Chapter 10 Tapping Mode AFM

This chapter covers procedures for operating the MultiMode SPM using tapping mode in air. It is assumed that the operator has previously prepared a tapping mode probe tip and aligned the SPM head per instructions provided in Chapter 7 of this manual.

The following sections are included in this chapter:

- **Principles of Tapping Mode:** Section 10.1

- **Basic TappingMode AFM Operation:** Section 10.2

    - **Select the Microscope:** Section 10.2.1

    - **Select Mode of Operation:** Section 10.2.2

    - **Check Parameters:** Section 10.2.3

    - **Adjust Laser and Photodetector:** Section 10.2.4

    - **Additional preparations:** Section 10.2.5

    - **Tune the Cantilever:** Section 10.2.6

    - **Automatic Tuning:** Section 10.2.7

    - **Set Initial Scan Parameters:** Section 10.2.8

    - **Engage:** Section 10.2.9

    - **Optimize Scan Parameters:** Section 10.2.10

    - **Withdraw the Tip:** Section 10.2.11

- **Advanced TappingMode AFM Operation:** Section 10.3

    - **Resonating Techniques:** Section 10.3.1

    - **Cantilever Oscillation:** Section 10.3.2

   - **Decreasing the Cantilever Drive Frequency:** Section 10.3.3

10.1 Principles of Tapping Mode

Figure 10.1a depicts a cantilever oscillating in free air at its resonant frequency. A piezo stack excites the cantilever substrate vertically, causing the cantilever to move up and down. As the cantilever moves vertically, the reflected laser beam, or "return signal," deflects in a regular pattern over a photodiode array, generating a sinusoidal, electronic signal. This signal is converted to a root mean square (RMS) amplitude value, which is displayed in volts on the upper left (Tapping Mode Output Signal) meter located on the front of the MultiMode base.

Figure 10.1a   Tapping Cantilever in Free Air

Laser beam

Return signal
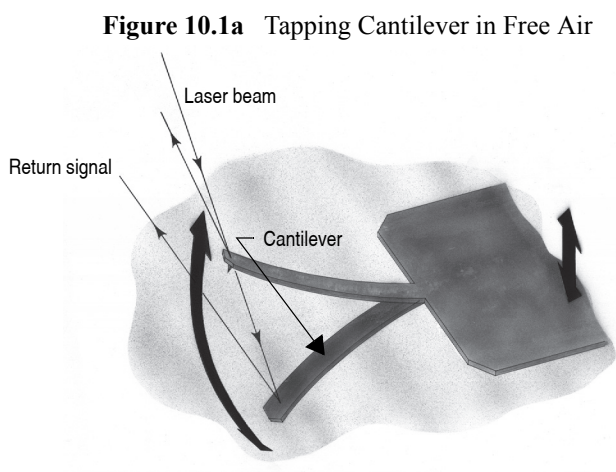
Cantilever

Figure 10.1b represents the same cantilever at the sample surface. Although the piezo stack continues to excite the cantilever substrate with the same energy, the tip is deflected in its encounter with the surface. The reflected laser beam reveals information about the vertical height of the sample surface and characteristics of the sample material itself. These material characteristics include elasticity, magnetism, and presence of electrical forces.

Figure 10.1b   Tapping Cantilever on Sample Surface
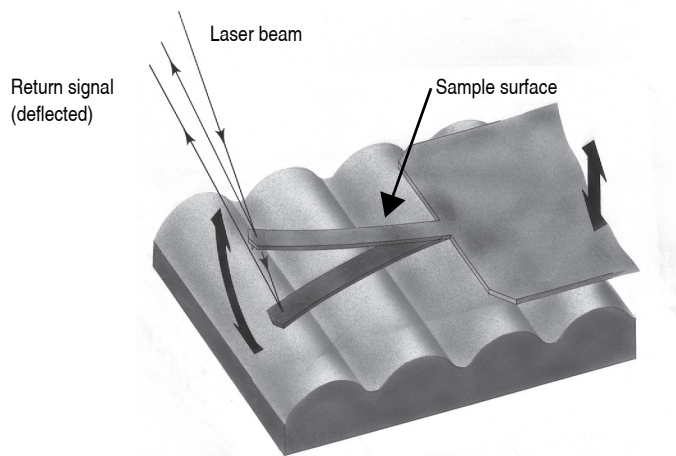
> **Note:**   Deflection of the cantilever and return signal are exaggerated in the figure for illustrative purposes.

10.2   Basic TappingMode AFM Operation

The following is a general outline of basic operational procedures involved in TappingMode AFM. For more detailed instructions, refer to Chapter 7 of this manual.
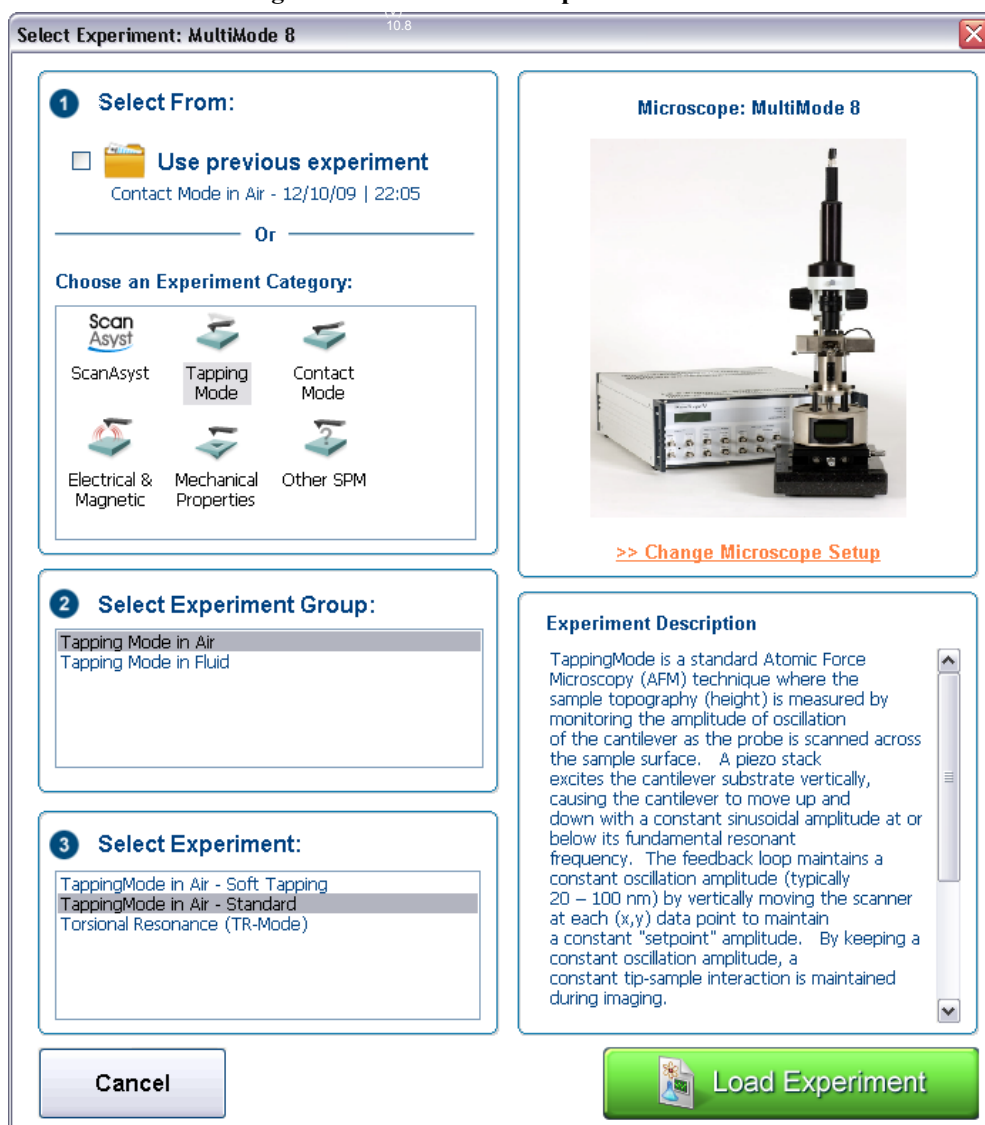
10.2.1 Select the Microscope

