NanoScope Software 6.12
User Guide

Part Numbers
004-132-000 (Standard)
004-132-100 (Cleanroom)

Document Revision History: NanoScope Software 6.12 User Guide

Revision	Date	Section(s) Affected	Ref. DCR	Approval
C	06/23/2004	All	-	C. Kowalski
B	07/10/2003	All	404	T. Geschwender C. Kowalski
A	04/20/2002	Release	404	T. Geschwender

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Chapter 1 Getting Started with NanoScope v6.12 Software

The focus of this manual is the NanoScope software version 6.12. It is a reference to the tasks related to your NanoScope system. The material provides an overview (i.e., theory and applications), procedures, interface definitions and optimization tips.

Refer to the following sections to begin to understand the NanoScope software:

- **Installing the NanoScope Software:** Section 1.1
- **Getting to Know the NanoScope Software:** Section 1.2
- **Setting up the Workspace** Section 1.3
- **Quick Guide to a 4K Point Image:** Section 1.4
- **Using Online Help:** Section 1.5
- **Technical Support at Veeco:** Section 1.6

1.1 Installing the NanoScope Software

1.1.1 System Requirements

CAUTION: Contact Veeco Technical Support (see **Contact Information** Section 1.6.2) before attempting to increase the RAM of your system. Failure to do so could cause irreparable damage to your system.

The 6.12 version of software requires the following:

- A minimum computer configuration of 600MHz (800MHz recommended)
- 256Mb RAM (512Mb recommended)
- G450 Video (G550 Video recommended)

1.1.2 Before You Install

CAUTION: Ensure you have backed up all critical data onto external media before installing the NanoScope 6.12 software.

1. If you are upgrading from a previous version of NanoScope, ensure you are starting with a working version. The settings from the working version will be used for the new version.

2. Note that some of the installation screen views may not appear, or may appear slightly different, depending on your particular system configuration.

3. Make sure you have downloaded and installed NS Toolbox. This is available on the NanoScope 6.12 CD or from the Veeco FTP site (contact Veeco for more information).

4. Make sure you are logged in as Administrator on the local workstation.

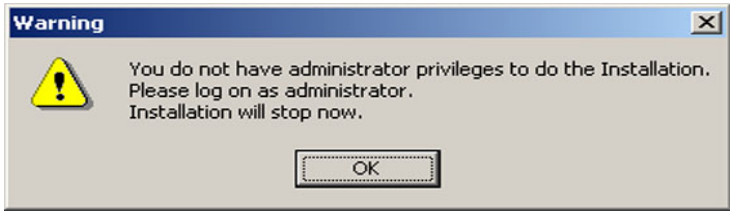
1.1.3 NanoScope 6.12 Installation

Note: Most systems are configured on the microscopes prior to delivery.

1. Insert the NanoScope 6.12 CD-ROM in your CD drive, open the CD-ROM files, open the v612 folder, and select the **Setup.exe** icon.

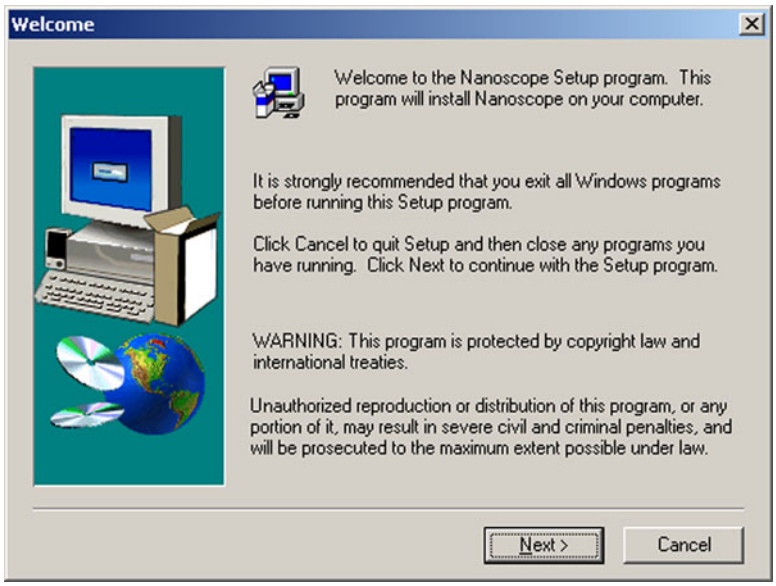
If you do not have Administrator privileges on your workstation, a WARNING will appear on the screen and installation will discontinue (see Figure 1.1a).

Figure 1.1a Administrator Warning



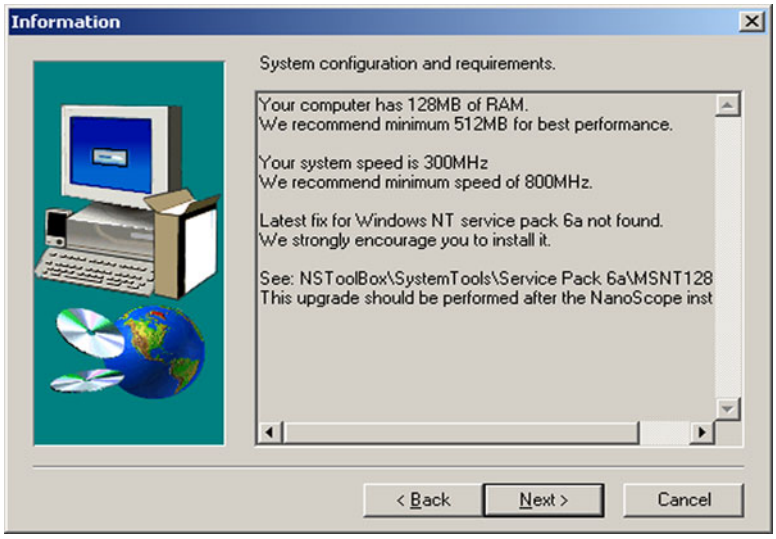
2. The **Welcome to NanoScope 6** dialog box will open (see Figure 1.1b). Click **Next**.

Figure 1.1b Welcome to NanoScope 6 Dialog Box



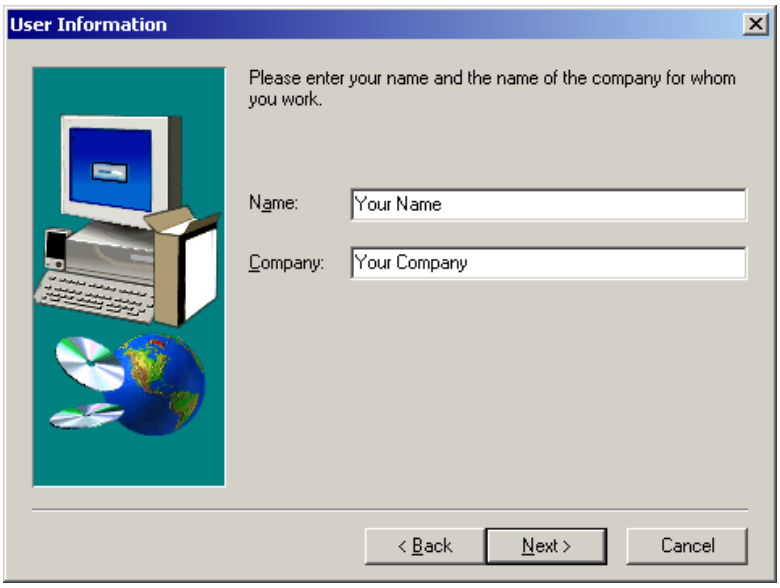
3. The InstallShield will display system requirements and recommendations (see Figure 1.1c).

Figure 1.1c System Requirements and Recommendations Dialog Box



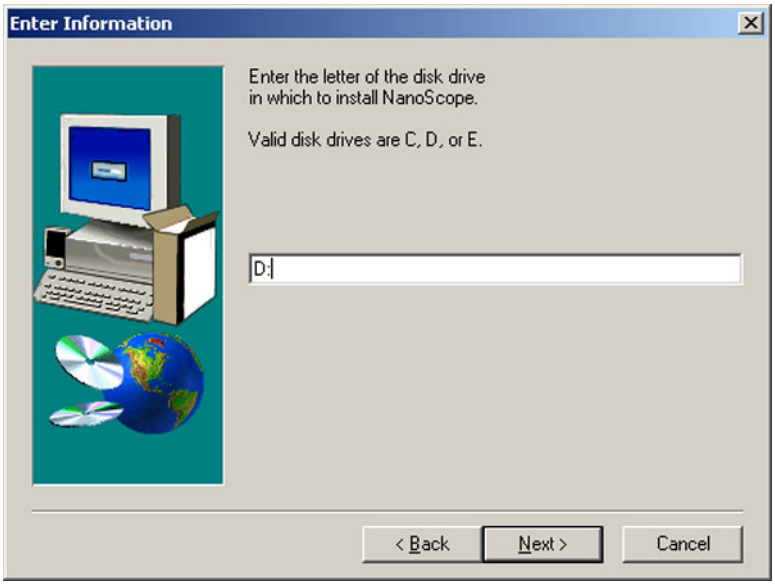
4. The **User Information** dialog box will open (see Figure 1.1d). Enter the required information in the appropriate spaces, then click **Next**.

Figure 1.1d User Information Dialog Box



5. The **Enter Information** dialog box will open (see Figure 1.1e). Enter the letter of the drive where you wish to install the NanoScope 6.12 software and click **Next**.

Figure 1.1e Enter Information Dialog Box

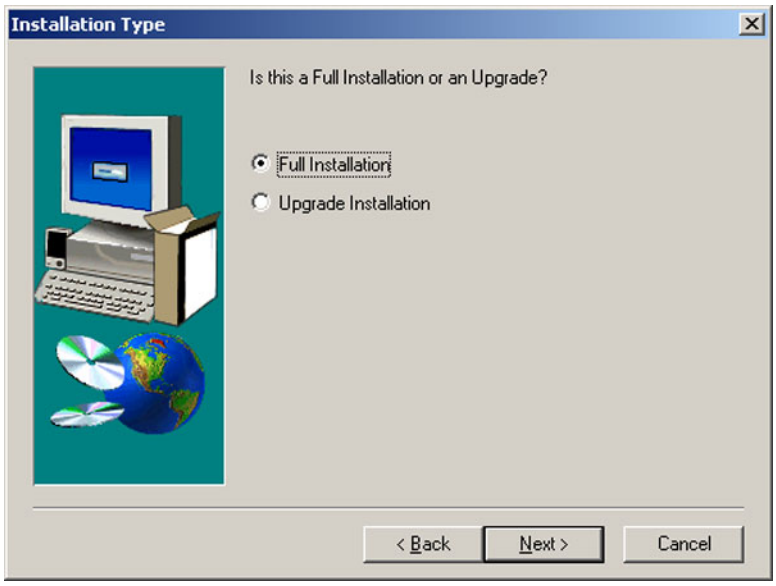


6. The **Installation Type** dialog box will open (see Figure 1.1f).

   a. To install the NanoScope 6.12 software for the first time, select **Full Installation** and go to 1.1.4, "NanoScope 6.12 Full Installation Procedure".

b. To upgrade your existing NanoScope software to version 6.12, select **Upgrade Installation** and go to 1.1.5, "NanoScope 6.12 Upgrade Procedures".

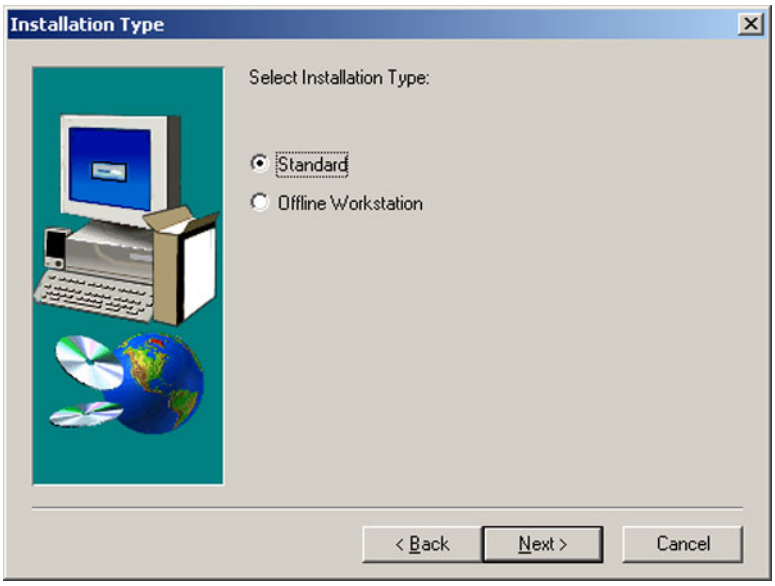
Figure 1.1f Installation Type Dialog Box



1.1.4 NanoScope 6.12 Full Installation Procedure

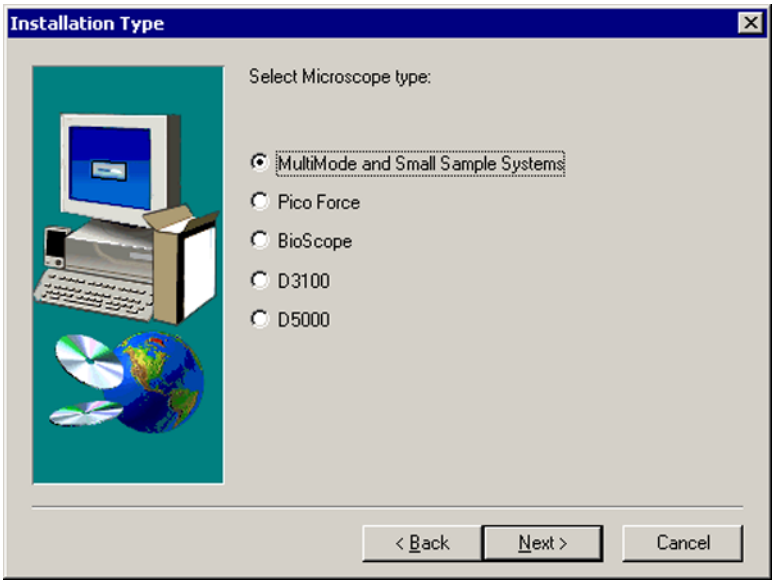
1. A second **Installation Type** dialog box will open (see Figure 1.1g). Select **Standard**, then click **Next** to continue the installation.

Figure 1.1g Installation Type Dialog Box



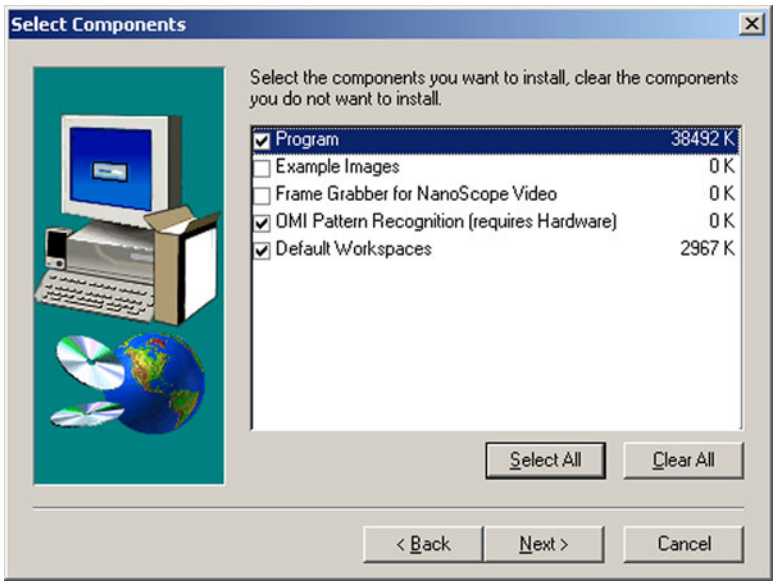
2. The **Select Microscope** dialog box will open (see Figure 1.1h). Choose the installed microscope and click **Next**.

Figure 1.1h Select Microscope Dialog Box



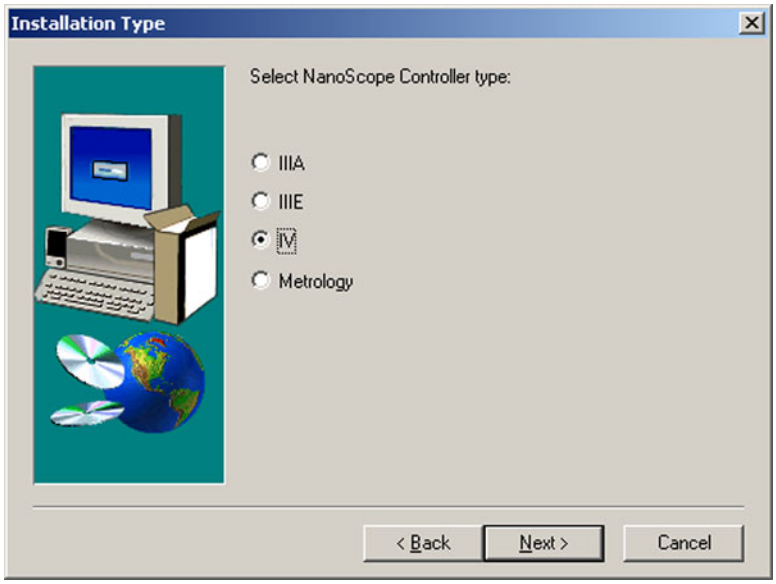
3. The **Select Components** dialog box will open (see Figure 1.1i). Choose the required components from the list by clicking on the adjacent check box(es) and then click **Next**.

Figure 1.1i Select Components Dialog Box



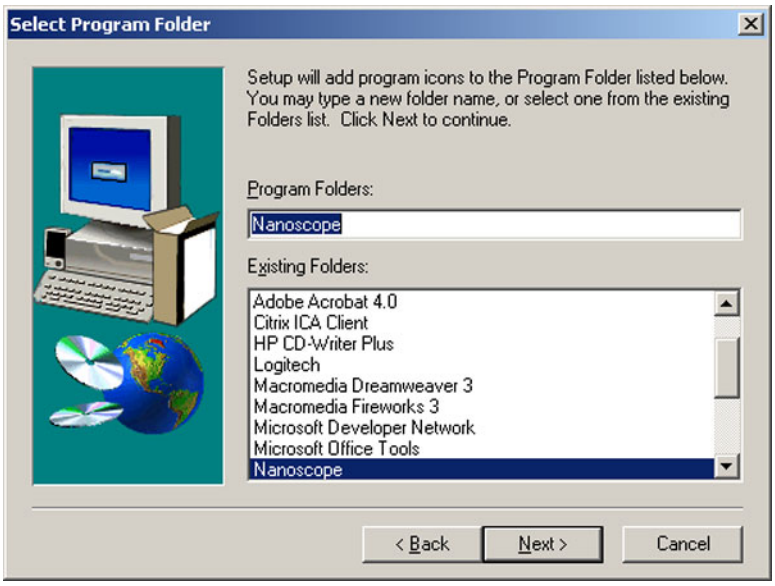
4. The **Select NanoScope Controller Type** dialog box will open (see Figure 1.1j). Choose your NanoScope Controller type from the list and click **Next**.

Figure 1.1j Select NanoScope Controller Type Dialog Box



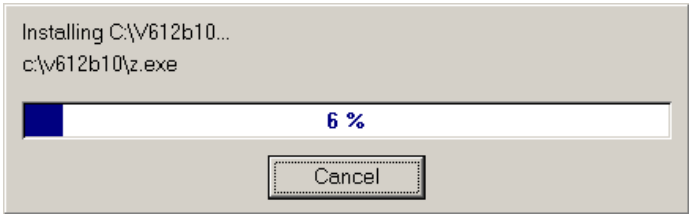
5. The **Select Program Folder** dialog box will open (see Figure 1.1k). Use the defaults, or change the program folder names as desired, and click **Next**.

Figure 1.1k Select Program Folder Dialog Box



6. The new software will start installing, the **NanoScope Setup** dialog box will open, and the software installation progress indicator will show installation progression (see Figure 1.1l).

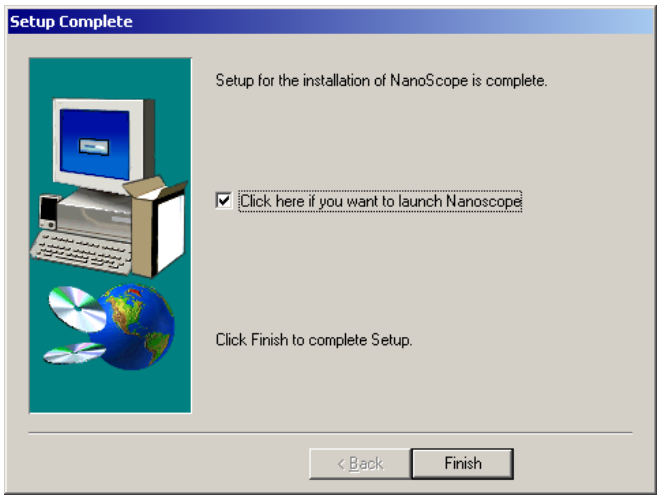
Figure 1.1l NanoScope Software Installation Progress Indicator



7. One of two **Setup Complete** dialog boxes will open.

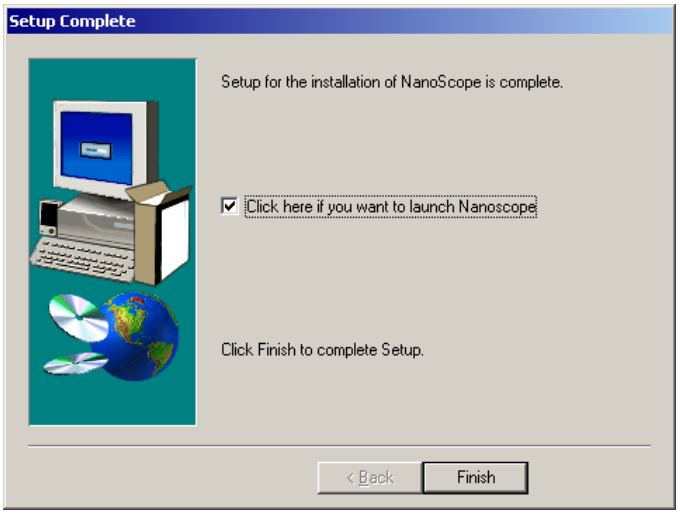
   a. If you chose to install the Frame Grabber driver in Step 5, the Setup Complete dialog boxes (see Figure 1.1x) will inform you that you must restart your computer before being able to use the new NanoScope software. Select the **Yes, I want to restart my computer** radio button.

Figure 1.1m Setup Complete Dialog Box With Frame Grabber



   b. If you chose not to install the Frame Grabber driver in Step 5, the Setup Complete dialog box (see Figure 1.1y) will inform you that setup is complete. If you wish to start the software immediately, click the **Click here if you want to launch NanoScope** check box.

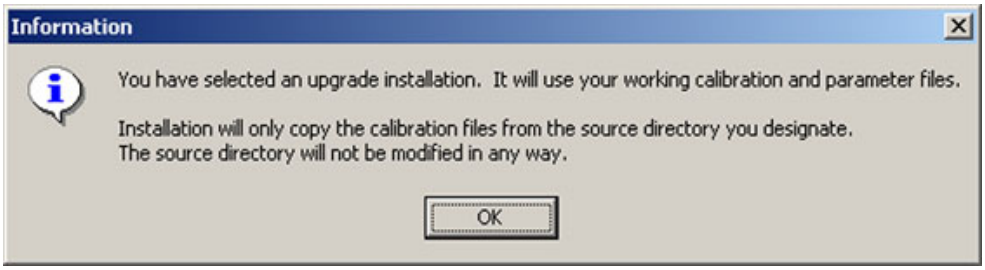
Figure 1.1n Setup Complete Dialog Box Without Frame Grabber



1.1.5 NanoScope 6.12 Upgrade Procedures

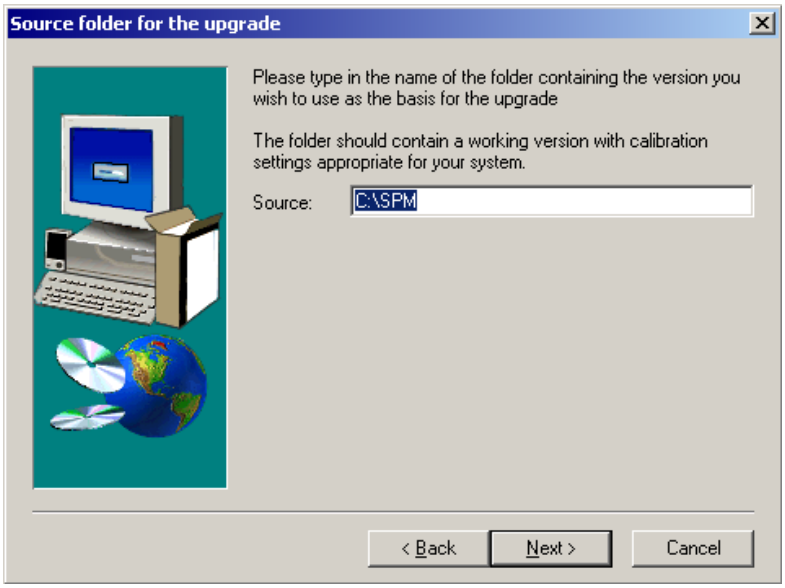
1. If you selected to upgrade an existing version of NanoScope, an information box will open explaining the use of the calibration and parameter files (see Figure 1.1o). Click the **OK** button.

