MicroMill Sampling System Operator's Manual

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PART NO. 90-1539A

Preface

This manual contains information for proper installation and operation of the MicroMill Sampling System and accessories.

Do not attempt to repair the drill. Report all warranty problems to New Wave Research, Inc. for repair.

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Chapter One

Safety

Introduction to Safety

Read, understand and follow the safety precautions prior to power-up or operation of this system to avoid injury and prevent damage to the MicroMill Sampling System or any interfacing devices. Use the system only as specified in this manual.

Follow the instructions and precautions in this manual for proper installation and safe operation of this tool.

- Consult ANSI, (American National Standards Institute), ACGIH (American Conference of Industrial Hygienists) and OSHA (Occupational Safety and Health Administration) standards for safety guidance.

WARNING: The MicroMill Sampling System contains internal components that present severe electrical hazards. Improper operation or servicing can result in death, personal injury or material damage. Only qualified personnel should operate or service this equipment.

The MicroMill Sampling System presents numerous health and safety hazards. These dangers include but are not limited to:

- Fire Danger from Electrical Components.
- Electrical Shock Hazard.

Electrical Safety

The MicroMill Sampling System meets Conforité European (CE) safety and emission standards.

There are no user serviceable electrical parts in the MicroMill Sampling System. New Wave Research must conduct any service procedures. General rules of electrical safety must be followed at all times.

Safety Features

The following safety features are incorporated into the MicroMill Sampling System and conform to government regulations to provide safe operation.

System Housings

The MicroMill Sampling System is enclosed in a protective housing that limits exposure to dangerous electrical hardware. This cover should be removed only by New Wave trained personnel performing periodic maintenance or repair.

Interlocks

Never disable or defeat an interlock. The MicroMill Sampling System is equipped with the following interlocks which prevent operation in specific unsafe conditions:

Sample Slide Interlock

Cause: The sliding stage that the sample is mounted on is not in the Drill position (all the way to the left). It is normal for this interlock to be activated when the sample is in the microscope view position.
Result: The drill is disabled. The video view is switch to the microscope when the slide is not in the Drill position, and is switched back to the drill video when the slide is returned to the Drill position.

Drill Overload Interlock

Cause: The drill motor current limit has been exceeded.
Result: The drill is disabled.

Drill Z Sensor Interlock

Cause: The drill has moved up (vertically) due to pressure on the bit.
Result: The drill is disabled.

Stop Button Interlock

Cause: The Stop button (on the front of the MicroMill Sampling System) has been pressed.
Result: The drill and stages are disabled. You need to press the Stop Button indicator on the Interlock Failure window to clear the indicator and re-enable the stages and drill.

Chapter Two

System Description

System Overview

This section describes the installation and use of New Wave Research Products MicroMill Sampling System software. The MicroMill Sampling System is a solid sampling system that uses a drill mounted on a video microscope assembly and a set of motorized stages to precisely drill and mill samples.

Hardware

A MicroMill Sampling System is a special video microscope mated with a high-speed drill and a set of computer-controlled motorized stages. The sample to be milled is mounted on top of the stages so that it can be positioned underneath the microscope. Two computer-controlled light sources are included -- a reflected light and a transmitted light source. The drill is mounted off to the side of the microscope, so a special sliding sample holder is used to shuttle the sample back and forth between the drill position and the microscope position. A video camera is mounted on the microscope to send an image of the microscope view to the computer; another video camera is mounted near the drill to monitor the milling procedure.

Software

- Runs on Intel-compatible PC computers using the *Windows 98*©, 2000, *NT, ME and XP* operating systems.
- Is used to control the drill, lights, stages, monitor safety interlocks and automate record and monitor the milling process.
- Is a 32-bit application completely written in object-oriented Pascal using Borland Delphi.
- Based on a point-and-click interface, where the live video image of the sample is displayed in a window on the computer monitor, with crosshairs on the image to show where the drill is aimed.

See Minimum System Requirements on page 8 for information on what you need to run the software.

Chapter Three

Installation and Setup

Installing the Software

The CD supplied with the system will guide you through the Software Setup. If you have any questions or problems, please contact New Wave Research.

Minimum System Requirements

Operating System - *Windows* 95/98©, or *Windows* NT©
Computer – Pentium 300 MHz or faster.
Display -- 800x600
To get live video, you must have the Imagination PXC card and drivers installed in your system. At the time of this writing, you must also set the computer's display to 24-bit color mode (True Color) for live video to work.

Unpacking and Setup Instructions

Computer

Computer purchased with MicroMill Sampling System

If you purchased a computer with your MicroMill Sampling System, then it has already been configured and had the necessary software installed. Simply unpack the system following the computer manufacturer's instructions, and setup and boot the computer. If your system was supplied with *Windows* NT, there is no password required – leave the password entry blank and press Enter. (You can change the password later if you'd like.)

Computer supplied separately

If you did not purchase a computer with the MicroMill Sampling System, then you will need to install the live video overlay board in the computer, and install the MicroMill Sampling System software.
In the MicroMill Sampling System accessories box you will find the video capture card, a CDROM containing the necessary software drivers and manuals, which explains how to install the card.

Note: where the manuals refer to floppy disks, you should use the appropriate directory on the supplied CDROM instead. You will need to install the appropriate display driver for your operating system.
The MicroMill Sampling System accessories box also contains a floppy disk containing the MicroMill Sampling System initialization files.
These files must be copied into the MicroMill program directory. The initialization files contain the calibration information created when the system was manufactured and set up at the factory.

MicroMill

Follow the instructions below to unpack and assemble the MicroMill Sampling System.