Follow the procedure described in **Start the Microscope Program:** Section 7.3.

10.2.2 Select Mode of Operation

1. Click the SELECT EXPERIMENT icon. This opens the **Select Experiment** window, shown in Figure 10.2a.

Figure 10.2a   The **Select Experiment** window

2. Select TAPPINGMODE AFM in the **Choose an Experiment Catagory** panel.

3. Select **TAPPINGMODE IN AIR** in the **Select Experiment Group** panel.

4. Select either **TAPPINGMODE IN AIR - SOFT TAPPING** or **TAPPINGMODE IN AIR - STANDARD** in the **Select Experiment** panel and click **LOAD EXPERIMENT**.

5. This opens the **Workflow Toolbar**, the **Scan 2 Channels** windows and the **Scan Parameters List** window, shown in Figure 10.2b.

Figure 10.2b   Tapping Mode (Simple Mode) configuration
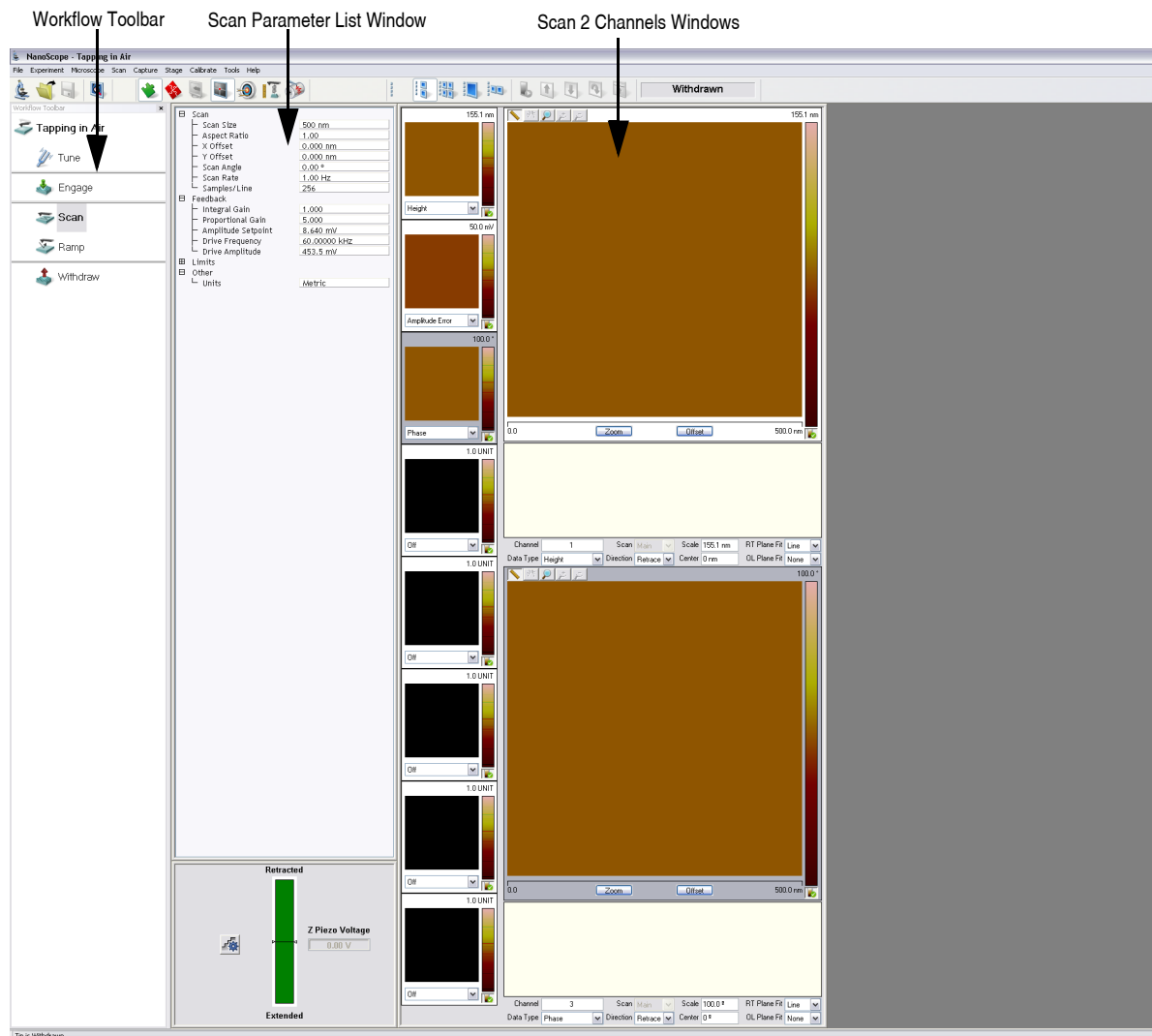
10.2.3 Check Parameters

Check that the **Realtime** control panel parameters are set within reasonable limits for tapping mode operation. If you are uncertain what parameter settings to start with, try the values below:

Panel	Parameter	Setting
Scan	**Scan Size**	1μm
	X Offset	0.00nm
	Y Offset	0.00nm
	Scan Angle	0.00°
	Scan Rate	1.00Hz
	Sample/Line	256
	Slow Scan Axis	Enabled
Feedback	**Integral Gain**	4.00 (see "d")
	Proportional Gain	8.00 (see "d")
	Amplitude Setpoint	a
	Drive Frequency	b
	Drive Amplitude	c
Other	**Microscope Mode**	Tapping
	Engage Setpoint	1.00
Interleave	**Interleave Mode**	Disabled
Limits	Five settings	Set to max (see "e")

a. **Amplitude Setpoint** is initially set by the software during engagement. It may be adjusted up or down afterward.

b. **Drive Frequency** is determined during Cantilever Tune (Section 10.2.6).

c. **Drive Amplitude** is determined during Cantilever Tune (Section 10.2.6).

d. Gains vary with the size of the scanner. The values given are typical for small scanners and should be reduced for larger scanners. Use the Scope window while scanning to optimize gains for good surface tracking. Gains for tapping mode are typically about 10% of gains for contact imaging.

e. Input very large values so maximum acceptable value will be determined by program when the input value exceeds the max acceptable. The **Amplitude Range** setting is the peak to peak photodetector output resulting from cantilever oscillation.

