variant ) as Integer	Sets the phase data to <i>PhaseDataArray</i> .  A return value of 0 indicates no error.
GetMetroProIntensData <i>IntensDataArray</i> as Variant ) as Integer	Returns the phase data in <i>IntensDataArray</i> . <i>IntensDataArray</i> must either be a properly dimensioned 3D array of Integers or and empty Variant.  A return value of 0 indicates no error.
SetMetroProIntensData <i>IntensDataArray</i> as Variant ) as Integer	Sets the phase data to <i>IntensDataArray</i> .  A return value of 0 indicates no error.

## **Installing the DLL**

### **Manual Installation**

Step 1: Copy the DLL and the type library (TLB) onto your hard drive. The files can be placed in any directory, but typical locations are the System32 directory in the Windows directory or in the metropro\bin directory.

Step 2: Register the DLL. Use one of the methods below.

- From the command line: type regsvr32 <DLL\_NAME> where <DLL\_NAME> is the full path and file name for the DLL. If there are spaces in the path or filename, then the path and file name needs to be placed in double quotes (“ ”).
- From Windows Explorer: right-click on the file and select Open with.... If asked to select a file to open the DLL, select regsvr32 or click on the “Other... button and find regsvr32. Finally click the OK button.
- From Visual Basic, select the Project → References... menu item. The click on the Browse... button. Select the directory in which the type library is located (from step 1) and select the type library. Finally click the Open button.

The DLL is now registered with your system.

## Using the DLL

### Visual Basic

Start a new project or open an existing project. Select the Project → References... menu item. Check the MetroPro DAT ## Type Library (where ## is a version number) from the list box and click “OK”.

### Microsoft Visual C++

Start a new project or open an existing project. Open the MFC Class Wizard by pressing CTRL-W or selecting the View → Class Wizard... menu item. Click the Add Class... button and select From type library.... Select all the objects that you want available to your project and click OK. Finally close the MFC Class Wizard.

The above procedure makes the objects available to the current project.

### Microsoft Visual C++ 7

Start a new project or open an existing project. Import classes from the type library by selecting the Project → Add Class... menu item. Select the MFC Class From TypeLib template and click Open. Next, select the MetroProDAT type library from the list or browse to select the MetroProDAT.dll file. Select all the objects that you want available to your project and click Finish.

The above procedure makes the objects available to the current project.

## Accessing *IZygoDataAttributes2* Attributes

The ZygoDataAttributes class supports both the IZygoDataAttributes interface and the IZygoDataAttributes2 interface. By default, the IZygoDataAttributes interface is used; therefore to get access to the IZygoDataAttributes2 properties, the ZygoDataAttributes variable must be cast to an IZygoDataAttributes2 variable.

### Visual Basic

```
Dim file As ZygoDataFile
Dim attr As ZygoDataAttributes
Dim attr2 As IZygoDataAttributes2

` Code to create and load the data file omitted

` Get the attributes using the IZygoDataAttributes interface
Set attr = file.Attribute

` Get the attributes using the IZygoDataAttributes2 interface
Set attr2 = attr
```

### Microsoft Visual C++ 7

```
CZygoDataFile file;

// Code to create and load the data file omitted

// Get the attributes using the IZygoDataAttributes interface
CZygoDataAttributes attr(file.get_Attribute());

// Get the attributes using the IZygoDataAttributes2 interface
CZygoDataAttributes2 attr2(file.get_Attribute());
```