Figure 1.1o Information Box



2. The **Source folder for upgrade** dialog box will open (see Figure 1.1p). If your old software is installed in the default directory, click **Next,** or enter the directory of the old software and click **Next**.

Figure 1.1p Source Folder For Upgrade Dialog \Box

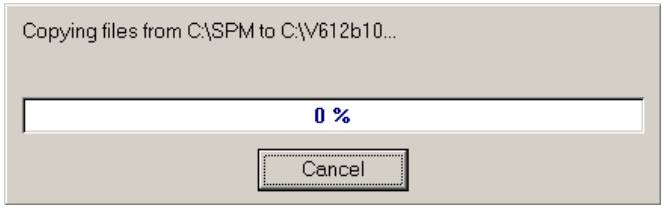


3. If there is an existing directory of this software version on the chosen drive, an information dialog box will open explaining that the files will be overwritten and instructing you to rename the directory before proceeding if you wish to preserve it (see Figure 1.1q). Click the OK button to continue the installation.

Figure 1.1q Repeated Directory Name Indicator

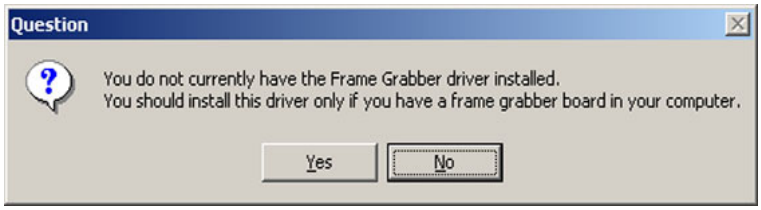
4. A progress box (see Figure 1.1r) will open showing the copying of the old files by the upgrade.

Figure 1.1r Copy Files Progress Box



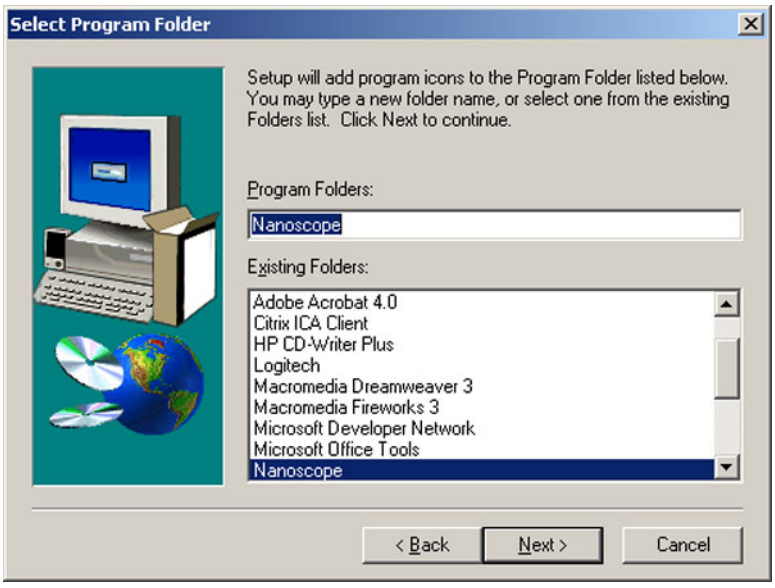
5. When copying is complete, a **Question** dialog box (see Figure 1.1s) may open, asking if you wish to install the Frame Grabber driver. If you have a Frame Grabber card installed on your system, click **Yes**, otherwise click **No**.

Figure 1.1s Frame Grabber Driver Question Dialog Box



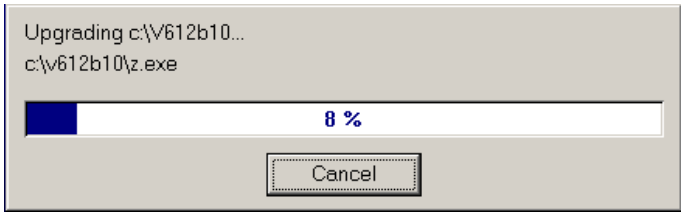
6. The **Select Program Folder** dialog box will open (see Figure 1.1t). Use the defaults or change the program folder names as desired and click **Next**.

Figure 1.1t Select Program Folder Dialog Box



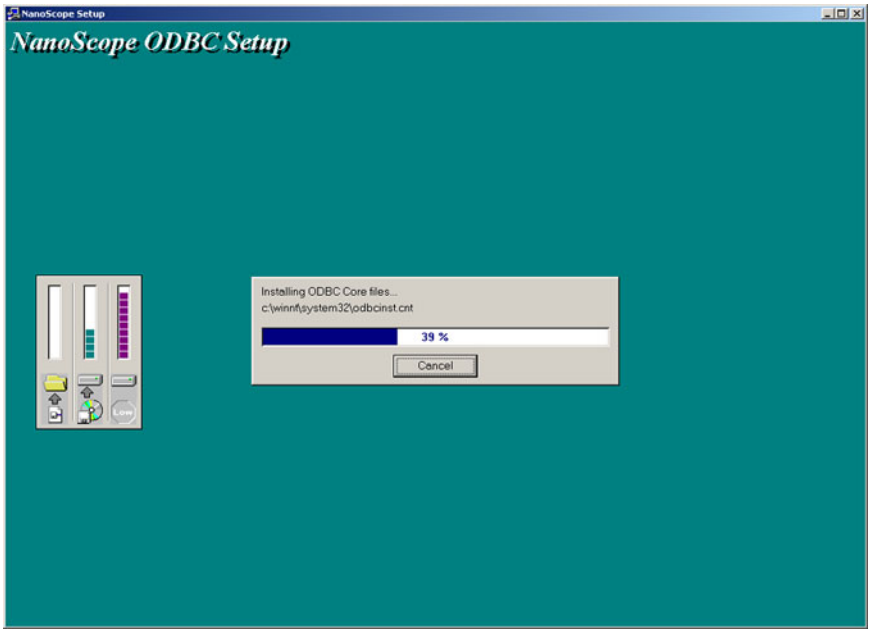
7. The NanoScope 6.12 software will begin upgrading and a progress box will appear (see Figure 1.1u).

Figure 1.1u Upgrading 6.12 Progress Box



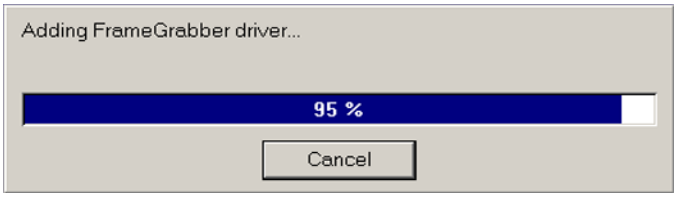
8. At approximately 95% progress, the **NanoScope ODBC Setup** box will open (see Figure 1.1v) and install the Desktop Database Drivers.

Figure 1.1v NanoScope ODBC Setup Box



9. Upgrading will then continue. If you chose to install the Frame Grabber Driver in Step 5, it will be installed at this time (see Figure 1.1w).

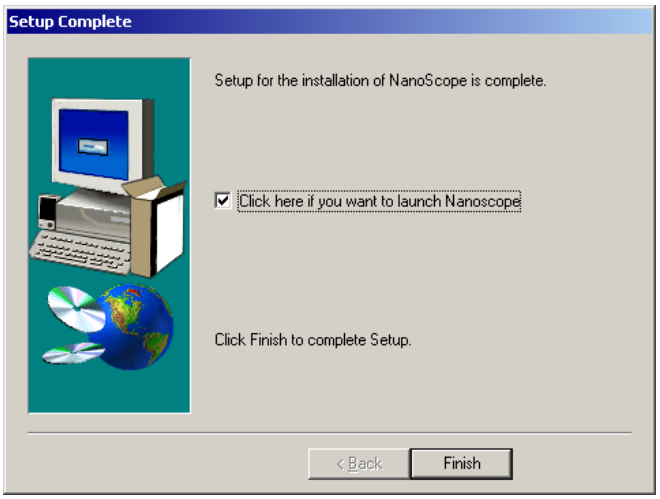
Figure 1.1w Frame Grabber Driver Installation Progress Indicator



10. One of two **Setup Complete** dialog boxes will open.

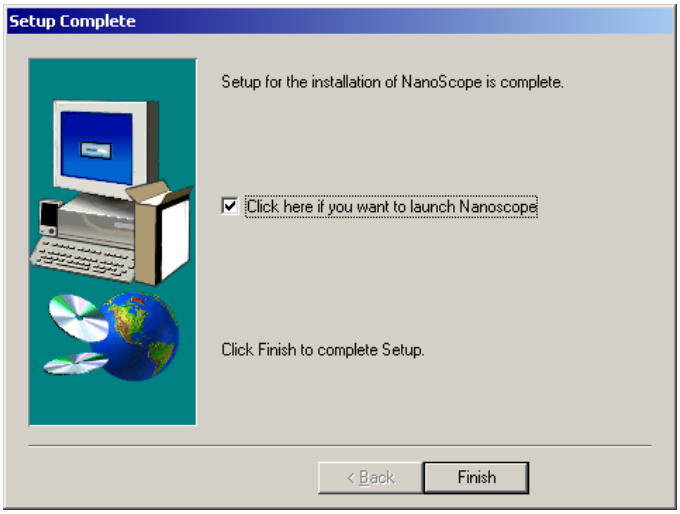
    a. If you chose to install the Frame Grabber driver in Step 5, the **Setup Complete** dialog box (see Figure 1.1x) will inform you that you must restart your computer before being able to use the new NanoScope software. Select the **Yes, I want to restart my computer** radio button.

Figure 1.1x Setup Complete Dialog Box With Frame Grabber



    b. If you chose not to install the Frame Grabber driver in Step 5, the Setup Complete dialog box (see Figure 1.1y) will inform you that setup is complete. If you wish to start the software immediately, click the **Click here if you want to launch NanoScope** check box.

Figure 1.1y Setup Complete Dialog Box Without Frame Grabber



11. Click the **Finish** button.

1.2 Getting to Know the NanoScope Software

Start the NanoScope software by double-clicking on the desktop shortcut labeled **NanoScope 6.12**.

1.2.1 Software Interface

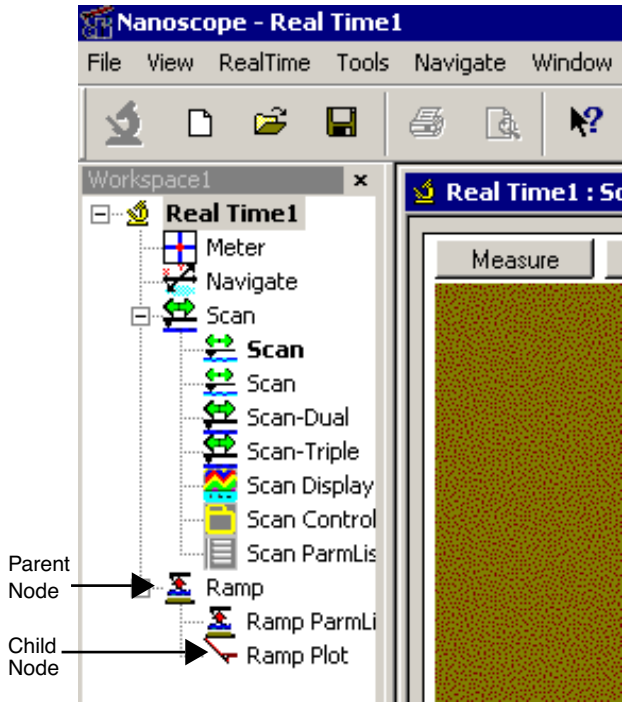
The NanoScope software contains two modes of operation: **Realtime** (i.e., all operations related to controlling of the microscope) and **Image Processing** or **Offline** (i.e., analysis and modification of captured images). In previous versions of NanoScope software, these modes were separate work environments. With version 6.12, both work environments have been combined into a "workspace."

1.2.2 What is a Workspace?

A workspace is a configuration of views and parameters in the NanoScope software. Within the workspace window, the user configures a hierarchy of commands (i.e., nodes) for running the microscope and processing images. Auto programs are run in the order that commands are configured.

The behavior and appearance of the workspace window may be controlled using the **Workspace > Preferences** menu or by right-clicking in the workspace window.

Figure 1.2a Workspace Nodes



Nodes

The top level node is known as the *parent node* and each node underneath is known as a *child node* (see Figure 1.2a). Parent nodes are usually the name for the microscope mode (e.g., Realtime) or a file name of an image within the workspace. Parent nodes are the higher level nodes for auto programs. Child nodes, also known as "views," are typically associated with a window that is used to carry out an analysis, image processing, or Realtime control function of the software.

Each node may be renamed, deleted and grouped. Node names may be preceded by an icon and/or lines indicating the relative positions of nodes in the hierarchy.

1.2.3 The Main Screen Elements

Workspace Window	A dockable window in the client window for viewing and configuring a series of views.
Client Window	A central window for viewing all Realtime graphical displays, input parameters, results parameters and graphs.
Menu Bar	A group of items for executing commands or viewing files.
Toolbar	A group of icons for executing commands or viewing dialog boxes to configure input parameters.
Status Bar	A read only list that displays the stage X, Y, Z coordinates and enabled functions (e.g., Capture: On).
RT Status Window	A dockable window in the client window displaying information about the sample during Realtime.
Browse Window	A dockable window in the client window for browsing files. Available in list or thumbnail format.
Help Window	A dockable window in the client window for displaying the Help screen.

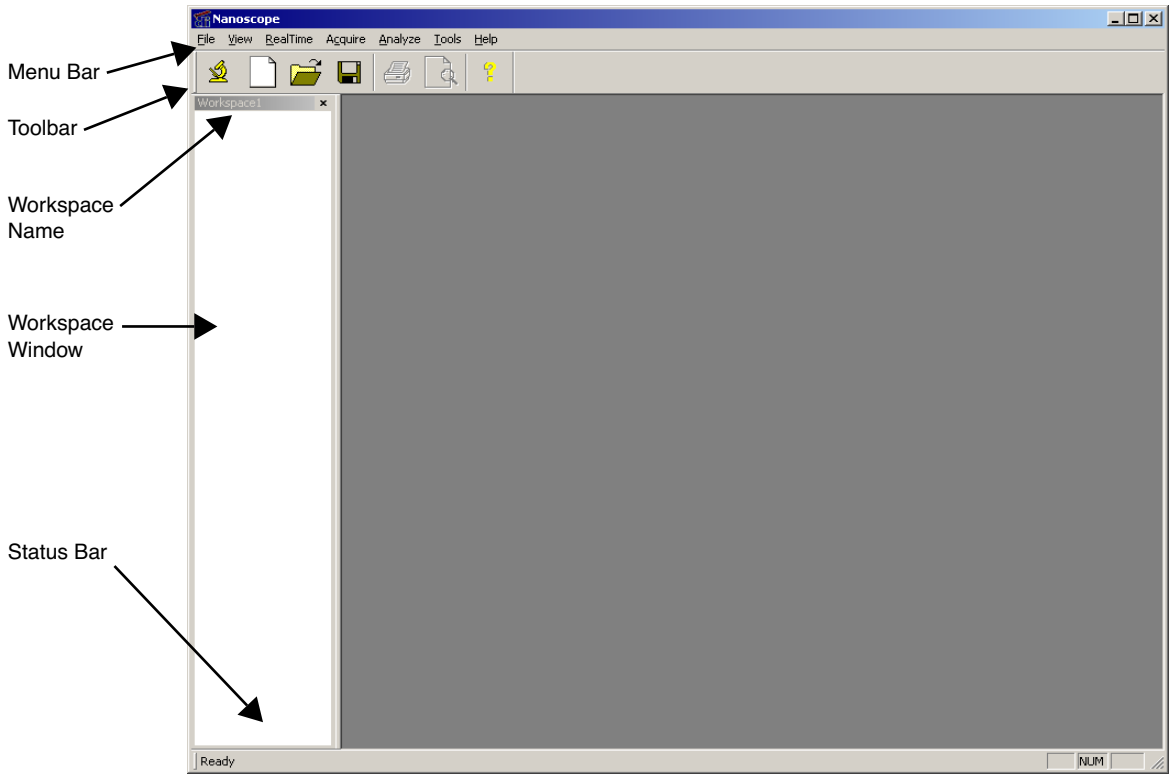
Start the NanoScope Software

Complete the following to open the NanoScope software:

1. Double-click the desktop shortcut labeled **NanoScope 6.12**.
2. The default screen appears with menu items (**File**, **View**, **Help**, etc.), a blank workspace and a toolbar (see Figure 1.2b).

   Note: Select **File > Open Workspace** to open a previously created workspace file.

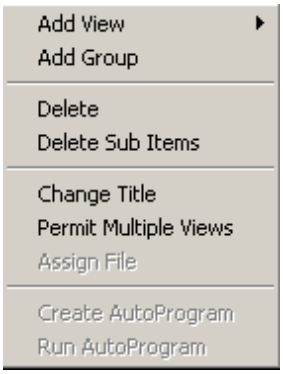
Figure 1.2b Screen Elements



Functions Menu

The **Functions** menu is accessed by right-clicking on a parent node (i.e., Realtime or a filename). It includes specific elements for viewing multiple windows, renaming views, grouping views, and adding and deleting views. This menu also includes the command for running an Auto Program (i.e., **Run AutoProgram**) where the image processing commands may be run in a series on multiple images and results may be saved in a data file (see Figure 1.2c).

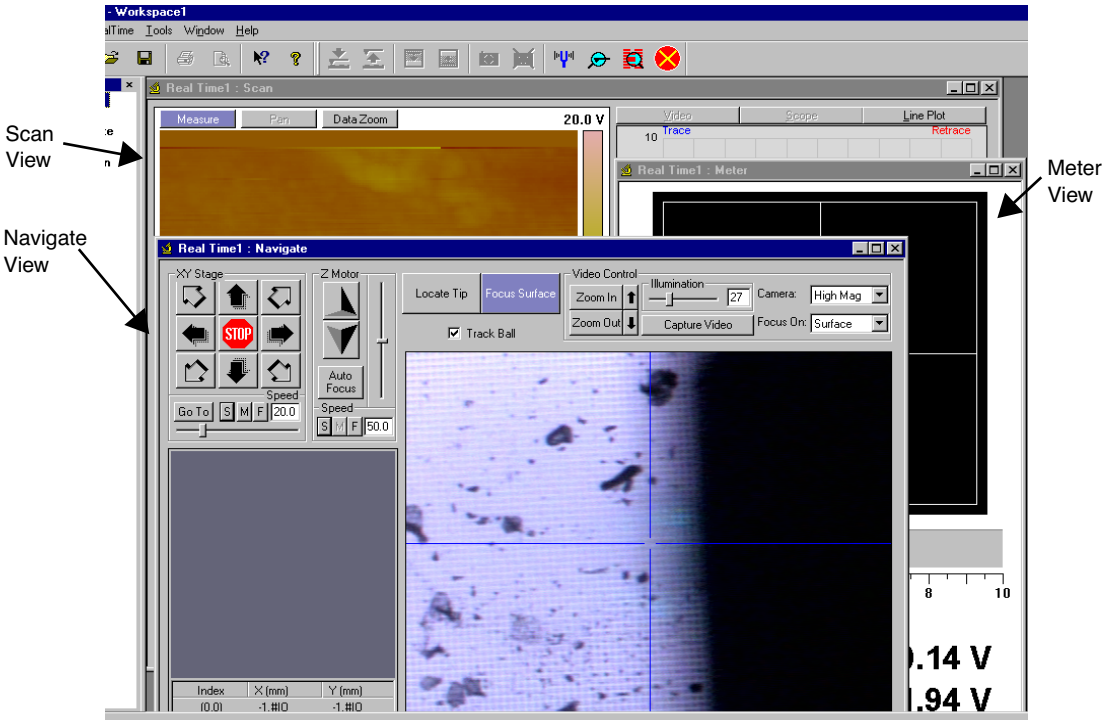
Figure 1.2c Functions Menu



Menu Items

Add View	Accesses a submenu of Realtime or offline commands.
Add Group	Adds a **Group** node to the workspace for creating a defined set of commands.
Delete	Deletes the currently selected node in the workspace. If changes were made, a prompt appears to save the view.
Delete Sub Items	Deletes the items listed under the currently selected node in the workspace. If changes were made, a prompt appears to save the view.
Change Title	Allows for the selected view title to be changed.
Permit Multiple Views	Selecting this item allows for multiple views to appear in the client window (see Figure 1.2d).
Assign File	TBD
Create Auto Program	Allows you to create a new Auto Program based on analysis done on a node.
Edit AP Attributes	If the currently selected node is in Auto Program, this parameter allows you to edit the Auto Program properties.
Run Auto Program	Accesses the Auto Program Results view to run the selected image processing commands.

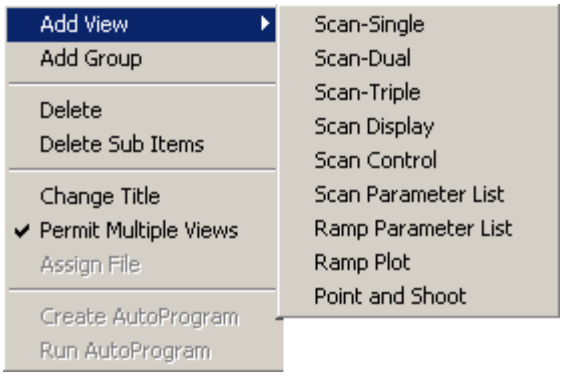
Figure 1.2d Permit Multiple Views



Functions Submenu

The **Functions** submenu allows for adding new views to the workspace in the **Add View** command (see Figure 1.2e).

Figure 1.2e Realtime Workspace Functions Submenu



Functions Submenu Items

The **Add View** submenu includes commands for running the microscope, analyzing and reporting. Selecting a command adds the item name and icon as a new child node to the workspace window. Click on a node to invoke the view in the client window.

Depending upon the microscope type and mode (i.e., Realtime, Image Processing and Profiler), each workspace has unique commands in the **Add View** submenu. For the Realtime functions **Add View** submenu, see Figure 1.2e. For more detailed descriptions about the views, see Chapter 2.

Quick Key Commands

Many commands have **quick key** commands (series of keys to enter in place of using the mouse). You can open menus, access panels and execute commands with the keys or combination of keystrokes. In the NanoScope software, the quick keys are designated by an **underlined letter** in the command name (e.g., ***R*** is the quick key in Realtime).

To activate a quick key command, press the **Alt** button then the quick key, or select the command with the mouse and press the indicated quick key.

Quick keys only apply when in an *active* box, menu, panel or window that is currently visible on the screen. *Active* panels are designated in color with a highlight on the panel title or with a heavy frame around the panel.

1.2.4 Menu Bar Items

The initial menu bar includes: **File**, **View** and **Help** to begin the process of initializing and opening files in the client window. Once a workspace is open an expanded toolbar exists for running and configuring the microscope to scan or process images.

The menu items include:

- **File**—Accesses menu selections for opening, saving and printing files and documents.
- **View**—Accesses menu selections allowing to choose display properties.
- **Format**—Accesses menu selections for opening the **Note** and **Color Scale** options.
- **Realtime**—Accesses menu selections to administer commands during data collection.
- **Acquire**—Accesses all Realtime Views.
- **Analyze**—Accesses all Offline Views.
- **Tools**—Accesses menu items for selecting and calibrating various settings.
- **Window**—Accesses menu selections for arranging windows.

- **Help**—Accesses menu items for initializing and displaying the help screen, a **Bug Report** dialog box to submit bugs/requests to Veeco, and NanoScope information about your system.

1.2.5 Cursor Types

Within captured images, it may be necessary to do analysis or modification on a selected area or exclude this area from the analysis. Cursors allow for specifying this information.

The cursor types are as follows:

- **Lines**—Selecting specific data (e.g., lengths of features or sectioning features) along the line.
- **Boxes**—Selecting specific areas on the display for including or excluding data.
- **Grid Markers**—Horizontal or vertical line cursors within histograms and spectrum graphs for choosing data ranges or making measurements.

Using a Slider Cursor

In a graph or histogram, position the mouse with in the blank area between the axis and the edge of the graph and drag the slider along the graph to position the cursor. The cursor will change to ↔.

Positioning a Line or Box Cursor

- Click and drag the image to draw a line or box cursor.
- To resize an existing line or box cursor, click and drag on a corner edge or end of the object. Cursor will change to ↔ or ↕.
- To move an existing object, click and drag the center of the object to the desired location. The cursor will change to ✥.

1.3 Setting up the Workspace

1.3.1 Create or Open a Workspace

1. A workspace can be opened or created by selecting the following:

   - **File > New Workspace**.
   - **File > Open Workspace** and browse to open an existing workspace.
   - **File >** Select the **Workspace Name** from the Recent files list.

     Note: A new blank space will automatically display when version 6.12 is opened.

2. To begin Realtime operations, open a Realtime node. Select **Realtime > Start Realtime** or click the **NanoScope** icon.

A **Realtime** mode appears in the workspace, along with a dialog box allowing you to add views to the **Realtime** node.

1.3.2 Add Views and Configure the Workspace

1. Position the mouse on the **Realtime** icon and right-click to view the functions menu (see Figure 1.3a).

2. If one of the views (**Scan-Single**, **Scan-Dual**, or **Scan-Triple**) does not appear automatically, in the functions menu, select **Add View** and one of the scan views or click the **Scan** button.

3. Add the following views to your workspace to set up the hardware for scanning:

   - **Meter View**—for verifying the laser signal on the cantilever. (If desired, the Realtime Status Window can be opened in place of **Meter View**).
   - **Navigate View**—for setting the tip to sample focus, locate tip and stage alignment (not present for MultiMode).