10.2.4 Adjust Laser and Photodetector

Verify that the probe holder has been fitted with a tapping mode, single crystal silicon probe and aligned per instructions provided in Chapter 7 of this manual. Photodetector voltage values are displayed on meters mounted on the front of the MultiMode base. The laser photodetector is adjusted using the photodetector adjustment knobs on the left-top and left-rear of the head (see Figure 10.2c below). Recall that RMS amplitude is an AC signal which does not have any real meaning until cantilever tuning is completed (see Section 10.2.5). The laser spot should be approximately centered on the photodetector prior to entering the cantilever **Tune** routine.

Figure 10.2c   Photodetector adjustment knobs and SPM voltage meters.

Photodetector adjust-
ment knobs.

Photodetector output signal (RMS AC volts). This value is directly influenced by the Drive amplitude parameter when tip is at resonance.

RMS	VERT
0.26	*0.00*

SUM
4.0

Deflection voltage. This changes according to how beam is centered vertically. At 0.00 Volts beam is centered.

Sum signal. This value changes according to how much of the beam falls on the photodetector.
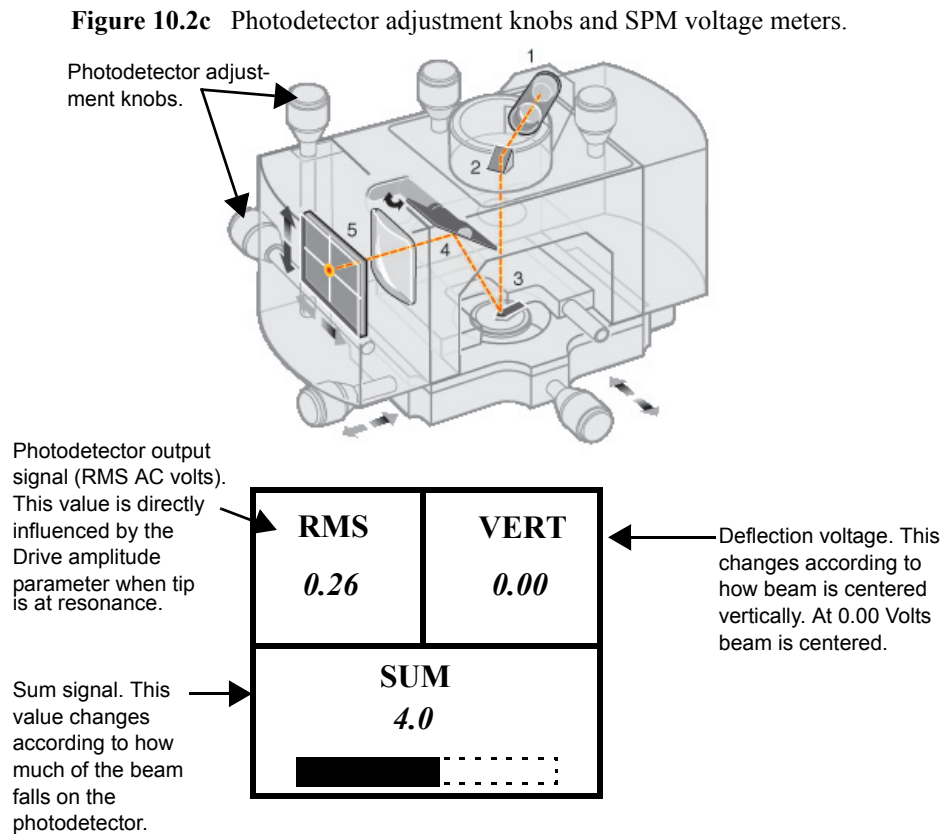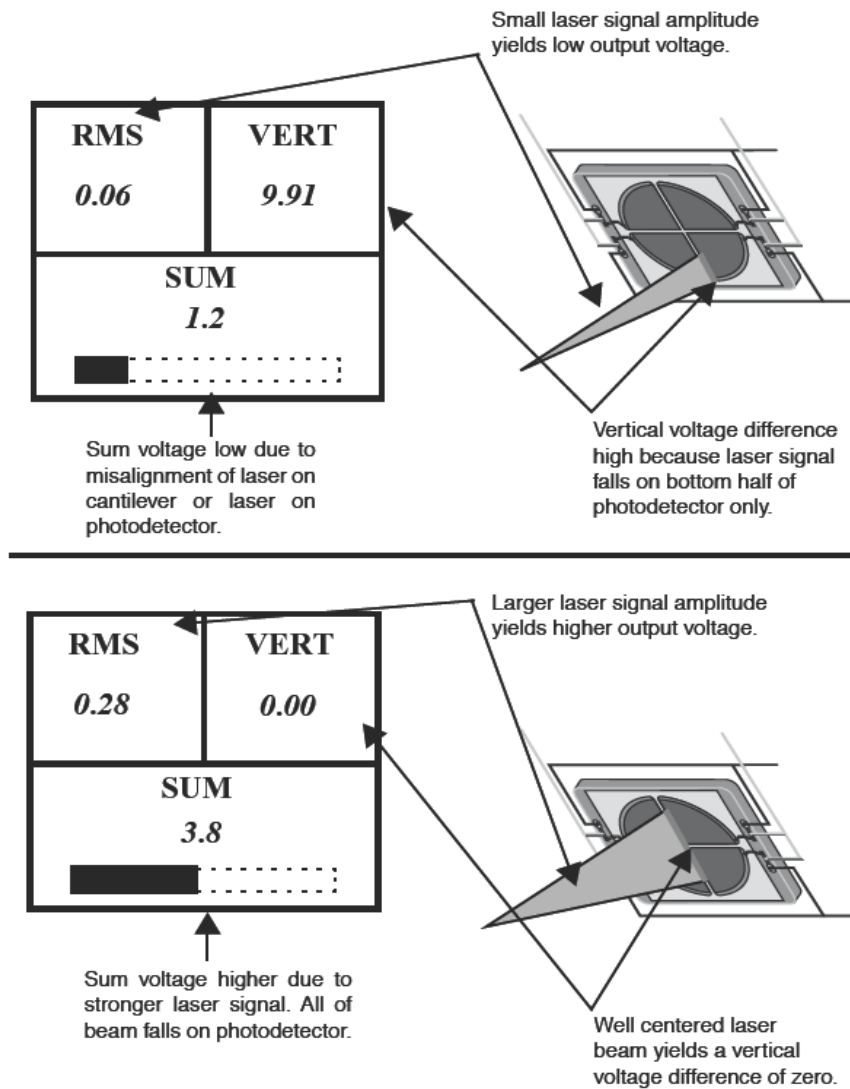
Figure 10.2d Voltage meters on the MultiMode base reveal a great deal about the amplitude and alignment of the tapping mode laser signal on a tuned tip operating at its resonant frequency.