## Reading A MetroPro Data File

The following sample code shows how to read a MetroPro data file and convert the phase data from zygos to waves.

```
Public Sub LoadData(ByVal FileName As String)
    Dim oData          As ZygoDataFile
    Dim Attr           As ZygoDataAttributes
    Dim Phase          As ZygoDataMatrix
    Dim Intens         As ZygoIntensityMatrix
    Dim ConvFactor     As Single
    Dim InvalidPhase   As Long
    Dim PhaseData()    As Long
    Dim PhaseF()       As Single
    Dim idx            As Long
    Dim jdx            As Long

    ' Create the data file object
    Set oData = New ZygoDataFile
    Set Attr = oData.Attribute

    ' Load the data
    oData.LoadData FileName

    ' Get the phase and intensity data
    Set Intens = oData.IntensityData
    Set Phase = oData.PhaseData

    ' Create the array of converted phase data
    ReDim PhaseF(LBound(Phase.Matrix, 1) To UBound(Phase.Matrix, 1), _
                LBound(Phase.Matrix, 2) To UBound(Phase.Matrix, 2) _
                ) As Single

    ' Get the value of invalid data
    InvalidPhase = oData.InvalidPhase

    ' Get the conversion factor
    ConvFactor = Attr.IntfScaleFactor * Attr.ObliquityFactor
    If (Attr.PhaseRes = HighRes) Then
        ConvFactor = ConvFactor / 32768
    Else
        ConvFactor = ConvFactor / 4096
    End If

    ' Convert the phase data from zygos to waves
    PhaseData = Phase.Matrix
    For idx = LBound(PhaseF, 1) To UBound(PhaseF, 1)
        For jdx = LBound(PhaseF, 2) To UBound(PhaseF, 2)
            If (PhaseData(idx, jdx) >= InvalidPhase) Then
                PhaseF(idx, jdx) = 0
            Else
                PhaseF(idx, jdx) = ConvFactor * PhaseData(idx, jdx)
            End If
        Next jdx
    Next idx

    ' Delete the data file object
    Set oData = Nothing
End Sub
```



## Backward Compatible Format

The following sample code shows how to read a MetroPro data file and convert the phase data from zygos to waves. The bold line shows the only change needed to existing code.

```
Public Sub ReadMetroProDataFile(ByVal PathName As String)
    Dim Attr As MetroProDataAttr

    Dim nPhaseRows As Integer
    Dim nPhaseCols As Integer

    Dim nIntensRows As Integer
    Dim nIntensCols As Integer
    Dim nBuckets As Integer

    Dim Err As Integer
    Dim ErrMsg As String

    Dim IntensMat() As Long
    Dim PhaseMat() As Long
    Dim PhaseMatF() As Single

    Dim ZygosPerFringe As Long
    Dim PhaseVal As Long
    Dim ConvFactor As Single

    Dim nRow As Integer
    Dim nCol As Integer

    Dim InvalidInten As Long
    Dim InvalidPhase As Long

    Const NO_ERROR As Integer = 0

    Set Attr = New MetroProDataAttr

    InvalidInten = 64512
    InvalidPhase = 2147483640

    Err = NO_ERROR

    ' Load the data file
    Err = LoadMetroProDataFile(PathName, Attr)
    If (Err <> NO_ERROR) Then
        ErrMsg = "Error reading data file " & PathName
        MsgBox ErrMsg
        Exit Sub
    End If

    ' Set size of Intensity and Phase arrays based on
    ' row and column attributes returned in MetroProDataAttr parameter
    nPhaseRows = Attr.PhaseMatRows
    nPhaseCols = Attr.PhaseMatCols

    nIntensRows = Attr.IntensMatRows
    nIntensCols = Attr.IntensMatCols
    nBuckets = Attr.IntensMatBuckets

    If (nPhaseRows <> 0 And nPhaseCols <> 0) Then
        ' Resize phase matrices
        ReDim PhaseMat(0 To nPhaseCols - 1, 0 To nPhaseRows - 1)
        ReDim PhaseMatF(0 To nPhaseCols - 1, 0 To nPhaseRows - 1)

        ' Get the loaded phase matrix into PhaseMat
        Err = GetMetroProPhaseData(PhaseMat)
        If (Err <> NO_ERROR) Then Exit Sub
    End If

    If (nIntensRows <> 0 And nIntensCols <> 0) Then
```

**Backward Compatible sample code - continued**

```

' Resize intensity matrix
ReDim IntensMat(0 To nIntensCols - 1, _
                0 To nIntensRows - 1, _
                0 To nBuckets - 1)

' Get the loaded intensity matrix into IntensMat
Err = GetMetroProIntensData(IntensMat)
If (Err <> NO_ERROR) Then Exit Sub
End If

' Calculate factor to convert phase values
' from zygos to waves
If Attr.PhaseRes = 0 Then
    ZygosPerFringe = 4096
Else
    ZygosPerFringe = 32768
End If

ConvFactor = (Attr.IntfScaleFactor * Attr.ObliquityFactor) _
             / ZygosPerFringe

' Convert phase values to waves
For nCol = 0 To Attr.PhaseMatCols - 1
    For nRow = 0 To Attr.PhaseMatRows - 1
        PhaseVal = PhaseMat(nCol, nRow)
        If (PhaseVal < InvalidPhase) Then
            PhaseMatF(nCol, nRow) = ConvFactor * PhaseVal
        Else
            PhaseMatF(nCol, nRow) = 0!
        End If
    Next nRow
Next nCol
End Sub

