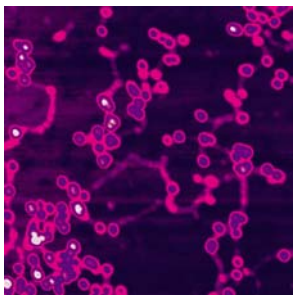
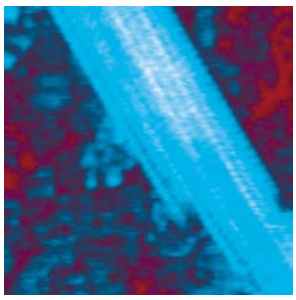
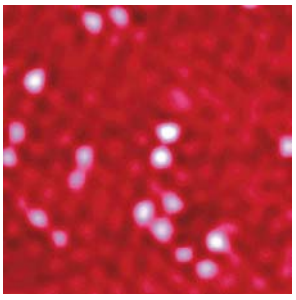
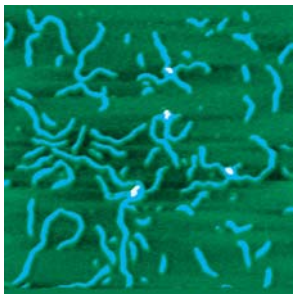
Operation Instructions

Multi-Purpose XYZ Closed-Loop
and
Z Closed-Loop Scanner

v 1.1

Molecular Imaging

1 Hardware/Software Requirements

Molecular Imaging offers unique Multi-Purpose Closed-Loop scanners equipped with inductive positioning sensors. It has been optimized for use with PicoPlus™ and MAC Mode® (Magnetic AC Mode) family of products. Scanner operation allows interchangeability between open and closed loop modes.

It requires PicoScan software version 5.3.3., PicoScan 3000 series controller and a special 6 feet Micro-DB9 cable.

2 Instrument Setup

Setup procedure for the closed loop scanner is the same as of standard (open loop) scanner. User should follow the steps described in the PicoPlus user manual.

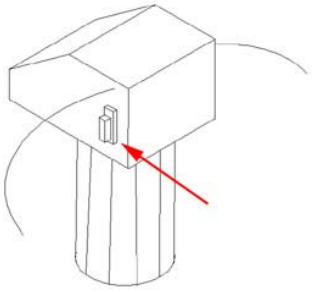


Figure 1

In addition to the standard AFM scanner set up, connect the additional 6 feet micro-DB 9 cable to the scanner (shown in figure 1) and connect the other end to the back panel of the SPM II electronics box.

Closed loop scanner should come with a calibration disk. It contains several calibration files. Copy the files with extensions .afm and .stm into the PicoScan hardware directory; copy the files with extension .par into scripts directory.

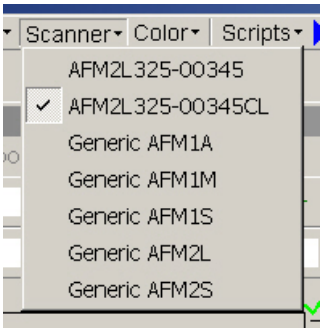


Figure 2

Prior to imaging, please select the desired calibration file in the scanner menu (figure 2). Choose closed loop calibration for XY closed loop imaging, and open loop calibration for open loop imaging. Since Z closed loop is independent of XY closed loop, user can also do XY closed loop with open loop Z scan.

XY Closed loop operation

To turn on the XY closed loop scan, select the XYClosedLoop control panel under the script menu (figure 3) and check the box by "Enable XY Closed loop". In the XY closed loop control panel (figure 4), there should be a set of preset parameters for X and Y sensors. Check the numbers against the parameters (from the 'Closed loop calibration parameters' document in the floppy that came with the scanner). Adjust the parameters to be the same as the same as those in the document.