1) Remove the MicroMill from the packing crate. In the crate you will find the main mill chassis, the video camera assembly, and the accessories box.
2) Remove the mill chassis and the video camera from their packaging material. Remove the black cap covering the video port on the top of the microscope, and install the camera assembly; being careful to orient the camera as shown, with the camera serial number label towards the front of the mill. Lightly tighten the camera on the top of the microscope video port to hold the camera in place. You will need to align the camera later.
3) REMOVE STAGELOCKS. You will need to remove all 4 screws holding the stage locks in place (2 per axis). **Moving the stages with the locks in place will damage the stages!**

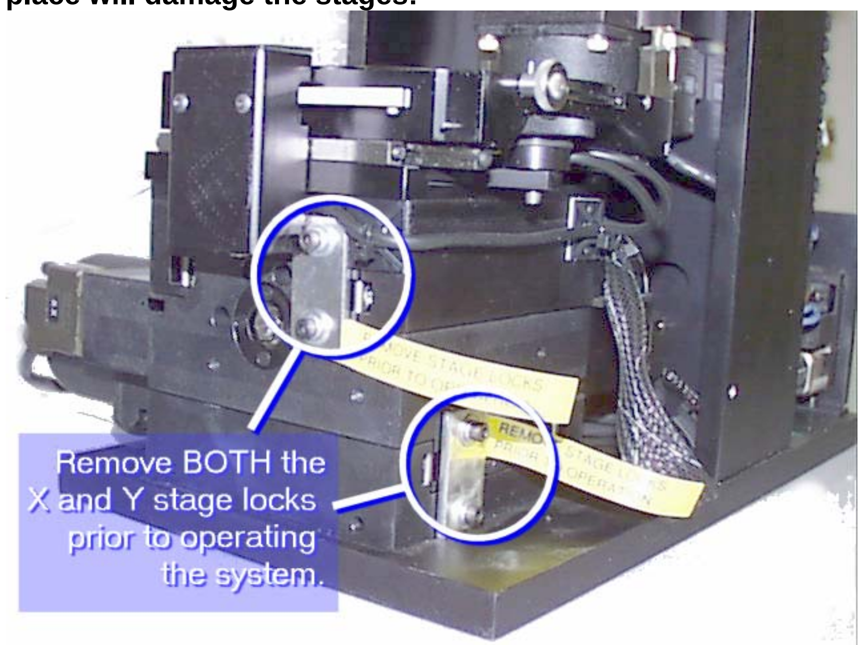


Figure 3-1: X and Y stage locks

4) Find the microscope eyepieces in the accessories box and install them in the microscope.
5) Remove the cables from the accessories box and connect to the MicroMill Sampling System to the computer. Connect the RS232, the SVIDEO, and the Drill Video cables to the appropriate connector on the computer. Connect the power cord to the system.
6) Power up the computer and the MicroMill Sampling System, then run the MicroMill Sampling System software – the software will perform a system self-test and verify that all the components of the system are functioning.

7) Perform the alignment checks and procedures on the following pages.

Figure 3-2: Attaching camera after removing from accessory box.

8) Screw camera onto video port located on top of the Microscope head. The serial number label on the camera should be facing towards the user. Once this is done, the camera should need only nominal alignment. Parfocal and confocal adjustments may need nominal alignment. The stage to camera alignment should be the only one needing adjustment. You can achieve this alignment by referring to the section Aligning the Microscope Video with Stages on page 12.

Microscope Video Parfocal Adjustment

In order for the video camera mounted on the microscope and the microscope eyepieces to both be in focus at the same time, it is necessary to adjust the focus of the video relay lens, located on the microscope video adapter as shown in Figure 3-3. This adjustment is made at the factory prior to shipping, but you may wish to double check it to make sure it hasn't moved during shipment.

Figure 3-3: Parfocal Adjustment Screws

Performing the Adjustment:

1) Place an object under the microscope and turn up the illumination. Move the Z axis up or down until the view through the microscope eyepieces is in focus when zoomed in and zoomed out.
2) Zoom the microscope all the way in, and then look at the microscope video on the computer screen. You may have to slide the video source selector rod in and out on the side of the microscope to view the desired image. If it is not in focus, then you will need to loosen the video relay lens adjustment screws and rotate the assembly until the video is in focus. Rotating the assembly will raise or lower the camera position to attain parfocal. Zoom the microscope all the way out and check the focus. Adjust the lens until the video remains in focus when zoomed in and out. Tighten the lens adjustment screws.

Aligning the Microscope Video with Stages

In order for the drill to accurately track any scans you place on the video screen using the mouse, the video must be aligned with the stages. Since the MicroMill Sampling System is shipped with the camera assembly removed from the unit, it is necessary to perform this alignment when first setting up the system.

> ***NOTE**: When the camera is properly aligned, it will appear to be rotated slightly with respect to the front of the MicroMill -- this is because the optical axis of the camera port on the back of the microscope is at a slight angle.*

Checking Alignment

1) Alignment is checked by focusing on a distinct point on the sample or on the sample plate itself. Find a feature that is easily recognizable and move the stages to position the feature so that it is centered over the horizontal crosshair on the left side of the screen.
2) Move the <u>X stage only</u> until the spot is on the right side of the screen. The spot should still be centered on the horizontal crosshair; if it isn't then you need to adjust the camera alignment. You should check the alignment at both 100% zoom (zoomed in) and 0% (zoomed out).

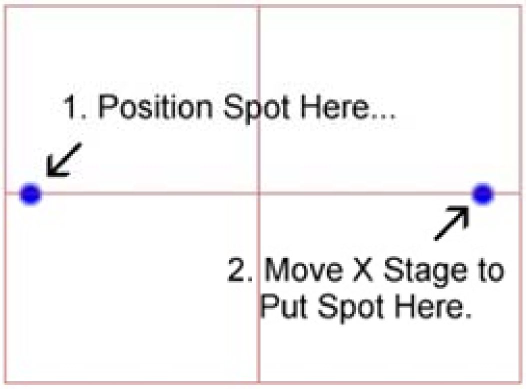


Figure 3-4: Spot alignment

Figure 3-5: Video misaligned

Adjusting Camera Alignment

To adjust the alignment, locate the camera set screws on the sides of the camera.