Small laser signal amplitude yields low output voltage.

RMS 0.06   VERT 9.91

SUM 1.2

Sum voltage low due to misalignment of laser on cantilever or laser on photodetector.

Vertical voltage difference high because laser signal falls on bottom half of photodetector only.

Larger laser signal amplitude yields higher output voltage.

RMS 0.28   VERT 0.00

SUM 3.8

Sum voltage higher due to stronger laser signal. All of beam falls on photodetector.

Well centered laser beam yields a vertical voltage difference of zero.

Note: The actual value of **SUM** will also depend upon the type of probe in use. Uncoated silicon probes are less reflective and will produce a smaller **SUM**.

10.2.5 Additional preparations

In TappingMode, the RMS amplitude representing AC voltage signal is used to provide the dynamic feedback signal for surface height tracking. The vertical deflection signal (displayed on the "Vertical or Horizontal Difference" meter) should be close to zero (± 1.0V) prior to running cantilever **Tune** and/or attempting engagement. If you are uncertain how to set parameters for the **Channel 1** panel, try the following settings:

Panel	Parameter	Setting
Channel 1	**Data Type**	Height
	Scale	(see note)
	Direction	Retrace
	Scan	Main
	Realtime Plane Fit	Line
	Offline Plane Fit	None

Note: Setting depends upon sample height. A data **Scale** value of 4.50μm is the maximum for most "J" scanners. Always start with a low data **Scale** value if feature height is unknown, then increase until the image is optimized. On the 200nm step height calibration sample, a reasonable data **Scale** setting would be 300nm initially. The data **Scale** setting does not offset the scan but how the data is displayed. It is used similarly to a contrast control.

10.2.6 Tune the Cantilever

This section describes steps required to find the resonance peak of the cantilever and adjust the oscillation voltage so the cantilever will vibrate at an appropriate amplitude. A range of vibration frequencies will be applied to the cantilever to determine the frequency which produces the largest response (the resonant frequency). In most instances, the resonant peak will have a sharp Gaussian distribution but at times the peak can be somewhat asymmetric. The system will tolerate some deviation in the shape of the peak.

1. Select **Microscope** > **Cantilever Tune** or click the **TUNE** icon on the Workflow Toolbar.

2. The initial **Cantilever Tune** panel, shown in Figure 10.2e, appears with the **Frequency Sweep** (a plot of cantilever response as a function of applied oscillation frequency).

3. Choose either the automatic or manual tuning method (see **Automatic Tuning:** Section 10.2.7 and **Manual Cantilever Tuning:** Section 10.3.4).

10.2.7 Automatic Tuning

For most purposes, the **Auto Tune** function will suffice.

- Ensure that **Mode** is set to **MAIN** (not **INTERLEAVE**).

- Verify the starting parameters. The nominal resonant frequency of a probe can be found on the probe box label. Ensure the start and end frequencies correlate with this value.

- Click **Auto Tune**. The computer and controller begin automatic tuning. See Figure 10.2e.

Figure 10.2e   Auto Tune Control Panel
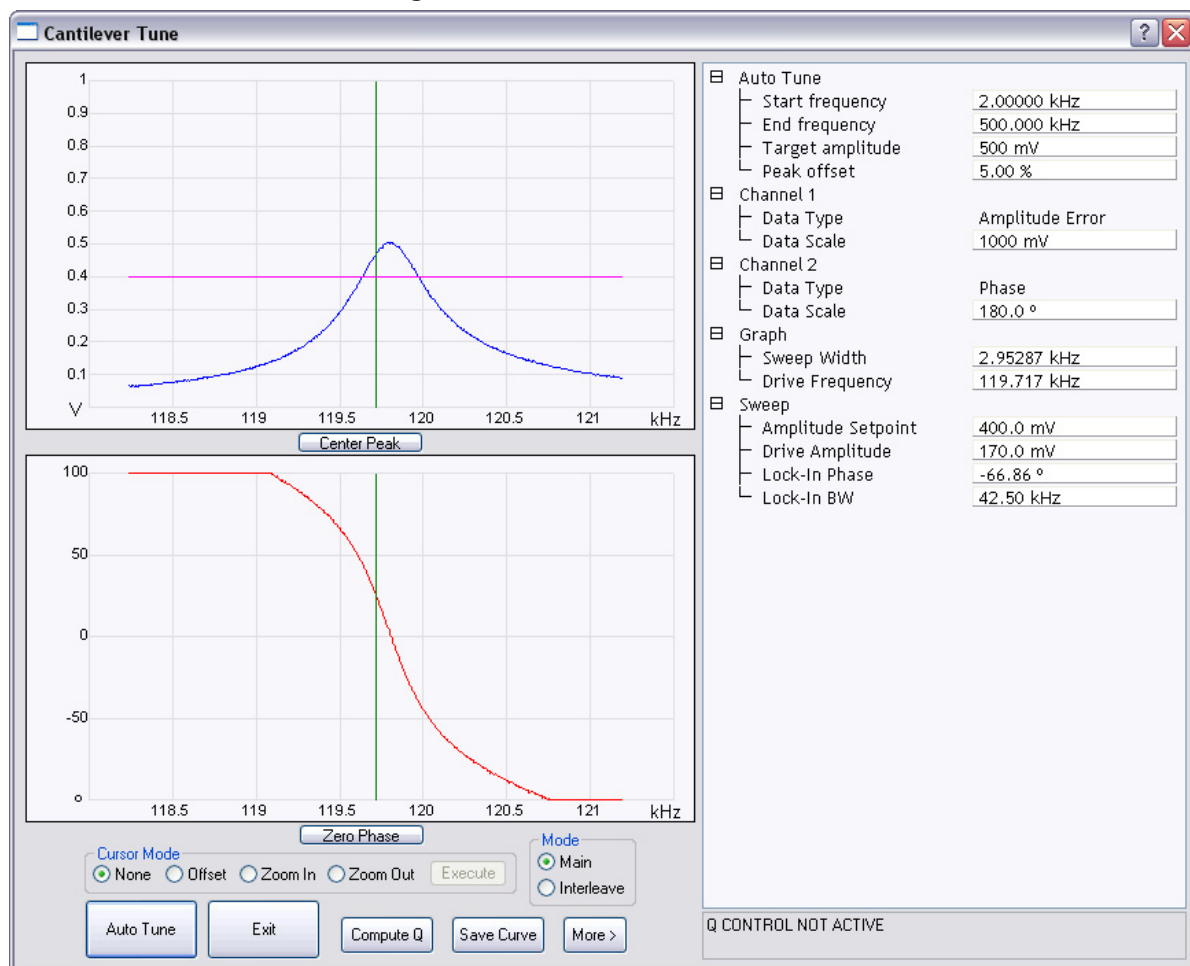
10.2.8 Set Initial Scan Parameters

Scan Panel

In the **Scan Controls** panel, set the following initial scan parameters (see Figure 10.2f).