4. Customize your workspace with any additional views using the same procedure as in Step 2.

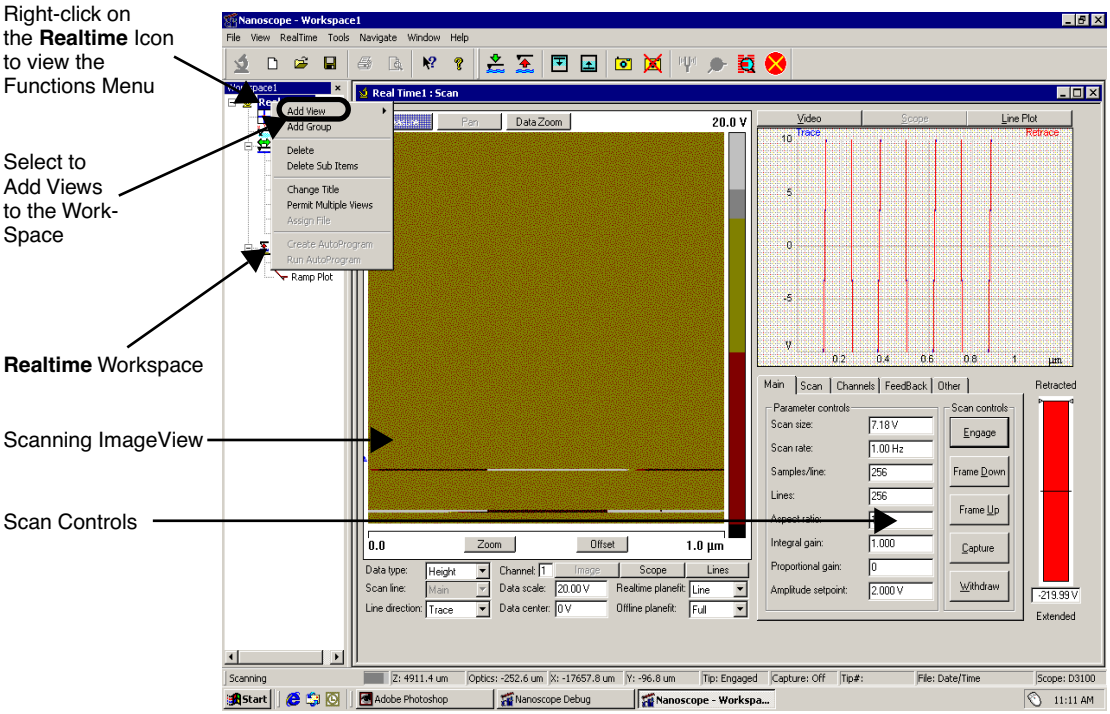
   Note: In the **Functions** menu, select **Permit Multiple Views** for allowing several windows to display.

1.3.3 Multiple Users using NanoScope

The NanoScope computer can save multiple user preferences/settings in the computer registry. Once a user sets up an account on the computer, several settings are automatically saved for the user. These settings include:

- Previous image file type
- Browse window settings
- Option to disable video while scanning
- Section View results
- Location of Abort dialog box
- Review curve settings
- Force Filter settings
- Help settings
- Script directory
- Track ball on
- Default Parameter dialog box location
- Point and Shoot View settings
- Sweep dialog box settings
- Workspace settings
- Image control settings
- Grid control settings
- Meter View control settings
- Color control settings
- Z center control settings

Figure 1.3a New Realtime Screen



1.4 Quick Guide to a 4K Point Image

The following procedures provide quick steps for using the NanoScope 6.12 software. Follow these steps to quickly scan a sample and then capture and analyze an image. Along the way, you'll see how the NanoScope 6.12 software works, learn some useful tricks, and find out how to learn more later.

If you have used the "classic" NanoScope software, you'll see that the new interface is Microsoft Windows-based.

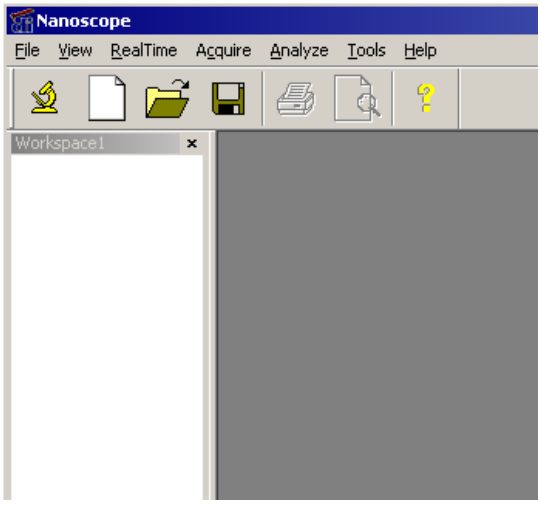
This section is not intended to teach a new user how to run an AFM, but only to introduce experienced users to V6.x.

1.4.1 Starting the NanoScope Software

After the software installation is complete, you are ready to start the NanoScope software and add some views to the software workspace.

1. To start the NanoScope software, double-click the **NanoScope 6.12** startup icon on the computer desktop. You will see the NanoScope software window (see Figure 1.4a), which can span one or two monitor displays. This large window will contain all the areas and views you use to control the microscope and analyze your results.

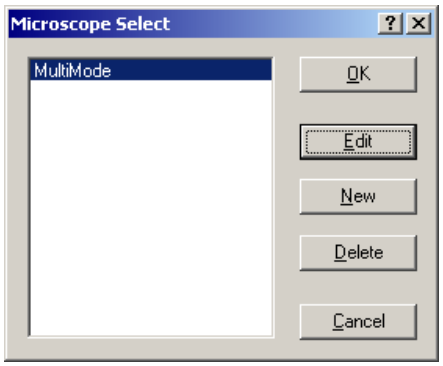
Figure 1.4a NanoScope Software Window



2. Notice the white area on the left side of the NanoScope software window. This white area is the "workspace." This area acts as an organizer for operations you use in the software—including scanning and analysis. Each item in the workspace has a view window that lets you set parameters, perform actions, or view results. The sequence of items in the workspace is important only for Auto Programs that use analysis functions.

3. Select **Tools > Select Microscope** to open the **Microscope Select** dialog box.

Figure 1.4b Microscope Select Dialog Box



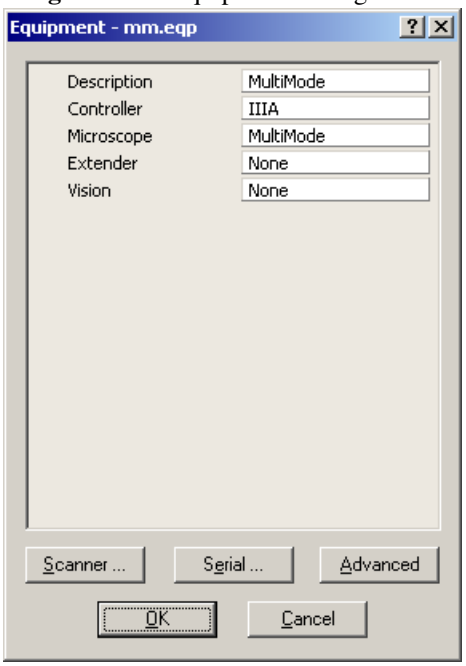
In the **Microscope Select** dialog box:

a. You can add a new set of hardware configuration parameters by clicking **New**, or edit the parameters of the selected microscope by clicking **Edit**. The parameters include things such as the controller, extender, and vision system.

b. In the **Equipment** dialog box, choose the microscope you are using (see Figure 1.4c). If you are using a MultiMode AFM, select the scanner you plan to use (**Scanner** button).

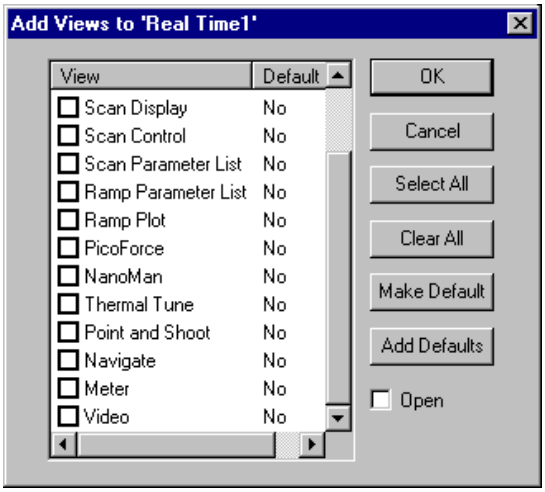
Note: Select the **Advanced** button to view all equipment parameters.

Figure 1.4c Equipment Dialog Box



4. Click the yellow **Realtime** icon in the toolbar. This adds a "**Realtime**" group and a **Scan View** to the workspace. It may take a moment the first time **Realtime** is added. A dialog box (see Figure 1.4d) will appear giving you the option to add more views.

Figure 1.4d Add Realtime Views Dialog Box



5. Right-click on **Realtime** in the workspace and select **Permit Multiple Views** from the pop-up menu. When this item is enabled (that is, has a check mark next to it), you can have several views open at the same time.

Note: Areas in the NanoScope software window can be resized and moved to make it easier for you to use. When you reopen the software, it will remember your changes. Drag the edge of an area to resize it. Drag the title bar or double raised lines on an area to move it to another edge of the window or to make it a floating window. (In Microsoft Windows terminology, these areas are "dockable.") Click the "X" in the upper-right corner to close an area. Use the **View**, **File**, or **Scan** menu to open an area. For details about the areas of the NanoScope software window, see Section 1.2.

If you are using a Dimension Series AFM, continue with the steps in Preparing a Dimension Series AFM for a **Realtime** Scan. If you are using a MultiMode AFM, skip to **Scanning and Scan Parameters** Section 1.4.4.

1.4.2 Preparing a Dimension Series AFM for a Realtime Scan

Once you've created the workspace, prepare the system to scan. This includes selecting the operation mode, aligning the laser, adjusting the photodetector, locating the cantilever tip with the optical microscope, and focusing the optical microscope on the surface. If you have not yet learned these procedures please refer to your **Dimension Microscope Manual** and/or **SPM Training Notebook**.

For details on using the Realtime **Scan Views**, see Chapter 2.

1. Click **Scan** in the workspace to see the **Scan View**. In the **Scan View** parameters area, select the **Other** tab. Set the **Microscope mode** parameter to **Tapping** or **Contact**.

2. Mount the probe into the cantilever holder

3. Mount the cantilever holder onto the end of the scanner head.

4. Align laser on cantilever.

5. Click **Meter** in the workspace to see the **Meter View**. Turn the two screws on the side of the scanner to adjust the laser position in the photodetector. In the **Meter View**, the location of the red dot and the values at the bottom of the display change.

6. Click **Navigate** in the workspace to see the **Navigate View**. This view shows the video and stage controls. Activate the **track ball** by clicking on the **Track ball ON** button inside the **Navigate View**.

7. Click the **Locate Tip** icon in the toolbar or the **Locate Tip** button within **Navigate View**. Using the two adjustment screws to the left of the optical objective of the microscope, center the tip of the cantilever under the crosshairs.

8. Focus on the tip end of the cantilever either by using the trackball while holding down the bottom-left button or by using the **Optical Focus** mouse controls. Click and hold the large arrow keys to move the focus up or down. The speed is controlled by the sliding bar or by typing a value from 0 to 100. Click **OK** to set the focus and enter **Focus Surface** mode.

When you leave **Locate Tip** mode, the optics move to a focus position, typically 1mm below the tip. To set this, select **Tools** > **Engage Settings** > **General** > **Motor**.

9. Focus the optics on the sample surface using either the trackball or the **Z Motor** arrows in the **Navigate View**. To use the track ball, set the **trackball** to **On**, and roll the trackball up or down while holding down the bottom-left button. To use the **Z Motor** arrows, click and hold them down. You can use the speed controls in the **Z Motor** area to adjust the speed. This adjustment raises or lowers the Z stage on which the SPM and optics are mounted.

10. Move the x-y stage to align the desired location on the sample under the crosshairs either by using the trackball without holding down any buttons or by using the **XY Stage** arrows in the **Navigate View**.

11. If you are using TappingMode, click the **Tune** icon. Check your parameters in the **Auto Tune** list.

12. Click the **Auto Tune** button. Notice that the status bar at the bottom of the NanoScope software window says “Cantilever Tuning” during automatic tuning. When tuning is complete, click **Exit** in the **Cantilever Tune** dialog box. Proceed to Section 1.4.4, "Scanning and Scan Parameters".

1.4.3 Preparing a MultiMode AFM for a Realtime Scan

Once you've created the workspace, prepare the system to scan. This includes selecting the operation mode, mounting the probe, selecting the scanner, mounting the sample, aligning the laser, and adjusting the photodetector. If you have not yet learned these procedures, please refer to your **Multimode Manual** and/or **SPM Training Notebook**.

1. Click **Scan** in the workspace to see the **Scan View**. In the **Scan View** parameters area, select the **Other** tab. Set the **Microscope mode** parameter to Tapping or Contact.

2. Change the mode switch on the base of the microscope. Set it to **TMAFM** if you are using TappingMode. Set it to **AFM & LFM** mode if you are using Contact mode.

3. Mount the probe into the cantilever holder.

4. Put the cantilever holder in the optical head. Secure the holder by tightening the screw in the back of the optical head.

5. Choose a scanner (A, E, or J) by clicking on **Tools > Select Scanner**. Mount and plug the scanner into the base. Attach the corresponding springs to the microscope base.

6. Mount sample onto scanner.

7. Place optical head on scanner, making sure there is enough clearance between the tip and the sample.

8. Align laser.

9. Adjust the photodiode signal.

10. If you are using TappingMode, click the **Tune** icon. Check your parameters in the **Auto Tune** list.

11. Click the **Auto Tune** button in the **Cantilever Tune** dialog box. Notice that the status bar at the bottom of the NanoScope software window says "Cantilever Tuning" during automatic tuning. When tuning is complete, click **Exit** in the **Cantilever Tune** dialog box.

1.4.4 Scanning and Scan Parameters

Next, you set scan parameters and scan the sample.

1. In the **Scan View**, use the following initial parameter settings in the **Scan** tab. These values may already be set; they are handy starting values.

Scan size:	1μm
Aspect Ratio:	1.00
X offset:	0nm
Y offset:	0nm

Scan angle:	0.00 °
Scan rate:	2Hz

2. Most of these commonly-used parameters are also shown on the **Main** tab. You can right-click on the field in the **Main** tab to open a dialog box that allows you to change which parameters are shown on the **Main** tab.

3. To collect 4K points of data per line, set the following parameters in the **Scan** tab:

Samples/line:	4096
Lines:	512 (or 1024)
Aspect ratio:	8.00 (or 4.00 if Lines is 1024) and you want square pixels

Note: You can use the mouse to adjust the value in many parameter fields. Click on the value and drag the mouse left to decrease the value or right to increase the value.

The **Aspect ratio** controls the X:Y ratio of the pixels in the displayed image. Since there is a 8:1 ratio between 4096 samples/line and 512 lines using an **Aspect ratio** of 8 causes the pixels displayed in the image to be square.

4. For TappingMode, use the following initial parameter settings in the **Feedback** tab:

SPM feedback:	Amplitude
Integral gain:	0.2
Proportional gain:	0.3

5. For Contact mode, use the following initial parameter settings in the **Feedback** tab:

Integral gain:	2.0
Proportional gain:	3.0
Deflection setpoint:	0V (vertical defection = -2V (before engage)

6. Click the **Engage** button in the **Main** tab or click the **Engage** icon. Scan lines appear in the **Scan View** once the tip engages and scanning begins.

7. Click the **Scope** button. Check to see whether the trace and retrace lines are tracking each other well. They should have a similar shape, but they may not overlap each other horizontally or vertically. Adjust the **Scan rate**, **Integral gain**, **Proportional gain**, and/or **Setpoint** (that is, **Amplitude setpoint** for TappingMode and **Deflection setpoint** for Contact Mode) parameters. Once the trace and retrace are tracking well, your tip is scanning the sample surface.

8. At this point, you may want to adjust the **Scan size**, **X offset**, **Y offset**, and **Scan angle** (**Scan Tab**) parameters to locate the scan over features of interest. If you increase the **Scan size**, remember that the **Scan rate** should be lowered.

Note: You can zoom in on the scan image by selecting the **Zoom** button below the image. Then, use your mouse to drag a box outline over the area you want to zoom in on. Click **Offset** to offset the center position of your scan.

9. With a 4K image, it may be useful to zoom in on the scan without changing the scan size. Select the **Data Zoom** button above the image. Use your mouse to drag a box outline on the image (begin by clicking where you want the center of the box to be). When you release the left button, you will be zoomed in (scan size of image display will change) but the scanner will remain scanning the original scan size. At this point you can choose to "pan" over to other areas of the total scan. Select the **Pan** button and click and hold the left mouse button as you move the mouse. The left arrow button above the image allows you to go back to the original scan and the right arrow button allows you to go to more zoomed in scans (if you have done multiple zooms). You may also choose to physically change the scan size or X/Y offsets by using the **Zoom** or **Offset**.

1.4.5 Capturing an Image

Once you have adjusted the scan parameters, you can capture a scanned image. Perform these steps once a scan you want to capture is in progress.

1. You can capture a scan in any one of three ways:

   - From the menu bar, select **Realtime > Capture**.
   - On the **Main** Tab in the **Scan View**, click the **Capture** button.
   - Click the **Capture** icon in the toolbar.

The scan will continue. Notice that the status bar at the bottom of the NanoScope window (see Figure 1.4e) says Capture: On. When the current scan is complete, the image will be stored automatically in the Capture Directory with the file name indicated in the status bar. The file name and directory can be changed by selecting **Realtime** > **Capture Filename** from the menu bar (see Figure 1.4f).

Figure 1.4e Status Bar

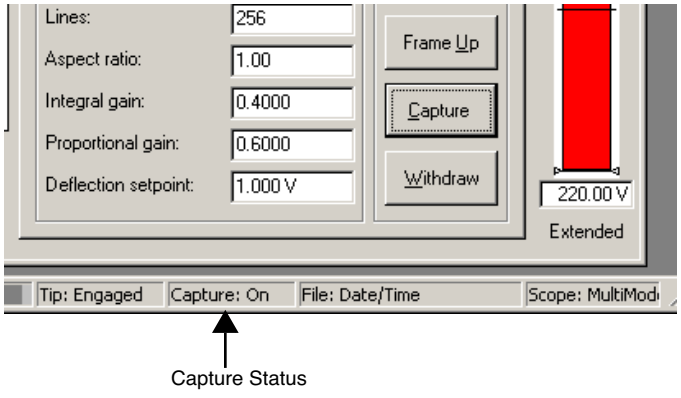
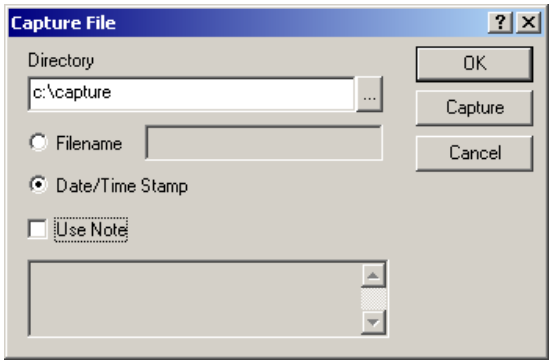
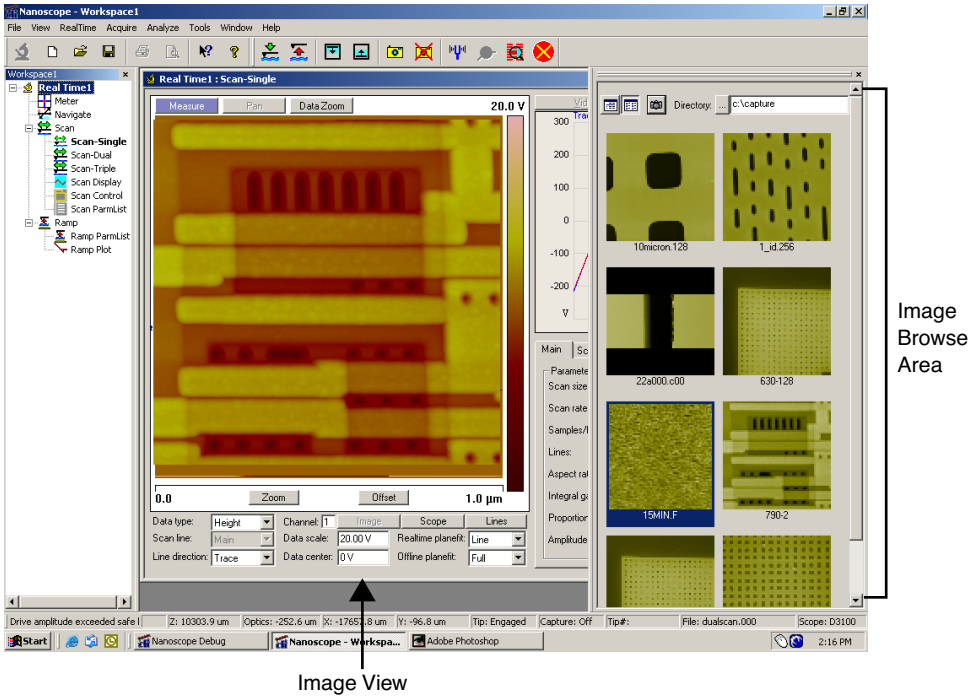


Figure 1.4f Change Filename



2. In the Image Browser area (see Figure 1.4g), check to see if you are looking at the Capture Directory. If not, select the **Capture Directory** icon (or click the "**...**" button and select the Capture Directory, which is usually **DI > Capture**). If you don't see the Image Browser, choose **View > Browse**.

Figure 1.4g NanoScope Image View Window

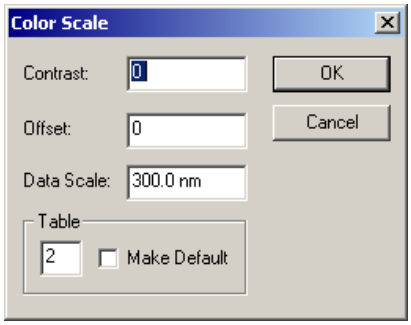


3. Double-click the image you just captured. The image opens in the **Image View** window (see Figure 1.4g). Notice that the image filename and an image view are added to your workspace.

4. If you need to change the **Data Scale**, use **Format > Color Scale** on the menu bar. or right-click on the data scale value in the top right corner of the **Image View** window, and change the **Data Scale** value in the popup window. To change the **Color Contrast**, use **Format > Color Scale** on the menu bar to right-click on the thin color bar to the right of the image. If you need to change the **Color Table**, click and hold the color bar, then drag the mouse left or right.

   Note: To rename image files, you can **Save As**, use Explorer to rename the file, or right-click on the image in the image browser and select **Move**.

Figure 1.4h Color Scale



1.4.6 Analyzing an Image with the Section Analysis

After opening the captured image, you can analyze the image. In this example, the **Flatten** filter and **Section** analysis views are used.

1. Right-click on the name of the image in your workspace. Choose **Add View > Flatten** from the pop-up menu, select **Analyze > Flatten** from the menu bar, or click the **Flatten** icon.

   The **Flatten** filter can be used to remove image artifacts due to vertical (Z) scanner drift, image bow, skips, and anything else that may have resulted in a vertical offset between scan lines. Refer to the **Command Reference Manual**, **004-122-000** for a detailed description of Flatten.

2. Set the input parameters for the filter. For example, you can choose the order of the polynomial to use to fit scan lines.

3. Click **Execute**.

4. If you want to modify the parameters used for flattening, click **Reload**. Then change the parameters and click **Execute** again.

5. Right-click on the name of the image in your workspace again. Choose **Add View > Section** from the pop-up menu, select **Analyze > Section** from the menu bar, or click the **Section** icon. **Section** analysis allows you to easily make depth, height, width, and angular measurements.

6. Drag a line across the image. A vertical cross section along that line is shown in the upper graph area. The lower graph shows the power spectrum (Fourier Transform) of the cross section.

7. In the upper grid, drag the two cursors around to make measurements. You can grab two or more measurement cursors from the outside of the grid. You will see the cursor change from a to a  , at which point you can grab the measurement cursors. The results area at the bottom of the view shows various measurements at the marker position.

8. If you would like to make an Average Section, right-click on the image, select **Rotating Box**. After drawing the box, you can make it rotate by holding down the shift key while grabbing anywhere in the box.

1.5 Using Online Help

The NanoScope software now includes complete documentation in online Help, including: Theory, Procedures and Interface references.

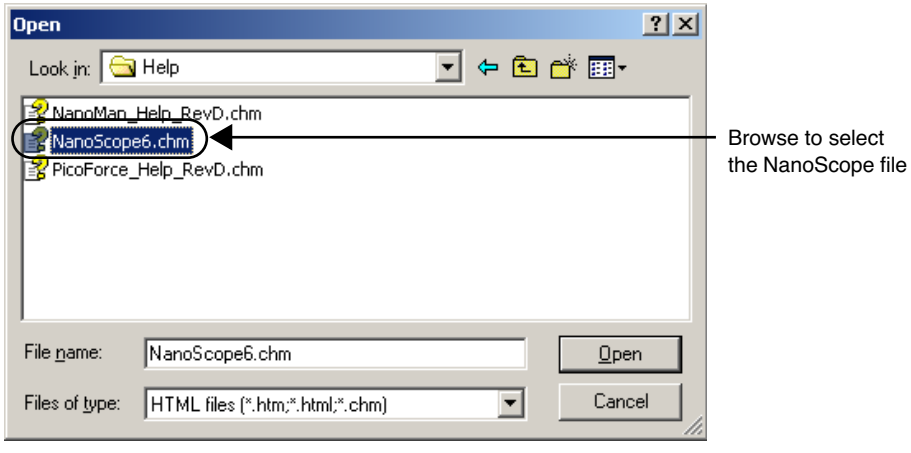
If the help is not open, you must initialize the Help interface as follows:

- Select **View > Help** to open the Help window.
- Use **Help > Nanoscope Help** to display and hide the Help window.

