Conductive Atomic Force Microscopy (C-AFM)

300.1 Overview

This support note describes how to perform Conductive Atomic Force Microscopy (C-AFM) on a Dimension™-series microscope. C-AFM enables AFM users to accurately measure low currents (sub-picoampere) through conductive samples with a lateral resolution of a few nanometers (≤10 nm). This support note includes:

- **Theory of Operation:** Section 300.2

- **Safety Requirements:** Section 300.3

- **C-AFM Instrumentation:** Section 300.4

- **Installation/ Setup of the C-AFM System:** Section 300.5

- **Collecting Data:** Section 300.6

- **IV- Spectra:** Section 300.6.4

- **Offset Correction:** Section 300.7

- **Maintenance:** Section 300.8

- **Troubleshooting:** Section 300.9

Document Revision History: Support Note 300

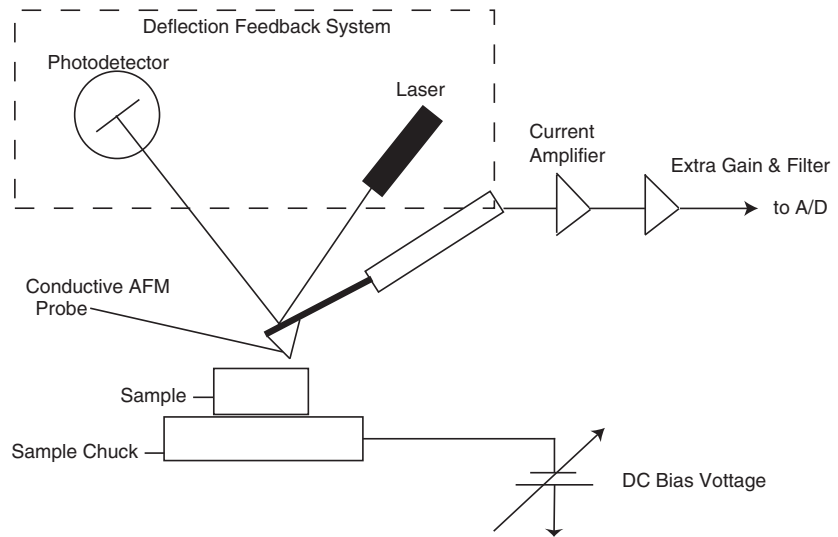| Rev.	Date	Sections	Ref. DCR	Approval
Rev. A	17-Nov-00	Preliminary Release	0363	M. Hardin

300.2   Theory of Operation

To perform C-AFM measurements on all Dimension series microscopes, the user applies a selectable bias between the sample and the conductive SPM tip, with the tip being on virtual ground. As the tip is scanning the sample in contact mode and imaging the topography, a linear amplifier with a range of 1pA to 1μA senses the current passing through the sample. Thus, the sample's topography and current image are measured simultaneously, enabling the direct correlation of a sample location with its electrical properties.

C-AFM is also very useful for the measurement of other higher resistivity films, such as ferroelectric films and diamond-like-carbon (DLC) films, which find widespread use in data storage. Further examples of applications include conductivity measurements on light-emitting conductive polymers or nanotubes, to name a few. Figure 300.2a shows a rough schematic of the C-AFM setup.

Figure 300.2a   How C-AFM Works

Deflection Feedback System

Photodetector

Laser

Current
Amplifier

Extra Gain & Filter

to A/D

Conductive AFM
Probe

Sample

Sample Chuck

DC Bias Vottage

5700

300.3   Safety Requirements

This section details the safety requirements involved in the installation and operation of the C-AFM system. Specifically, these safety requirements include all safety precautions, conditions and equipment safety applications. Training and compliance with all safety requirements is essential during installation and operation of the Nanoscope SPM.

WARNING: Service and adjustments should be performed only by qualified personnel who are aware of the hazards involved.

ATTENTION: Toute réparation ou étalonnage doit être effectué par des personnes qualifiées et conscientes des dangers qui peuvent y être associés.

WARNUNG: Service- und Einstellarbeiten sollten nur von qualifizierten Personen, die sich der auftretenden Gefahren bewußt sind, durchgeführt werden.

WARNING: Follow company and government safety regulations. Keep unauthorized personnel out of the area when working on equipment.

ATTENTION: Il est impératif de suivre les prérogatives imposées tant au niveau gouvernemental qu'au niveau des entreprises. Les personnes non autorisées ne peuvent rester près du système lorsque celui-ci fonctionne.

WARNUNG: Befolgen Sie die gesetzlichen Sicherheitsbestimmungen Ihres Landes. Halten Sie nicht authorisierte Personen während des Betriebs fern vom Gerät

WARNING: Voltages supplied to and within certain areas of the system are potentially dangerous and can cause injury to personnel. Power down everything and unplug from sources of power before doing ANY electrical servicing. (Bruker personnel, *only*.)

ATTENTION: Les tensions utilisées dans le système sont potentiellement dangereuses et peuvent blesser les Utilisateurs. Avant toute intervention électrique, ne pas oublier de débrancher le système. (Réservé au personnel de Digital Instruments, Bruker seulement.)

WARNUNG:	Die elektrischen Spannungen, die dem System zugeführt werden, sowie Spannungen im System selbst sind potentiell gefährlich und können zu Verletzungen von Personen führen. Bevor elektrische Servicearbeiten irgendwelcher Art durchgeführt werden ist das System auszuschalten und vom Netz zu trennen (Nur Digital Instruments, Bruker Personal).

WARNING:	Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous laser light exposure. The use of optical instruments with this product will increase eye hazard.
ATTENTION:	Toute utilisation, ou étalonnage ou essai de modification, autre que ci-dessous décrits, peut entraîner une exposition dangereuse à la lumière du laser. L'utilisation de systèmes optiques avec ce produit peut entraîner un danger pour les yeux.
WARNUNG:	Die falsche Verwendung dieses Gerätes mit nicht in diesem Handbuch beschriebenen Vorgehensweisen kann gefährliche Laserstrahlung freisetzen. Optische Instrumente, die zusammen mit diesem Produkt verwendet werden, können evtl. Augenschäden hervorrufen und verstärken.

300.4   C-AFM Instrumentation

300.4.1 System Requirements

The minimum system requirements needed to install and operate C-AFM are:

- Software V4.44 or higher, Windows NT

- Application Module System

300.4.2 Hardware Description

The C-AFM hardware consists of the following items:

- **Application Module AFM Scanner**: This scanner allows the user to mount the C-AFM sensor using two screws (size: 2-56, 1 1/4 inch socket head; See Figure 300.4a).