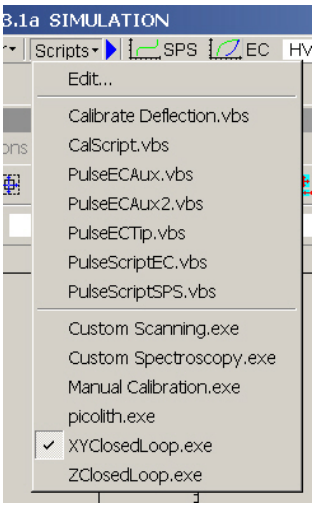


Figure 3

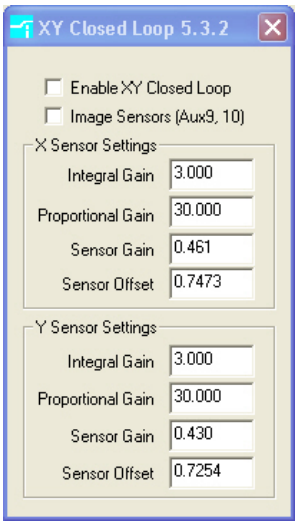


Figure 4

Z closed loop operation

Z closed loop option is independent of XY closed loop option. It is used to control z position of the probe. There are primarily two applications for Z closed loop option. One is to hold z position at a given height. When the check box for "hold z" is checked (figure 5), the position of the probe is held at the previous position. Typing in a distance in "Move nm" will move the probe away from current position. The other application is to perform a closed loop sweep. The range of sweep has to be specified in the force spectroscopy panel. Similar to a regular force-distance sweep, the closed loop option offers more precise control of the sweep.

In addition to the two applications mentioned above, there may be a need to display the measured z height information as topography instead of using the mapping of high voltage value applied to the z piezo as topography, which is a common practice in the AFM imaging. The drawback of this display method is that sensor noise is added into the topography display. Typically it gives a few times additional noise than the mapping of high voltage value.

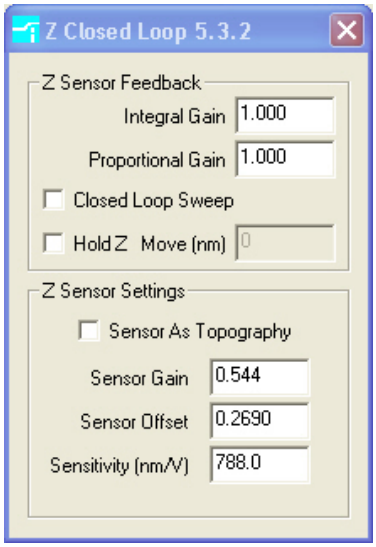


Figure 5

3 Control parameters adjustment

Sensors are factory tested and set for proper range and offset in maximizing scanner sensitivity and resolution. In case of a discrepancy in the calibration, user can adjust the parameters through the sensor menu.

X-Y sensor Adjustment

The X-Y Sensors are factory tested and set for proper range and offset. The typical parameters are (as shown in figure 6):

X sensor:
Integral gain = 3
Proportional gain = 30
Sensor gain= .461
Sensor offset = 0.7473

Y sensor:
Integral gain = 3
Proportional gain = 30
Sensor gain= .430
Sensor offset = 0.7254

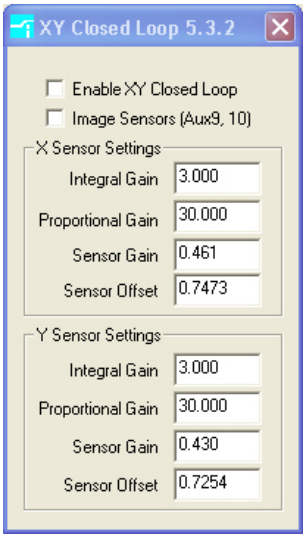


Figure 6

Each scanner should come with a text file ('Closed loop calibration parameters') containing all optimized parameters for the scanner. Check the list again the parameters in the menu. Use may correct the parameters in the menu if a discrepancy is found.

In case of further adjustment is needed, please follow the steps outline in appendix 1.