To manually select the Help file:

1. Select **Tools > Options > Set Help File**.
2. A browse dialog box appears to select the NanoScope 6 help file (see Figure 1.5a).

Figure 1.5a Initialize Help Dialog Box



3. Select the NanoScope6.chm file.

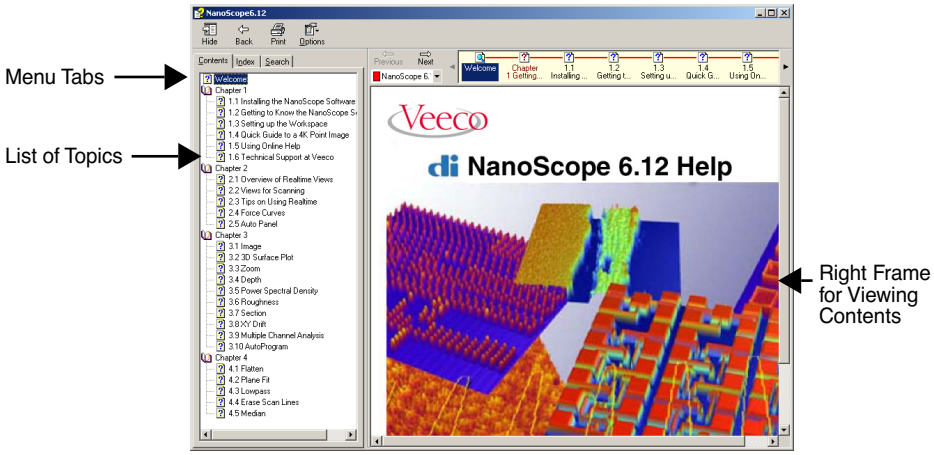
4. Select **View > Help** to open the **Help** window.

1.5.1 Help Window

The **Help** window includes four tabs (see Figure 1.5b):

- **Contents**—Displays a list of topics and subtopics to search.
- **Index**—Allows searching by indexed items in alphabetical order.
- **Search**—Allows for searching the entire online help for a word or phrase.

Figure 1.5b Help Window



Contents

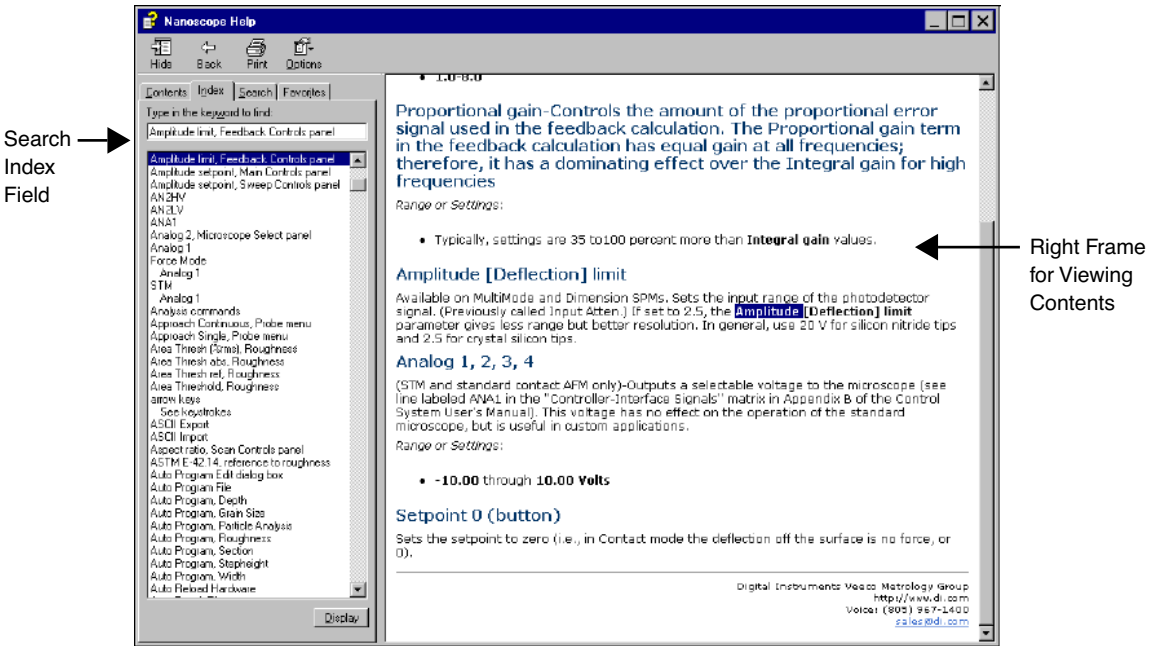
The **Contents** tab allows for scrolling between main topics and subtopics. Click on a topic to view documentation in the right frame (see Figure 1.5b).

Index Tab

The **Index** tab allows to search the index of items, then select display to view the contents in the right frame (see Figure 1.5c).

Note: Often, the indexed item displays the top level help page where the item is found. For viewing the exact location, select the indexed item, display the page, then select the contents tab to view the related topic of the indexed item.

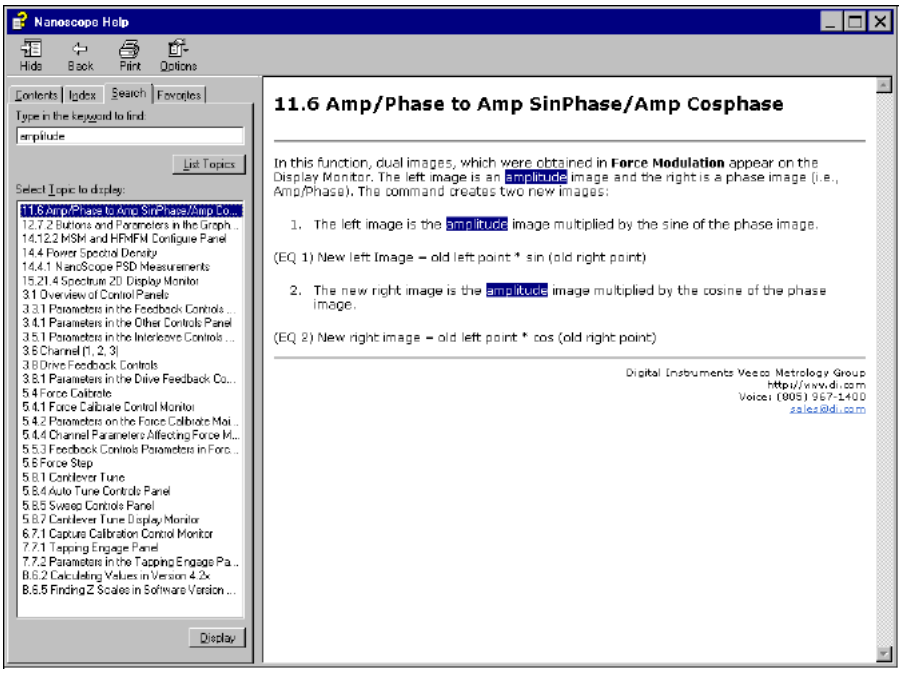
Figure 1.5c Index Tab



Search Tab

The **Search** tab allows to search the entire help text, then view the content in the right frame (see Figure 1.5d).

Figure 1.5d Search Tab



1.6 Technical Support at Veeco

Your satisfaction and productivity regarding Veeco products and documentation are absolutely essential.

1.6.1 Submitting Bug Reports

The NanoScope software automatically generates a bug report if the system should abort for any reason. This bug report form may help a Veeco programmer correctly analyze the problem that caused the abort.

If the system should abort, the next time the software is initiated a bug report form automatically displays. For submitting bug reports, complete the following:

1. Enter your name and a brief description of the functions in use when the crash occurred. Please describe the situation as accurately as possible.

   Note: The form also includes crucial internal coding information for the developer.

2. Select **Ok** to transmit the file.

   Note: A file labeled `BUG.TXT` will be created in your SPM directory. If another bug.txt file exists, the number on the file name is incremented or the information is appended to the previous file.

   Note: If there is no SPM directory or bug.txt file, the software prompts to place the file in another location.

3. Once the file is created, attach the `BUG.TXT` file to an e-mail and send to bugs@di.com.

   Note: You may not get a response to your bug submittal, but be assured that our programmers will analyze the problem and fix it in a future release if necessary.

1.6.2 Contact Information

Mailing Address

Technical Documents, Technical Support or Bug Reports at Veeco
Veeco Instruments Inc.
112 Robin Hill Rd.
Santa Barbara, CA 93117

E-mail: help@veeco.com

Voice Phone

(805) 967-1400, (800) 873-9750

Fax

(805) 967-7717

E-Mail (Documentation Feedback only)

TechPubsSBO@veeco.com

World Wide Web

http://www.veeco.com

Chapter 2 Realtime Views

The Realtime Views control the Realtime collection of data. Each part of the screen is an integral part of the scanning process. For more information on controlling views and the workspace, reference Chapter 1.

For general procedures in setting the parameters and data definitions, refer to the following sections:

- **Overview of Realtime Views:** Section 2.1
- **Views for Scanning** Section 2.2
- **Tips on Using Realtime** Section 2.3
- **Force Curves** Section 2.4
- **Auto Panel** Section 2.5

Note: If you have never used an AFM before, please refer to your microscope manual or contact Veeco for training.

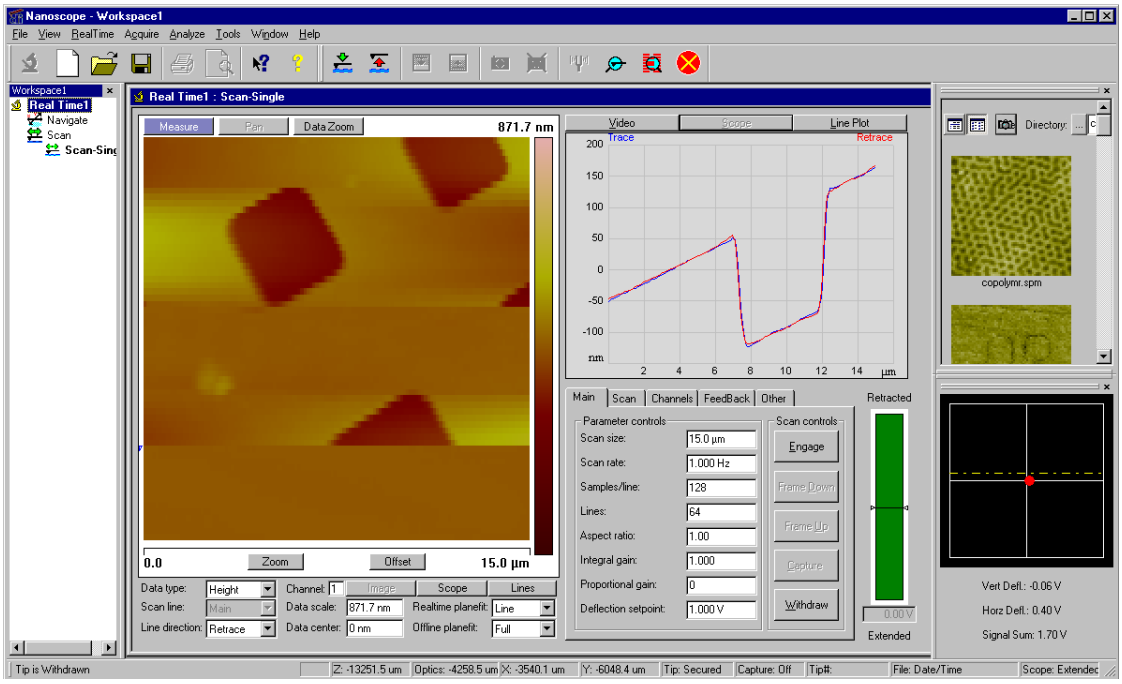
2.1 Overview of Realtime Views

The **Scan View** includes all SPM parameters previously found in the Realtime control panels. The settings and parameters configure the microscope and NanoScope controller signals to optimize each scan.

You can access Realtime views such as **Scan-Single**, **Scan-Dual**, **Scan-Triple**, **Meter**, **Navigate**, **Video**, and **Point and Shoot** by any of the following methods (see Figure 2.1a):

1. Right-click on Realtime in the workspace and select the desired view from the **Add View** menu.
2. Click on the desired view icon in the Realtime button bar.
3. Select a view from the **Acquire** menu.

Figure 2.1a Manual Scanning in Realtime



2.1.1 Typical Procedures to Begin to Scan

Set **Scan** parameters to affect piezo movement and data collection. The **Scan** functions control the type of scan to run, how large the scan is, its angle, scan rate, and number of samples per scan line. Prior to scanning a sample, the user must have knowledge of the following:

- Basic SPM processes
- Microscope safety, handling and tip/probe handling procedures (see your system manual)
- Sample handling procedures

2.2 Views for Scanning

The general interface views associated with configuring parameters for scanning include:

- **Navigate View** Section 2.2.1
- **Meter View** Section 2.2.2
- **Point and Shoot View** Section 2.2.3
- **Cantilever Tune** Section 2.2.4
- **Scan View Interface** Section 2.2.5
- **Scope Trace Plot** Section 2.2.6
- **Main Tab Interface** Section 2.2.7
- **Scan Tab Interface** Section 2.2.8
- **Channels Tab Interface** Section 2.2.9
- **Feedback Controls Tab Interface** Section 2.2.10
- **Other Tab Interface** Section 2.2.11

2.2.1 Navigate View

Use the Navigate commands to locate the tip, focus on the surface, enable the trackball and move the stage. Use the **Navigate View** (previously the **Realtime > Stage** menu commands) to position the tip, locate a surface position for referencing Z height and move the stage for scanning the sample surface.

To access the **Navigate View**, click on the **Navigate** icon in the Realtime workspace. If the **Navigate** icon is not present, right-click **Realtime** in the workspace to view the functions menu. Select **Add View > Navigate** and the **Navigate View** appears in the client window.

Navigate Commands

The **Navigate** commands allow you to focus surface or locate the tip (see Figure 2.2a). To view the Navigate commands select **Tools > Stage** or the command icons for **Focus Surface** or **Locate Tip**.

Figure 2.2a Navigate Menu Commands

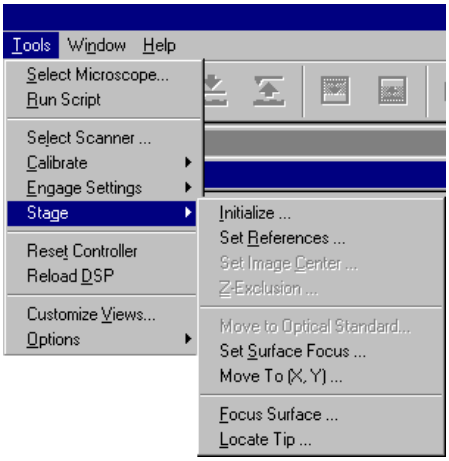
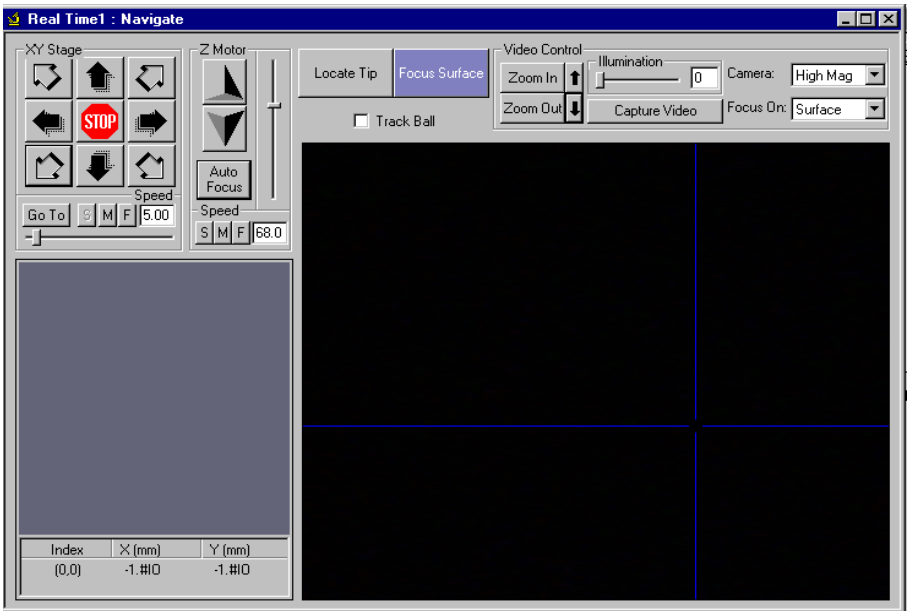


Figure 2.2b Navigate View



Using the Navigate View

CAUTION: If **Tip Focus** is not accomplished before **Focus Surface**, there is a danger of crashing the tip during **Engage**.

Access the **Navigate View** at any time when the stage movement or focus surface and locate tip settings are necessary.

Note: Some microscope options, such as **Engage** and **Withdraw**, are unavailable when the **Navigate View** is active. You must select another view, such as the **Scan View**, to enable these options.

1. Access **Locate Tip** and **Focus Surface** in the **Navigate View** or select the appropriate icons.
2. Select the **Locate Tip** button and focus on the tip using the trackball or arrow keys. When finished, click the **Ok** button.
3. For **Focus Surface**, use the trackball or arrow keys to move the stage in X, Y or Z directions.

Navigate View Parameters:

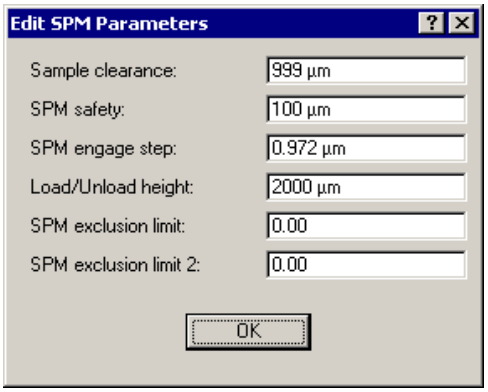
XY Stage Motion	Controls the horizontal, vertical and diagonal movement of the stage.
Speed	Buttons allow for setting slow (**S**), medium (**M**) and fast (**F**) stage speeds by entering a speed value to the right of the buttons or using the scroll bar then select the S, M or F button.
Z Motion	Up and down arrow keys control the height movement of the tip toward or away from the stage.
Auto Focus	Opens an Auto Focus dialog box to set the Z axis focus from vision settings.
Trackball	Enables or disables the X, Y stage and Z cantilever movement by using the trackball.
Camera	Controls the magnification used to view the stage or tip. *Range*: High Mag, Low Mag.
Illumination	Sets the light intensity in the optics.
Zoom	Changes the optical field of view (i.e., without stage or tip movement).
Vision System	Displays the surface (in focus surface mode) or tip (in locate tip mode) and tip on the surface (in Realtime scanning mode).

SPM Parameters

To access the SPM Parameter controls, select **Tools > Engage Settings > General** or right-click in **Navigate View** and select **Edit SPM Parameters** (see Figure 2.2c). Parameter Controls are:

- Sample Clearance
- SPM Safety
- SPM Engage Step
- Load/Unload Height

Figure 2.2c Edit SPM Parameters Dialog Box



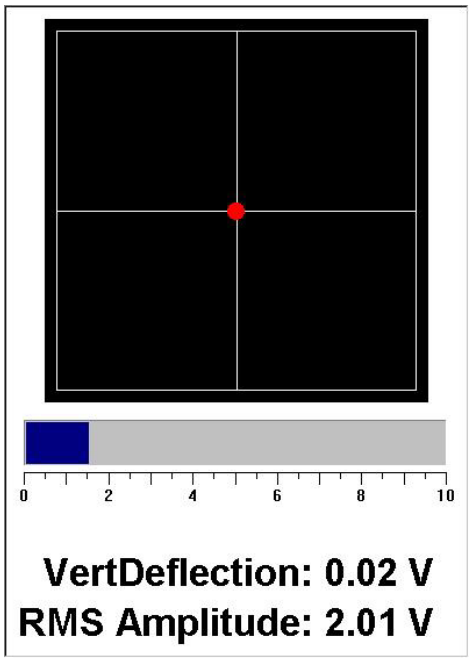
2.2.2 Meter View

Access the **Meter View** (select **Acquire > Meter**) to view the photodetector signal, RMS amplitude, horizontal and vertical deflection signals, and the signal sum.

Meter View Interface

- **Photodetector Signal**—Corresponds to the positioning of the laser on the photodiode detector.
- **Signal Sum**—Sum of the voltage response from the laser in all 4 sections of the photo detector.
- **Vertical Deflection**—Corresponds to the voltage for vertical displacement of the laser signal. Should be “0” for centering.
- **Horizontal Deflection**—Corresponds to the voltage for the horizontal displacement of the laser signal. Should be “0” for centering.
- **RMS Amplitude**—Root mean square (RMS) signal measured at the detector (TappingMode only).

Figure 2.2d Meter View

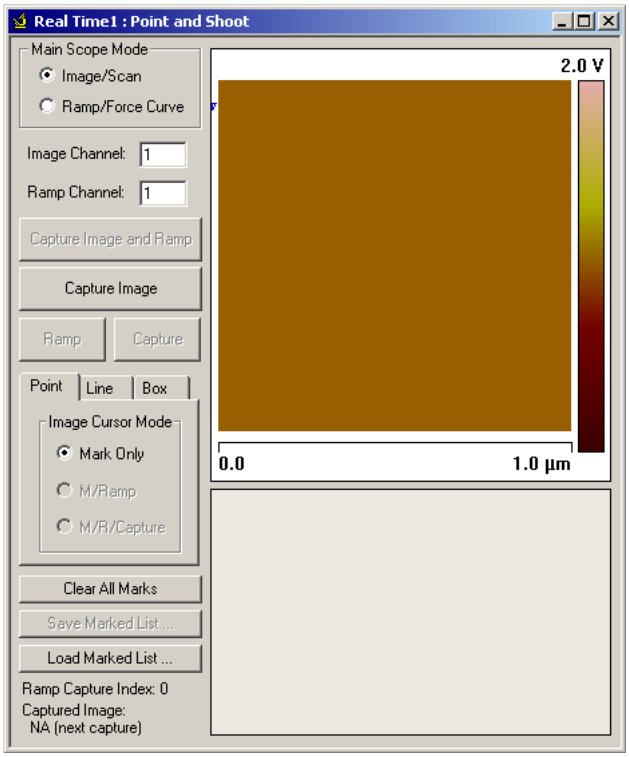


2.2.3 Point and Shoot View

The **Point and Shoot View** allows you to select specific points on an image (see Figure 2.2e). Use **Point and Shoot** to capture an image and/or collect a force curve for every point you designate.

When you click a point on an image, a crosshair (+) marks the location. You can designate individual points, or use the tools in the **Point and Shoot View** to assign multiple points simultaneously.

Figure 2.2e Point and Shoot View



Controls and Parameters

Image/Scan	Allows you to switch to Image/Scan mode. Use Image/Scan mode to adjust scan parameters in any scan view.
Ramp/Force Curve	Allows you to switch to Ramp/Force Curve mode. Use Ramp/Force Curve mode to adjust the ramp settings. You can select points on an image, ramp each point, and create a force curve for each point.
Image Channel	Select the channel to use for the image.
Ramp Channel	Select the channel to use for the ramp display.

Capture Image and Ramp	Click this button to capture an image and save it in the Capture Directory, and to then capture a force curve at each designated point.
Capture Image	Click this button to capture an image and save it in the Capture Directory. After the capture the software switches to Ramp/Force Curve mode.
Ramp	Click this button to ramp a variable determined from the force curve menu at each point.
Capture	Click this button to ramp each point, capture the ramp/force curve, and save it in the Capture Directory.
Point Parameters	Image Cursor Mode Settings: **Mark Only**—Select points of interest on the image. **M/Ramp**—Select points of interest. Software will automatically ramp each point. **M/R/Capture**—Select points of interest. Software will automatically ramp each point and capture a ramp/force curve.
Line Parameters	Draw a line to select specific points on an image. **Point Number**—Number of points in the line. **Spacing**—The distance in nm between each point. All points are equidistant. **Clear Path**—This button clears the current line and associated points. **Convert to Points**—Places a **+** in the location of each point in the line. The line disappears.
Box Parameters	Draw a box in the area you want to place a group of points. You can use the parameters below to create a grid of points. **Row Number**—Designates the number of rows of points in the grid. **Column Number**—Designates the number of columns of points in the grid. **Row Space (nm)**—Designates the distance in nm between each row of the box. **Col Space (nm)**—Designates the distance in nm between each column of the box. **Clear Path**—This button clears the current box and associated points. **Convert to Points**—Places a **+** in the location of each point in the grid. The box disappears.
Clear All Marks	Removes all user-defined marks from the Point and Shoot image.
Save Marked List...	Save the marks on the image as Path Files (*.psm).

Load Marked List... Opens and loads a previously saved Path File (*.psm) which contains marks on a Point and Shoot image.
Note: If there are points on the image prior to selecting this option, when this button is selected the saved marks will appear *in addition* to the previous marks.