Figure 300.4a   Application Module AFM Scanner

> **Note:** Screws and a matching screwdriver are included in the application module accessory kit.

- **Application Module Electronics Box**: This electronics box contains specialized electronics for standard AFM imaging, extended AFM imaging, C-AFM imaging and

other application module techniques including: scanning capacitance microscopy (SCM), scanning spreading resistance microscopy (SSRM) and tunneling AFM (TUNA).

> **Note:** Using the application module AFM scanner and electronics box, it is possible to operate other application modules such as SCM and SSRM provided the corresponding sensor and tip holder are available.

- **C-AFM Sensor**: The C-AFM sensor may be mounted on the application module AFM scanner using the two screws. The C-AFM sensor contains the current amplification circuit necessary for the ultra-low current measurements. It connects to the application module electronics box using the subminiature D-15 connector (See Figure 300.4b).

Figure 300.4b   C-AFM Sensor
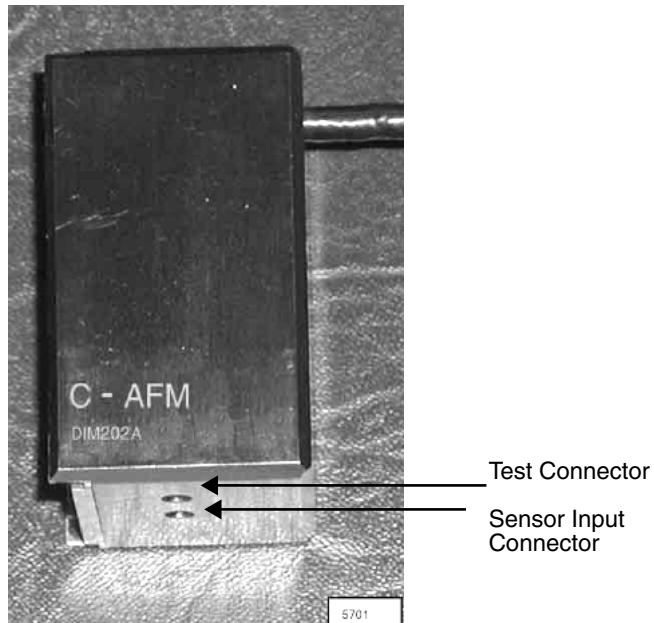
- **C-AFM Tip Holder**: The C-AFM tip holder provides electrical connection from the tip to the C-AFM sensor, while maintaining standard features for contact mode and tapping mode imaging (See Figure 300.4c).

> **Note:** This tip holder is also used for TUNA
> and SSRM measurements. It is not
> intended for general purpose scanning.

Figure 300.4c C-AFM Tipholder
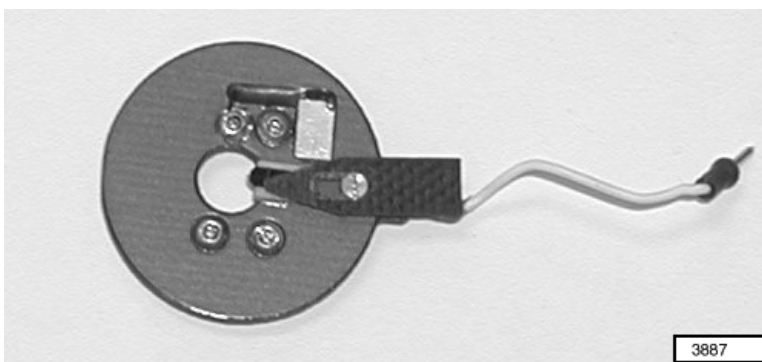
300.5 Installation/ Setup of the C-AFM System

Installation of the Dimension system for tunneling atomic force microscopy differs from a standard Dimension system only in the installation of the C-AFM module on the SPM head. For other installation issues, see your *Dimension Series Instruction Manual*.

300.5.1 Installation of the C-AFM Module

1. Unplug the Dimension head's 21-pin connector. Retract the clamping screw on the right hand side of the dovetail mount by turning it clockwise. Gently remove the head.

2. Place the C-AFM sensor flush on the flat part of the piezo guard, and tighten it down using the two screws provided with the sensor.

    > **Note:** Do not overtighten screws. The screws and a matching screwdriver are included in the application module accessory kit.

3. Carefully install the Dimension head on the dovetail mount.

CAUTION:	When installing the Dimension head, carefully check the clearance between the sample/ stage and the tip/ scanner to prevent the tip/ scanner from crashing into the sample/ stage. If it appears that the tip/ scanner may crash when fully inserted into the dovetail mount, remove the Dimension head completely and execute the **Motor/ Withdraw** command or select **Stage/ Focus Surface** and use the trackball to obtain sufficient clearance.

4. Tighten the clamping screw by turning it counter-clockwise until the head is secured.

    > **Note:** It is important to fasten the clamping screw on the dovetail, and tightly secure the Dimension head. The reduced rigidity of the mechanical support of a loose Dimension head causes a large increase in image noise.

5. Plug the head 21-pin connector and the C-AFM module 15-pin connector into the receptacles on the front of the microscope's electronics box.

300.5.2   Select the Desired Microscope Mode

Prior to any C-AFM measurement, first select the proper hardware and software settings. Select the following settings:

1. Toggle the **Analog 2** switch on top of the electronics box of your microscope into the forward position. This enables the application of a bias to the chuck/ sample through the Nanoscope software.

2. Make sure the **STM/ AM** switch is in the **AM** position (See Figure 300.5a).

> **Note:** The **STM** position is for STM measurements only.

**Figure 300.5a**   Toggle Switches on Dimension Electronics Box

3. Using the mouse, click and hold on the **Digital Instruments** icon located in the upper left hand corner of the control screen (See Figure 300.5b).