Z Adjustment

The Z Sensors are factory tested and set for proper range and offset. The typical parameters are (as shown in figure 7):

Z sensor:
Integral gain = 1
Proportional gain = 1
Sensor gain= .544,
Sensor offset = 0.2690
Sensitivity = 788

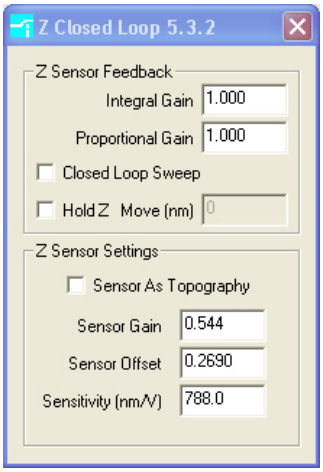


Figure 7

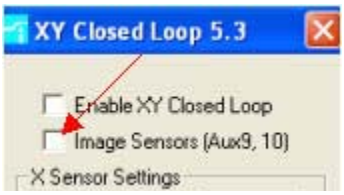
Check these parameters against the parameters from the text file that comes with each scanner to ensure the values are all set properly.

In case further adjustment is needed, please follow the steps outline in appendix 1.

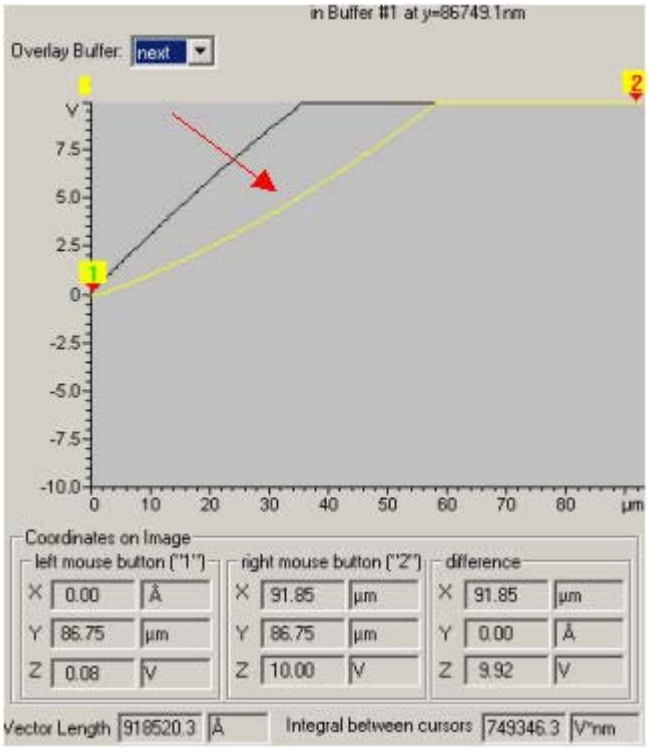
Appendix 1

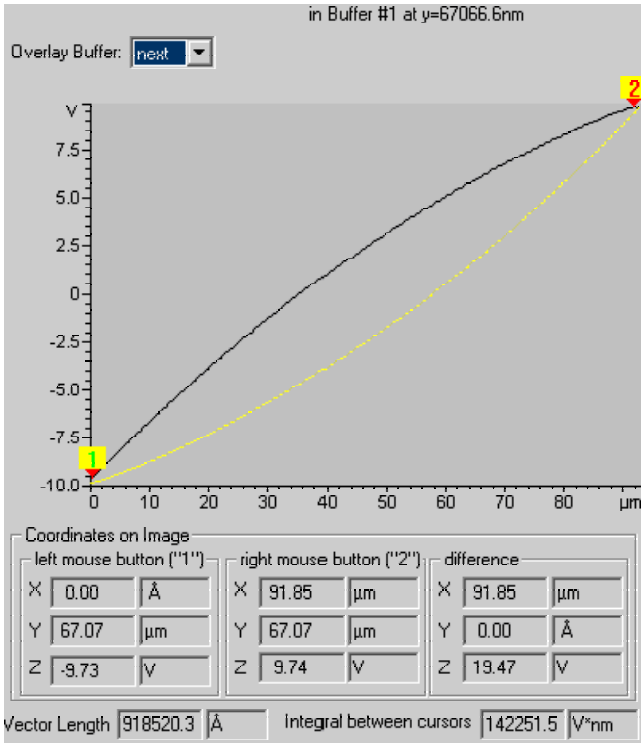
X Sensor Adjustment

1. Make sure the correct scanner calibration file is used (shown in figure 2). Typically, the closed loop file names contain the letters "CL XYZ" for easy identification.
2. Set-up to view two buffers simultaneously. Set buffer 1 and 2 to AUX 9 and select "right" and "left" scan directions for monitoring the trace retrace movement on the sensor.
3. Set scan rate between 1- 2 lines per second.
4. Select "Image Sensors" in the 'XY Closed Loop' window.
5. Hit "Approach" then "Stop" on the approach window to enable high voltage, engaging the tip is not necessary.
6. Open "Cross Section Analysis" window and choose to display buffer 1 and 2 in overlap by selecting "next". Observe the sensor signal during simultaneous right and left scans.