1. Set the **Scan Rate** to **1 Hz**.

2. Set the **Scan Size** to **500 nm**.

3. Set the **Scan Angle** to **0**.

Figure 10.2f   Suggested Tapping Mode in Air Scan Settings

Feedback Panel

1. Set the **Integral gain** to **0.5** and the **Proportional gain** to **5** (see Figure 10.2f).

    Note: The **Drive Frequency** and **Drive Amplitude** values were determined during the Cantilever Tune procedure. It is not necessary to enter a value for the **Amplitude Setpoint**; this will be determined automatically during the engage process.

Other Panel

1. Set the **Units** to **METRIC**.

Channels

1. Set the **Channel 1 Data Type** to **HEIGHT** (see Figure 10.2g).

2. Set the **Channel 2 Data Type** to **AMPLITUDE ERROR**.

3. Set the **Channel 3 Data Type** to **PHASE**.

4. Set **Data Scale** to a reasonable value for the sample.

    Note: For example, for a 200nm step height calibration sample, a reasonable **Data Scale** setting is 300nm initially.

5. Set **Line direction** to either **Trace** or **Retrace**.

6. Set the **Channel 4** through **Channel 8 Data Type** to **OFF**.

Figure 10.2g   Suggested Channel Settings

Channel	1	Scan	Main	Scale	155.1 nm	RT Plane Fit	Line
Data Type	Height	Direction	Retrace	Center	0 nm	OL Plane Fit	None
Channel	2	Scan	Main	Scale	50.00 mV	RT Plane Fit	Line
Data Type	Amplitude Error	Direction	Retrace	Center	0 mV	OL Plane Fit	None
Channel	3	Scan	Main	Scale	100.0 º	RT Plane Fit	Line
Data Type	Phase	Direction	Retrace	Center	0 º	OL Plane Fit	None

10.2.9 Engage

1. Move the probe to the area of interest using the X-Y translation knobs on the MultiMode head.

2. Use the meters to verify that the vertical deflection is between -1 and +1, the RMS amplitude (top left meter) is 1-2V, and the sum voltage is greater than 1V. Do not readjust the RMS (see note).

    Note: Auto-tune will set the RMS to be approximately 90-95% of the target amplitude. For example: tuning with a target amplitude of 500 mV causes the RMS on the display meter set to approximately 480 mv.

3. Select **Microscope** > **Engage** or click the **ENGAGE** icon on the toolbar. A pre-engage check begins, followed by Z-stepper motor motion. If for any reason the engage aborts because the tip is still too far away from the surface, use the coarse adjustment screws and/or the Tip Down motor control switch to bring the tip and surface closer together. If all goes well after re-engaging, a well-formed image will begin to appear.

If it becomes necessary to image another part of the sample, execute a **Withdraw** command before moving the X-Y translation stage; otherwise, the tip may be damaged. After the tip is engaged, the

control panel values can be readjusted to provide the desired scan parameters. Refer to Section 10.2.10 below for scan parameter optimization.

> **Note:** After the tip engages, adjust the control panel values to provide the desired scan parameters. Refer to Section 10.3.5 for scan parameter optimization.

4. After engaging, it may be necessary to recheck the Cantilever Tune parameters. Select **MICROSCOPE > CANTILEVER TUNE** or click the **TUNE** icon in the **Workflow Toolbar**. In the **Tip offset** box, shown in Figure 10.2h, enter **200nm** and click **OK**. Adjust the **Drive Frequency** if necessary.

Figure 10.2h   Start Sweep On Surface

10.2.10   Optimize Scan Parameters

The procedure to optimize the scan parameters is similar to that of Contact Mode.

1. In the **Scan** panel, set **Slow Scan Axis** to **DISABLED**. This function is available in the Expanded Mode.

2. Observe the agreement between the Trace and Retrace lines. Adjust the **Scan Rate, Gains,** and **Amplitude Setpoint** to bring these two lines in to coincidence. A more detailed discussion of these parameters can be found in Section 10.3.

10.2.11   Withdraw the Tip

1. Select **RealTime** > **Withdraw** or click the **WITHDRAW** icon in the **Workflow Toolbar**. The SPM will stop scanning and then ascend approximately 10μm. If more clearance between tip and sample is desired, toggle the **Up / Down** switch on the top-right side of the MultiMode base.

2. Replace or move the sample.

CAUTION: Never withdraw samples without verifying that the tip has adequate clearance during the entire sample removal sequence.

10.3   Advanced TappingMode AFM Operation

This section discusses the more subtle aspects involved in operating the MultiMode in TappingMode.

10.3.1 Resonating Techniques

Without a thorough understanding of principles associated with cantilever resonating techniques, you may generate distorted data. Understanding the **Cantilever Tune** process and the effects of real-time scan parameters is critical for effective operation of the microscope. It is also important to understand similarities and differences between **Ramp Mode** in **Contact AFM** and **Ramp Mode** in **TappingMode** (see Chapter 14).

10.3.2 Cantilever Oscillation

The response of the cantilever to inputs plays an important role in the operation of the MultiMode SPM while in TappingMode. There is an important trade-off between the response time of the cantilever and the force applied to the sample. The cantilever does not respond instantly to perturbations in oscillation amplitude. The cantilever drive system pumps energy gradually into the cantilever oscillation. Figure 10.3a illustrates a typical response curve of the cantilever amplitude as a function of time. To demonstrate the conflicting requirements, the performance of the system is analyzed at two operating points.