Figure 300.5b   Digital Instruments Pull-Down Menu/ Microscope Select Panel
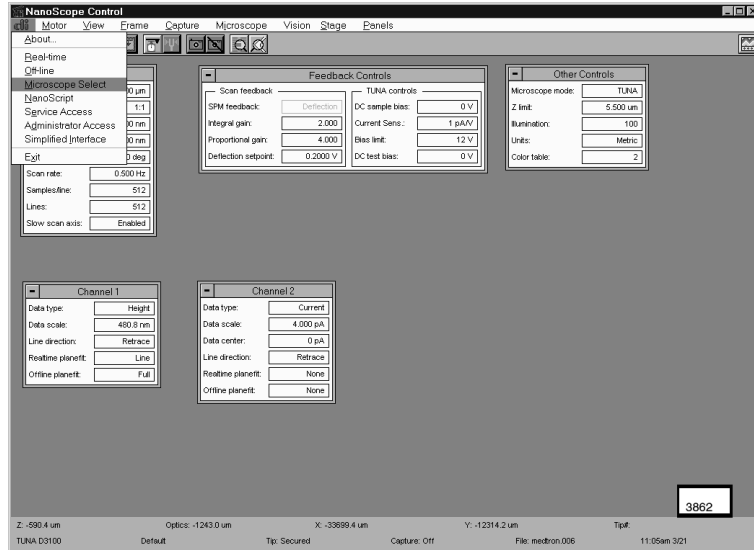
4.   Single click on **Microscope Select** to open the Microscope Select panel. From the Microscope Select Panel, select the **C-AFM D3100** option (See Figure 300.5c).

Figure 300.5c   Microscope Select Panel
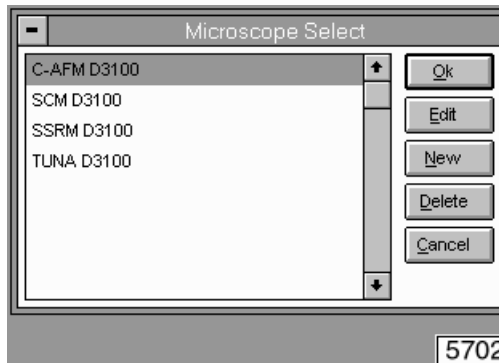
5.   Click **Edit** to open the **Equipment** panel. In the Equipment panel, verify that the **C-AFM** module is selected for the option **Sensor** (See Figure 300.5d).

Figure 300.5d   Equipment Panel
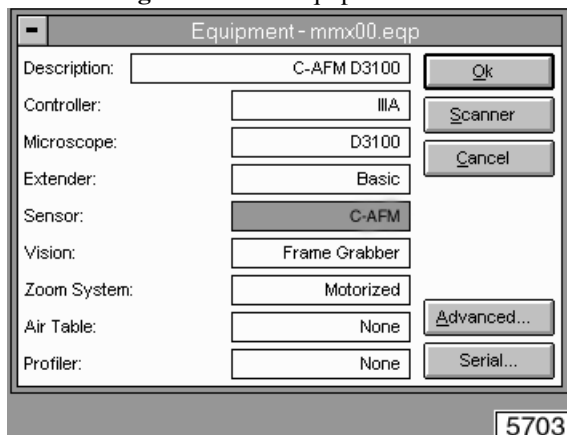
> **Note:** To enable all sensor options, set the
> **Extender** option to **Basic**.

6. Click the OK button to close panels. The system loads the new
    software configuration.

7. In the **Other Controls** panel, select different Microscope modes:
    contact, tapping, STM and C-AFM.

8. Select **C-AFM** as the microscope mode (See Figure 300.5e).

**Figure 300.5e**   Other Controls Panel
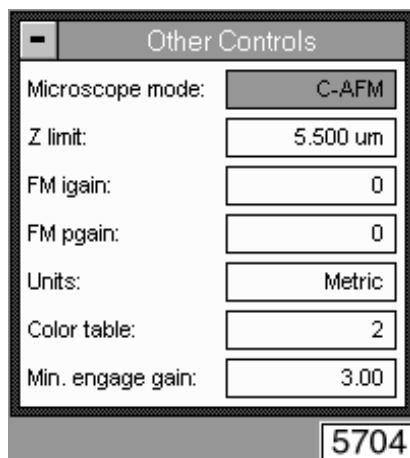
300.5.3 C-AFM Controls Panel

C-AFM measurements can be performed in closed loop or open loop mode. In open loop mode, the user selects a fixed DC bias and the current passing through the sample is measured. For these standard measurements only a few of the parameters available in the **Feedback Controls- C-AFM Controls** panel are necessary. You may deselect all other parameters. Table 300.5a summarizes all C-AFM controls parameters and their functions. To access these additional parameters, a user must complete the following steps:

1. Select the EXPANSION button in the top left hand corner of the **Feedback Control** parameters (See Figure 300.5f). A pull-down menu appears

Figure 300.5f .Feedback and C-AFM Control Panel
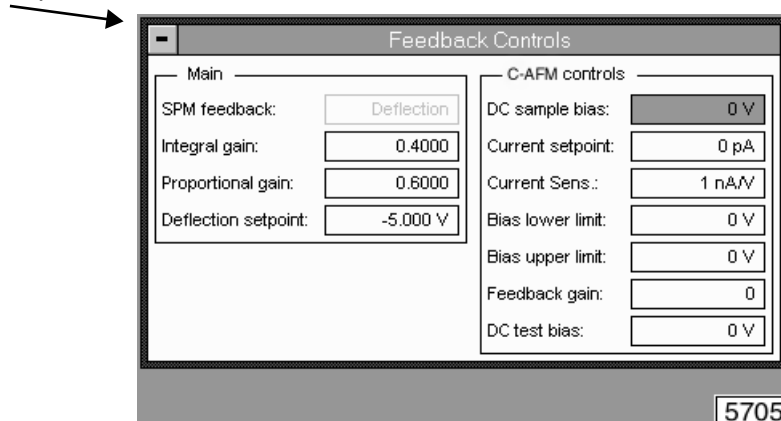
2. Select **View All** to view additional parameter options.

Table 300.5a: C-AFM Control Parameters

Feedback Mode	Selects between open and closed loop mode. In C-AFM, select **open**.	Deselect
DC Sample Bias	Selectable bias to chuck/sample.	Select
Current Setpoint	Selects the current setpoint in closed loop mode.	Deselect
Current Sensitivity	Selects the gain of the C-AFM sensor:[a] 1nA/V = gain of 10^9 100nA/V = gain of 10^7	Select
Bias Lower Limit	Limits the minimum bias applied to the chuck/ sample in closed loop mode.	Deselect
Bias Upper Limit	Limits the maximum bias.	Deselect
Feedback gain	Adjusts the feedback gain in closed loop mode.	Deselect
DC Test Bias	Provides an additional bias for the purpose of testing the C-AFM sensor.	Select

a.1nA/V and 100nA/V refer to the output voltage of the C-AFM sensor. If a signal access module is available, the output voltage can be measured at Aux D.