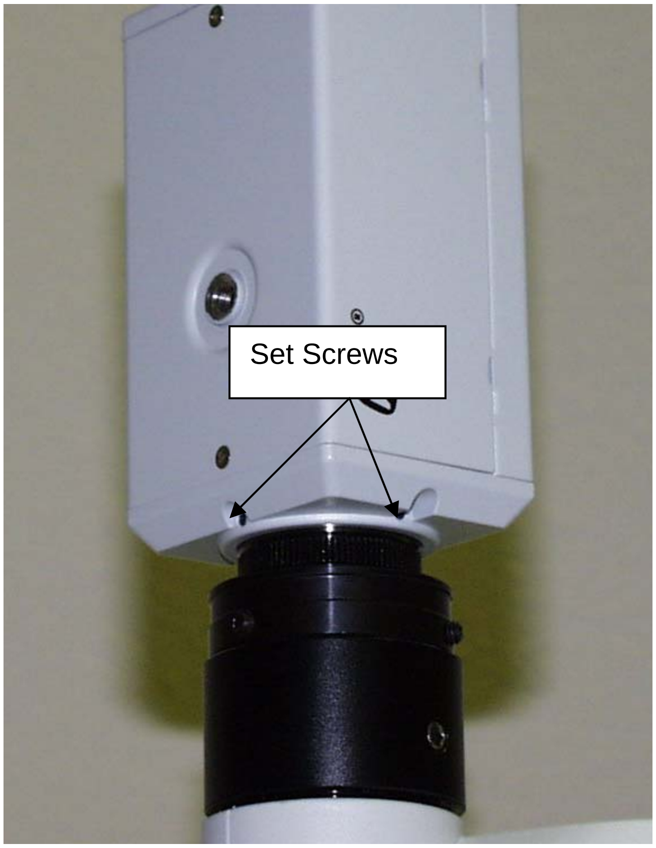


Figure 3-6: Camera set screw

Loosen the set screw slightly (typically about half a turn is enough) -- if you loosen it too much the camera will not be held in place firmly enough, making it difficult to do the alignment. The camera can now be rotated by grabbing onto the body of the camera and twisting it slightly. Repeat the alignment test and make slight adjustments to the camera rotation until the video is aligned.
Re-tighten the set screw, being careful not to let the camera rotate.

Microscope Video Confocal Adjustment

The confocal adjustment is done to insure that the microscope video remains centered on the same position regardless of the zoom position. This adjustment is made at the factory, but you may wish to check it. To check the adjustment, simply focus the microscope on a small feature, then move the stages to center the feature on the video crosshairs, then zoom the microscope in and out and see if the feature remains centered on the crosshairs. If it does not, then you will need to adjust it by adjusting the set screws shown below.

Performing the Adjustment

1) Zoom the microscope all the way in and focus on a small feature. Move the X and Y stages to center the feature on the video crosshairs.
2) Zoom all the way out. If the feature does not remain centered, then center it up by loosening and tightening the adjustment set screws (qty 3) until the feature is centered on the crosshairs. Alternately loosen and tighten the opposing screws to translate the image.
3) Repeat steps 1 and 2, making small adjustments each time, until the crosshairs remain centered on the same location at any zoom level.

Figure 3-7: Confocal Adjustment Screws

Chapter Four

Controls and Operations

Starting the Software

To run the software, make sure the MicroMill is powered on and connected to the computer.

Click Start →Programs →Merchantek EO→ MicroMill icon.
The software will then begin its startup sequence and display the Startup screen.

Startup Screen

The startup screen displays a graphic on the left and the system information panel on the right.

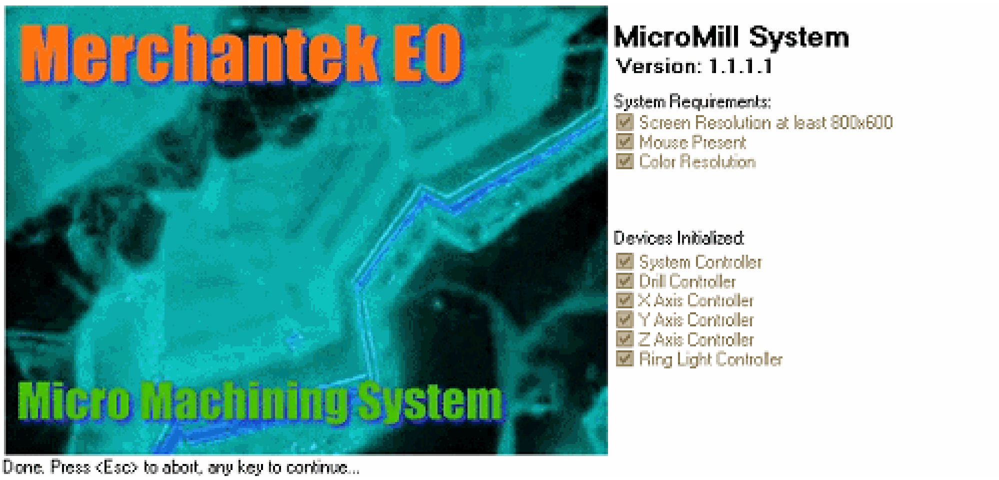


Figure 4-1: Splash Screen

System Information Panel

To the right of the splash screen is the MicroMill information panel. This is a list of required hardware to run the program. If the computer does not meet any of the system requirements, an error message is displayed and the program terminates.

The software must have one serial port to communicate with the MicroMill Sampling System.

Tip

If you encounter an error make sure that any software that might use a serial port is not running. Serial ports are often referred to as COM1, COM2 etc...

Installed Devices Check

After the Splash Screen is displayed, the software will check for attached devices. As each device is found and initialized, the name of the device is displayed.

Following is a list of what the software will search for in the order in which it will search:

1) **System controller.** The System controller communicates what options are installed (light sources, Z axis etc..) This memory is configured at the factory and is non-volatile (it retains its contents even when power is not present).
2) **Stage motor controller**.
3) **Light sources** and any other options.

A check mark will appear in the box to the left of each found device name. If a device fails initialization, an error message is displayed -- the software will continue to run, but that device will be disabled.

Once the system startup sequence is complete, the main program window is displayed.

Setting up the Software

Main Program Window

The main program window is the "home" for most operations in the MicroMill Sampling System software. It is divided into several sections.

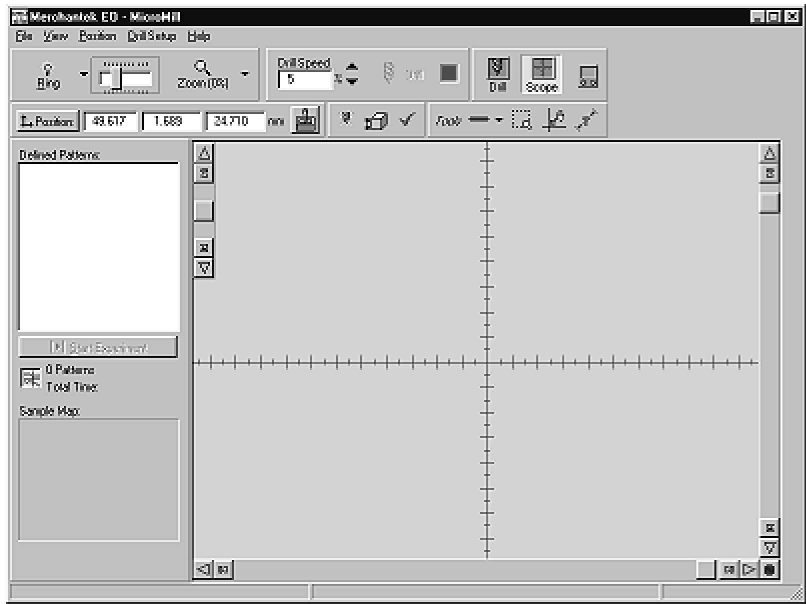


Figure 4-2: Main Program Window

The major elements of the main window are:

- Setup Checklist
- Live Video Display Window
- Light Source Toolbar
- Stage Scroll Bars
- Stage Position Toolbar
- Drill Controls
- Scan Pattern Toolbar

Each of these elements is described in the following sections.