```

**Writing A MetroPro Data File**

The following sample code shows how to generate a MetroPro data file. The phase data is generated as waves and is then converted to zygos. The bold line shows the only change needed to existing code.

```

Public Sub SaveData(ByVal FileName As String)
    Dim oData      As ZygoDataFile
    Dim Attr       As ZygoDataAttributes
    Dim Phase      As ZygoDataMatrix
    Dim idx        As Long
    Dim jdx        As Long
    Dim PhaseData() As Long
    Dim PhaseF()   As Single
    Dim ConvFactor As Single

    ' Create the data file object
    Set oData = New ZygoDataFile
    Set Attr = oData.Attribute

    ' Make changes to the attributes
    With Attr
        .CameraWidth = 320
        .CameraHeight = 240

        .LateralResolution = 0.000000001
        .PhaseRes = HighRes
        .RefractiveIndex = 1

        .PixelWidth = 0.000022
        .PixelHeight = 0.000022
    End With

```

## Writing a MetroPro Data File sample code-continued

```

' Resize the data matrix
ReDim PhaseF(0 To Attr.CameraWidth - 1, _
             0 To Attr.CameraHeight - 1) As Single

' Generate PhaseF matrix (in waves)
' The surface function is: Z = 0.001 * (col + row)
' which is a tilted plane
For idx = LBound(PhaseF, 1) To UBound(PhaseF, 1)
    For jdx = LBound(PhaseF, 2) To UBound(PhaseF, 2)
        PhaseF(idx, jdx) = 0.001 * (idx + jdx)
    Next jdx
Next idx

' Get the conversion factor
ConvFactor = Attr.IntfScaleFactor * Attr.ObliquityFactor
If (Attr.PhaseRes = HighRes) Then
    ConvFactor = 32768 / ConvFactor
Else
    ConvFactor = 4096 / ConvFactor
End If

' Resize the phase data
ReDim PhaseData(0 To Attr.CameraWidth - 1, _
               0 To Attr.CameraHeight - 1) As Long

' Convert the PhaseF data to zygots
For idx = LBound(PhaseF, 1) To UBound(PhaseF, 1)
    For jdx = LBound(PhaseF, 2) To UBound(PhaseF, 2)
        PhaseData(idx, jdx) = ConvFactor * PhaseF(idx, jdx)
    Next jdx
Next idx

' Save the phase data
oData.PhaseData.Matrix = PhaseData

' Save the data file
oData.SaveData FileName

' Delete the data file object
Set oData = Nothing
End Sub

```

## Backward Compatible Format

The following sample code shows how to generate a MetroPro data file. The phase data is generated as waves and is then converted to zygots. The bold line shows the only change needed to existing code.

```

Public Sub WriteMetroProDataFile(ByVal PathName As String)
    Dim Attr As MetroProDataAttr

    Dim PhaseMatF() As Single
    Dim PhaseMat() As Long

    Dim ZygotsPerFringe As Long
    Dim PhaseVal As Long
    Dim ConvFactor As Single
    Dim C As Single

    Dim row As Integer
    Dim col As Integer
    Dim nRows As Integer
    Dim nCols As Integer

    Dim Err As Integer

    Const NO_ERROR As Integer = 0