2.2.4 Cantilever Tune

The **Cantilever Tune** command allows determination of the cantilever resonant frequency and the setting of the operating point for TappingMode feedback (see Figure 2.2f). In addition, it is possible to determine the spring constant of a Contact Mode cantilever quickly and easily. **Cantilever Tune** sweeps the cantilever drive frequency over a selectable range, then displays a plot of the cantilever amplitude versus drive frequency on the Display Monitor. This command is enabled *only* when the **Microscope mode** parameter on the **Other Controls** panel is set to **Tapping**. On Small Sample MultiMode SPMs, verify that the switch located on the base is toggled to **TM AFM** before selecting the **Cantilever Tune** command.

Note: The sweep channel is determined by the data selection in the **Channel 1**, **Channel 2**, or **Channel 3** control panels.

Figure 2.2f shows how the maximum amplitude is attained in air at the cantilever natural resonance. Figure 2.2g shows the amplitude is reduced when it is in contact with the sample surface.

Figure 2.2f Tapping Cantilever in Mid-air

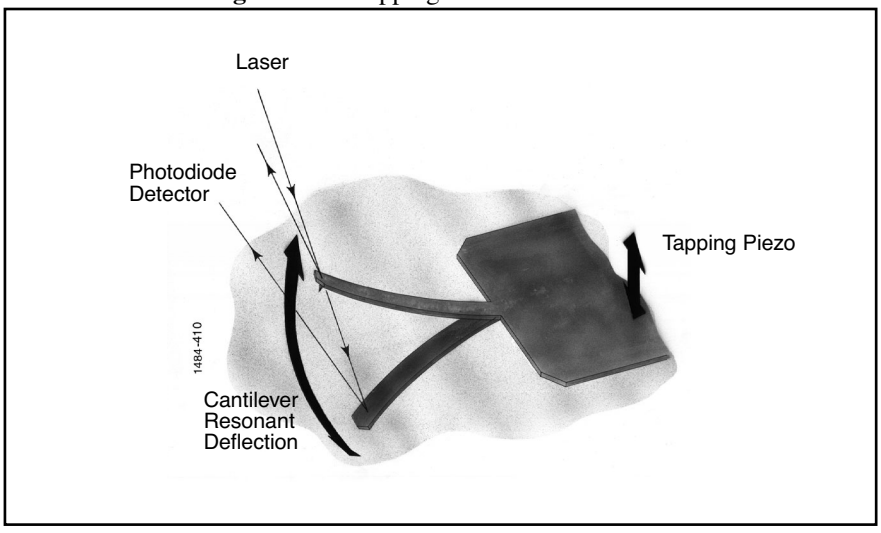
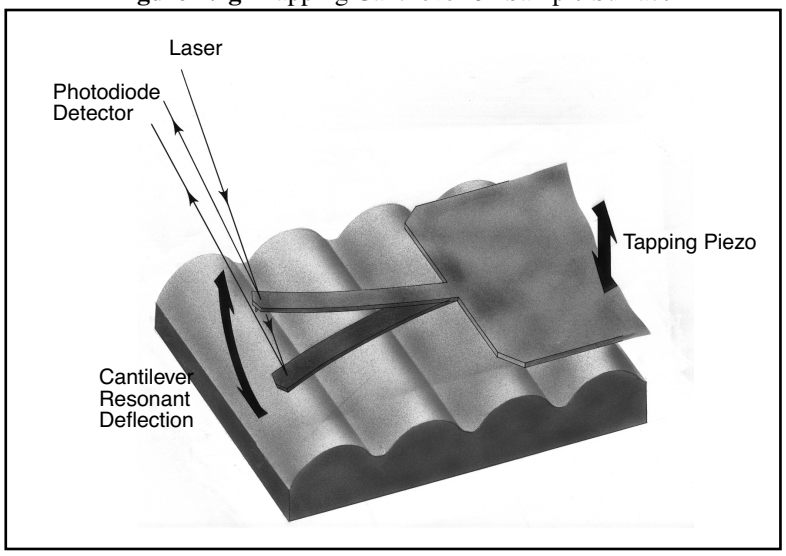


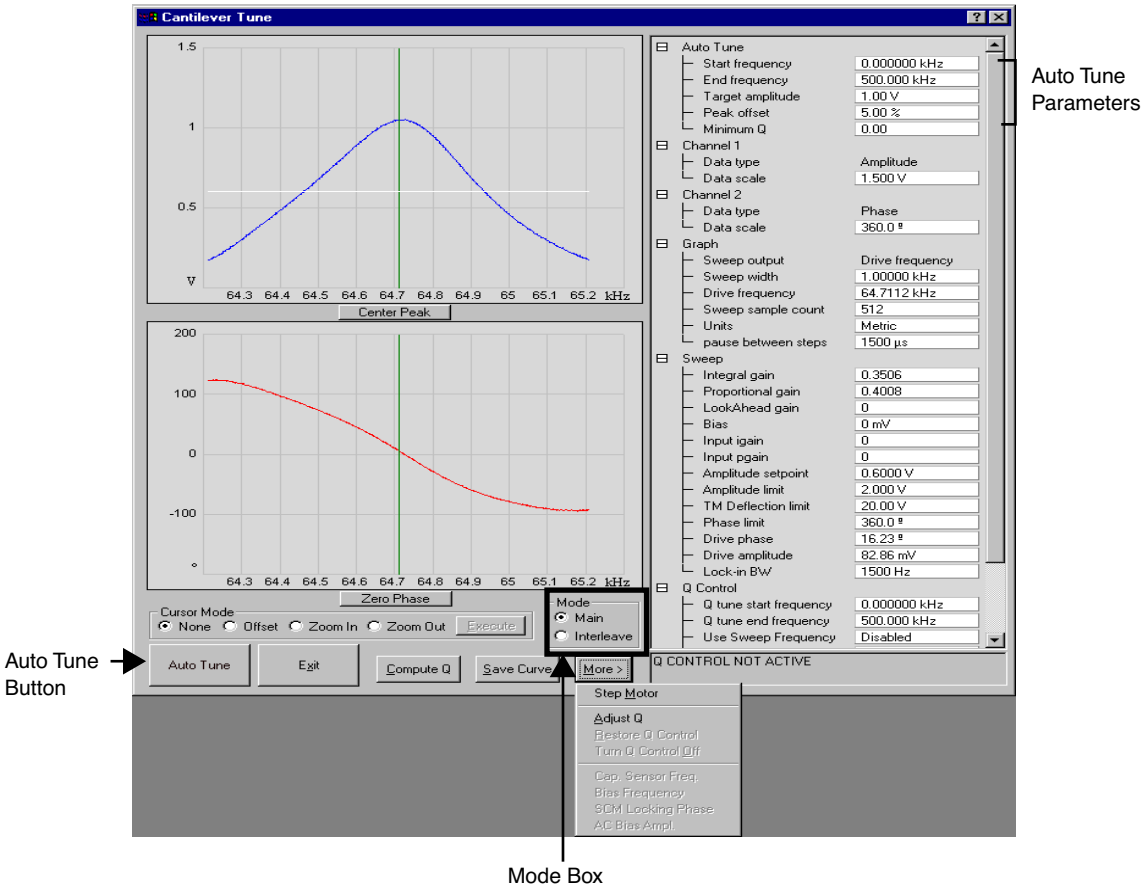
Figure 2.2g Tapping Cantilever on Sample Surface



In TappingMode, the optical lever technique reflects a laser beam off the back of the oscillating cantilever, thence to a segmented photodiode. The differential signal between the top and bottom photodiode segments provides a sensitive measure of cantilever deflection. As the sample is scanned, analog circuitry determines the RMS value of the rapidly changing cantilever deflection signal. The RMS value of the cantilever deflection signal corresponds to the amplitude of the cantilever oscillation. Changes in amplitude of the cantilever oscillation is controlled by the feedback system to track the sample surface.

Access the **Cantilever Tune** dialog box by selecting the **Tune** icon or by selecting **Tune...** from the **Realtime** menu.

Figure 2.2h Cantilever Tune Dialog Box



Select Cantilever Tune Dialog Box Definitions:

Mode box

Toggles the Auto Tune signal from the main to interleave signals.

Settings:

Main— Displays the set of parameters applied to the main scan (see Section 2.2.7).

Interleave—Displays a duplicate set of parameters applied only to the interleaved portions of the scan.

Auto Tune Button

Executes the automatic tuning procedure: the cantilever is excited through a range of frequencies beginning at the Start frequency and ending at the End frequency.

Auto Tune Parameters:

Start Frequency	Starting point of the **Auto Tune** frequency sweep.
End Frequency	Ending point of the **Auto Tune** frequency sweep.
Target Amplitude	Targeted output signal amplitude *at the photodiode detector*. This value should *not* be confused with Drive amplitude, which is the amplitude applied directly to the cantilever itself (see Drive amplitude). *Range and Settings*: **0.00** to **8.00 V** Note: Dimension Series SPMs, nominal = 2.00V Small Sample MultiMode SPMs, nominal = 3.00V
Peak Offset	Percentage of cantilever's free-air resonant frequency to be automatically offset. Peak offset is used to compensate for changes in resonance before engagement due to the tip's interaction with the surface after engagement. *Range and Settings*: **0** to **50%**; typical value = **1** to **2%**
Minimum Q	Q is the value defined by the amount of oscillation it takes for a wave to drop to 1/e (e = 2.718) of its amplitude value (i.e. a wave with an amplitude of ten would have a Q of 10/e, or 3.6788). Minimum Q establishes a minimum "width of peak" value allowed by the AutoTune function. Peaks not meeting the Minimum Q may be ignored by setting the Smash Q factor.
Smash Width Factor	The width of the area beneath the wave *smashed* (set to zero) when a peak not meeting the Minimum Q requirement is found. **Note**: This parameter does not appear if Minimum Q is 0.

2.2.5 Scan View Interface

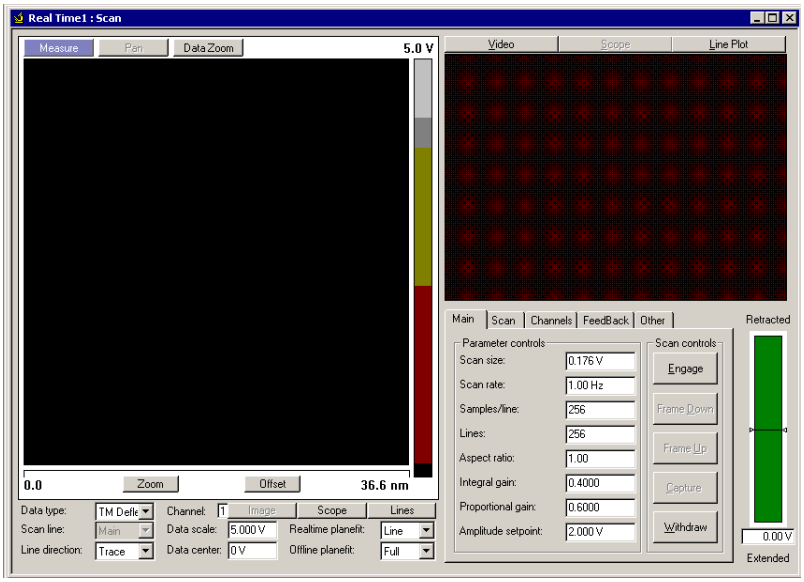
The **Scan View** display includes an image viewer, color bar, scope viewer, vision control viewer (for systems configured with vision controls), and numerous parameters to configure Realtime data collection. Most SPM operators use only a few of these parameters to obtain images. The parameters within each tab are also microscope-specific or level-access dependent and may be greyed out or hidden, depending on microscope configuration.

Scan View Interface:

Image Window	During scanning, the Realtime image of the sample appears along with a cursor. The cursor moves along the image vertically to show the engaged tip position on the surface. The **Measure** button allows you to make line measurements. The **Data Zoom** button allows you to "zoom in" to a smaller view, but doesn't change the scan size. The **Pan** button allows you to pan over to other areas of the total scan if you are zoomed in.
Color Bar	Sets the color table for viewing height data in the image window. Left-click on the color bar and drag the mouse left or right.
Image Parameters	Configure options below the image window to select the channel and image display values, (e.g. **Data type**, **Line direction**, **Data scale**, and so on).

Vision Window The Vision window displays the Optics or **Scope** data. Select the **Video** or **Scope** or **Line Plot** button.

Figure 2.2i Scan View and Main Controls



User-Defined Parameters in the Scan View

Clicking on a parameter and then dragging the mouse back and forth increases or decreases a parameter value much like an old analog slider. The significance, range of acceptable values, and specific information about control panel parameters are discussed in this section.

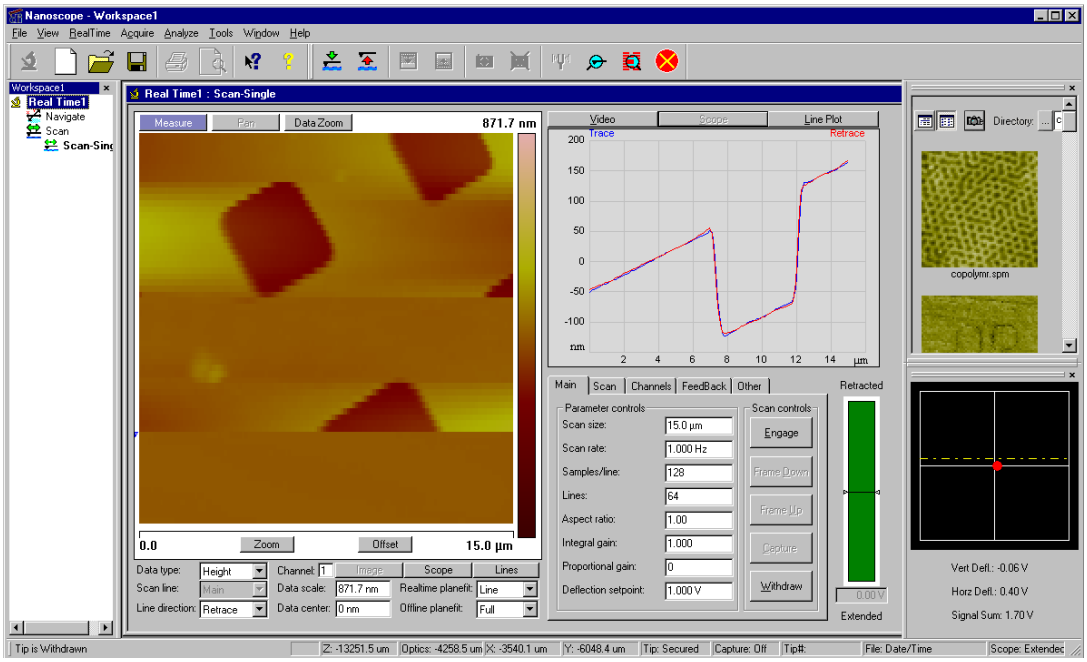
Parameters listed in the **Scan** tabs depend on the microscope selected and the **Show All Items** function (right-click on tab interface **> Show All**). Parameters necessary for one style of microscope are not applicable to another. For example, the **Drive frequency** and **Drive Amplitude** parameters are enabled on the **Feedback** tab only when the mode is set to TappingMode.

Some users find operating an SPM less confusing if the number of parameters is limited to only the most essential ones. For this reason, The **Main** tab in the **Scan View** contains user specified parameters.

2.2.6 Scope Trace Plot

Select the **Scope** button in **Scan View** (see Figure 2.2i) for a scope to display a plot versus the probe position in an oscilloscope-type format on the image display (see Figure 2.2j).

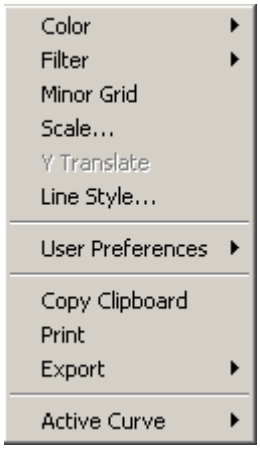
Figure 2.2j Scope Grid



Scope Trace Interface

By right-clicking the **Scope** grid**,** you will get a menu of different options (see Figure 2.2k).

Figure 2.2k Scope Grid Parameters



These menu options allow you to make the following changes:

Color — Allows operator to change color of:

- Curve (data)
- Text
- Background
- Grid
- Minor Grid
- Markers

Filter — Typically used for a Profiler Scan.

- **Type**—Allows the user to plot the mean, maximum or minimum y-value per x-value.
- **Points**—Allows user to plot multiple vertical axis (y-)values at each horizontal axis (x-)value. Select 4K, 8K, 16K or 32K Points to limit the display to 4, 8, 16 or 32 times 1024 points.

Minor Grid — Places a minor grid in the background of the **Vision** Window.

Scale — Allows user to auto scale, set a curve mean, or set their own data range.

Y Translate — Offsets the curve by placement of vertical cursor on the grid. Grab vertical cursor in the black space above the grid and pull down onto grid.

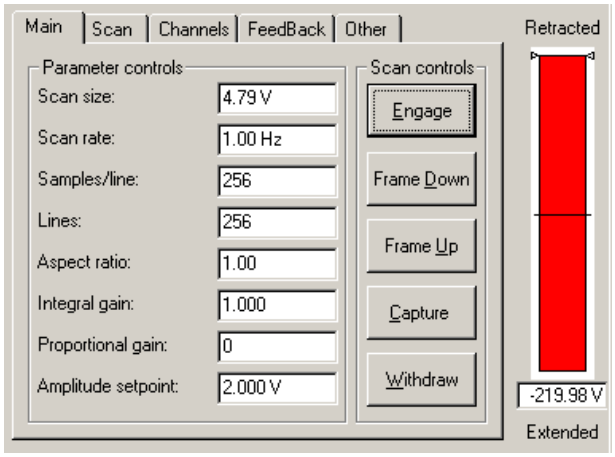
Line Style — For each curve, operator can choose, connect, fill down, or point.

User Preferences	**Restore**—Reverts to initial software settings **Save**—Saves all changes operator has made during this session. This becomes the new default settings.
Copy Clipboard	Copies the grid image to the Microsoft Clipboard.
Print	Prints out the current screen view to a physical printer.
Export	Exports data in bitmap, JPEG or XZ data format.
Active Curve	Determines which curve you are analyzing.

2.2.7 Main Tab Interface

Figure 2.2l shows an example of parameter controls and settings for scanning in TappingMode.

Figure 2.2l Main Controls Panel



Engage Button — The **Engage** command brings the tip into contact with the sample surface and starts the Realtime imaging process.

Withdraw Button — The **Withdraw** command stops the scanning process and withdraws the tip from the surface.

Frame Down Button — The **Down** command restarts the Realtime scan at the top of the frame. This allows you to go directly to the start of the frame and not have to wait for the previous frame to end.

Frame Up Button — The **Up** command restarts the Realtime scan at the bottom of the frame. It is an easy way to begin a view an entire Realtime frame from the bottom. By clicking on this icon, the Realtime scan restarts and moves up at the bottom of the frame. This allows you to go directly to the start of the frame and not have to wait for the previous frame to end.

Capture Button — The **Capture** command stores the image data of the current scan. During the image scanning process, the cursor moves up and down a square image frame. When the cursor moves up or down one complete frame the **Capture** is complete and an image file is saved.

Capture Cancel Button — The **Capture Cancel** command stops the capture process.

Procedures to Set the Main Tab

The parameters in the **Main Control** panel (see Figure 2.2m) are unique to your specific needs. Configure specific parameters as follows:

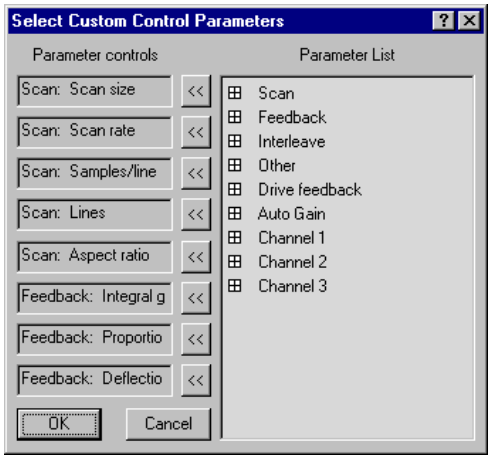
1. Right-click in the **Main Control** panel.
2. In the **Parameter** list, verify each **Scan View** tab name.
3. Expand the desired tab name by clicking on the plus (+) sign next to each name (i.e., Scan, Feedback, Interleave, etc.) to view a list of parameters.
4. Highlight the desired parameters for viewing on the **Main Controls t**ab.

   Note: Only eight parameters may be selected. Therefore, take note of the most used parameters to view in the **Main Controls** tab.

5. With the parameter selected, click the double arrows (<<) to position the selected parameter.
6. Repeat Step 2 - Step 5 for displaying eight main controls parameters for viewing during the scanning process.

Select **Ok** to accept the changes or **Cancel** to revert to the previous view.

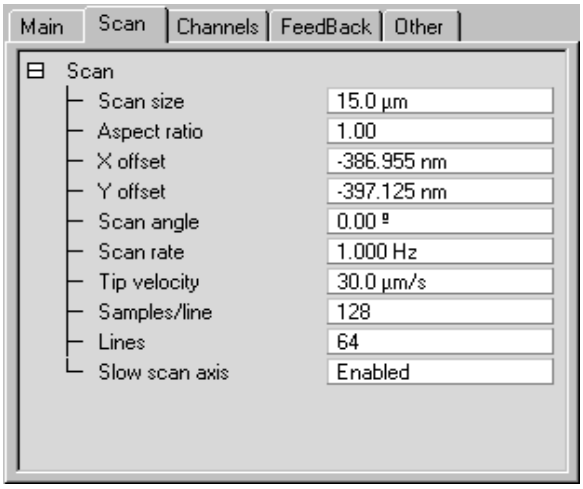
Figure 2.2m Select Scan View Controls



2.2.8 Scan Tab Interface

The **Scan** tab (see Figure 2.2n) includes parameters influencing piezo movement and data acquisition, as well as the ability to execute non-square scans. This **Tab** panel is probably the most frequently used panel, as it controls what type of scan to run, how large the scan is, its angle, scan rate, and number of samples per scan line.

Figure 2.2n Scan Tab Parameters



Scan Tab Parameters

Scan size

Determines the size of the scan by controlling the voltage applied to the X and Y piezos.

Range or Settings:

- **0** to **440V**
- **0** to **XXμm** (scanner-dependent)

The units of this parameter are volts if the **Units** parameter (**Other Controls** panel) is set to **Volts**. The units are linear distance (nm or μm) if the **Units** parameter is set to **Metric**.

See also, Optimizing the Scan Size Parameter on page 85.

Aspect ratio

Controls the width-to-height size ratio of scans. Set **Aspect ratio** to 1.00 for square scans. An **Aspect ratio** of 2.00 yields scanned images having width equal to twice the height.

Range or Settings: (depends upon the number of scan lines) **1** to **256**.

Figure 2.2o Aspect Ratio Example

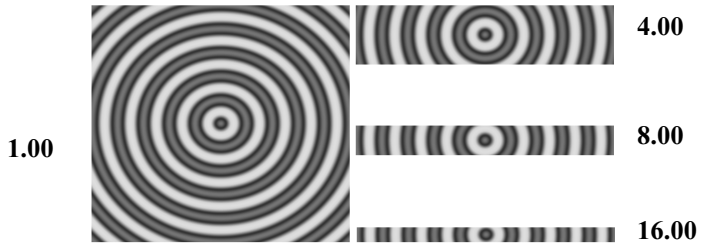
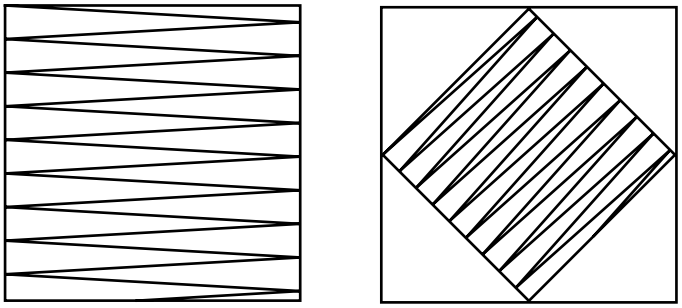


Figure 2.2p Scan Angle Rotated Example.



X offset, Y offset

Controls the center position of the scan in the X and Y directions, respectively.

Range or Settings: **±220V**; **± XX*µ*m** (dependent on **Scan size** and scanner).

See also, Optimizing the X Offset, Y Offset Parameter on page 85.

Scan angle

Controls the angle of the X (fast) scan relative to the sample.

Range or Settings: **0** to **359°** (Any angular value can be entered with the keyboard)

Changing this parameter can dramatically affect the quality of images due to tip effects (tip side wall angle).

Setting this parameter to a setting besides 0 or 90° may reduce the maximum allowable **Scan size** 10-20 percent due to corner constraints (see Figure 2.2p).

Scan rate

The **Scan rate** sets the number of fast scan lines performed per second. When the Scan rates are low, it can take a fairly long time to scan an entire frame. For example, With the **Scan rate** set to **0.5Hz** and the **Number of samples** set to **512**, it can take over 17 minutes to capture a single image.

Range or Settings: **0.1**-**237Hz**, depending on the number of **Samples/line**.

See also, Optimizing the Scan Size and Scan Rate Parameters on page 85.

Lines

Selects the number of lines to scan in a frame. The **Lines** parameter reduces resolution along the Y axis. It also speeds imaging (or frame rate) and reduces the size of the resulting image file.

Range or Settings: **2** to **1024**. The maximum number of lines may be limited by the value for **Samples/line**.

Tip velocity

Velocity of the tip (in μm/s) as it scans over the surface.