300.6   Collecting Data

300.6.1 Sample Mounting

1.   Attach the sample to a magnetic puck provided with the system and place the puck on top of the sample chuck. For larger samples or wafers, use the chuck vacuum to hold the sample in place.

When measuring large samples, the use of the hood is recommended. Depending on the sample's electric properties, large samples can act as an antenna and transmit electrical noise from the environment into the input of the C-AFM sensor. As a result, the background noise of the sensor can reach much larger orders of magnitude than the specified noise.

WARNING: The sample chuck and its surrounding area is electrostatic sensitive. Wear a grounding device at all times.

300.6.2 Tip Mounting

Selection

In C-AFM an electrically conductive tip is used. Standard C-AFM tips include platinum-iridium coated tips (SCM-PIT, SCM-PIC) and cobalt chromium coated tips (MESP). Alternative tips are diamond coated tips (DCT-ESP) when selecting a tip for C-AFM.

> **Note:** When selecting a tip, keep in mind that C-AFM is being operated in contact mode.

Mounting

Mount the tip as described in Chapter 5 of your SPM's *Instruction Manual*. Plug the wire attached to the cantilever holder into the C-AFM sensor.

> **Note:** Tweezers may be used to plug in the connector.

300.6.3 Imaging

Quick Start

For a quick start, use the C-AFM profile.

1. Select **Microscope/ Profile** and the **Profile Select** panel appears.

2. Highlight the profile **C-AFM** (file name C-AFM) and click on **Load Master**. The software automatically sets the scan parameters to acceptable values.

Real -time Mode

1. To perform a **Real-time** mode measurement, select **DI/Realtime**.

2. In the **Other Controls** panel, select **C-AFM** as the Microscope mode (See Figure 300.5e).

3. Set the C-AFM Controls parameters to the following, initial settings:

> **Note:** The **Feedback Controls** panel shows the **Scan Feedback** parameters and the **C-AFM Controls** parameters simultaneously (See Figure 300.5f).

Table 300.6a: Initial Settings of C-AFM Control Parameters

DC Sample Bias	0V
Current Sens.	1nA/V
Bias Limit	12V
DC Test Bias	0V

C-AFM is a contact mode technique. For the initial settings of the **Scan Controls** parameters and the **Feedback Controls** parameters in contact mode, refer to Chapter 6 in your *SPM Instruction Manual*. Typically the **Feedback Controls** panel looks similar to what is shown in Figure 300.5f.

4. Set the **Deflection Setpoint** to no more than a few tenths of a volt above the engagement point. This will keep the contact force sufficiently low, thus not causing any damage to the tip or sample. This is especially important for metal coated tips or soft samples.

5. Once the parameters are set, click on the ENGAGE command and start a measurement.

> **Note:** It will probably be necessary to make adjustments to a number of parameters (**Integral Gain, Prop. Gain, Def. Setpoint**) before the image is optimized.

6. To view the topography and the current data set the **Data Type** to **Height** in the **Channel 1** panel and set the **Data Type** to **Current** on the **Channel 2** panel (See Figure 300.6a).

7. Set the current **Real-time Planefit** to **None** and the **Offline Planefit** to **None** or **Full** on the channel that displays the current.

8. The **Highpass** and **Lowpass Filters** should be turned OFF.

> **Note:** The **Data Center** option is useful for the measurement of small current variations in a sample with an overall larger background current.

Figure 300.6a   Channel 1 and Channel 2 Panels for Initial Set-Up (C-AFM)
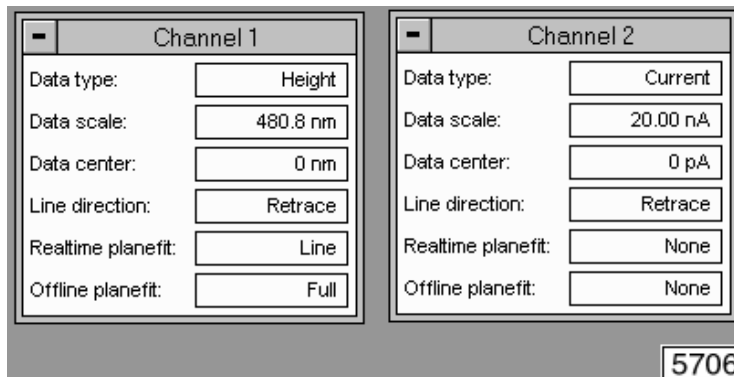
9. To reduce wear of the tip and sample, decrease the contact forces between the tip and sample as much as possible. This is done in one of the following two ways:

a. Obtain a force plot and adjust the setpoint to a level just before the pull-off point, thus minimizing force (See Chapter 11 of your *SPM Instruction Manual*).

b. Click on the **Scope Mode** command and observe the **Height** trace.

c. Lower the setpoint in small increments by highlighting the **Deflection Setpoint** in the **Feedback Controls** panel and repeatedly clicking on the LEFT ARROW key. This reduces the force applied to the sample until the tip eventually lifts off the surface.

d. Slowly increase the setpoint by clicking on the RIGHT ARROW key to obtain a focused image.

> **Note:** Adjusting the **Setpoint** to a few tenths of a volt above the engagement point provides a low contact force.

10. Slowly increase the **DC Sample Bias** while watching the current signal in either **image** or **scope** mode. For many samples, you will find a rapidly increasing current once a certain threshold bias is reached.

CAUTION: When increasing the bias, it is important to proceed carefully in order not to reach overly high current densities. In cases where metal coated tips are being used, the coating may melt if high current densities are used.

> **Note:** Such caution is used to avoid damage to the sample.

CAUTION: When scanning a sample during the application of a bias, keep in mind that the electrostatic force in most samples causes a strong attraction between the tip and the sample. This electrostatic force does not result in any additional deflection of the cantilever, thus disabling a correction through the SPM feedback system. The increased force causes more wear on the tip, and can be harmful to soft samples like polymers. It is necessary to lower the force between the tip and the sample by reducing the **Deflection Setpoint**. Another option is to apply the bias first before engaging with the AFM. However, this

method works only for experiments with a well-defined, known bias. In most cases further adjustment of the setpoint will be necessary.