```

**Backward Compatible Format sample code - continued**

```

Set Attr = New MetroProDataAttr

Err = NO_ERROR

' Clear any previous MetroPro data
' (matrices and attributes)
ResetMetroProData

' Generate PhaseMatF matrix (in waves)
' The surface function is:  $Z = C * (col + row)$ 
' which should be a tilted plane
nCols = 320
nRows = 240

C = 0.001
ReDim PhaseMat(0 To nCols - 1, 0 To nRows - 1) As Long
ReDim PhaseMatF(0 To nCols - 1, 0 To nRows - 1) As Single
For col = 0 To nCols - 1
    For row = 0 To nRows - 1
        PhaseMatF(col, row) = C * (col + row)
    Next row
Next col

' Assign required attribute values
Attr.CameraCols = nCols
Attr.CameraRows = nRows
Attr.CameraRes = 0!
Attr.PhaseRes = 1
Attr.IntfScaleFactor = 0.5
Attr.ObliquityFactor = 1!

' Calculate factor to convert phase values
' from waves to zygots
If (Attr.PhaseRes = 0) Then
    ZygotsPerFringe = 4096
Else
    ZygotsPerFringe = 32768
End If
ConvFactor = ZygotsPerFringe / _
    (Attr.IntfScaleFactor * Attr.ObliquityFactor)

' Convert phase values to zygots and load PhaseMat matrix
For col = 0 To nCols - 1
    For row = 0 To nRows - 1
        PhaseMat(col, row) = PhaseMatF(col, row) * ConvFactor
    Next row
Next col

' Set PhaseMat as the matrix to be saved in the file
Err = SetMetroProPhaseData(PhaseMat)

' Save the data file
Err = SaveMetroProDataFile(PathName, Attr)
If (Err <> NO_ERROR) Then
    MsgBox "Unable to save MetroPro Data file.", vbOKOnly, "Error"
End If
End Sub

```

## Summary

This appendix describes specialized options that affect the way MetroPro operates. By using command line options you can, for example, cause MetroPro to ignore an instrument, open two applications side-by-side, open a specific application and data file, or load MetroPro in icon form. These options can be temporary or permanent, depending on the how they are implemented.



Use of command line options is for advanced users. Command line options change the way MetroPro operates and may cause confusion between multiple users.

## Command Line Options

Every option begins with a plus sign (+) or a minus sign (-). Italicized type indicates optional parameters to enter; substitute the name of a file for the parameter. Be sure to enter the characters (comma, plus sign, or times sign) shown between multiple parameters.

<i>Option</i>	<i>Description</i>
<b>-app</b> <appName>	Load the application named <appName>, but leave it iconized.
<b>+app</b> <appName>	Load and open the application named <appName>.
<b>+app</b> <appName> [,<datafile>]	Load and open the application named <appName>, then load data from file named <datafile>.
<b>-cfg</b>	Ignore configuration file MetroPro.cfg (which is normally read at startup).
<b>+cfg</b> <configFile>	Use configuration file named <configFile> instead of MetroPro.cfg.
<b>dat_test -maps &gt;</b> <b>maps.txt</b>	Opens the utility program, “dat_test.exe” which enables you to obtain the latest map of the binary data file header.
<b>-DNAUS</b>	Disables the use of Non-ASCII Unit Symbols. MetroPro will display non-ASCII unit symbols by default.
<b>-help</b>	Display list of command line options and exit MetroPro.
<b>-ignore</b>	Ignore any instrument hardware. (This allows multiple MetroPro invocations without conflict. Only one MetroPro invocation at a time should access an instrument.)
<b>-imagegrey</b>	Send grey instead of color images when printing to a file or a printer.
<b>-imgbgwhite</b>	Sets bitmap image file background color to white instead of blue.

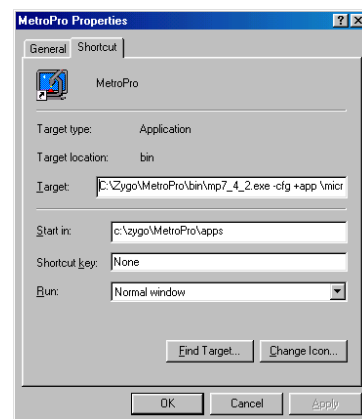
<i>Option</i>	<i>Description</i>	<i>continued</i>
<b>+logfile</b> <filename>	Output diagnostic messages to the file named <filename> instead of the default MetroLog.txt.	
<b>-noDropDownMenus</b>	Disables drop down menus for controls.	
<b>-noEchoBox</b>	Disables the echo box shown when opening or closing a window.	
<b>-oldSlicePrintFormat</b>	Saves profile data in the format used <i>prior</i> to MetroPro 8.3.2.	
<b>-pifoclog</b>	Disable the logging of pifoc diagnostic information.	
<b>+pifoclog</b> <number>	Set the maximum size of the pifoc diagnostic log file to <number>, which is the number of bytes (a positive integer).	
<b>-printgrey</b>	Send grey instead of color images when printing to a printer.	
<b>-screenKeyboard</b>	Enable touch screen keyboard.	
<b>-script</b> <filename>	Set the top-level script file name to<filename> but do not run the script.	
<b>+script</b> <filename>	Set the top-level script file name to<filename> and run the script.	
<b>-touchScreen</b>	Enable touch screen options	
<b>-windowsDialog</b>	Use windows dialog for loading/saving files.	
<b>-z</b>	Enable diagnostics	
<b>+z</b> <number>	Enable diagnostics option <number>.	