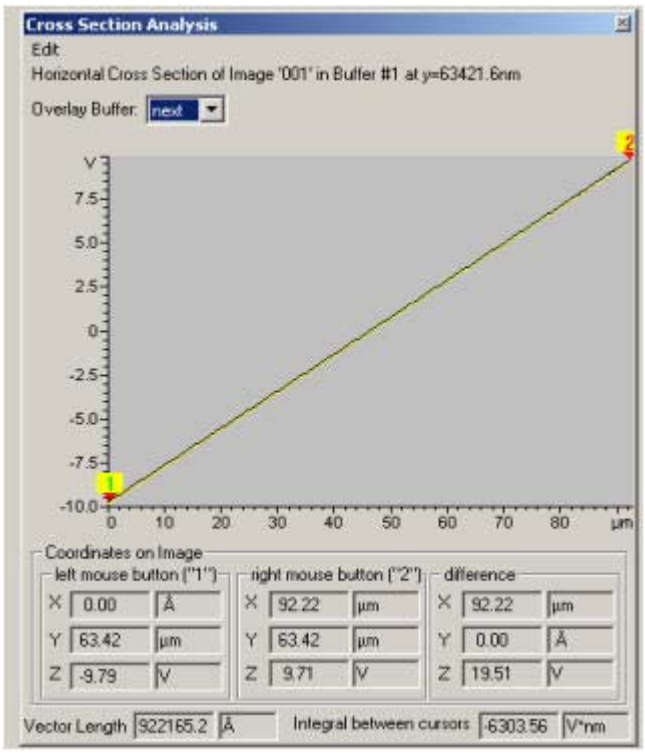


7. Set the scan size to 'Full Range' and start a raster scan by clicking "Start" in the Scan window.
8. Adjust for offset **by adjusting the 'Sensor offset' value in the script window as required.**





9. Stop sweep and "Enable X-Y Closed-Loop", which turns on sensor feedback. Observe the linearity of the sensor signals. Adjust P/I gains for maximum response.