11. Save the data as described in Chapter 6 of the *Command Reference Manual*.

300.6.4 IV- Spectra

The Nanoscope software permits IV measurements in a specified location on the sample. Typically the SPM tip is placed at the center of an image where an IV-spectrum is captured. By applying X and Y offsets, the tip may be moved to other locations.

Perform an IV Measurement

1. To perform an IV measurement go to **View/ Force Mode/ Calibrate**.

Note: The command screen appears, displaying the ramping panels (See Figure 300.6b).

Figure 300.6b Ramping Panels
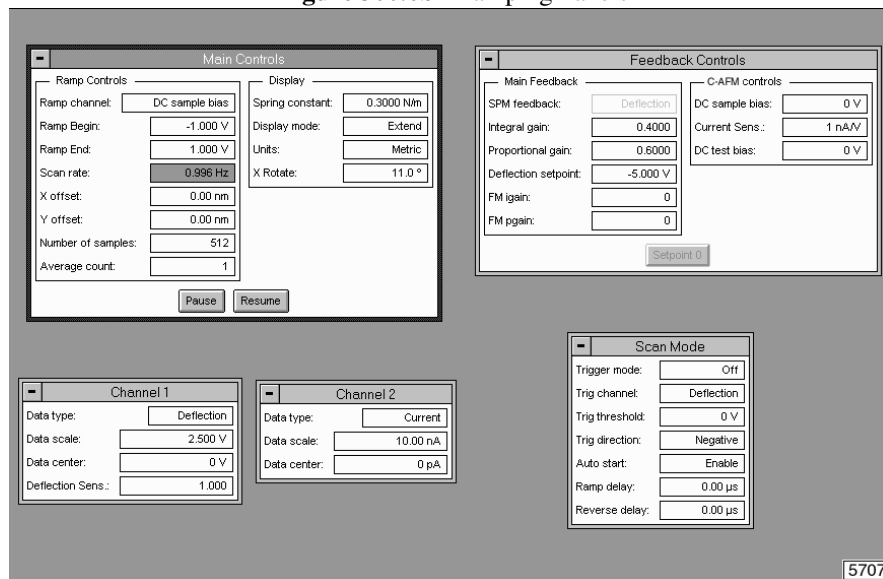
The following tables (Table 300.6b through Table 300.6f) summarize the ramping parameters and their functions:

Table 300.6b: Main Controls/ Ramp Controls Panel

Ramp Channel	Select **DC Sample Bias** to ramp the bias applied to the chuck/sample.
Ramp Begin/Ramp End	Define beginning and ending of ramp. Both values may be positive or negative.
Scan Rate[a]	All ramps are *begin-end-begin* cycles (V-start-V-end-V-start), and the scan rate refers to one complete cycle.
Forward Velocity [a] & Reverse Velocity [a]	Defines the ramp velocity from beginning to end value, and end to beginning value, respectively.
X and Y Offset	Moves the tip to a different location.
Number of Samples	Sets the number of samples per ramp (minimum 16, maximum 64,000).
Average Count	Allows several ramps to be averaged (minimum 1, maximum 1024).

a.**Scan Rate**, **Forward Velocity** and **Reverse Velocity** are inter-dependent. Changing one of the velocities will affect the overall scan rate and the changing of the scan rate will affect both velocities.

For proper feedback during the measurement of IV-spectra, adjust the following parameters in the **Main Controls/ Display** Panel:

Table 300.6c: Main Controls/ Display Panel

Units	Select Metric for IV-spectra
Feedback Type	Ensures that deflection feedback is on while ramping the DC sample bias; select **ramp**, **cycle** or **pixel**. **Ramp**- Enables feedback after each ramp or half cycle (V_{start}-V_{end}-feedback). **Cycle**- Enables feedback after each ramp cycle (V_{start}-V_{end}-V_{start}-feedback). **Pixel**- Enables feedback after every sample point of the ramp. This might be useful for extremely slow ramps with few sample points.
Feedback Counts	Select 50 for proper feedback.
Feedback Value	This parameter is only relevant to STS in STM mode.

2. To view IV-spectra, on either the **Channel 1** or the **Channel 2** panel, set the **Data Type** to **Current** (See Table 300.6d).

Table 300.6d: Channel 1/ Channel 2

Data Type	For IV Spectra select **current.**
Data Scale	Adjust according to data.
Data Center	Offsets IV-spectrum along the vertical/ current axis.

Start and Save IV-spectra

1. To start and stop voltage ramps, select the appropriate icon located in the toolbar (See Figure 300.6c).

> **Note:** In order to take IV-spectra, the AFM must be engaged.

Figure 300.6c   Toolbar Buttons Used for Starting, Stopping and
Capturing Ramp Curves
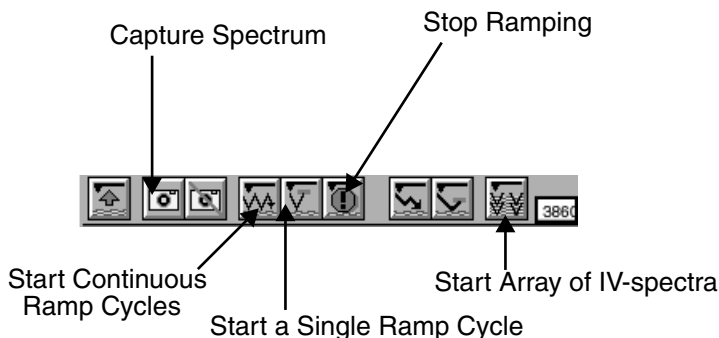
Start Continuous Ramps Icon: This option starts continuous ramps
and permits the averaging of several spectra. To select the number of
averaged spectra, select the **Average count** parameter in the **Main
Controls/Ramp Controls** panel. This measurement continues until the
user clicks the stop button (See Figure 300.6c).

> **Note:** The voltage ramp stops at whatever
> value is applied at the time the stop
> button is selected. To stop multiple
> voltage ramps at a specific voltage
> value, switch to the single ramp cycle
> icon before pressing the STOP button.
> This will add a single ramp to the
> multiple ramps and leave the bias
> voltage at V-start.

- **Single Ramp Icon**: Starts a single ramp. The voltage ramp
  starts at the **Ramp Begin** value, is increased or decreased
  until the **Ramp End** value is reached, and is then ramped
  back to the **Ramp Begin** level.