Figure 10.3a   Cantilever Response Curve
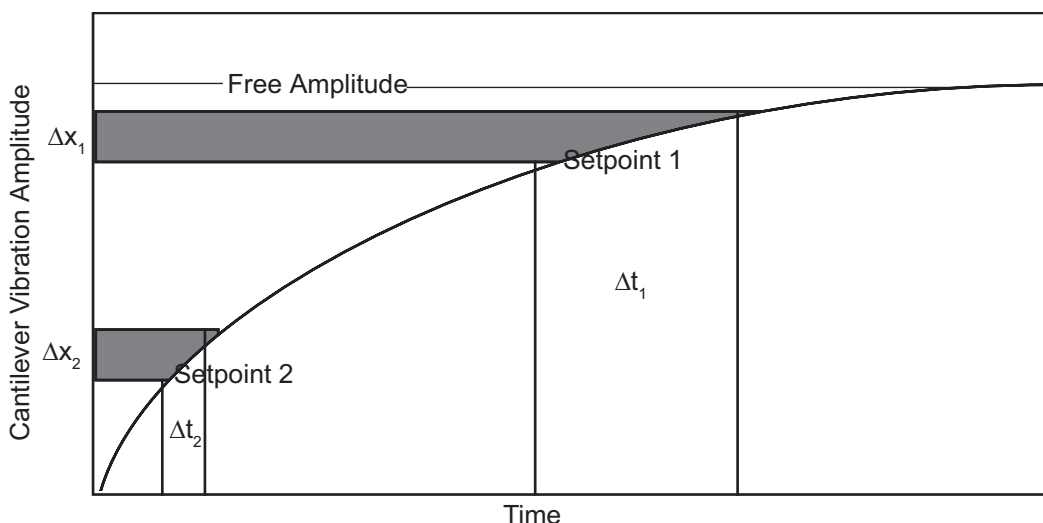
At Setpoint 1 the operating point is only slightly lower than the free oscillation amplitude. This has the advantage of dissipating very little energy to the sample surface. The disadvantage is that the system takes longer to recover from a given perturbation in the amplitude. Consider the situation where the tip travels off a step with a height of Δx. At Setpoint 1 it takes longer for the amplitude of

the cantilever oscillation to increase; therefore, the feedback system is slow in responding to the error created by going off of the step. At operating Setpoint 2 the cantilever amplitude builds up more rapidly. The feedback system senses the error caused by going off of the step and responds more rapidly. However, more energy transfers to the sample surface while scanning at this operating point.

The nature of the sample influences the decision between response time and contact force. For example, harder samples can withstand higher contact forces, so the response time improves by lowering the **Amplitude Setpoint**. Soft samples that are relatively flat should run with higher **Amplitude Setpoint** values to reduce the energy imparted to the sample. In general, the solution to the problem is to decrease the scan rate and increase the feedback gains. In some situations, the feedback gains cannot increase without causing piezo oscillations; in such cases there is no choice but to reduce the scan rate.

Inadequate response time typically occurs when the tip encounters a low point in the sample. The amplitude of the cantilever oscillation decreases very quickly when taller portions of the sample are encountered. As a result, the system response is markedly different depending on whether the tip is climbing or descending a feature in the sample. For this reason, viewing the **Scope** trace (below the scan) is very useful when setting scan parameters. As the tip descends, features are evaluated by comparing the **Trace** and **Retrace**. Figure 10.3b illustrates the effects of poorly selected scan parameters on a calibration standard that includes a series of sharp-walled pits. Regardless of the scan direction, the tip does not track the wall of the pit when the tip encounters a pit. However, it does track the surface closely when moving out of the pit.
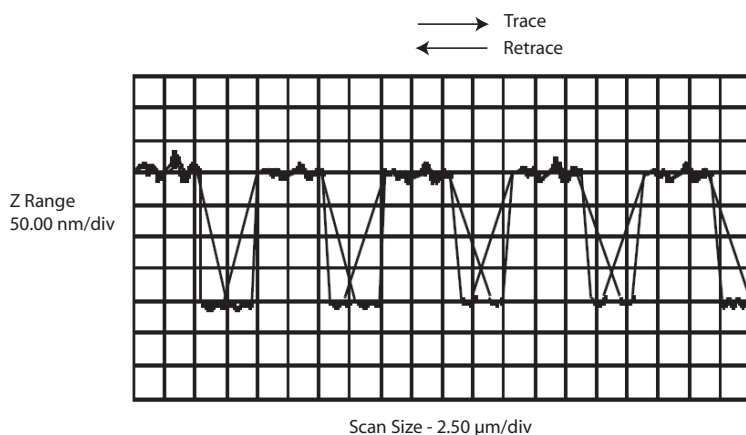
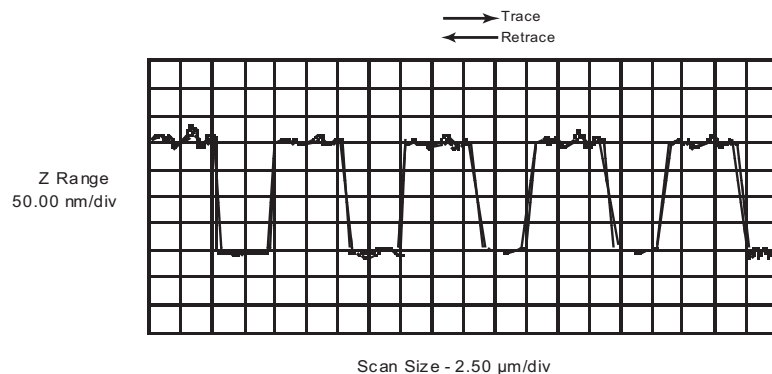**Figure 10.3b**   Scope Trace with High Scan Rate

Figure 10.3c depicts the same sample with a slight increase in the **Integral Gain** and a twofold decrease in the **Scan Rate**. The tip now tracks the surface when it descends into the pit as well as when it exits. The **Trace** and **Retrace** lines now coincide closely.
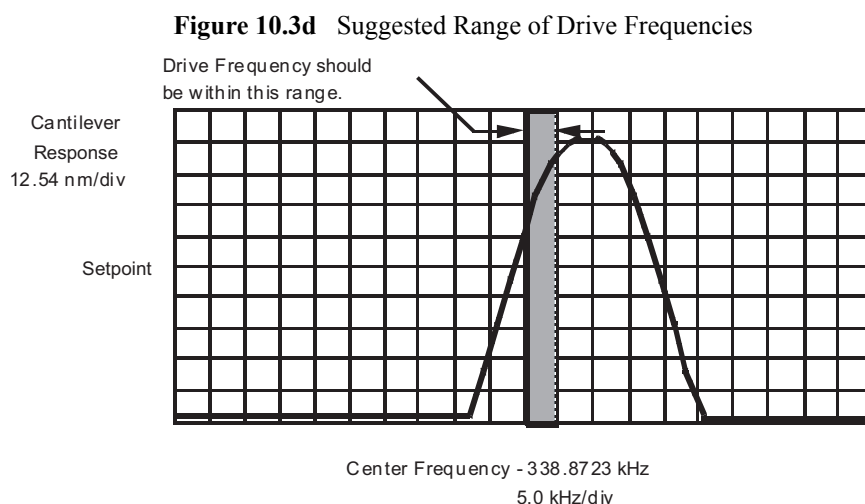
Figure 10.3c Scope Trace with Correct Scan Rate

10.3.3 Decreasing the Cantilever Drive Frequency

The **Drive Frequency** selected to oscillate the cantilever plays an important role in the performance of the microscope while in TappingMode. As a first step it is important to determine the resonant frequency of the cantilever, but the **Drive Frequency** can be further tuned to improve scanning performance.