Setup Checklist

To properly position the drill and the sample, define scans and display the video correctly, the MicroMill Sampling System software must know certain information about the hardware. Most of this information is obtained by running special setup and calibration procedures.
Each time you run the software, the Setup Checklist will be displayed in a "floating" window, showing you what system setup procedures have been done. By working through the procedures in the order indicated on the checklist, you know the system is setup properly. To run a procedure, click on the corresponding button in the checklist.

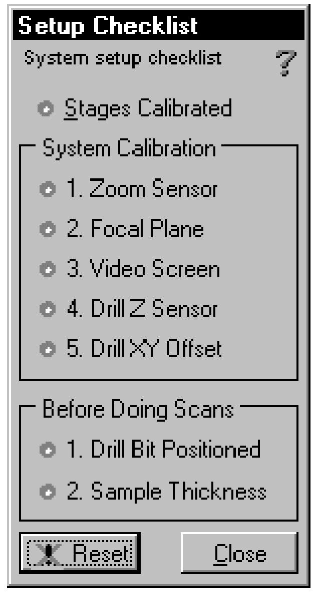


Figure 4-3: Setup Checklist screen

Status Indicators Some procedures only need to be done once; others must be done each time you run the system. An indicator next to each item provides a visual cue of the status of that item. The indicator will show:

- "**Grayed Out" or Disabled** - the procedure cannot be done at this time because the prerequisite procedure has not run.
- **Blue** - the procedure has not been done. Click on the button to activate the procedure.
- **Dark Green** - indicates that the procedure has been done but it is waiting on another procedure to be complete. Some procedures have prerequisites that must be done first -- for example, the stages must be calibrated before the Drill XY offset can be determined.
- **Light Green** - the procedure has been performed, and all dependent procedures are done.

The checklist is divided into sections; each section contains items that are logically grouped together according to when and how often the procedures must be performed. Items in the System Calibration section only need to be performed when:

- The system is first set up
- Something in the hardware has changed
- The system has been subjected to strong vibrations (due to begin transported or knocked over etc...).

Note that the stage calibration procedure is a prerequisite to almost all of the other procedures.

Setup Toolbar

You can also access various system setup options by clicking on buttons in the Setup Toolbar:

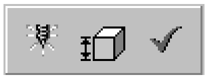


Figure 4-4: Setup Toolbar

The three buttons on the toolbar are, in left-to-right order:

- **Drill Bit Position** button - activates the procedure for loading a new bit, and/or determining the position of the bit tip.
- **Sample Thickness** button - activates the procedure for measuring the sample thickness.
- **Checklist button** - toggles the display of the system checklist on and off.

System Calibration

Some procedures only need to be done when the system is being set up for the first time, or when the hardware has been changed. These are grouped in the System Calibration section of the Setup Checklist:

- **Zoom Sensor** - a sensor mounted inside the microscope used to determine the position of the zoom optics. Used to adjust the graphics on the microscope video display to the proper scale.
- **Focal Plane** - defines the focal plane of the microscope. Used to place the sample in focus under the microscope.
- **Video Screen** - defines the scaling between distance (in pixels) on the microscope video display window and the actual distance (in microns or millimeters) on the sample. The scaling will change depending on the microscope zoom magnification -- the software will automatically adjust for changes in the zoom.
- **Drill Z Sensor** - a sensor mounted on the drill holder that is used to sense when the drill has contacted a surface. This sensor is used to determine the location of the sample surface, and the location of the drill bit tip.
- **Drill XY Offset** - because the drill is mounted off to the side of the microscope, the XY stages need to move a certain amount to adjust for the difference between the centerline of the drill and the center of the microscope view. This distance is used to position the sample for running scans.

Each of these sensors and procedures are explained in detail in the following sections.

Zoom Sensor

For the on-screen live video to display the correct magnification, the position of the zoom knob on the microscope must be known. There is a sensor embedded in the microscope that is used by the program to determine the zoom position -- for this sensor to be accurate it must be calibrated. This is normally done at the factory, but you may want to verify it in case anything moved during shipment. Once done, the calibration should not need to be repeated.

The calibration is done by clicking on the appropriate button in the Setup Checklist, or selecting View –> Calibrate Zoom.

After calibrating the zoom, the video screen should also be calibrated. See Video Calibration Procedure on page 21.

Focal Plane

To position your sample under the microscope so it is in focus, the program must know the thickness of the sample, and the Z position of the microscope focal plane. For calibration purposes, the focal plane is defined as the Z position where the top surface of the sample plate is in best focus (with no sample loaded). For best results, the focal plane should be determined with maximum zoom, when the depth of focus is the smallest.

This figure shows the sample plate positioned at the focal plane:

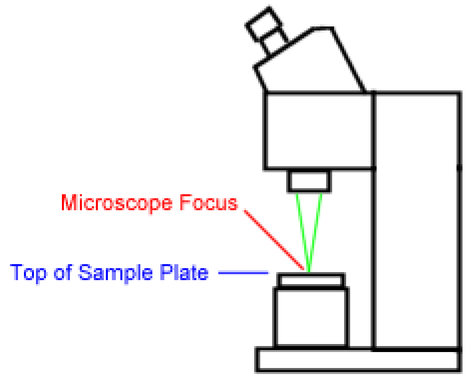


Figure 4-5: Focal Plane

To set the focal plane, click on the appropriate button in the Setup Checklist, or Select Position → Microscope Focal Plane.

When measuring the focal plane, the software waits for you to focus the image, and then records the current Z position.

Interactions

Since the microscope video is off-axis, the distance between the drill axis and the video axis changes as the Z stage moves up and down. Thus, the Drill XY Offset is defined as the distance from the drill axis to the microscope video axis, at the focal plane of the microscope. When scan patterns are defined in the software (by drawing on the screen with the mouse), it is important that the sample be positioned at the focal plane, otherwise, the XY Offset may not be right and the scan will not be milled accurately (there will be a constant offset error).