- **Stop Icon**: Click this option to stop the ramping process.

- **Start an Array of IV-spectra Icon**: Starts an array of IV-
  spectra. For a full description of this function see Multiple
  IV-spectra in Section 300.6.

- **Capture Icon**: Saves the spectrum during a measurement.

> **Note:** At the bottom of the **Main Controls** panel there are two buttons, PAUSE and RESUME. PAUSE interrupts the voltage ramp and holds the voltage at the current value until the user continues the measurement. To continue with the measurement select the RESUME button.

Figure 300.6d shows ramp control settings for a typical IV-spectrum measured using C-AFM. The DC sample bias ranges from -5 to +5 V.

Figure 300.6d   Typical DC Bias Ramp Applied to Sample for IV-Spectrum Measurement
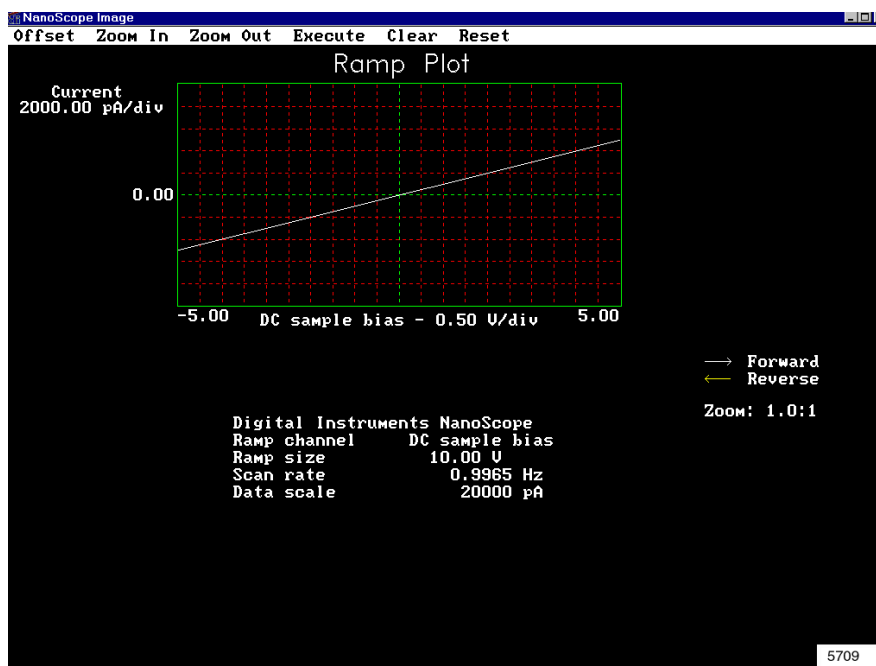
Function and Operation of the Trigger Mode

In certain cases it is necessary to limit the current passing through a sample in order to protect it from destruction. The **Trigger Mode** enables the user to limit the current to a selected value. All necessary parameters, and additional parameters, may be found in the **Scan Mode** panel (See Figure 300.6e). The following tables (Table 300.6e and Table 300.6f) describe the individual functions of the parameters.

Figure 300.6e   Scan Mode Panel
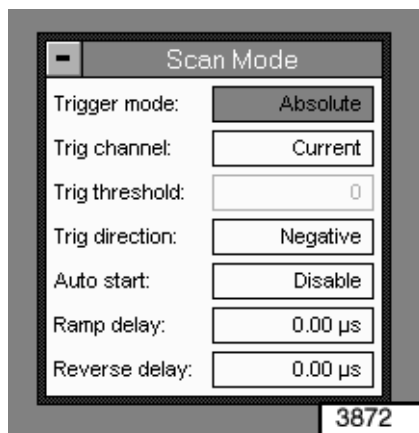
Table 300.6e: Scan Mode Panel Parameters

|	
Trigger Mode	This turns the **Trigger Mode** on and off. For IV-spectra select **Absolute** to turn the trigger on.
Trigger Channel	For IV-Spectra select **Current** for triggering of the current.
Trigger Thresh-old	This sets the trigger value. For a current sensitivity of 1nA/V, select any value between +10nA and -10nA. For a current sensitivity of 100nA/V, select any value between +100μA and -100μA.
Trigger Direction	(See explanation below)
Auto Start	Set to **Disable**.

Explanation of Trigger Direction:

For the **Trigger Mode** to function properly, it is imperative to select the correct trigger direction for a given ramp.

1. When ramping from a larger **Ramp Begin** value to a smaller **Ramp End** value (this means V(t) follows a negative slope), select **Negative** for the **Trigger Direction**.

Figure 300.6f   Negative Trigger Direction for V_{Start}-V_{End}

V (t)

V- Start

Negative Trigger Direction
for V-Start > V-End

V-End

t

3850
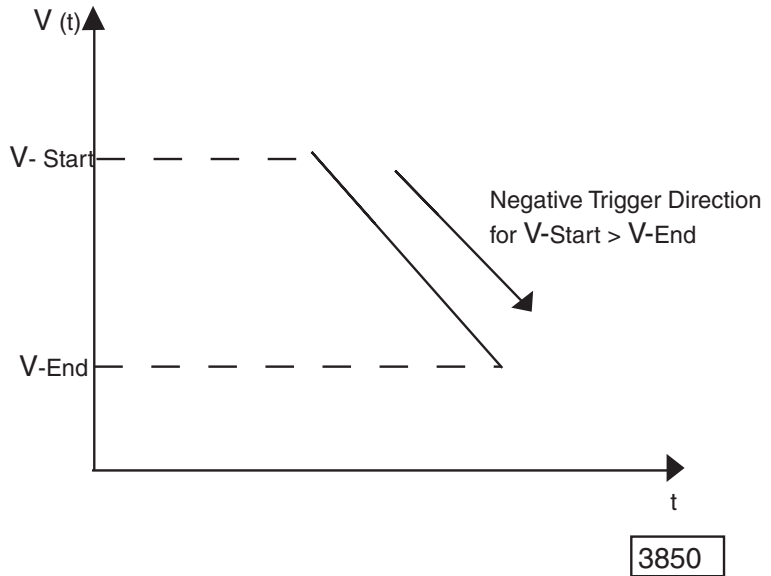
2. When ramping from a smaller **Ramp Begin** value to a larger **Ramp End** value (this means V(t) follows a positive slope), select **Positive** for the trigger direction.