The microscope produces better data in TappingMode when the **Drive Frequency** is set lower than the resonant peak of the cantilever. The **Drive Frequency** is set such that it coincides with a 1-10 percent decrease in the oscillation amplitude by setting **Peak Offset** in the **Auto Tune** controls to the desired percent. Figure 10.3d shows a suggested operating region. This is a suggestion based on our observations; users are encouraged to experiment with the microscope and decide what produces the best results.

Figure 10.3d   Suggested Range of Drive Frequencies

Drive Frequency should be within this range.

Cantilever Response 12.54 nm/div

Setpoint

Center Frequency - 338.8723 kHz
5.0 kHz/div

10.3.4 Manual Cantilever Tuning

With Force Modulation or Fluid Tapping applications, it may be useful to tune the cantilever manually. MFM and EFM imaging often offset the drive frequency above or below the resonant frequency.

> **Note:** More than one type of cantilever exists. Cantilevers can have different dimensions and different resonant frequencies. The box containing the probe will have a label indicating the nominal resonant frequency of the probes. Certain parameter values, particularly the center frequency and the sweep width used in the following example, apply to a particular cantilever type. In the following example, nominal parameter values will vary depending on the actual cantilever used.

1. In the **Graph** panel of the **Cantilever Tune** window, set the **Drive Frequency** parameter to a value near the center of the resonant frequencies range specified for the wafer. For example, if the frequency range is specified as 240—420 KHz, select a drive frequency of **330 KHz**.

2. Start with a **Drive Amplitude** of about 50 mV. It is possible to detach the cantilever from the substrate by applying too large of a drive amplitude; therefore, it is important to exercise some caution when adjusting the **Drive Amplitude** parameter. Note that the **Drive Amplitude** is set automatically during the engage process.

3. Set the **Sweep Width** to the same value as the **Center Frequency**.

4. The **Sweep Width** must be large enough to cover the frequency range specified for the wafer.

5. Zero the **Amplitude Setpoint**. Note that the **Amplitude Setpoint** will be reset automatically during the engage process.

6. Set the **Amplitude Range** to **4000 mV**.

7. Center the peak on the frequency sweep plot shown using the **ZOOM IN** and **OFFSET** commands after identifying the maximum amplitude peak with the lowest frequency in the frequency response plot.

   > **Note:** The **OFFSET** command sets the center frequency equal to the cursor position to shift the plot. The **ZOOM IN** command decreases the sweep width and shifts the center frequency value to stretch the plot.

8. Increase the **Amplitude Setpoint** until the peak appears.

9. Continue to **ZOOM IN** and center the peak until the peak coincides with the vertical center line within **10 Hz**. The value displayed for center frequency is now used as the resonant frequency of the cantilever.

   > **Note:** The system works well in TappingMode if the center frequency is at, or below, the peak in the resonance plot. The center frequency can decrease to the point

where the oscillation amplitude reaches 90 percent of the maximum value. Operate at a frequency lower than the resonant frequency to avoid shifting the resonant frequency upon approach of the tip to the surface (see Figure 10.3f).

Figure 10.3e   Cantilever Tune Control Panels for Main Controls
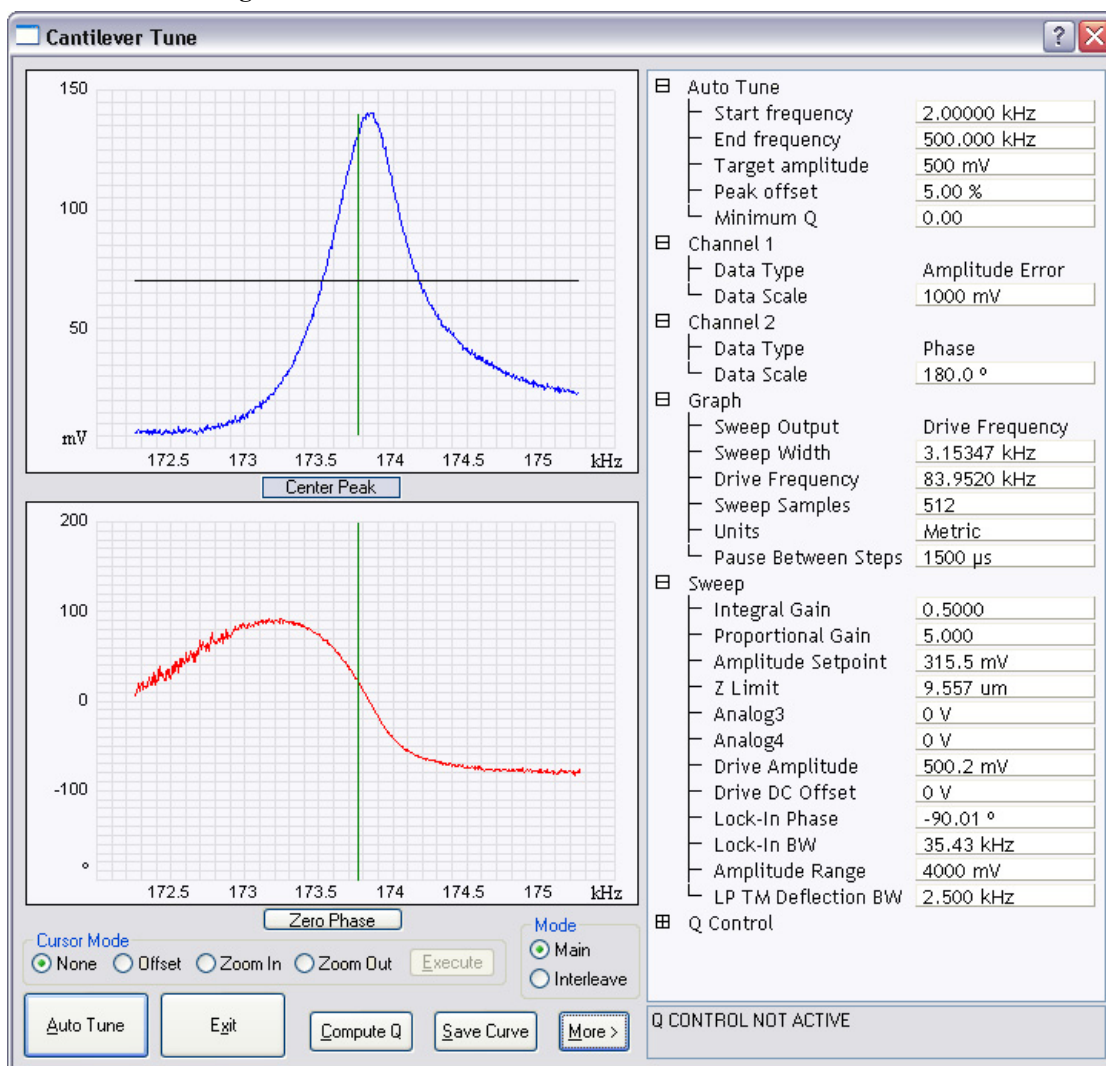
10. Specify the **RMS amplitude** after tuning the cantilever to its resonant frequency. The desired operating amplitude depends on the sample and other scanning conditions.