Video Screen

To accurately place scans and measure distances when viewing the microscope video, the live video display window must be calibrated. The drill view video does not need to be calibrated.

Calibrate the Zoom Sensor First

Before calibrating the screen, make sure that the zoom sensor has been calibrated. See Zoom Sensor on page 19 for details.

Video Calibration Procedure

Activate the screen calibration procedure by selecting View → Calibrate Screen or by right-clicking on the video window:

Figure 4-6: Screen Calibration Wizard

This window will guide you through the process of calibrating the video screen so that the position of the mouse cursor on the screen can be correlated with the position of the sample and motor stages. Because the zoom optics does not typically produce a perfectly linear magnification range, <u>you must do the calibration at all of the preset zoom positions</u> (0, 25, 50, 75 and 100%). The software will interpolate the magnification when the zoom is set at a value between any of the preset positions.

A metal ruler is normally supplied with each system and is used in the calibration procedure. Focus the ruler under the microscope and continue with the following steps.

First, select a zoom position in the Screen Calibration Wizard and then adjust the zoom knob on the microscope to match the selected value. Click Next and the software will automatically switch to the "measuring tool" to measure a distance on the screen.
<u>Without moving the stages</u> click at two different locations on the image in the video window -- <u>you must know the exact distance between these two points</u>! The ruler is useful for this procedure because the lines on the ruler are located a known distance apart.

You will get the best results if you click on points that are as far apart on the video image as possible -- this reduces the error in the calculations since the measurement is made over a longer distance.

Repeat this procedure for each of the preset zoom positions in the Screen Calibration Wizard.

Drill Z Sensor The drill is mounted on a slide that can move up and down vertically. There is an electro-optical sensor mounted on the drill slide that can detect when the drill moves up, such as when the Z-axis is lowered and the drill contacts a hard surface. In this way, the drill is used as a "sensor probe" to determine the Sample Thickness and the Drill Tip Position. The drill must move a finite distance before the sensor can detect the movement; this distance is set at the factory and is typically about 0.5 mm, but must be calibrated to find the exact value. When measuring the offset, the software first records the Z position at which the tip is just making contact with a hard surface, it then moves the Z axis until the sensor is tripped, and then calculates the difference between the two positions to determine the offset.

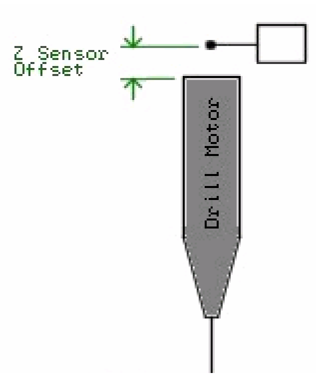


Figure 4-7: Drill Z Sensor

The calibration is initiated by clicking on the appropriate button in the Setup Checklist, or selecting Drill Setup → Calibrate Drill Z Sensor. The software will then guide you through the steps necessary to do the calibration.

Note: it is critical that you initially position the drill so that it is just touching the surface. You can even install the bit in upside down, so that the blunt end is protruding from the drill chuck, and then move the Z-axis down until the bit is just touching a hard surface (an extra sample plate placed on top of the original plate works well). Try sliding the extra plate around and feel for when the bit touches it.

Interactions **This is probably the most critical calibration parameter** because it is used by the software when measuring the Drill Tip Position and the Sample Thickness. Take your time and be very careful when performing this procedure -- you may even want to repeat it a few times and make sure you get the same results (within a micron or two) each time. If the Z Sensor Offset is changed, the Drill Tip Position and Sample Thickness measurements should be updated as well.

Drill XY Offset

The Drill XY Offset is defined as the distance between the drill vertical axis and the microscope video vertical axis at the focal plane. When defining this distance, it is important that the microscope video be focused as accurately as possible. For that reason, it is suggested that the microscope is set at maximum zoom, to reduce the depth of focus and minimize any area of uncertainty when determining the best focus. The software determines the XY Offset by tracking the distance the stages have moved during the measurement procedure – be sure to follow the procedure carefully.

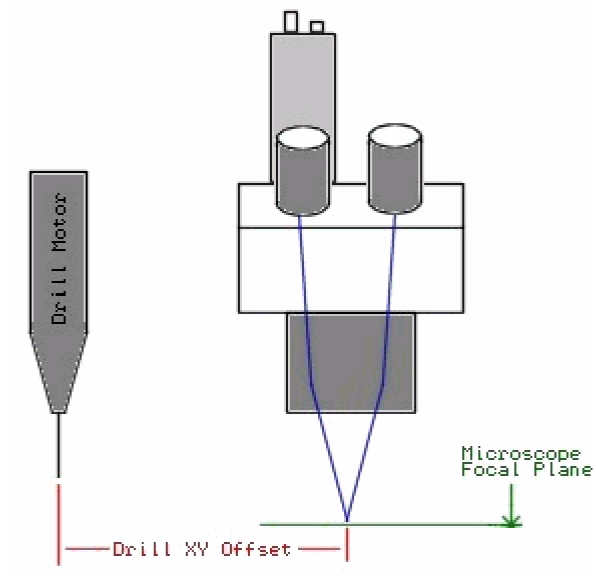


Figure 4-8: Drill XY Offset

Click on the appropriate button in the Setup Checklist, or select Drill Setup →Calibrate Drill XY Offset to initiate the calibration procedure. The program will then guide you through the necessary steps.

Interactions

The software uses the XY Offset to position the drill at the proper location when running mill scan patterns. Since the XY Offset is defined relative to the Microscope Focal Plane, the XY Offset should be double-checked anytime the focal plane has changed.

Running the Software

Video Window

The main program window is dominated by the live video display window, which shows a real-time view of the image from either the video camera mounted on the microscope, or the camera mounted near the drill. When viewing the video from the microscope, crosshairs are overlaid on the video image to designate the drill "aim point". Scan patterns can also be shown overlaid on the video image. Along the edges of video display are the stage scrollbars that can be used to move the sample around.