## Using a Command Line Option

*Example:* Start MetroPro and open a specific application.

1. Go to the Program Manager; select the MetroPro program icon and select the File/Copy command (NT version 3.51). Or create a shortcut to the MetroPro executable file (NT version 4.X).
2. Select the copy (or shortcut) and press Alt+Enter.
3. Enter at the Command Line or Target:  
`C:\Metropro\bin\mpX_X_X.exe -cfg +app \Path\AppFile`

Where *Path* is the directory path to the application file *AppFile*. “mpX\_X\_X.exe” should be the name of the executable file on your system, the X’s represent numbers.



## Reason for this Appendix

This appendix is an alphabetical list of applications provided with MetroPro. This appendix is to help you find information on a particular application.

The “MetroPro Name” column is the application name as provided with MetroPro. The “OMP” column is the Zygo Corporation manual number; many of these manuals are provided on *Manuals on CD* in Adobe Acrobat Reader (pdf) format. The “License as” column lists if the application requires separate licensing from the standard MetroPro license, and if so what it is licensed as. The “Comment” column provides additional information.

<b><i>MetroPro Name</i></b>	<b><i>OMP</i></b>	<b><i>License as</i></b>	<b><i>Comment</i></b>
AAB1.app	0374	ABS Geometry	
AAB2.app	0374	ABS Geometry	
AdvText.app	0362	none	
Angles.app	0381	none	
AutoLatCal.app	0347	none	In Section 4
CornCube.app	0384	Corner Cube	
CrossHatch.app	0491	Cross Hatch	
Delta_Operator.app	0465	none	
Delta_Part_Setup.app	0465	none	
Delta_StepHtCal.app		none	
DiskFlat.app	0385	Disk Flatness	
DubOff.app	0363	none	
DVD400.app		none	Not documented
DVD400AutoNull.app		none	Not documented
EtchPTR.app	0365	Pole Tip Recession	
FlashPhase.app	0497	Flash Phase	
FTP_cal.app		none	Not documented
FTP_Generic_Oper.app		none	Not documented
FTP_grr.app		none	Not documented
FTP_Home_Stages.app		none	Not documented
FTP_Part_Setup.app		none	Not documented
FTP_Service.app		none	Not documented
FTP_Start_Up.app		none	Not documented
GPI2.app	0380	none	
GPI.app	0380	none	
Mesa.app	0419	none	
MesaDisk.app		none	Not documented
MetroCell.app		none	Not documented, see OMP-0478
Micro.app	0360	none	
MicroErr.app	0360	none	
MicroLUPI.app	0448	none	

**METROPRO REFERENCE GUIDE**

<i><b>MetroPro Name</b></i>	<i><b>OMP</b></i>	<i><b>License as</b></i>	<i><b>Comment</b></i>
MstCstCav.app	0487	none	
MstPHom.app	0486	none	
MstPSurf.app	0486	none	
MstTwoSurf.app	0483	none	
MultiSurf.app	0376	none	
PHom.app	0386	Homogeneity	
PTI250_MP.app		Flash Phase	For PTI 250 software
PTR.app	0365	Pole Tip Recession	
PTRCoat.app	0365	Pole Tip Recession	
PTRUncoat.app	0365	Pole Tip Recession	
RadScale.app	0389	none	
RadScI3Z.app	0389	none	
Rail2.app	0374	ABS Geometry	
Rail2Cmp.app		ABS Geometry	Not documented
Rail3.app	0374	ABS Geometry	
RitchComm.app	0492	none	
RmpSlpCal.app		none	Not documented
SPS.app	0374	ABS Geometry	
Static.app	0382	none	
StepHt.app	0368	none	
StepHtCal.app		none	Not documented
Stitch.app	0375	none	
SysErrGen.app	0409	none	
Taper.app	0369	none	
ThreeFlt.app	0387	none	
TPC.app	0374	ABS Geometry	
TrimPTR.app	0367	Trimmed PTR	
TwoSpher.app	0388	none	
Zern.app	0383	none	



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