Figure 10.3f Cantilever Tune Frequency Sweep

Frequency Sweep

Cantilever
Response

Setpoint

Center Frequency - 337.8723 KHz
0.05 KHz/div
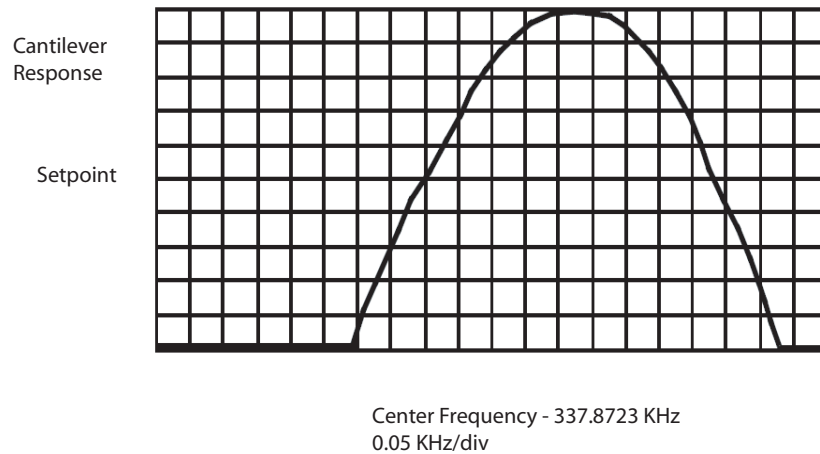
11. Click **AUTO TUNE**. The parameters set in the **Cantilever Tune** control panel appear in the **Realtime** control panel.

12. Click **ABORT TUNING** to exit the **Cantilever Tune** command and leave the parameters unchanged.

10.3.5 Optimization of Scanning Parameters

The user is encouraged to review Section 9.2.2 which discusses parameter optimization for Contact AFM.

10.3.6 Data Type

Data Type is the first parameter to set because the values of other parameters depend on it. The **Data Type** parameter in the **Channel 1**, **Channel 2** and **Channel 3** panels selects the type of data collected by the system. **Height** data corresponds to the change in piezo height needed to keep the amplitude of the cantilever constant. **Amplitude** data measures the change in amplitude relative to the amplitude setpoint.

The scan parameters required to collect good **Height** data are different than the optimal parameters for **Amplitude** data. To collect **Height** data while tracking the sample surface with minimal change in the tip's oscillation amplitude, the feedback gains must be high.

⚠	**CAUTION:**	Do not conduct TappingMode microscopy with low feedback gain values, as this will cause damage to both the tip and sample. The maximum amplitude of the cantilever oscillation is not sufficient to track tall features.

Amplitude data collected with high feedback gains is the derivative of the height. **Amplitude** mode provides a sensitive edge detection technique. It is possible to capture both **Height** and **Amplitude** data simultaneously.

10.3.7 Gain Settings

The **Integral** and **Proportional Gains** on the **Feedback** panel must be high enough to force the feedback system to track the sample surface. When scanning in TappingMode, set the **Integral** and **Proportional Gains** to lower values than those values used in Contact mode. The **Proportional Gain** can usually be set 30%-100% higher than the **Integral Gain**. To optimize the gains, increase the **Integral Gain** until the piezo begins to oscillate (feedback oscillation usually occurs with **Integral gains** of **10-20)**, then eliminate the oscillations by reducing the gain with two or three clicks of the left arrow key. Repeat the process for the **Proportional Gain**.

10.3.8 Scan Size, Scan Rate, and Setpoint

The **Scan Size**, **Scan Rate**, and **Setpoint** values affect data output differently. As in Contact mode, decrease the **Scan Rate** as the **Scan Size** is increased. Use **Scan Rates** of **0.5-1.0 Hz** for large scans on samples with tall features. High scan rates help reduce drift, but only use them on flat samples with small scan sizes.

The **Amplitude Setpoint** parameter defines the desired voltage for the feedback loop. The **Amplitude Setpoint** voltage is constantly compared to the present **RMS amplitude** voltage to calculate the desired change in the piezo position. When the gain values are high, as they should be when the **Data Type** is set to **Height**, the Z piezo position changes to keep the amplitude voltage close to the **Amplitude Setpoint**; therefore, the oscillation amplitude remains nearly constant.

As discussed above, changing the **Amplitude Setpoint** alters the response of the cantilever oscillation and changes the amount of force applied to the sample surface.

The force applied by the tip on the sample increases as the **Amplitude Setpoint** is decreased. To minimize the force on the sample:

- Increase the **Amplitude Setpoint** using the right arrow key on the computer keyboard until the tip is no longer interacting with the surface. This can be observed by monitoring the trace and retrace lines in the oscilloscope display and by monitoring the **Z Center Position**. When the tip is no longer interacting with the surface, the Z Center Position will move to the retracted limit.

- Slowly decrease the amplitude setpoint using the left arrow key on the keyboard until features appear in the trace and retrace lines in the oscilloscope display.

10.3.9 Surface Tune

It is often desirable to check the cantilever tune after engaging.

A warning, shown in Figure 10.2h, appears indicating that cantilever tuning while engaged can result in damage to the tip or sample. This warning prompts you to enter a **Tip offset**. This is the distance above the sample that the tip will be raised before displaying the tuning spectrum. Use a minimum **Tip offset** of **100-200nm**.

Observe the plot of amplitude vs. driving frequency to see if the cantilever tuning curve shifted during the engagement. The drive frequency can be adjusted to compensate for such a shift by using the **Offset** command located in the **Cantilever Tune** plot. The phrase response curve can be adjusted as well.

10.4   Troubleshooting

10.4.1   Frequency Response Plot

If a peak in the frequency response plot does not appear, perform the following steps:

1. Increase **Sweep Width** to the maximum value.

2. Increase the **Drive Amplitude** in intervals of 200-300mV until you have reached 2-3V.

3. If the peak still has not appeared, then increase the **Sweep Width** by first increasing the **Center Frequency**, then maximizing the **Sweep Width**. If there is still no peak on the response plot, check the laser alignment.

10.4.2   Engaging the Sample

If the engage aborts because the tip is still too far away from the surface, use the Tip Down motor control to bring the tip and surface closer together. After successful re-engaging, a well formed image appears.

10.4.3   Cantilever Will Not Tune

If the Cantilever Tune fails, check the following:

- Ensure the laser is properly aligned at the free end of the cantilever (the end furthest from the substrate).

- Ensure there is good physical coupling between the probe and the probe holder. Make sure that the groove the probe is held in is free of debris, and that the probe substrate is in firm contact with the back wall of the groove and is pushed firmly against one side of the groove.