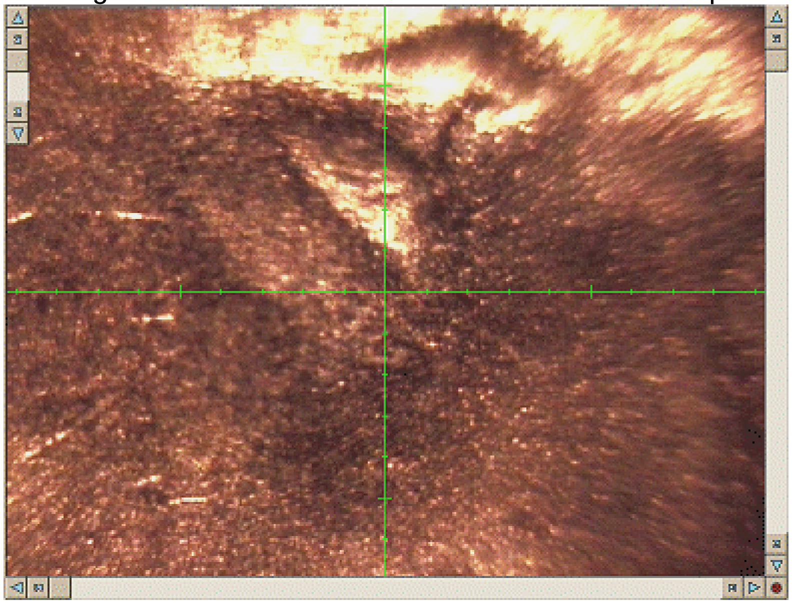


Figure 4-9: Live Video Display

Selecting Drill or Microscope Video

You can select between two different video cameras -- the microscope video or the drill video by using the view selection buttons located above the video window:

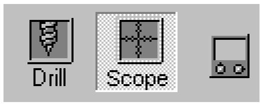


Figure 4-10: Scope icon

When you select either view, the motorized sample slide is moved to place the sample in position under the selected camera.

Zooming the Microscope Video

The magnification of the microscope video is adjusted by turning the zoom knobs on the microscope. This changes the magnification by moving optics inside the microscope. There is a sensor inside the microscope so that the software can read the position of the zoom knobs, and have the video display match the video. The zoom sensor and the video screen must be calibrated when the system is first set up to insure proper operation. See Video Calibration Procedure on page 21 for details.

Panning and Zooming the Drill Video

The drill video camera is not equipped with a zoom lens, but using the image processing capabilities of the video board it is possible to electronically zoom the video. You can adjust the drill video zoom by right-clicking in the video window and selecting the Zoom and Pan menu.

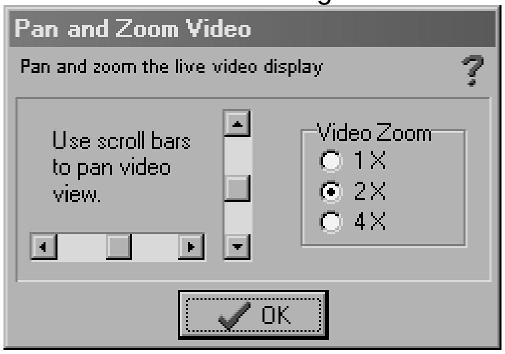


Figure 4-11: Pan and Zoom Video screen

You can select a zoom level of 1X, 2X or 4X, and use the pan controls to center the view.

Note that at the 4X zoom level, the quality of the video image will be degraded due to the effects of the electronic zoom.

Adjusting the Video and Crosshair Display

You can adjust properties such as the brightness of the video display, the colors used to display the cursors and many other properties from the View->Video Properties menu, or by right-clicking the video image.

Saving a Video Image

You can save a copy of the current video image in a file that can be imported into a graphics or word-processing program, or saved for archival purposes. Select File →Save Video Image, enter a file name and click OK. Files can be saved in *Windows* bitmap, TIFF or Targa format. Each image is saved at full resolution to obtain the best quality, so the files can be quite large (about 900KB per image for the bitmap format).

Freezing the Video Image

Sometimes you need to show a stationary image on the video display, such as when capturing a screen image of the program. Because of the way the live video hardware works, if live video is being displayed when you try and capture a screen image, you will not see any live video in the resulting image. If you select View →Freeze Video before capturing the screen image, the live video display will be captured on the screen and will show up in the screen image.

Display Options

The Display Options are accessed from the View menu, or by right-clicking the video window. From here you can customize the appearance of graphics drawn on the video window.

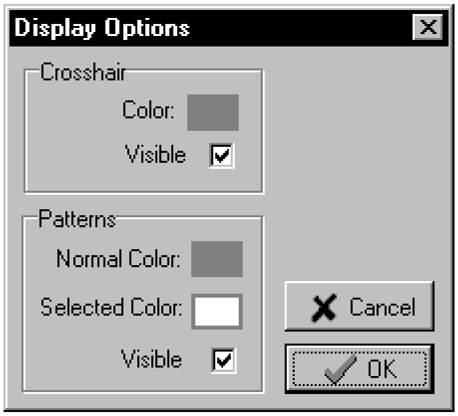


Figure 4-12: Display Options screen

Crosshair Options

Here you can adjust the color of the crosshairs and turn them on and off. Choose a color that contrasts with the sample you are viewing to make the crosshairs easier to see.

Pattern Options

Here you can adjust the color of the scan patterns drawn on the screen and turn them on and off. Choose a color that contrasts with the sample you are viewing to make the patterns easier to see. You also change the width of the line that is used to draw the patterns -- setting it wider will make the patterns easier to see.

Video Display Properties

You can access the Video Display Properties by right-clicking the video window, or from View → Video Properties.

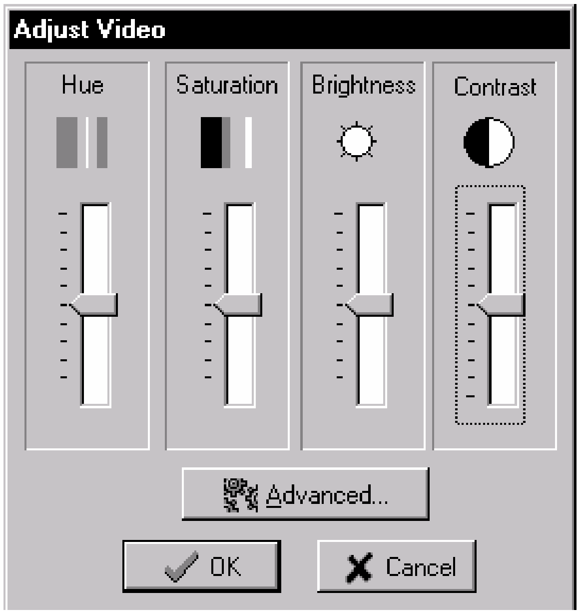


Figure 4-13: Adjust Video screen

Hue Adjusts the red-green color balance of the live video image.