Y Sensor Adjustment

1. Set scan rotation to 90 degrees, change buffer 1 and 2 to AUX 10.
2. Repeat step 4 to 10 for Y sensor.

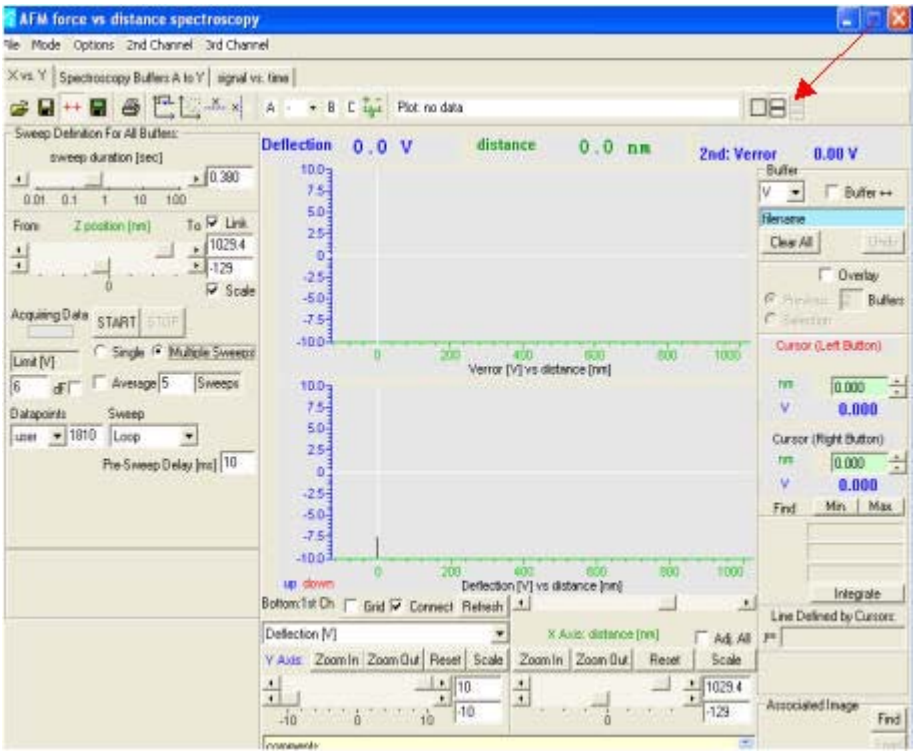
X-Y Sensor Scale Calibration

After the range and offset for X-Y sensors have been adjusted, sensitivity will have to be checked.

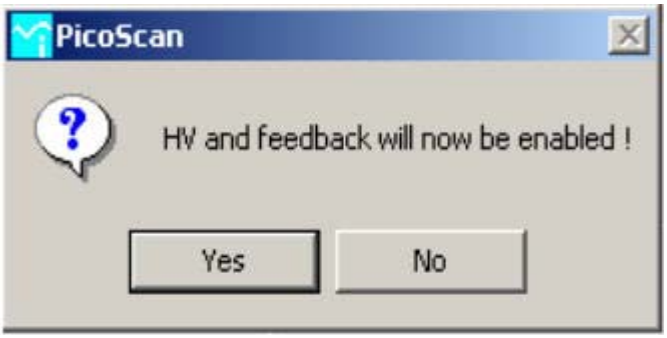
1. Take a proper X-Y calibration grid and set-up for contact mode imaging using a scan speed of 1 – 2 lines per second.
2. Engage and toggle image collection. Open the cross section analysis window and set AUX 9 for X and AUX 10 for Y. **Adjust "sensor gain" (for x and y) in the Script window for proper lateral spacing in x and y respectively.**

Z sensor adjustment

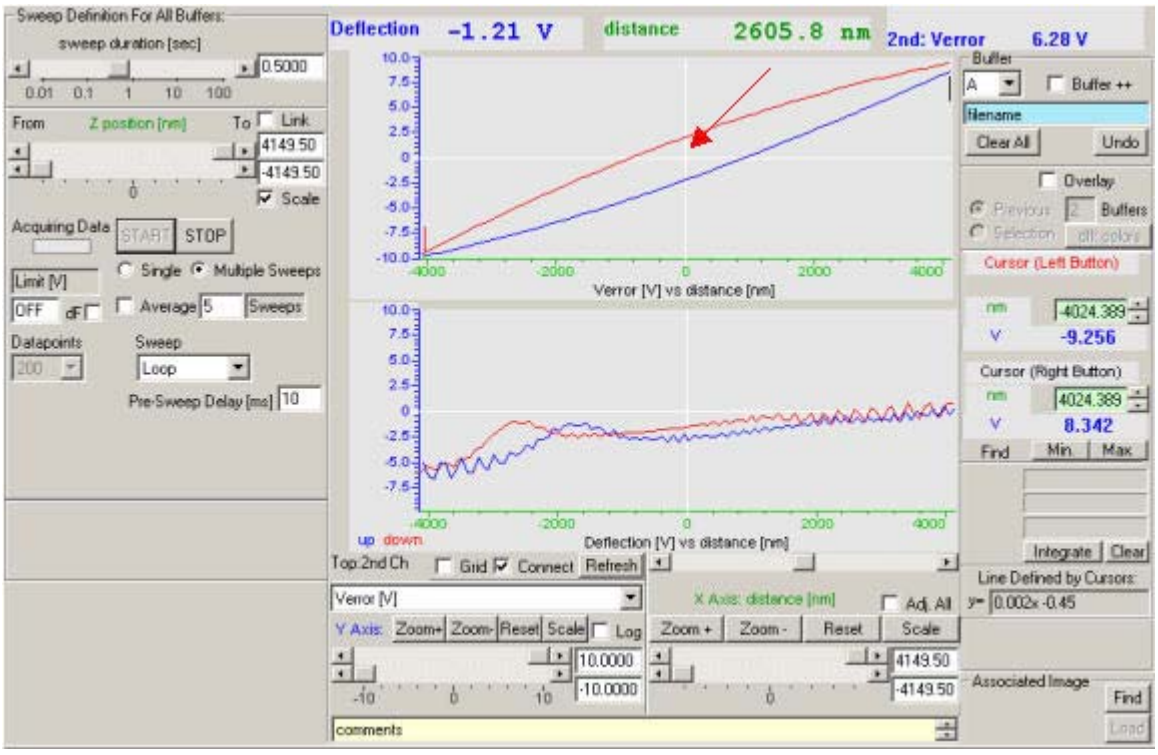
1. From the "AFM force vs. distance spectroscopy" window under Mode, select the "force-distance (amplitude-distance for AC AFM) as the method of operation.
2. From the same window select "2nd channel" and enable "Verror" to monitor activity on the Z sensor. View by choosing the dual channel display icon as followed.