Figure 300.6g   Positive Trigger Direction for $V_{Start} > V_{End}$

V (t)

V-End

Positive Trigger Deflection
for V-Start < V-End

V- Start

t

3851
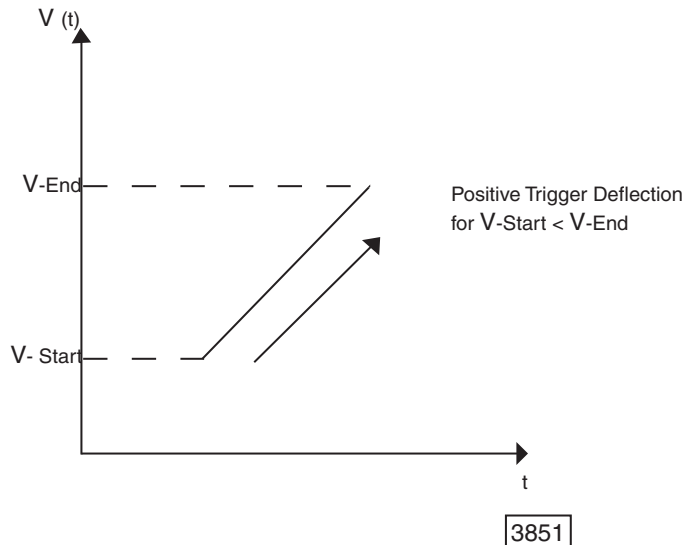
Note: Trigger values can be either positive or negative, depending on the requirements of a specific experiment.

Note: Select **Trigger Mode/Absolute** when operating in IV-spectra. Parameter options may seem confusing. In addition to IV-spectra parameters, the panel displays parameters relevant only to force curves. Disregard these additional parameters.

CAUTION: It is important to set the **Trigger Mode** to **Absolute** when performing IV-spectra. Since IV-spectra and force curves share parameters on a common control screen, it is very important to closely follow the above instructions. Some parameters are relevant only to force curves, disregard these parameters for C-AFM measurements.

Delaying Ramps

The **Scan Mode** panel offers two more parameters that are used to independently add delay times at the end of a *start-end* ramp, or at the end of a complete *start-end-start* cycle (See Figure 300.6h).

Table 300.6f: Ramp Delays

| **Ramp Delay**	This adds a delay time following each *start-end* ramp.
Reverse Delay	This adds a delay time following each complete *start-end-start* cycle.

Figure 300.6h Delaying Ramps

3852
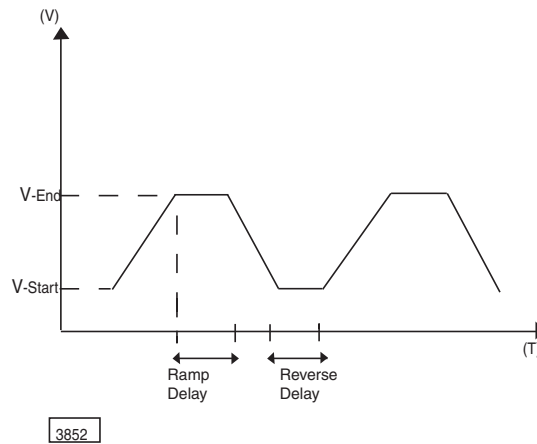
Note: Delay times are not included in the **Scan Rate** parameter.

Note: When switching from one start/end value to another, the **Scan Rate** is kept at a protected value. **Forward** and **Reverse Velocity** are automatically adjusted to keep the **Scan Rate** constant.

Multiple IV- Spectra

1.   Open the **Auto Panel** by selecting **Panels/Auto** (See Figure 300.6i).

Figure 300.6i   Auto Panel for Multiple IV-Spectra
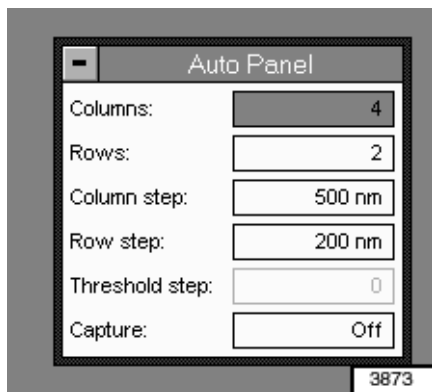
2.   Set the number of IV-spectra in the array using the **Columns** and
     Rows parameters. The **Columns** and **Rows** parameters are the
     number of IV-spectra to be performed in the X and Y direction,
     respectively.

3.   Set the spacing between the columns and rows in the array using
     the **Column Step** and **Row Step** parameters. The **Column (Row)
     Step** parameters define the distance between two neighboring IV-
     spectra along the X(Y) direction.

4.   Set the trigger threshold currents for the array of IV-spectra using
     the **Trigger Threshold** parameter (abbreviated **Trig. Threshold**)
     and the **Threshold Step** parameter.

> **Note:** The **Trigger Threshold** parameter is
> located in the **Scan Mode** panel. The
> **Threshold Step** parameter is located in
> the **Auto Panel**.

5.   For automated IV-spectra, increment the trigger threshold current
     in the X direction using the **Trigger Threshold** and **Threshold
     Step** parameters.

   a.   Set the **Trigger Threshold** to the initial value for the first IV-
        spectrum in each row.

   b.   Increment the **Trigger Threshold** according to the value of the
        Threshold Step for every subsequent IV-spectrum in each
        row.

Example:

If a **Trigger Threshold** is 1.0nA and the **Threshold Step** is 0.1nA, then any row of the IV-spectra will use a trigger threshold current varying from 1.0, 1.1, 1.2,... nA. The threshold current is always incremented from the right to the left. To execute an array of IV-spectra with the same trigger threshold current, set the **Trigger Threshold** to the desired threshold and set the **Threshold Step** to 0.0nA.

6. To execute an array of IV-spectra click on the START ARRAY button in the toolbar (See Figure 300.6c).

7. To capture the IV-spectra set the **Capture** parameter (located in the **Auto** panel) to **Enable** before starting the array. Save each spectrum of the array separately.

> **Note:** If **Capture** is set to **Off**, the IV-spectra will be lost.

Export IV-Spectra

To export IV-spectra in ASCII or any other format offered by the Nanoscope software, complete the following steps:

1. Save the current data.

2. Export this saved data. The export function is located in the **Utility** menu in the Off-line mode.

300.7   Offset Correction

For proper measurements you must adjust any offset of the C-AFM sensor.
This is done through a potentiometer, which is covered by the bottom flat head
screw on the right hand side of the sensor housing (See Figure 300.4b).