Saturation Adjusts the color saturation of the live video image. Turning the saturation all the way down results in a black and white image.

Brightness Adjusts the brightness of the live video image. Setting this too high can reduce the image quality and produce a "grainy" image.

Contrast Adjusts the contrast of the live video image.

Advanced… Brings up the Advanced Video Properties box.

Light Source Controls The light control toolbar is location in the upper-left area of the main window and is used to control illumination of the sample in the video window.

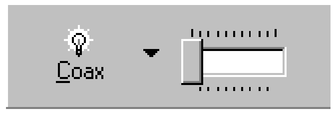


Figure 4-14: Use this slider to control illumination

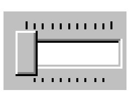
Light Source Selector Click to toggle through the available light sources. Alternately, you can click on the down arrow to display a drop-down menu of light sources.

Figure 4-15: Click to toggle through light sources

The system is normally equipped with the following sources:

- **Reflected** - light comes from a set of bulbs or fibers installed in a circle around the imaging objective and comes down onto the sample at an angle, then bounces back up into the camera. Good for seeing surface structure and texture and uniformly illuminating the sample, but may have some shadows.
- **Transmitted** - light shines up from underneath the sample, through the sample and up into the camera. This only works if the sample is at least partially transparent and is mounted on a transparent substrate.

Illumination Control



This is used to set the light level for the selected source. Move the slider bar to the right to increase the light level.

Using the Stages

You can position the microscope over your sample and focus on the sample surface by controlling three motorized stages that move in the X, Y, and Z axes. When running scans, the software controls all stage movements; otherwise you can control the stage movements by using the Stage Scroll Bars, much like the scroll bars in a word processing program.

If your computer is equipped with a joystick, you can use the joystick to move the stages as well. See Using a Joystick on page 52 in the Appendix for details.

Calibrating the Stages

To know the position of the stages, the system must first perform a calibration procedure on the stages. This is necessary because the stage position is determined as an offset from the location of a limit switch at the stage's "home" position, and until the stages are moved to home position and the limit switch is tripped, the software does not know where the stages are located.

The calibration procedure performs the following steps:

1. The stage is moved at its maximum speed toward the limit switch.
2. When it hits the limit switch, the stage controller electronics stop the motor.
3. The software moves the stage away from the limit switch.
4. The software moves the stage towards the limit switch again, this time at slow speed.
5. When the stage hits the limit switch, the motor is stopped, and the software resets the internal stage position counter to zero.

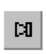
If the stages have not been calibrated, the software will prompt you to calibrate them as soon as you use a feature that requires that the stage position is known.

Stage Scroll Bars

Located along the edges of the Video Window, the stage scroll bars are used to control the movement of the X, Y and Z axis motors to position the sample in the video window.

The X and Y scroll bars are located along the bottom and right sides of the video window respectively, while the Z scroll bar appears in the upper left portion of the video window.

Each scroll bar is made up of several buttons:


Click to move the stage 1 step in the indicated direction. The step size depends on the stage properties and the stage motion multiplier.


Click and hold to move the stage in the indicated direction. The speed at which the stage moves depends on the stage settings and the stage motion multiplier.


Click to stop all the stages.


Click and drag the scroll bar "thumb" to move the stages to the desired position. As you move the scroll thumb, a small window pops up showing you how far (in mm) the stages will move once you let go of the mouse button.

Right-click on a scroll bar to change the Stage Motion Multiplier or to edit the Stage Motion Properties (described in the next section).

Stage Motion Multiplier

When you right-click on a stage scroll bar, you can select a scale factor that is applied to the stage motion parameters when moving the stages manually using the scroll bars or when using the joystick. The scale factor is applied to both the stage step size and the stage jog speed. This allows you to quickly change the jog and step rates without having to edit the stage properties and type in a value.

Example If the stage Jog Speed is set to 100 µm/sec, and the Multiplier is set to

10X, then the stages will move at 1000 µm/sec when the Jog button is held down.

Stage Motion Properties

This is where you set how fast and far the stages move in response to the stage scroll bars. Right click the Stage scroll bars and select Properties to access the properties window or click Position -->XY Stage Properties or Z Stage Properties menus.
The X and Y stages use the same settings, but the Z settings are set separately. In other words, right-clicking on either the X or Y scroll bars will set the properties for <u>both</u> stages, but you must right-click on the Z scroll bar to change its settings.

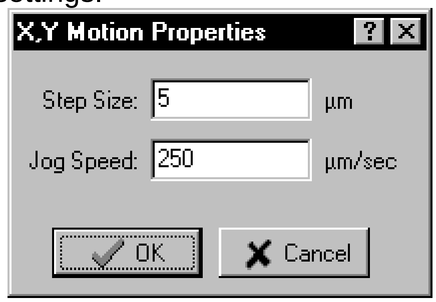


Figure 4-16: X,Y Motion Properties box

Step Size

Sets the amount that the stage moves each time the stage step button is pressed.

> *Note that the step size is multiplied by the current stage motion multiplier.*

Jog Speed

Sets the speed that the stage moves at each time the jog button is pressed.

> *Note that the jog speed is multiplied by the current stage motion scaler.*

Stage Position Toolbar

Displays the current XYZ stage positions, lets you save and recall positions and allows you to change the options for the joystick control. This is located above the live video display on the main window.

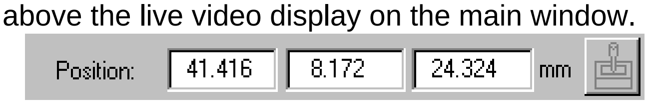


Figure 4-17: Stage Position Toolbar

Position Button

Brings up the Stage Position dialog box -- from there you can save and recall stage positions, and define a new position.

XYZ Position Display

Displays the current position of the X, Y and Z stages in millimeters. If the stages have not been calibrated (homed), then a "?" is displayed. See Calibrating the Stages on page 28 for more info.

Joystick Button

Enables joystick control of the stage if the computer is so equipped. (The joystick and *Windows*-compatible driver required are not supplied by New Wave Research.) See Using a Joystick on page 52 in the Appendix.

Recalling and Saving Stage Positions

Clicking Stage Position Toolbar → Position brings up the Stage Position dialog box. From here you can save and recall stage positions, as well as move to any specified XYZ position. The Stage Position box has two sections, one for defining and saving positions and the other for recalling saved positions.

Defining a New Position

Used to move to a specific set of coordinates, or to save the current position for later use.