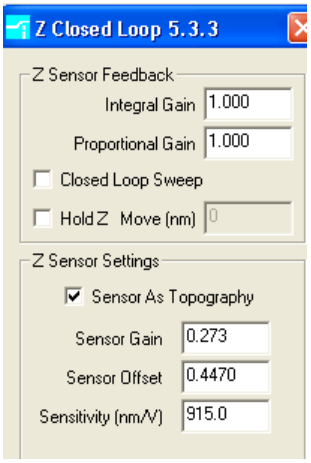
3. Set sweep range to maximum by expanding the "Z position" in both directions.
4. Set sweep duration to .5 sec. and activate a "Multiple Sweep".
5. Set servo range on the "Servo window" to full scale.
6. Ensure "Closed Loop Sweep" is unchecked.
7. It is not necessary to actually engage the tip for Z sensor adjustment. Only the HV needs to be activated. This can be done by selecting "START" to begin a sweep. A message box will pop-up "HV will turned on", click 'OK' to close the message prompt.



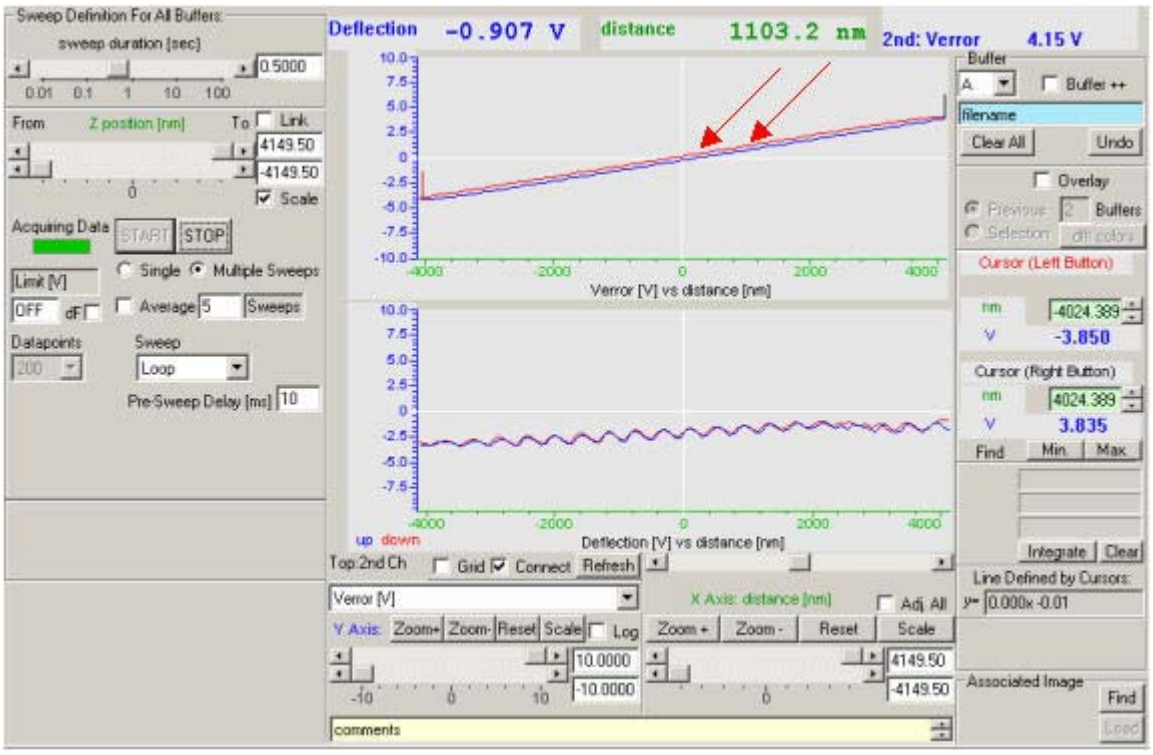
8. The "Verror" channel now displays sensor output against the Z position as high voltage is applied. The curved lines show the nonlinearity and hysterisis of the piezo movement in open loop conditions.