When **Tip Velocity** is changed, the **Scan Rate** adjusts automatically.

Samples/line

Selects the number of sample data points per scan line.

When this parameter is changes, the number of scan lines per image (**Lines**) are automatically adjusted to maintain the same ratio between the samples/line and lines per image.

Range or Settings: **128** to **16384**. This setting influences the memory size of captured files and image resolution (see Table 2.2a).

Table 2.2a File Size/Samples per line

Samples/line value	File size (for square scans, including 8K header)
128	40Kb
256	136Kb
512	520Kb

Note: **Samples/line** should be kept at 512 or higher for high resolution scans. To increase the frame rate (rate at which complete images are generated), the **Lines** parameter should be reduced. When the **Lines** parameter is reduced, file sizes in Table 2.2a are reduced accordingly.

Slow scan axis

Allows the slow scan to be disabled, causing the fast scan to be repeated continuously at the same position. This means that the image displays the same line continuously. Images may be presented either as "true" X-Y renderings of the sample surface (Enabled), or as "stretched" single-line scans of length equal to the **Scan size** (Disabled).

Range or Settings:

- **Enabled—**Sample is scanned in the slow scan direction. (This is the normal setting of this parameter.)
- **Disabled—**No scanning of the sample in the slow direction is performed. The fast scan is repeated at the same position.

Note: Disabling the **Slow scan axis** and viewing the **Scope Mode** display is a convenient way of setting the **Feedback Gain** parameters.

The advantage of using the **Slow Scan Axis > Disabled** parameter is to emphasize one area (line) to adjust SPM parameters. For example, an area of the image appears fuzzy (believing SPM parameters are not optimized for the sample). **Disable** the **Slow Scan Axis**, view the image in **Scope** mode, and reconfigure scan parameters to optimize the scan.

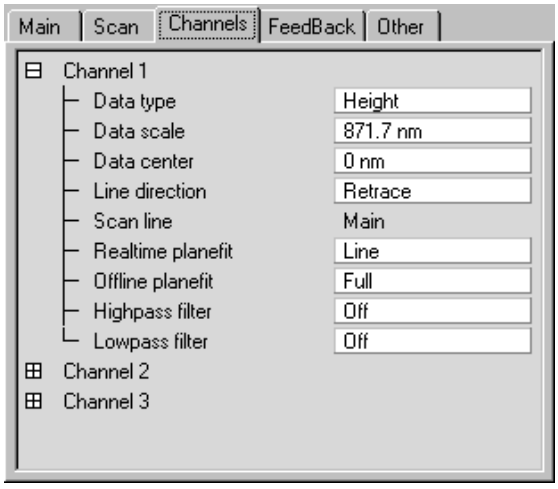
Note: Setting the **Slow scan axis** parameter to **Disable** stops the slow scanning of the piezo, but does not stop the movement of the Realtime display in Y. Lines are replicated in the Y direction.

2.2.9 Channels Tab Interface

The Channels tab (see Figure 2.2q) consists of parameters for three channels. Each channel represents a unique scanning image. Up to three data **Channels** may be opened by selecting each channel and choosing a data type to view simultaneously, opening up Realtime 3 times. Channels are numbered **1**, **2** and **3** and feature their own control panels. When a Data type is selected on a Channel, its image appears on the Display Monitor. It is possible to have up to three separate images from each scan. For example, a TappingMode scan might simultaneously present a **Height** image on **Channel 1**, a **Deflection** image on **Channel 2**, and an **Amplitude** image on **Channel 3**.

Parameters shown on each **Channel** control panel vary slightly, depending upon the type of microscope selected and its operating mode.

Figure 2.2q Channels Tab



Channel Tab Parameters

Data Type Settings vary, depending upon the microscope selected and operating mode as shown in the field descriptions below. The **Data type** parameter may receive: no data (**Off**); sample-height data (**Height**); cantilever oscillation amplitude data for TappingMode (**Amplitude**); cantilever deflection data (**Deflection**); STM current data (**Current**); phase data (**Phase**).

See also, Optimizing the Data Type Parameters on page 86.

Data Type Range or Settings

Amplitude (TappingMode and Force Mode only) The RMS of the cantilever amplitude signal is displayed and captured.

Current (STM only) Data displayed and captured is the tunneling current generated by the preamplifier. (When set to **Current**, the units of the data are **nA**.)

TM Deflection Cantilever deflection signal data is displayed and captured. (When set to **TM Deflection**, the units of the data are in distance or volts.)

Height The Z piezo voltage set by the feedback calculation in the Digital Signal Processor (DSP) is displayed. (The displayed data comes from the voltage output to the Z piezo.) Units are distance (e.g., **nm**, **μm**, etc.). Standard imaging of topography.

Off Channel is turned off.

Phase (MFM, EFM) Phase data from oscillating TappingMode tips, generally used with Magnetic Force Microscopy (MFM) and Electrical Force Microscopy (EFM), is displayed and captured. This setting appears when the microscope is configured with an Extender™ Electronics Module.

Potential (EFM) Surface potential data is displayed. (For detailed information on Surface Potential or EFM features, see Support Note 231, *Electric Force Microscopy on the MultiMode Systems*.)

Thermal Temperature data from thermal tips is displayed and captured.

Deflection Cantilever deflection signal data is displayed

Friction Torsional deflection signal data is displayed

Data scale

The Data Scale controls the Z scale corresponding to the full height of the display and color bar.

Range or Settings:

- **0.0067** to **440V** (**Data type** set to *height*, **Units** are set to *volts*).
- **XX** to **XXX µm** (Scanner dependent; where **Data type** is set to *height*, **Units** set to *metric*).
- **XX** to **XXX µm** (Sensitivity dependent; where the **Data type** is set to *deflection* or *amplitude*; **Units** are set to *metric*).
- **0.00003815** to **2.5V** or **20V** (**Data type** set to *amplitude*; **Units** set to *volts or deflection*)
- **0.0031** to **200nA** (**Data type** set to *current*; **Units** are set to *metric*).
- **0.0003052V** to **20V** (**Data type** set to *current*; **Units** are set to *volts*).

See also, Optimizing the Data Scale Parameters on page 86.

Data center

Offsets centerline on the color scale by the amount entered.

The **Data Center** offset does *not* become a permanent part of the data.

Range or Settings:

- **± 220V**
- **± TappingMode**

Line direction

Selects the direction of the fast scan data collection that is displayed in the image.

The feedback calculation is always performed regardless of the scan direction. This parameter simply selects whether the data is collected on the trace or the retrace. This parameter selects the relative motion of the tip to the sample.

Range or Settings:

- **Trace—**Data is collected when the relative motion of the tip is left to right as viewed from the front of the microscope.
- **Retrace—**Data is collected when the relative tip motion is right to left as viewed from the front of the microscope.

Scan line

The scan line controls whether data from the **Main** or **Interleave** scan line is displayed and captured.

Range or Settings: **Main** or **Interleave**

This parameter is not selectable when the **Interleave mode** parameter is set to **Disable**. The system is locked on the **Main** scan lines whenever the interleaved mode is turned off.

Realtime Planefit Applies a software *leveling plane* to each Realtime image, removing up to first-order tilt. Three types of planefit are available to each Realtime image.

Range or Settings:

- **None—**Only raw, unprocessed data is displayed.
- **Offset—**Takes the Z-axis average of each scan line, then subtracts it from every data point in that scan line.
- **Line—**Takes the slope and Z-axis average of each scan line and subtracts it from each data point in that scan line. This is the default mode of operation, and should be used unless there is a specific reason to do otherwise.

Offline Planefit Applies a software "leveling plane" to each captured image for removing up to first-order tilt. Three types of planefit are available to each Offline image.

Range or Settings:

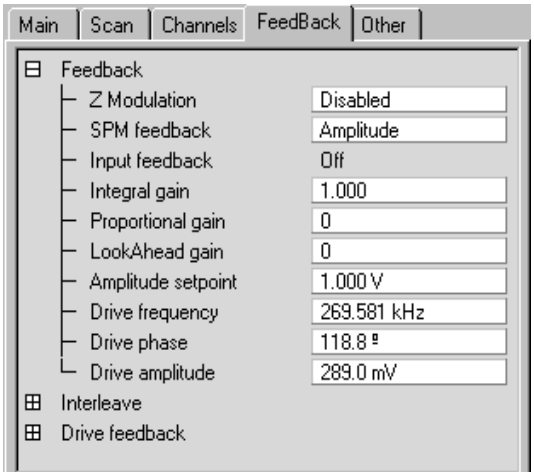
- **None—**Only raw, unprocessed data is displayed.
- **Offset—**Captured images have a DC 21 offset removed, but they are not fitted to a plane.
- **Full—**A best-fit plane which is derived from the data file subtracted from the captured image.

See also, Optimizing the Offline Planefit Parameter on page 86.

2.2.10 Feedback Controls Tab Interface

The **Feedback Controls** parameters allow for monitoring the signals between the **NanoScope Controller** and the cantilever. These signals adjust the setpoint, oscillation frequency, drive voltage, Z response for surface tracking, and output voltages. The purpose of the **Feedback Controls** is to maintain a constant setpoint (deflection, amplitude, or current) in the **Feedback Loop** for tip/sample control and tracking optimization.

Figure 2.2r Feedback Controls Tab in TappingMode



Feedback Control Parameters

Z Modulation (Fluid TappingMode only)

Allows the user to add the drive oscillation signal to the Z piezo voltage. This parameter is used to set up fluid cell oscillation in any Dimension system for Fluid TappingMode.

Range or Settings:

- **Enabled—**Enables Z modulation. Drive oscillation signal (Drive Frequency) is added to Z piezo voltage. **When enabled, the Z limit must be set ≤ 420V**.
- **0—**Disables the Z modulation (i.e., no additional signal is added to Z piezo voltage).

The desired **Drive amplitude** and **Drive frequency** voltages (**Realtime > View > Sweep > Cantilever Tune**) need to be set for Fluid **TappingMode** operation.

SPM feedback

Selects the signal to be used for tip feedback according to the selected **Microscope mode** parameter (**Other Controls** panel). For Contact AFM, the choice defaults to **Deflection**; however, for TappingMode, you may select either the **Deflection** or the **Amplitude**. STM offers three choices of feedback: Linear, Log and Boost.

Range or Settings:

- **TappingMode—Amplitude**, **TM Deflection-Phase** (Forcemod only)
- **Contact Mode—Deflection** only
- **STM—Linear**, **Log**, **Boost**

Linear—*The linear difference between the instantaneous tunneling current and the* ***Setpoint*** *current is used in the feedback calculation*.

Log—*The difference between the log of the instantaneous tunneling current and the log of the* ***Setpoint*** *current is used in the feedback calculation*.

Boost—*Optimizes the feedback performance for high* ***Scan rates*** *over rough surfaces*. *This is not intended for atomic images*.

See also, Optimizing the STM Feedback Parameters on page 87.

Input Feedback

Controls Frequency Modulation (MFM or EFM) and Surface Potential.

Integral Gain

Controls the amount of integrated error signal used in the feedback calculation.

Range or Settings: ***0*** to ***1024***

See also, Optimizing the Integral and Proportional Gain on page 87.

Gain settings vary, depending upon the scanner used, the sample and scanner sensitivity. See Table 2.2b for approximate, nominal values (assumes a **Scan rate** of ≈ **2.5Hz**).

Table 2.2b Typical Integral Gain Ranges:

Scanner	Contact AFM and Forcemod	TappingMode	STM
A[a]	1.0 - 8.0	0.2 - 1.0	0.3 - 5.0

a. For atomic-scale images, scan rate must be increased to approximately 60 Hz.

Proportional Gain

Controls the amount of the proportional error signal used in the feedback calculation. The **Proportional gain** term in the feedback calculation has equal gain at all frequencies; therefore, it has a dominating effect over the **Integral gain** for high frequencies (scan rates).

Range or Settings: **0** to **1024**

(Typical settings for the **Proportional gain** parameter are 35-100% more than **Integral gain** values).

LookAhead Gain

Adjusts Z-axis tracking of the sample surface by "remembering" previous scan line data, then anticipating adjacent surface features on the current scan line. Look ahead gain is a valuable assist to the Integral gain parameter when scanning regular, steep features such as gratings and integrated circuits (e.g., by decreasing tip overshooting, etc.).

Range or Settings: **0** to **1**

See also, Optimizing the Look Ahead Gain Parameter on page 87.

Setpoint

The meaning of this parameter depends on the operating mode of the microscope as follows:

Amplitude Setpoint (TappingMode)—defines the amplitude of the cantilever oscillation signal to be maintained by the feedback loop. (Range: **0.00** to **10.00V**)

Deflection Setpoint (Contact Mode)—Controls the deflection-signal level used as the constant desired voltage in the feedback loop. (Range: **10.00** to **10.00 V**)

Current Setpoint (STM)—Controls the constant current maintained by the feedback loop. (*Range*: **0.0** to **100.0nA)**

Drive frequency (TappingMode and Force Mode only)	Selects the oscillation frequency applied to the piezoelectric crystal that vibrates the cantilever. *Range or Settings*: **0.00** to **250MHz** The **Center frequency** is adjusted with the **Cantilever Tune** command to find the resonance frequency of the cantilever. The maximum cantilever oscillation amplitude occurs at its resonant frequency. The software sets the **Drive frequency** equal to the current **Center frequency** value when the **Ok** button in the Cantilever Tune control panel is pressed.
Drive Phase (TappingMode and Force Mode only)	Selects the phase of the drive voltage applied to the piezoelectric crystal that vibrates the cantilever.
Drive amplitude (TappingMode and Force Mode only)	Selects the amplitude of the drive voltage applied to the piezoelectric crystal that vibrates the cantilever. *Range or Settings*: **0.00** to **20.00V** The **Drive amplitude** is also adjusted with the **Cantilever Tune** command. Increasing the **Drive amplitude** increases the cantilever-oscillation amplitude. The cantilever-oscillation amplitude is increased to an appropriate level with the **Cantilever Tune** command. In **AutoTune**, the **Drive Amplitude** automatically adjusts to get a cantilever oscillation (rms amplitude) equivalent to the user's **Target amplitude**.
Bias	Controls the sign and magnitude of the bias voltage applied to the sample. *Range or Settings*: **-10.00** to **10.00V** When used with STM, typical settings for the **Bias** voltage parameter are **20** to **100mV** for conductive samples and up to several volts with poorly conducting samples. Positive settings of the **Bias** voltage item correspond to negative current (electrons) tunneling from the tip into the sample on heads with the **Bias** applied to the **Sample** or **Tip**.
Analog 1, 3, 4	This voltage has no effect on the operation of the standard microscope, but is useful in custom applications. *Range or Settings*: **-10.00** to **10.00V**. **These settings are only displayed with either NSIV or NSIIIA with Quadrex extender**.
Aux Lockin	Directs an external input signal through the auxiliary lock-in amplifier.
Drive Phase	The phase of the AC bias signal applied to stimulate piezoresponse.
Lockin BW	The bandwidth of the effective bandpass filter centered on the TTL level reference frequency (i.e., the cantilever drive frequency in the NSIV Controller) used by the main lock-in amplifier.

InterSave Parameters Range or Settings

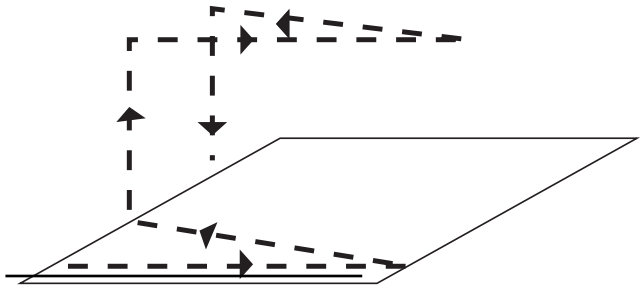
Several parameters (e.g. Z modulation, SPM Feedback, etc.) are highlighted by dark gray or green background. Dark grey indicates that the parameters are coupled with the equivalent values in the Feedback controls. By selecting (left-click) the Interleave parameters, the grey field turns green, indicating that the Feedback and Interleave parameters are decoupled and the value in those parameters will be used as feedback during the interleave scan line.

Interleave Mode

- **Interleave—**Adds a second, interleaved set of lines to the scan, which can be accessed from the Channel panel and captured as data. Invoking Interleave reduces the slow axis speed by one-half and doubles the capture time.

- **Lift—**A variant of Interleave, the Lift option uses the first set of scan lines to detect the surface, then lifts the probe above the sample surface on the interleaved set of scan lines according to the Lift start height and Lift scan height parameter settings. During the Interleaved scan, the tip mimics the surface topography from the previous surface scan line (see Figure 2.2s).

Figure 2.2s Interleave Lift Mode

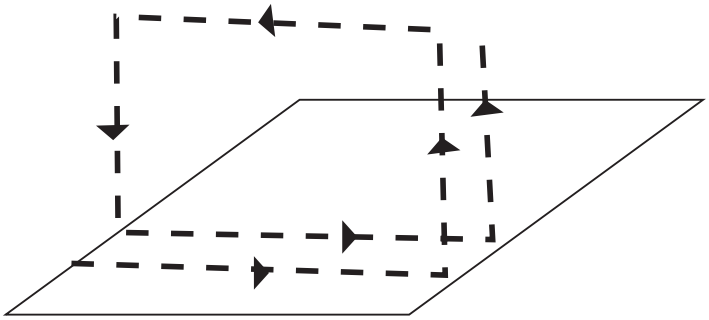


- **Linear—**Lifts the tip to a predetermined height and runs the interleave scan at that height.

- **Disabled—**Turns off the interleave scanning.

- **Retrace Lift—**Lifts after the trace scan in the retrace direction. This parameter is optimized with the **Rounding** parameter (**Microscope > Calibrate > Scanner > Rounding**). The suggested rounding setting is **0.2**.

Figure 2.2t Retrace Lift Mode



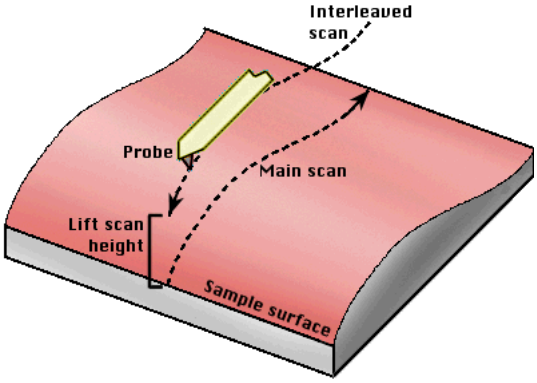
Lift scan height

Specifies the tip's height above the sample surface during interleaved scans. This parameter is in effect ONLY when the Interleave mode parameter is set to **Lift, Linear,** and **Retrace Lift** (see Figure 2.2u).

Range or Settings: XXμm (Scanner dependent)

The maximum meaningful value of the parameter depends on the Z voltages applied in the **Main** scan line and the maximum voltage that the system can output. The maximum voltage that can be applied to the piezo is ±220V. It will be lower if the Z voltage is restricted by the **Z limit** parameter.

Figure 2.2u Lift Scan Height Illustrated

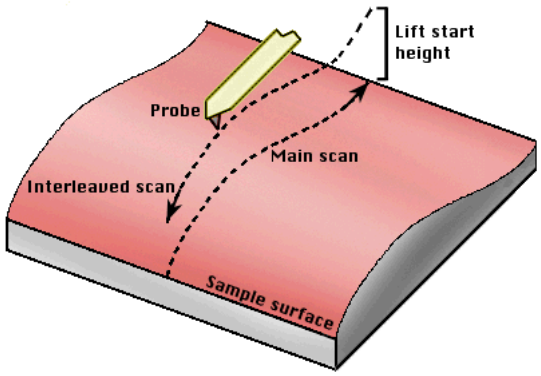


Lift start height

Specifies the height that the tip is to be lifted above the sample surface at the start of each interleaved scan. Generally, this parameter serves to lift the tip clear of any contamination layers present on the sample before assuming its Lift scan height during interleaved scans. This parameter is in effect ONLY when the **Interleaved mode** parameter is set to **Lift** and **Retrace Lift**. This parameter defines an offset from the Z voltage, or height, applied to the piezo on the **Main** scan line.

Range or Settings: XXμm (Scanner dependent)

Figure 2.2v Lift Start Height Illustrated



Tips for Using the Lift Start Height Parameter

- This value can be left at zero for TappingMode and STM. It is generally only used for Contact AFM to break the tip free of the adhesive force produced by the water layer before settling to the final tip height.
- The maximum meaningful value of the parameter depends on the Z voltages applied in the **Main** scan line and the maximum voltage that the system can output. The maximum voltage that can be applied to the piezo is ±220V. It will be lower if the Z voltage is restricted by the **Z limit** parameter.

The tip will go through this height at the start of every lifted scan line, then proceeds to the lift scan height for the rest of the scan line.

Drive Feedback Controls

The **Drive Feedback Controls** contain parameters for precisely maintaining feedback levels during TappingMode imaging. This protects tips and samples, and assists greatly in maintaining tip engagement. Many users are familiar with the difficulties of minimizing tip-sample forces on extreme surfaces (i.e., surfaces which are extremely hard or soft). Very hard surfaces tend to wear out silicon tips rapidly; very soft samples are easily damaged by the tips themselves. Minimizing tip-sample forces in TappingMode with a higher setpoint may also lead to a condition in which tips suddenly disengage from surfaces.

Refer to the following sections on the Drive Feedback interface:

- Theory on page 71
- Parameters in Drive Feedback: on page 71

Theory

When enabled, **Drive Feedback** works by readjusting the drive amplitude at the beginning and end of each scan line. As the tip reaches either edge of the scan area, the tip is lifted off the surface by the **Drive height** amount and the drive amplitude is adjusted by a factor equal to the **Drive gain** times the drive error signal. This occurs for a duration of **Drive time**. The tip then turns around, descends to the surface, and resumes scanning.

Use **Drive feedback** parameters *only* for TappingMode imaging and **Disable** during other types of imaging. Although automatic control of **Drive Feedback** is not required for most TappingMode imaging, it should be applied whenever imaging extreme surfaces and when making tip changes with **Automatic tip exchange**.

Parameters in Drive Feedback:

Drive height — Distance tip is lifted during readjustment of drive feedback. Default is 5.00nm. Maximum values are $\pm\frac{\text{ZLimit}}{2}$.

Drive time — Time required for the tip to exit the scan boundary, turn off feedback, ascend to the Drive height and adjust drive feedback.

Default: **10.00ms**

Maximum Drive Time: **100ms**

Drive setpoint — Drive amplitude setpoint, expressed as a fraction of the free-air amplitude.

Default: **0.90**

Range: **0.5** to **2.0**

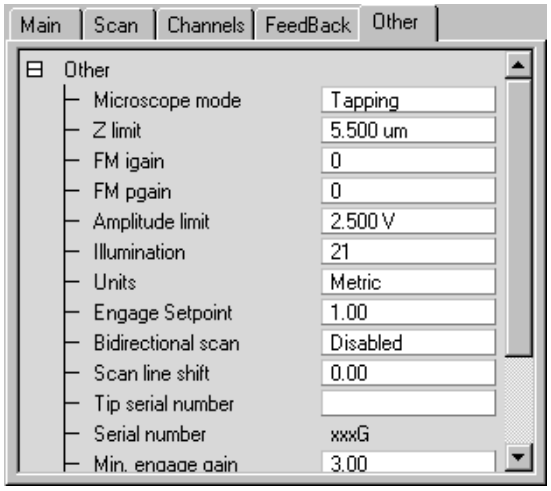
Drive gain — Integral gain applied to the feedback loop's drive error signal. Once the tip resumes normal scan height, Drive gain is no longer applied. Default is 1.00.
Range: **-1024** to **1024**

Drive feedback — The **Drive feedback** parameter turns drive feedback parameters on and off. **Enabled** is on, **Disabled** is off.

2.2.11 Other Tab Interface

The **Other Controls** parameters set the type of microscopy, Z tracking limits, units to use in measuring and other parameters specific the to microscope mode (i.e., the parameters that appear in the **Other Controls** panel will vary from one microscope to another). In the **Workspace** menu, select **R001 Time**. In the **Realtime Scan** window, select the **Other** tab.

Figure 2.2w Other Tab



Parameters in the Other Controls Tab:

Microscope mode — Selects the type of microscopy to be employed. Switching this parameter enables/disables other parameters. Also, on **MultiMode SPMs**, any change to the **Microscope mode** must be accompanied by use of the mode selector switch on the microscope's base.

Range or Settings:

Contact, **Tapping** or **STM**

Z limit — Permits attenuation of maximum allowable Z voltage and vertical scan range for achieving higher resolution (smaller quantization) in the Z direction.

Range or Settings:

11 to **440V** (with Units set to Volts)

FM igain — Integral gain for Frequency modulation. Controls the feedback loop that uses phase electronics.

FM pgain — Proportional gain for Frequency modulation. Controls the feedback loop that uses phase electronics.

Deflection Limit Use this parameter for attenuating the input voltage signal (appears only when performing Contact AFM).

Range or Settings:

- 2.500V to 20.0V for regular imaging
- 20.00V in **Force Mode** *only*

Amplitude Limit Use this parameter for attenuating the input voltage signal (appears only for TappingMode or STM).

Range or Settings:

- 2.500V for regular imaging
- 20.00V in **Force Mode** *only*

Illumination Controls the fiber optic illumination of the sample in **Dimension** series microscopes.

Range or Settings: **0** to **100**, recommended range is **20** to **50**

Units Selects whether the units of certain scan parameters are in Volts or in units of Metric distance (nm, etc.). Parameters affected include Scan size, X Offset, Lift start height and Lift scan height, Y Offset, Data Scale, Z Limit, Z Scan Start, Ramp Size, Column Step and Row Step.