1. Go to **Scope Mode**.

2. Remove the screw on the sensor housing and carefully adjust the
    potentiometer with the screw driver (provided in the application
    module accessory kit) until the the signal is along the horizontal
    zero line.

3. Adjust the **Data Scale** for better alignment.

300.8   Maintenance

300.8.1 Returning Components for Repair

No scanning probe microscope (SPM) components are customer serviceable.
If you experience trouble with any component of the instrument, please
review the troubleshooting section of this manual, then call Digital
Instruments/Bruker. If the Dimension head is in need of repair, return the
head to Digital Instruments/Bruker. Call to obtain a Return Materials
Authorization (RMA) and pack the components in the original box used for
shipping the head. Return other components in adequately strong boxes with
at least four inches of foam peanuts cushioning each bubble-wrapped
component. Ship return items directly to Digital Instruments/Bruker.

Digital Instruments/Bruker
112 Robin Hill Road
Santa Barbara, CA 93117
(805) 967-2700

300.8.2 Cleaning the Cantilever Holder

The cantilever holder is fragile. Gently wipe the cantilever holder clean.
Digital Instruments/Bruker recommends a camera lens cleaning kit. The rest
of the microscope requires only an occasional dry wipe.

300.8.3   Cleaning the Cantilever Holder Contacts

Periodically clean the electrical contacts for the Tapping Mode cantilever holder using a Q-tip dipped in alcohol and a slight scrubbing motion to both the cantilever holder sockets and the pins on the end of the scanner. Perform this procedure every three-to-four months, or whenever the contacts are contaminated.

300.8.4   Clean the Sample Holder and X-Y Stage Surfaces

To maintain proper operation of the X-Y Sample Stage, clean the top surface of the X-Y chuck base and both sides of the sample chuck weekly with a lint-free wipe soaked in alcohol.

300.9   Troubleshooting

If a current signal is not received, although you expect the sample to be adequate for this type of measurement, check for several possible problems with the system/ setup:

1. Apply a DC bias to the chuck and measure it with a voltmeter.

    a. If there is no bias, the ANALOG 2 switch on top of the electronics box of your microscope is probably in the wrong position.

    b. If the switch is in the correct position and there is still no bias, reset the microscope by clicking on **Microscope/Reset**.

    c. If the problem persists, please, contact Digital Instruments/ Bruker.

2. Check to see if the sample is in electrical contact with the chuck. If not, establish contact between the sample and the chuck.

3. Verify that the STM/AM switch is in the AM position. If not, toggle the STM/AM switch to the AM position.

4. If you suspect a problem with the C-AFM sensor, complete the following procedure:

    a. Unplug the sensor 15-pin connector from the electronics box.

    b. Plug a 1MΩ resistor between the input pin and the test pin of the sensor. (See Figure 300.9a.)

Figure 300.9a   Schematic Test Circuit of C-AFM Sensor
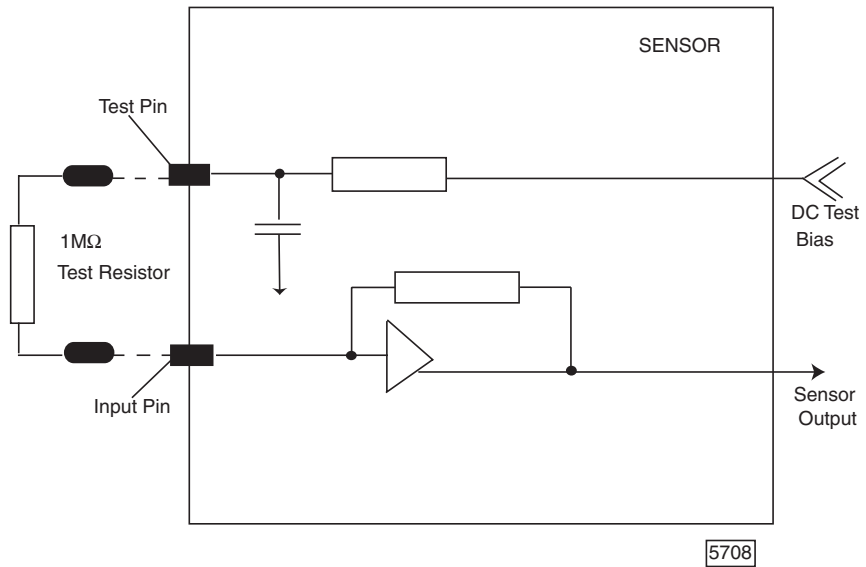
c. Before reconnecting the sensor 15-pin connector to the electronic box, make sure that the **C-AFM Controls** parameters are set to the following values:

Table 300.9a: C-AFM Controls Parameters

Feedback Mode	Open	May be deselected.
DC Sample Bias	0V	
Current Setpoint	0V	May be deselected.
Current Sensitivity	100nA/V	
Bias Lower Limit	0V	May be deselected.
Bias Upper Limit	0V	May be deselected.
DC Test Bias	0V	

Note: Verify that the **DC Test Bias** is set to 0V.

d. Attach the sensor to the scanner head and connect the wire to the 15-pin connector on the front of the electronics box.

e. Go to **View/Scope Mode** and select the following parameters for the **Channel 2** panel:

Table 300.9b: Channel 2 Parameters

Data Type	Current
Data Scale	100nA
Data Center	0pA
Line Direction	N/A
Realtime Planefit	None
Offline Planefit	None
Lowpass Filter	Off

f. Apply a **DC Test Bias** of +0.01V and -0.01V respectively. Verify that the current signal increases by +10nA and decreases by -10nA, respectively.

g. Check if current signals scales properly by applying ± 0.01V, ± 0.02 V, ± 0.03V and ± 0.04V. The current signal should change by ± 10nA, ±20nA, ±30nA up to ± 40nA.

Note: If scanner does not perform according to the previous description, something is wrong. In this case, contact Digital Instruments/Veeco.

300.9.1 External Disturbances

Keep in mind that you are engaging with extremely sensitive equipment. This equipment can measure small currents, but it also amplifies any external disturbances. Examples of such disruptive electronic equipment include: oscilloscopes, a fluorescent light in conjunction with certain samples, and other electronic equipment operated in close proximity.