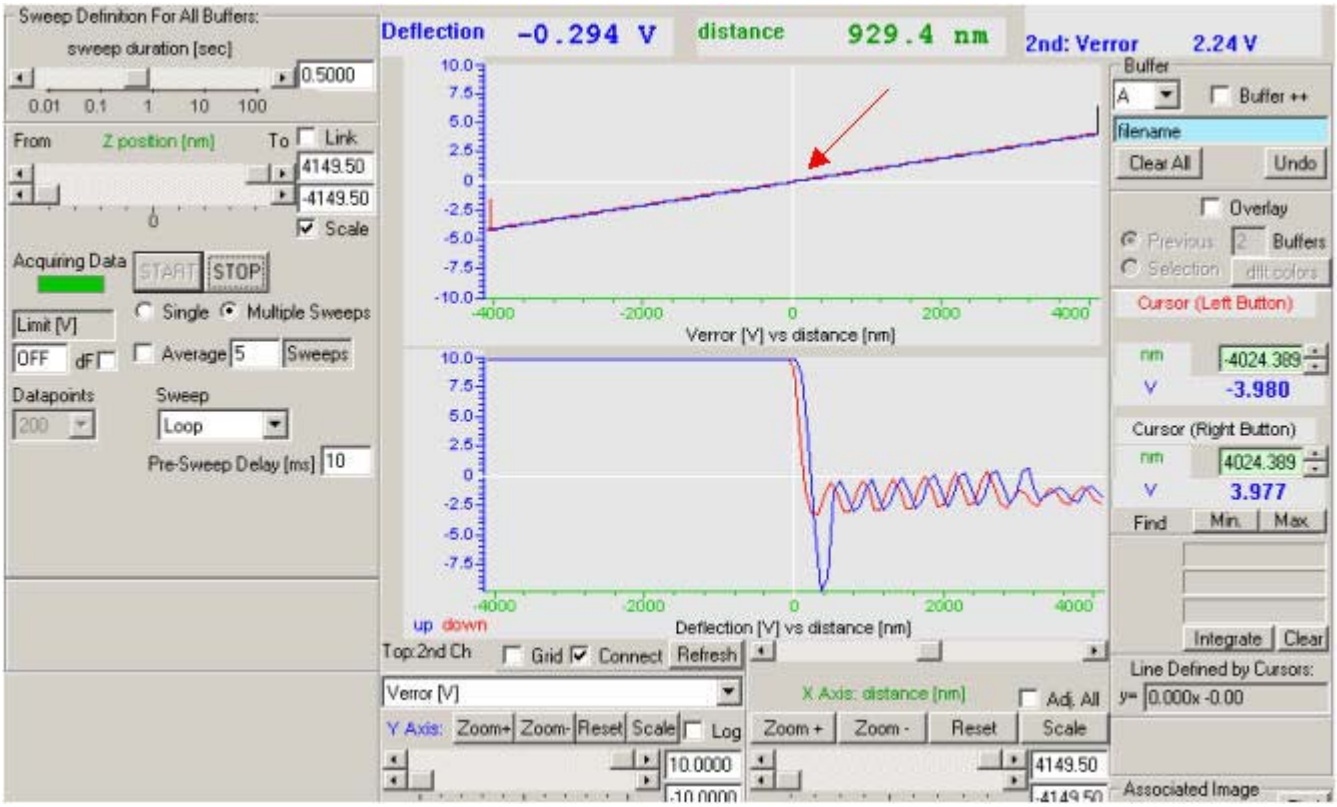
9. **Center any offset around 0 by adjusting the 'Sensor offset' value in the script window as required.**