Range or Settings:

- **Volts—**Parameters are in Volts.
- **Metric—**Parameters are in units of distance (nm, μm, etc.)

Engage Setpoint (TappingMode only)

Allows the user to correct for loss of tracking on engage due to sample differences. The automatic **Engage** procedure establishes the setpoint voltage at the smallest possible value that detects the sample surface, resulting in a value that protects both the sample surface and the cantilever tip. However, this value may not be sufficient for optimal surface tracking on all samples. The setpoint voltage determined by the automatic **Engage** procedure will be multiplied by the **Engage Setpoint** value, increasing or decreasing tapping force.

Range or Settings:

0.5 through **2.0**. A value of **1.0** results in no change to the tapping force. Values less than **1.0** increase the tapping force and values greater than **1.0** decrease the tapping force. A value of **0.9** is nominal for most samples.

Example of Engage Setpoint

The **Engage Setpoint** for a particular sample may be empirically determined. Procedures are as follows:

1. Set the **Engage Setpoint** to **1.0** and engage on the sample.
2. After engagement, make note of the **Setpoin**t parameter.
3. While watching the scan, adjust the **Setpoint** value until the tip tracks the surface correctly. Calculate the following:

   - Setpoint value/ Starting Setpoint value = Engage Setpoint
   (For optimal value, take the average of several engages on a selection of samples or different areas of the same sample).

Bidirectional scan

When the Bidirectional scan parameter is **Enabled**, data from both Trace and Retrace scans are used to capture frames in half the normal time. Images have alternately shifted lines, which cause features to lose some of their lateral definition; however, data may be used for metrological analysis. Use to save time while capturing images.

Range or Settings:

Enabled or **Disabled**

When **Enabled**, features shown in images lose some lateral definition, making point-to-point measurements inadvisable. Vertical data, however, is unaffected.

Use the **Scan line shift** parameter to readjust images with the **Bidirectional scan** parameter **Enabled.** This will shift scan lines relative to one another to restore some lateral definition in features.

Scan line shift

Use the **Scan Line Shift** parameter to shift trace and retrace lines relative to one another by up to 5 pixels in either direction. Units are in pixels and range from -5 to +5. Scan line shift is used for readjusting images captured when the **Bidirectional** scan parameter is **Enabled**.

Range or Settings: **-5** to **+5**

This parameter is generally only for images that have been captured with the **Bidirectional scan** parameter set to **Enabled**.

Tip Serial Number

Saves input in the image header (Ciao Scan List) for users who keep a tip filing system. This is to keep track of the tips used for certain images.

Serial Number: **Scanner Calibration** file.

Min. Engage Gain (STM only)	Allows user to engage tip in *constant height* mode. In constant height mode, the gains (feedback) is disabled. However, the **Min**. **Engage Gain** parameter provides for gain during engagement.
Strip Chart Rate	Frequency of (Z-position, deflection) data point acquisition. *Range*: **32kHz** *Typical value*: **1kHz**
Strip Chart Size	Time interval over which (Z-position, deflection) data points are displayed. *Typical value*: Tens of seconds. Note: Although the strip chart collects and displays data over the time interval defined by clicking **Start**, then later, **Stop**, this data is not saved for subsequent use until the **Capture** icon is clicked. If **Capture** is clicked while strip chart data is being taken, what is saved begins at the start of the chart (sooner than the icon is clicked).

Auto Gain

Auto Gain automatically sets the feedback parameters (**Proportional** and **Integral gain**) for a given sample.

Auto Gain works by analyzing the difference between **Trac**e minus **Retrace** (**TMR**). The analysis is used to choose a set of feedback parameters that minimizes the **TMR** value. By specifying the starting value of the **Integral gain** sweep, the ending value, and the size of the increments, Auto Gain may be used to calculate a set of useful feedback parameters.

For the purposes of this analysis, **Proportional gain** operates as a factor of **Integral gain**. The relationship is $\text{Proportional gain} = F \times \text{Integral gain}$, where *F* is a factor defined as **Pro. Gain factor**.

Auto Gain only requires the input of the three **Gain** values in order to calculate an effective **Integral gain**.

Parameters in the Auto Gain Panel:

Gain start	The starting value of the integral gain sweep. *Range or Settings*: Recommended settings are **0.10** for **TappingMode**, **0.5** for **Contact Mode**.
Gain end	The ending value of the integral gain sweep. *Range or Settings*: Recommended settings are **1.0** for **TappingMode**, **10.0** for **Contact Mode**.
Gain incr.	The increment step for each integral gain test. *Range or Settings*: **0.0** to **5.0**; Recommended settings are **0.1** for **TappingMode**, **0.5** for **Contact Mode**.
Pro. Gain factor	**Proportional gain** is set to: Pro. Gain factor × Integral gain *Range or Settings*: **0.0** to **10.0**; Recommended value is **1.50**
Max shift	The percentage of pixels to shift the Retrace line to match the trace line during the correlation routine. The more closely the Trace and Retrace lines match, the lower the TMR will be, and the more effective the Auto Gain feature. *Range or Settings*: **0** to **0.2**; recommended setting is **0.02** (or **2%**)
Gain offset	Specifies the number that determines the final, best fit Integral gain. Allows a change in the value produced by Auto Gain. *Range or Settings*: **0.0** to **2.0**; recommended setting is **0.95** (or **95%**)
Lines/gain	The number of lines to test and average for each integral gain step. Optimal settings are between 4 and 8. This, like Max shift, allows for a more accurate determination of TMR. *Range or Settings*: **1** to **20**, with a default setting of **8**

2.3 Tips on Using Realtime

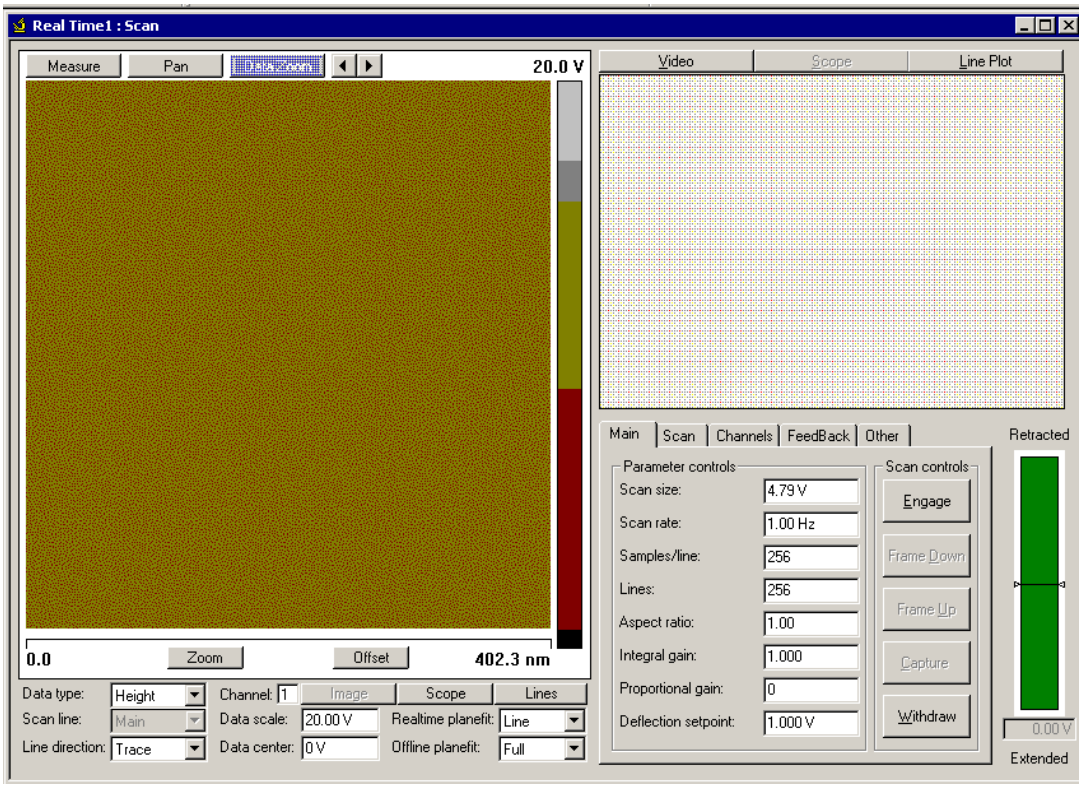
Please refer to the following Realtime commands available on the NanoScope software:

- **Using the Image Interface** Section 2.3.1
- **Multiple Channels** Section 2.3.2
- **Hints to Optimize the Engage Button** Section 2.3.3
- **Scan View Parameters Tips** Section 2.3.4
- **Channels Parameters Tips** Section 2.3.5
- **Feedback Parameters Tips** Section 2.3.6

2.3.1 Using the Image Interface

There are various commands available for use during a Realtime scan. Below is a description of these commands (see Figure 2.3a).

Figure 2.3a Image for Processing



Buttons

- **Measure**: Allows you to draw a line to make measurements.
- **Pan**: From a zoomed image, the user can pan around to other areas of the original image.
- **Data Zoom**: Left-click, hold, and drag out a box. Release the mouse button and the image will automatically zoom in to the area of the box. The original scan size remains the same.
- **Zoom**: Allows you to zoom in on a region of interest.
  - When you select **Zoom** a bounding box appears on the image display. Left-click on the outer edge of the box to resize.
  - Left-click in the center to reposition.
  - Click the **Execute** button to zoom in. This updates the **Scan size** and **X** and **Y Offset** parameters.
- **Execute**: Executes the **Zoom** and **Offset** commands. You must select the **Zoom** or **Offset** button for the **Execute** button to appear.
- **Offset**: Allows you to center the scan at the region of interest.
  - When you select **Offset** a crosshair displays at the center of the image.
  - Left-click and hold the crosshair to reposition it.
  - Click the **Execute** button to center the scan. This updates the **X** and **Y Offset** parameters.

Right-Clicking on the Image

By right-clicking on the image, you will get a menu that allows you to perform the following tasks:

- **Copy Clipboard**: Copies the image to the Microsoft™ clipboard.
- **Tooltip Info Level**:
  - Basic
  - Medium
  - Advanced
  - None

Right-Clicking on the Color Bar

Right-clicking on the color bar along the right side of the image (see Figure 2.3a) will produce a **Color** button (see Figure 2.3b). Clicking on this **Color** button will open the **Image Adjust** menu, where you can perform the following image adjustments (see Figure 2.3c):

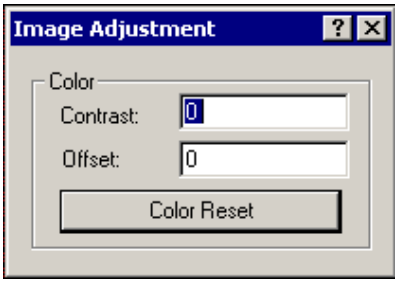
Figure 2.3b Color Button

a. You can adjust the color by changing the **Contrast** or **Offset** settings.

- **Contrast**—Number (-10 to +10) designates contrast of colors in displayed image (e.g., 0 shows little change, while 10 shows highest contrast).
- **Offset**—Number (-128 to +128) designates offset of colors in displayed image (e.g., 120 shows illuminated background on image).

b. Clicking the **Color Reset** button will change all the current readings to the default settings.

Figure 2.3c Image Adjust Menu



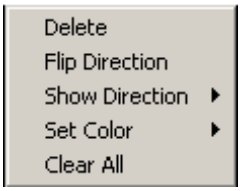
c. To change the color table, position the mouse over the color bar on the right side of the image. Click and hold the left mouse button, then drag the mouse from left to right to scroll through the different color tables.

Using the Mouse Within a Captured Image in Measure Mode

Left-click anywhere in image window, drag line out, and release	Creates a line of X length, at X^{o} of angle in the image window.
Place cursor on line	Displays length and angle values of line in the image window.
Place cursor on line, click and hold left button, and drag	Allows you to drag the line anywhere in the image window.

Click and hold on either end of line and drag	Changes length and/or the angle of the line.
Right-click	Clicking the right mouse button when the cursor is on the line accesses the **Image Cursor** menu (see Figure 2.3d). • **Delete**—Deletes the line. • **Flip Direction**—Switches the line end to end. • **Show Direction**—Adds small arrowhead to the line to indicate its the direction. • **Set Color**— Allows you to changes the color of the line. • **Clear All**—Deletes the line.

Figure 2.3d Image Cursor Menu



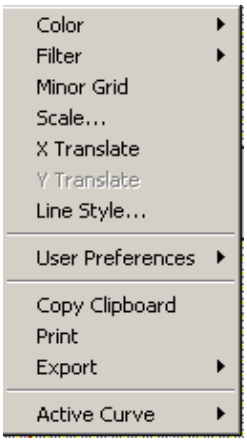
Using the Grid Display

Measurement cursors for the **Scope View** are provided to the left and right of the Grid Display. You can bring the cursors into the grid by placing the mouse cursor onto the measurement cursors, clicking and holding the left mouse button, and dragging them onto the grid. When you place the mouse cursor onto a measurement cursor, the cursor will change from a plus sign to a horizontal or vertical arrowhead cursor, which indicates you can grab and drag this cursor.

Right-clicking on the grid will bring up the **Grid Parameters** menu (see Figure 2.3e) and allow you to make the following changes:

Color	Allows operator to change the color of the: • Curve (data) • Text • Background • Grid • Minor Grid • Markers
Filter	Typically used for a Profiler Scan. • **Type**—Allows the user to plot the mean, maximum or minimum y-value per x-value. • **Points** —Allows user to plot multiple vertical axis (y-)values at each horizontal axis (x-)value. Select 4K, 8K, 16K or 32K Points to limit the display to 4, 8, 16 or 32 times 1024 points.
Minor Grid	Places a minor grid in the background of the Vision Window.
Scale	Allows user to auto scale, set a curve mean, or set their own data range
Translate	Offsets the curve by the placement of a horizontal cursor on the grid
Line Style	For each curve, the operator can choose a connect, fill down, or point line.
User Preferences	**Restore**—Reverts to initial software settings **Save**—Saves all changes operator has made during this session. This becomes the new default settings.
Copy Clipboard	Copies the grid image to the Microsoft Clipboard
Print	Prints out the current screen view to a physical printer
Export	Exports data in bitmap, JPEG or XZ data format
Active Curve	Determines which curve you are analyzing

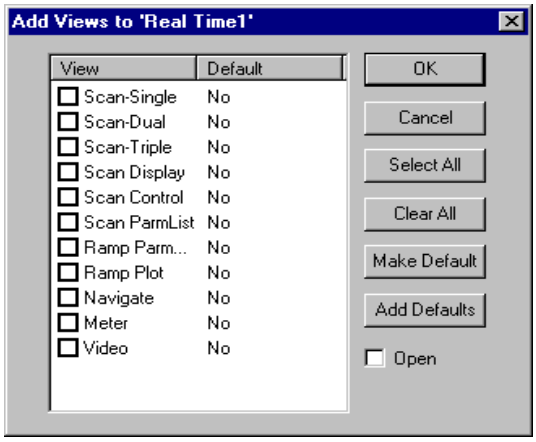
Figure 2.3e Grid Parameters



2.3.2 Multiple Channels

It is often helpful to view more than one channel of data simultaneously. **Scan-Dual** and **Scan-Triple** can be selected upon first opening Realtime by clicking on the appropriate check boxes in the **Add Views to Realtime1** dialog box (see Figure 2.3f).

Figure 2.3f Add Views to Realtime1 Dialog Box



If you are already in Realtime, you can also access multiple channel views by right-clicking on the **Realtime** icon in the Realtime workspace (see Figure 2.3g).

- Click **Add View > Scan-Dual** to add a window with two channels displayed.
- Click **Add View > Scan-Triple** to add a window with three channels displayed.

  Note: To open a single channel, click **Add View > Scan Display**.

Figure 2.3g Add Views to Realtime1 Menu

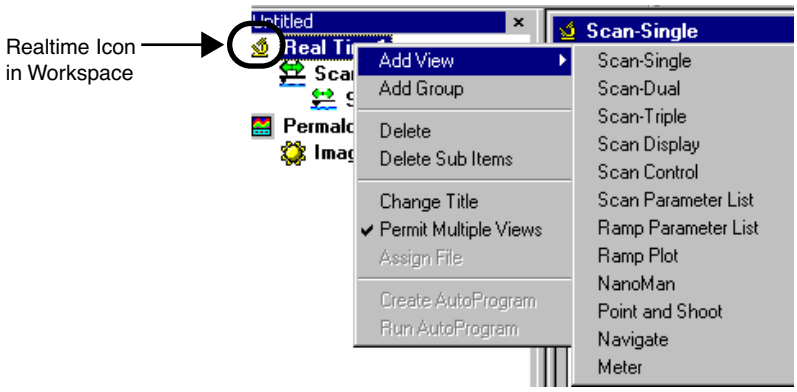
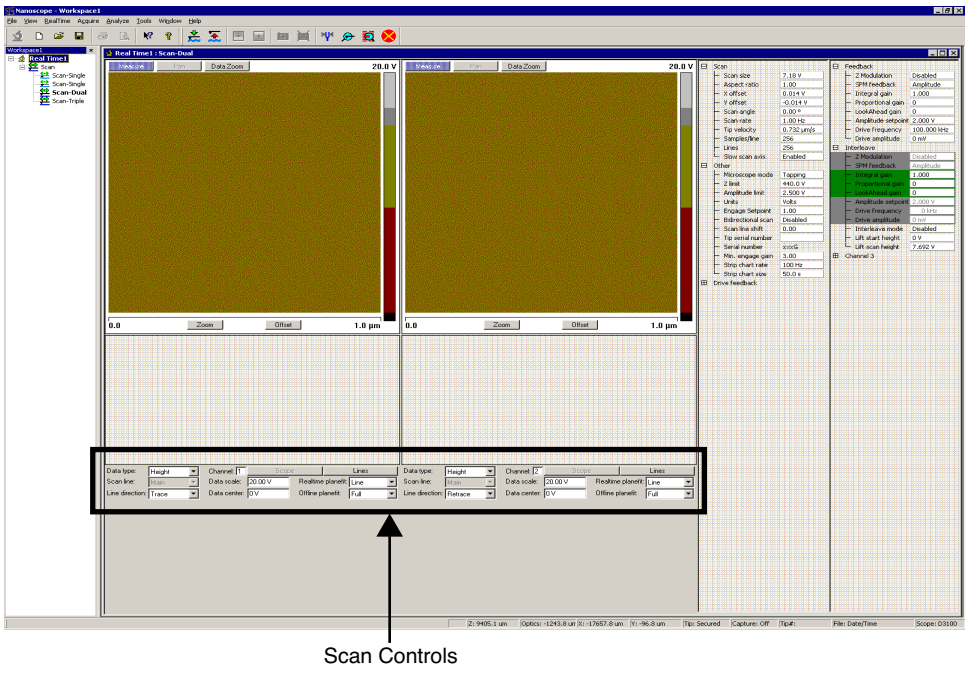


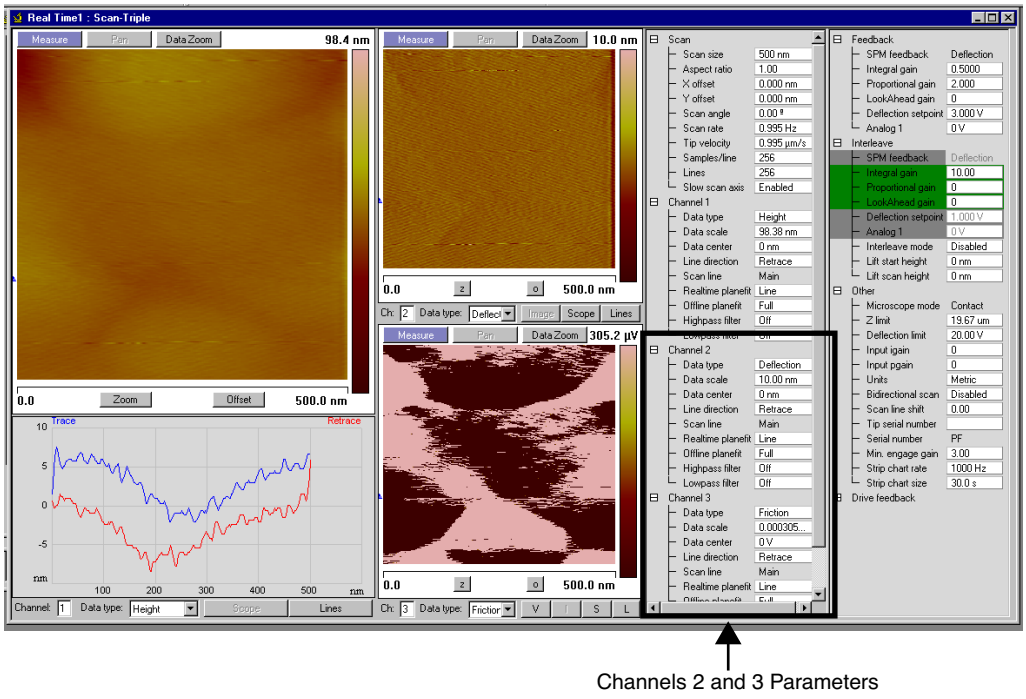
Image controls are displayed beneath each image (see Figure 2.3h).

Figure 2.3h Scan-Dual View



In **Scan-Triple**, the **Scan Line**, **Scan Direction**, **Data Scale**, **Data Center**, **Realtime Planefit**, and **Offline Planefit** settings are not displayed below the images and must be accessed using the parameters list to the right of the image display (see Figure 2.3i).

Figure 2.3i Scan Triple Dialog Box and Location of Channel 2 and 3 Parameters



Note: All three channel display options are included among the Realtime views presented as options to include in the workspace upon first opening the Realtime workspace (see Figure 2.3h).

Typical examples of the use of multiple channels:

- To simultaneously monitor both a TappingMode height image and a phase image of the same region.
- To simultaneously collect a topography and MFM image.

2.3.3 Hints to Optimize the Engage Button

- When used with stepper-motor-engagement microscopes, the tip is lowered under program control. While the tip is being engaged, the tip travel distance is shown in the center of the status bar on the Control Monitor. When the surface is detected, the workstation beeps, starts the Realtime imaging process, and displays **Engaged** in the status bar on the Control Monitor.
- During automatic engagement, the tip will travel a preset distance (200μm for Dimension AFMs, 125μm for MultiMode AFMs). If the sample surface is not detected in this distance, an error message will be displayed.
- If the tip is on the surface and the Z center voltage indicates that the piezo is near full extension or retraction, the tip may be withdrawn and re-engaged to center the Z center voltage. Alternatively, the *Tip Up* and *Tip Down* subcommands of the **Motor** command

can be used to center the Z voltage. If the Z center position indicates that the scanner is retracted, click the Tip Up button until Z center is near 0V (0.50V).

- Pressing **Ctrl-F** after the **Engage** command has been executed will cause a false engage to occur after the SPM safety height is recycled for Dimension, causing the Realtime software to start scanning independently of whether the surface has been detected or not.

2.3.4 Scan View Parameters Tips

Optimizing the Scan Size Parameter

- The **Scan size** and offsets can be set by using the **Zoom** and **Offset** subcommands in **Scan View** or in tabbed panels.
- Non-zero **X** and **Y offsets** reduce the maximum **Scan size**. Each volt of **X** or **Y offset** reduces the maximum scan size by 2V.
- Having a non-zero **Scan angle** will reduce the maximum allowable **Scan size**.
- The maximum **Scan size** will also decrease as the **Scan rate** increases.

Optimizing the X Offset, Y Offset Parameter

- These parameters use the sample as the position reference. Therefore, a more negative **X offset** value will move a feature in the current image to the *left* on the Image display Similarly, a more negative **Y offset** moves a feature in the current image *down* on the Image display.
- Using the left-arrow and right-arrow keys when the cursor is in these parameters will decrement and increment these parameters by 10% of the **Scan size**.
- Using the **Zoom** or **Offset** subcommands on the automatically changes the value of **X** and **Y offsets**.

Optimizing the Scan Size and Scan Rate Parameters

- The **Scan size** and height of features on the sample will affect the maximum **Scan rate** that should be used on a given sample. Scan rate should be set to a rate that allows the tip to closely track the sample surface in both trace and retrace. In general, larger scans and taller features require slower scan rates.

2.3.5 Channels Parameters Tips

Optimizing the Data Type Parameters

- The system can display up to three Realtime images on the Display Monitor.
- The **Data type** parameter does *not* switch the operating mode of the instrument, it simply changes the source of the data displayed.

Optimizing the Data Scale Parameters

- Data beyond the setting of the **Data scale** is clipped for the Realtime display. Captured data, however, is not clipped. Independent of the settings of this parameter, the captured data will be correct unless it exceeds the maximum vertical range of the scanner.
- Each **Data type** retains separate settings for **Data scale**.
- **Data Center** is used to manually offset the trace data when Realtime Planefit is set to none.

The conversion of volts to **nm** or **nA**, is dependent on the value **Sensitivity Detector** parameters in the **Tools > Calibrate > Detector** panel.

For example, nanometers of cantilever deflection are calculated using the **Sensitivity** parameter in the **Force Calibrate** panel.

Optimizing Realtime Planefit Parameters

The setting of **Realtime Planefit** only affects the displayed data. It does not affect the captured data The parameters are described below.

- **None** displays the raw data in the scope display.
- **Offset** applies a zero order correction to each line of data so that the average height of the line is centered in the scope display.
- **Line** applies a 1^{st} order correction, removing both tilt and offset from each line of data.