10. **Note that the range (+/- 9V) setting has been calibrated by the factory. However, if fine calibration is necessary, adjust 'Sensor gain' value in the script window as required.**
11. Stop the sweep and enable the "Closed Loop Sweep". Restart the sweep and observe the "Verror" plot as the data now displays linear.



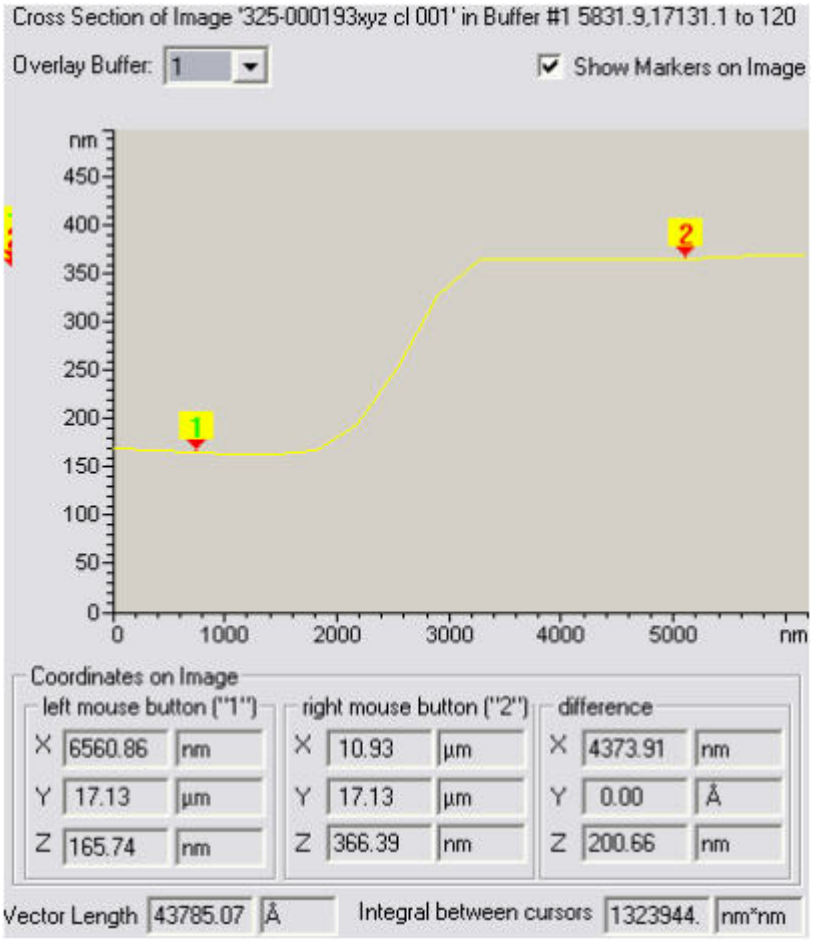
12. Increase the P/I gains in the script until the trace retrace scan lines overlap. If oscillation occurs lower the gain settings.



Z Sensor Calibration

*Z sensor like other parameters is calibrated in the factory and the value is noted in the 'Sensor calibration parameters'. This value has to be entered manually as the 'sensitivity' in the script window. Unlike 'offset' and 'gain' this calibration does not vary much from the factory to the user. So the calibration by the user may not be necessary. Checking "sensor as Topography" on the Z Script window allows the user to have Closed-loop sensor as topography. In case the recalibration is necessary, follow the procedure below:

1. Image a Z calibration standard with "sensor as topography" selected.
2. Open the "Cross Section" window.
3. Modify the "Sensitivity (nm/V)" in the Z Closed-Loop window for correct height of standard.



4. Ensure this modified value is manually noted as individual scanner sensitivity is slightly different and current software does not support updates to the calibration (.def) file.