  Note: If features are not evenly spaced along the scan line, using **Realtime Planefit Line** can result in artificial tilting of the scan line.

Optimizing the Offline Planefit Parameter

- The **None** option should only be used in special cases. The **Offset** and **Full** options provide greater dynamic range in the data to reduce round-off and other errors in subsequent calculations.
- The **Offline > Modify > Flatten** and **Planefit** commands can also be used to level the data after it has been captured.

2.3.6 Feedback Parameters Tips

Optimizing the STM Feedback Parameters

- The **Boost** and **Log** modes are preferable for most STM samples, because the tip responds in a more symmetric manner (i.e., the same going up and coming down). **Log** and **Boost** modes tend to linearize the entire feedback loop since $Z \approx \ln(i)$. The asymmetric response of the **Lin** setting distorts data.
- Use of **Boost** mode allows the **Proportional gain** and **Integral gain** values to be reduced and is preferable for large scans having high, vertical features (e.g., integrated circuits).
- When **Boost** mode is selected, the **Integral** and **Proportional gains** are often best set to lower values than when **Log** mode is used.

Optimizing the Integral and Proportional Gain

- The **Integral gain** is usually the major contributor to the performance of the feedback loop due to its “long term” influence. For this reason, it is usually adjusted before proportional gain.
- The integral term in the feedback calculation has the highest gain at low frequencies, and its effects diminish with increasing frequency.
- A nominal **Integral gain** value may be obtained by slowly increasing the value until the piezo begins to oscillate, then decreasing the value until oscillation ceases. Oscillation effects are best viewed using **Scope Mode** and show up first in error signal (i.e deflection or amplitude).
- The **Proportional gain** parameter is typically set to 35 to 100% more than the **Integral gain** value.

Optimizing the Look Ahead Gain Parameter

- **Look ahead gain** adds information from the previous scan line to the feedback loop calculation, so it is most useful for samples with long features oriented perpendicular to the scanning direction.
- Use **Look ahead gain** discreetly. For many surfaces, **0.5** to **0.8** is nominal.

2.4 Force Curves

Force Curves ramp tip-sample separation while holding the X, Y position constant in the center of the previous scan. The scanner's vertical position is plotted versus either the cantilever deflection (Contact AFM), or the amplitude of the cantilever oscillation (TappingMode). Alternatively, the cantilever deflection or oscillation amplitude can be plotted relative to a user-designated input signal.

2.4.1 Force Curves Procedure

Ramp Settings

To obtain force curves, it is necessary to first engage in Scan Mode using one of the **Scan Views** (see **Preparing a Dimension Series AFM for a Realtime Scan** Section 1.4.2), then switch to Ramp mode. If you want to calibrate deflection sensitivity, use a hard sample in the following procedure.

1. Activate Ramp mode (this causes the system to stop scanning, and the probe to position above the center of the previous image):

   a. Click the Ramp node in the workspace or any visible ramp plots.

   Or

   b. Add the **Ramp Parameter List** and **Ramp Plot(s)** to the workspace. Right-click **Realtime** or click the **Acquire** menu, and select **Ramp Parameter List** and **Ramp Plot**. It is possible to view three **Ramp Plots** at a time by adding ramp plots to the workspace. Arrange the **Ramp Plot(s)** and **Ramp Parameter List** so that all are viewable.

   Note: See **Ramp Parameter List** Section 2.4.2 - **Feedback Panel** Section 2.5.2 for a thorough discussion of the **Ramp Parameter List** Parameters. When in **Ramp** mode, a ramp- specific menu also displays, the **Ramp** menu. See **Ramp Menu** Section 2.5.3 for more information.

2. Enter the following parameter settings in the designated panels of the **Ramp Parameter List**:

   a. In the **Ramp** panel select:

Parameter	Setting
Ramp output	Z
Ramp size	1.00μm

Parameter	Setting
Z scan start	0nm
Scan rate	1.00Hz
Number of samples	512

b. In the **Channel 1** panel select:

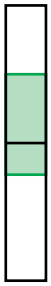
Parameter	Setting
Data Type	Deflection
X Data Type	Z
Display Mode	Deflection vs. Z

Gather Force Curves

1. Select **Ramp > Run continuous** from the menu bar.

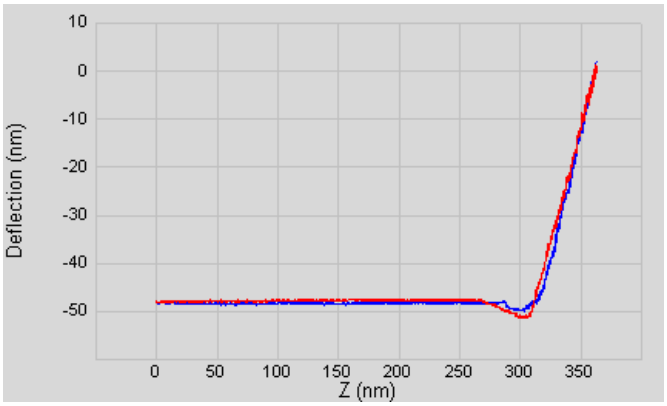
2. While watching the **Ramp View** and the Display Monitor's bar graph (see Figure 2.4a), increase the **Z Scan Start** to move the tip closer to the sample.

Figure 2.4a Bar Graph



3. When the force curve suddenly rises, the tip has reached the surface (see Figure 2.4b).

Figure 2.4b Force Curve



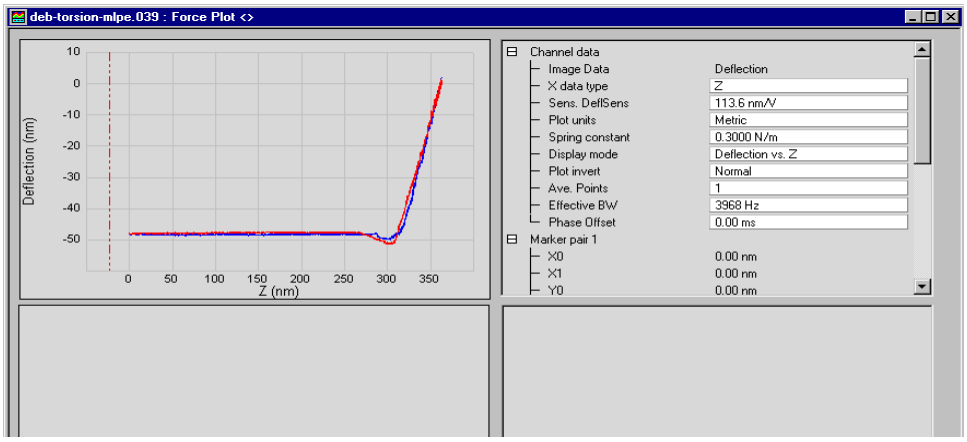
4. Click the **Capture** icon to save the force curve. Make note of the file name in the status bar (lower right corner of the window).

Calibrate Deflection Sensitivity

It is often necessary to calibrate the deflection sensitivity of a force curve. The deflection sensitivity depends upon several factors, such as the position of the laser spot on the cantilever, so it needs to be calibrated each time you change the probe. Use the following procedure to determine the deflection sensitivity:

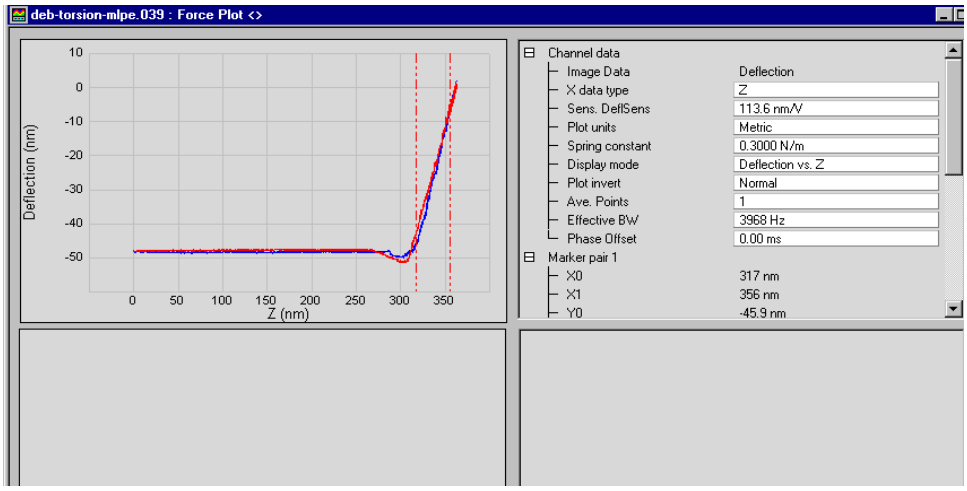
1. Move two cursors onto the Deflection vs. Z plot (see Figure 2.4c).

Figure 2.4c Realtime Force Curve



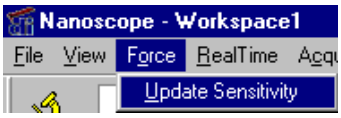
2. Arrange the cursors so that they surround the contact (steepest) portion of the graph (see Figure 2.4d).

Figure 2.4d Force Curve Cursors



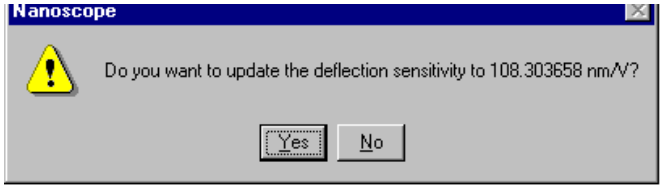
3. Select **Force > Update Sensitivity**. The software will automatically calculate the deflection sensitivity.

Figure 2.4e Update Sensitivity



4. Click **OK** to accept this deflection sensitivity in the dialog box that displays, and it will automatically be entered into the **Sens. DeflSens** parameter in the **Channel Data** panel to the right of the plot (see Figure 2.4c).

Figure 2.4f Deflection Sensitivity Dialog Box



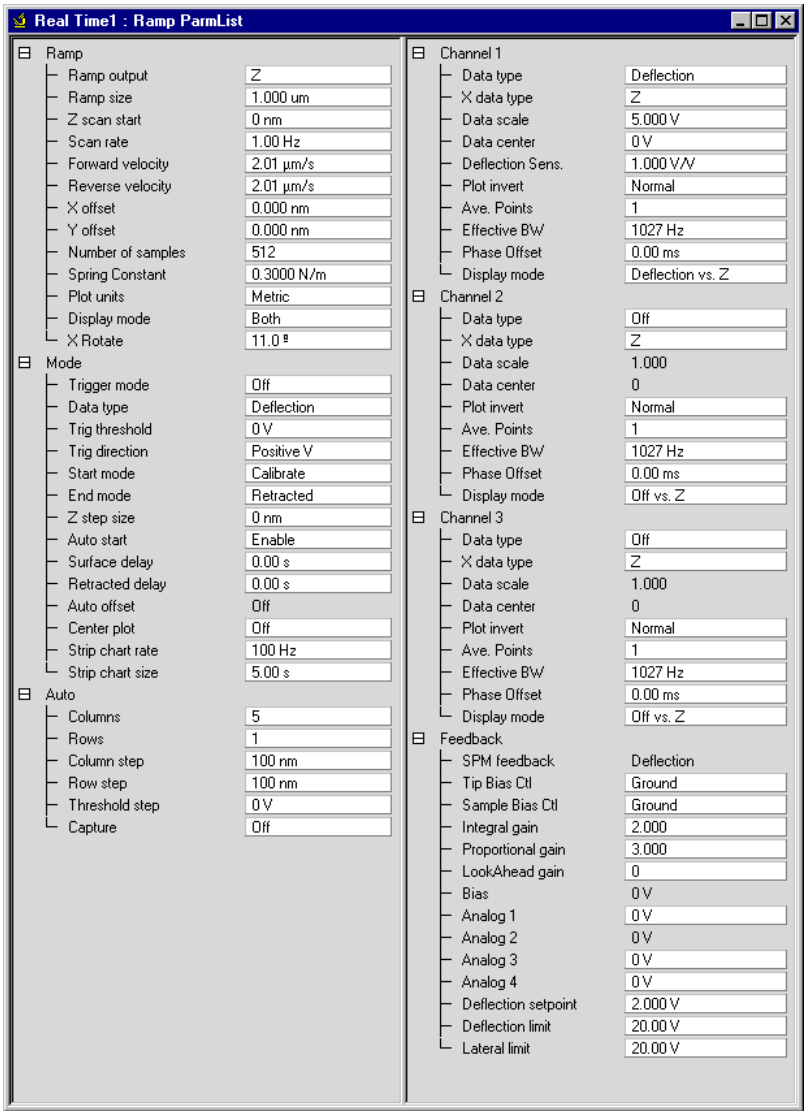
5. Replace the hard sample with the sample you wish to analyze. The deflection sensitivity will remain applicable as long as the position of the laser spot on the cantilever does not change.

2.4.2 Ramp Parameter List

When you open **Ramp Parameter List**, the **Ramp Parameter List** box displays (see Figure 2.4g). All force curve parameters can be set in the **Ramp Parameter List**. The **Ramp Parameter List** is sectioned into seven panels. The parameters in each panel are defined in the following sections:

- Ramp Panel on page 94
- Mode Panel on page 96
- Channel (1, 2 or 3) Panels on page 98
- Feedback Panel on page 99

Figure 2.4g Ramp Parameter List



2.4.3 Ramp Panel

Ramp Output: Specifies the **Ramp Channel**.

Ramp Size: Specifies the range of the **Ramp Channe**l. Visible only if the Ramp Channel parameter is set to Z. Settings depend on the specified units.

Z Scan Start: Visible only if the **Ramp Channel** parameter is set to **Z**. **Z scan start** is the bottom position of the Z-axis scan as represented on the Display Monitor's bar graph. When the **Force Calibrate** command is first accessed during imaging, this value is automatically set to the **Z Center Position**.

> **Note:** The value of this parameter will need to be increased to move the sample closer to the cantilever in the case where there is no deflection of the cantilever for a displacement of the sample.

- *Range and Setting*s: The range of this parameter depends on the scanner. The units of this parameter are volts or nanometers, depending on the setting of the **Units** parameter.

> **Note:** While the user is ramping Z in **Force Calibrate**, the feedback parameters (i.e., type, count and value) are inactive.

Scan Rate: The **Scan Rate** sets the ramping rate. Changing this value effects the Forward and Reverse Velocities.

Forward Velocity: **Forward Velocity** of the tip (in μm/s) as it approaches the surface. Increasing this value increases the **Scan Rate**.

Reverse Velocity: **Reverse Velocity** of the tip (in μm/s) as it retracts from the surface.

X Offset: Controls the center position of the scan in the X direction.

Y Offset: Controls the center position of the scan in the Y direction.

Number of samples: Number of data points collected during each upward (retraction) and downward (extension) travel cycle of the piezo. The Number of samples parameter sets the pixel density of the force curve. This parameter does not change the Z scan size.

- *Range or Settings*: **4** to **64,000** data points displayed per extension and retraction cycle.

Spring Constant: Records the spring constant of the cantilever that is currently being used. This parameter is input by the user and is recorded along with each force plot captured. It is used for Offline analysis of the force plot. It is not critical to set the **Spring constant** in Realtime, since it can be altered in the Offline analysis of the captured force plot. The Spring constant is necessary to display a graph of force vs. separation when conducting Offline analysis of the force plot.

Plot Units: Switches parameters in the control panels between units of Volts (V) or Metric units (nm or μm). Changing this parameter also changes the setting of the **Units** parameter on the AFM control panel.

- *Range or Settings*: **Volts** (V), **Metric** (nm) or **Force** (nm)

Display Mode: The portion of a tip's vertical motion to be plotted on the force graph.

- *Range or Settings*:
  - **Extend**—Plots only the extension portion of the tip's vertical travel.
  - **Retract**—Plots only the retraction portion of the tip's vertical travel.
  - **Both**—Plots both the extension and retraction portions of the tip's vertical travel.
  - If a channel other than Z is chosen, **Display mode** will not be available in Offline view.

X Rotate: Allows the user to move the tip laterally, in the X direction, during indentation. This is useful since the cantilever is at an angle relative to the surface. One purpose of **X Rotate** is to prevent the cantilever from plowing the surface laterally, typically along the X direction, while it indents in the sample surface in the Z direction. Plowing can occur due to cantilever bending during indentation or due to X movement caused by coupling of the Z and X axes of the piezo scanner. When indenting in the Z direction, the **X Rotate** parameter allows the user to add movement to scanner in the X direction. X Rotate causes movement of the scanner opposite to the direction in which the cantilever points. Without **X Rotate** control, the tip may be prone to pitch forward during indentation. Normally, it is set to about 22.0°.

- *Range or Settings*: **0** to **90°**; most effective values are between 15 and 25°.

2.4.4 Mode Panel

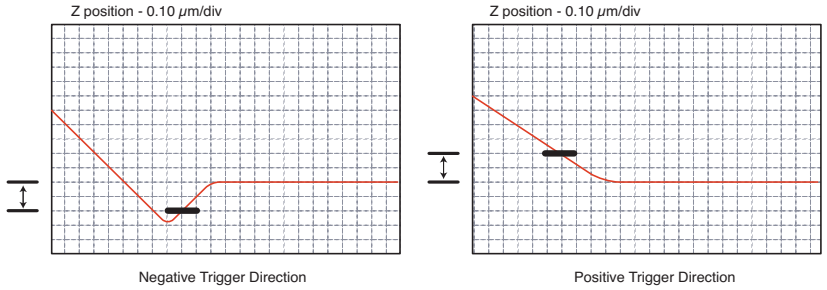
Trigger Mode: Limits the amount of force exerted by the tip upon the sample. It is possible to operate the trigger independent of drift (Relative) or at some arbitrarily fixed point (Absolute) depending on the trigger settings.

Data Type: Channels may be assigned for triggering to any input signal available including: **Deflection**, **Amplitude**, **Phase** or **Friction** data.

Trig Threshold: The value of the cantilever deflection, as measured by the photodetector, desired for the indentation or scratch. The **Trigger threshold** defines the maximum force applied to the sample corresponding to the upper right-most point on the force plot.

- *Range or Settings*: **-10V** to **+10V**, depending on the **Deflection Limit**. Try 0.5V to 1.0V.

Trig Direction: Determines the direction of the trigger and allows for a Positive, Negative, or Absolute trigger slope. In this way, the trigger may be configured to activate on either the positive or negative direction of the force curve.



Start Mode: Start mode allows you to switch between the various force modes without returning to image mode.

- *Range or Settings*:
  - **Calibrate**—Produces standard Force Mode force plots. Includes the ability to continuously cycle the tip up and down.
  - **Step**—Produces standard **Force Mode** force plots, with added control to step the tip towards the surface.

End Mode: Determines the location of the tip when the microscope is returned to Image mode. Choices include **Extended**, **Retracted**, or **Surface**.

Z Step Size: The change in tip height per step when using force step.

Auto Start: When enabled, autostarts **Force mode** when entering from **Image mode**. If off, you must start ramping by clicking the **Continuous** or **Single** icon, or by selecting the proper menu selection under the **Ramp** menu.

Surface Delay: Specifies a delay when the tip reaches the point closest to the sample.

- *Range or Settings*: **0** to **200 seconds**

Retracted Delay: Similar to **Surface delay**, this value specifies the duration of the delay when the piezo is at the top of the cycle (farthest away from the sample).

- *Range or Settings:* **0** to **200 seconds**

Auto Offset: Because of Z drift (thermal drift, piezo drift, etc.), the sample will sometimes drift out of Z range. When enabled, **Auto Offset** uses the Setpoint value from Image mode to Feedback and find the surface and resume Force imaging. The **Auto Offset** feature is a form of drift correction.

Strip Chart Rate: Frequency of (Z-position, deflection) data point acquisition for strip chart (only available for Picoforce and Nanoman).

- *Range*: **20kHz** to **0.01Hz**. Typical value: 1kHz

Strip Chart Size: Time interval over which (Z-position, deflection) data points are displayed in strip chart.

- Typical value: **10** to **10,000 sec.**

  Note: Although the strip chart collects and displays data over the time interval defined by clicking **Start**, then later, **Stop**, this data is not saved for subsequent use until the **Capture** icon (shown) is clicked. If **Capture** is clicked while strip chart data is being taken, what is saved begins at the start of the chart (sooner than the icon is clicked).

2.5 Auto Panel

The Auto Panel parameters are only available when Autoramping.

Columns: Number of points in the Y axis.

Rows: Points in the X axis.

Column Step: Offset distance between points in the X direction.

Row Step: Offset distance between points in the Y direction.

Threshold Step: The trigger point at which the deflection or the current activates the position change.

Capture: State is either enabled or disabled. When enabled, the software records and stores the ramp data for each data point in the matrix of rows and columns.

2.5.1 Channel (1, 2 or 3) Panels

Data Type: Channels may be assigned to any input signal available including: **Deflection**, **Amplitude**, **Phase**, **Friction** and so on. Any channel may be switched to Off, however, *at least one channel* is always on.

X Data Type: Type of data that the channel data is being compared to. This data displays on the X-Axis of the scope grid.

Data Scale: Voltage range for the vertical axis of the force curve plot.

> **Note:** This can be overridden by setting **Autoscale** On for the plot.

Data Center: Offsets centerline of scan by the amount entered.

> **Note:** The Data center offset does *not* become a permanent part of the data.

- *Range or Settings*: Depends upon the input signal, generally ± one-half of **data scale** maximum.

Deflection Sens.: Defines the conversion factor from cantilever deflection signal voltage to nanometers of cantilever displacement (in nm/V) using data in the contact region of a force plot.

Plot Invert: Inverts data along the Y-axis, effectively turning valleys into mounds and vice versa.

Ave. Points: Averages multiple points to smooth the curve.

Effective BW: A display (you cannot input a value to it) representing the sampling frequency with display averaging taken into account:

Effective BW = (force plot sampling rate)/(**Ave. Points**)

Phase Offset: Shift horizontal position of plot to compensate for averaging of endpoint data.

> **Note:** The numerical values of the two **Phase Offset** parameters can be ignored; set them to whatever values minimize the apparent hysteresis. Particularly when **Forward Velocity** and **Reverse Velocity** are unequal, the same numerical value for each **Phase Offset** may not correspond to an identical displacement on each axis.

Display Mode: The portion of a tip's vertical motion to be plotted on the force graph.

Range or Settings:

- **Extend**—Plots only the extension portion of the tip's vertical travel.
- **Retract**—Plots only the retraction portion of the tip's vertical travel.
- **Both**—Plots both the extension and retraction portions of the tip's vertical travel.
- If a channel other than Z is chosen and the force curve is captured Offline, **Display mode** may not be available in Offline view.

X Rotate: Allows the user to move the tip laterally, in the X direction, during the ramping of Z. This is useful because the cantilever is at an angle relative to the surface. One purpose of **X Rotate** is to prevent the cantilever from plowing the surface laterally, typically along the X direction, while it indents in the sample surface in the Z direction. Plowing can occur due to cantilever bending during indentation or due to X movement caused by coupling of the Z and X axes of the piezo scanner. When indenting in the Z direction, the **X Rotate** parameter allows the user to add movement to scanner in the X direction. **X Rotate** causes movement of the scanner opposite to the direction in which the cantilever points. Without **X Rotate** control, the tip may be prone to pitch forward during indentation. Normally, it is set to about 22.0°.

Range or Settings: **0** to **90 degrees**; most effective values are between **15** and **25**°.

2.5.2 Feedback Panel

Only the Force Curve-applicable menu parameters are described below:

Deflection Setpoint: Defines the deflection signal, and therefore the tip-sample force, maintained by the feedback loop.

- *Range or Settings*: ± **10.0V** maximum

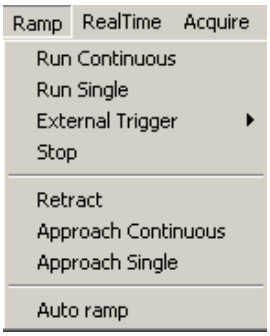
Deflection Limit: Use this parameter for attenuating the input voltage signal (appears only when performing Contact AFM).

- *Range or Settings*: **2.500V** for regular imaging and 20.00V in **Force Mode** *only*

2.5.3 Ramp Menu

While the microscope is engaged and in Realtime mode, opening the **Ramp** parameters will display the **Ramp** Menu.

Figure 2.5a Ramp Menu



Ramp Menu Definitions

Run Continuous: The tip is continuously lowered and raised by a distance equal to the **Ramp size**. This is the normal, default motion during **Force Calibrate**. “Raising” and “lowering” are relative to your system (e.g., On Dimension Series SPMs, the tip is raised and lowered to the surface; however, other SPMs raise and lower the sample beneath the tip).

Run Single: Lowers and raises tip *once* by a distance equal to the Z scan size, then halts.

External Trigger: (Not available)

Stop: Halts all tip movement.

Retract: The Z-axis piezo retracts to its limit in preparation for **Approach Continuous**. This command does *not* initiate motor movements.

Approach Continuous: The tip lowers to the surface and raises in a controlled series of steps, then indexed by the Z step size (see Scan Mode panel) distance. This process continues downward until the tip encounters the surface. When tip deflection exceeds the **Threshold Step** amount, **Approach Continuous** halts and the resulting force curve displays.

Approach Single: The tip is lowered to the surface and raised in a single, controlled step. This process is halted if the surface is encountered by the tip, causing deflection exceeding the Step threshold amount. The resulting force curve is displayed.

Auto ramp: Begins auto ramping as defined by the parameters specified in the **Auto Panel**.