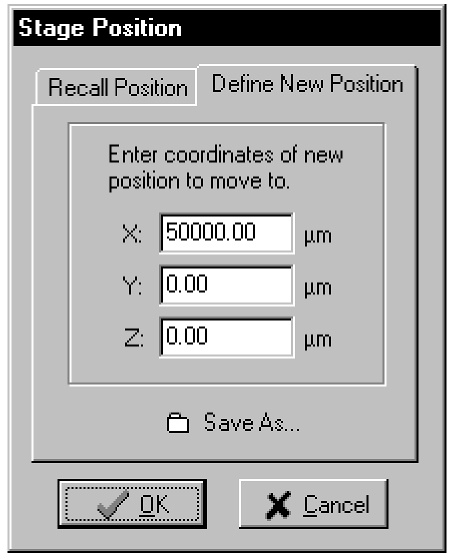


Figure 4-18: Stage Position-Define New Position

When this window is first displayed, the coordinates default to the current stage positions. Enter the coordinates to move the stages to, and then click OK. Click Save As. if you want to store this position for later use.

Recalling a Saved Position

Choose one of the previously saved positions from the list, then press OK to move the stages to that position. If you click on an item in the list of saved positions, a small "hint window" will pop up showing the XYZ positions corresponding to that item. Click OK, and the stages will move to the specified position.

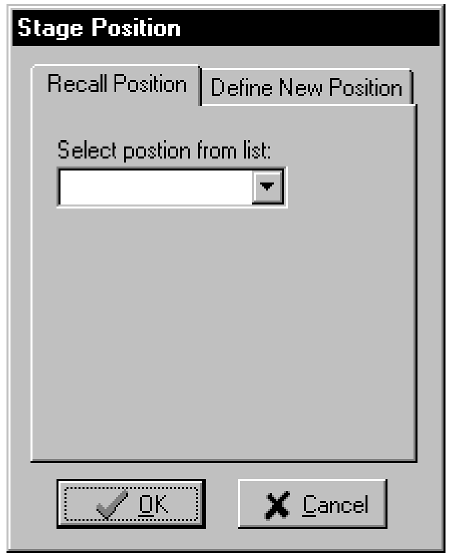


Figure 4-19: Stage Position - Recall Position screen

Position Files

Positions are saved as ASCII text files with a .POS extension in the Data folder. POS files can be edited with any text editor.

Using the Sample Map

A sample map is a composite image of the sample, made up by "stitching together" smaller images to produce a mosaic image of a large area of the sample. It is a powerful way to view and navigate a sample by giving you a "birds-eye" view of the sample, and allowing you to click on a location and have the stages automatically move to that location.

The sample map is displayed on the lower-left side of the main screen -- if no sample map is currently defined, the display area will be blank.

If a map is defined, clicking on the map image will move the stages and center the crosshairs on that location.

Click Sample Map to bring up the Sample Map management window.

Right-click over the sample map display and select the Erase Map menu to clear out the map display.

Creating Sample Maps

Sample maps are built in the Sample Map window. Click View → Sample Map or click on the Sample Map button above the map display area in the main window.

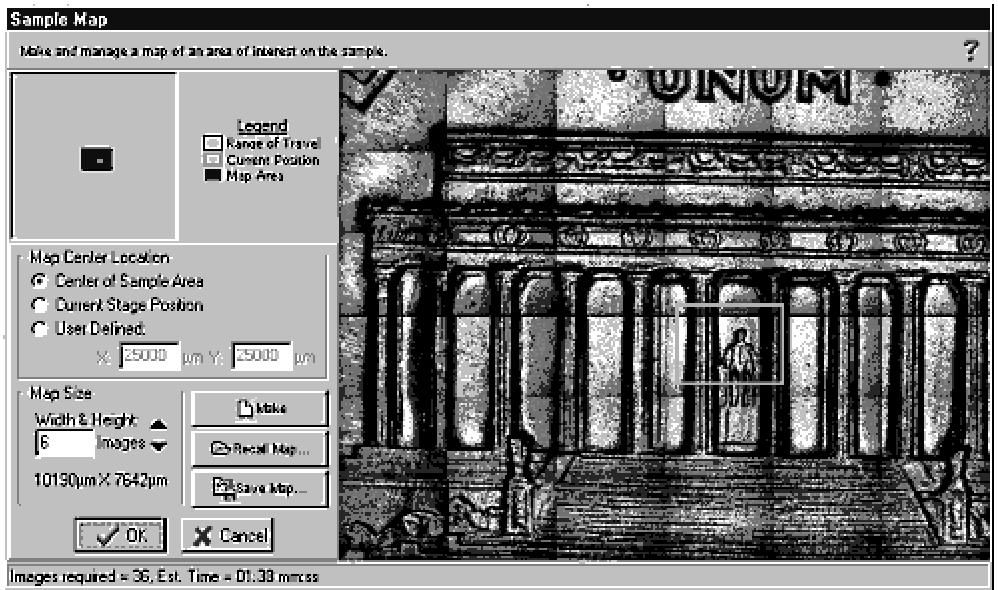


Figure 4-20: Sample Map

The sample map window is where you define how large an area of the sample to map, and where that area is located. You can also save and recall existing maps to and from files on the computer.

Map Positioning Box

Displayed in the upper left area of the Sample Map box are a set of rectangular boxes -- a large area shown in gray, with a smaller blue box inside it. The gray area represents the total area of the range of motion of the XY stages. The smaller blue box represents the current size and location of the area to be mapped. You can drag the blue box around with the mouse to change the location of the sample map, or select one of the predefined map locations described below.

Map Location

The map location is defined by specifying where the map should be centered. There are three options:

- **Centered on the current stage position** - the map will be centered at the current stage position, subject to the constraint that no part of the map can be outside the range of travel for the stages. In the case where a map would be outside the allowed area, the software puts the map as close to the outer edge of the sample as possible.
- **Centered within the Sample Area** - the map will be centered within the area of the total travel of the XY stages. For example, if the stages have 50 mm of travel, the map will be centered at (25, 25).
- **User Defined Location** - the map is centered at some user defined location. You can manually enter values, or drag the blue box in the map preview to the desired location.

Map Size

The size of the sample map is defined in terms of how many images wide and tall it is. The more images that are used to make the map, the larger the area covered will be.

> *Note that the current video zoom setting will affect how large each of the images are -- it is recommended that you make sample maps with the zoom set to 0% so as to cover as large an area as possible.*

As you change the map size, you will see an estimate of how long it will take to make the map displayed in the status line at the bottom of the window.

Making a Map

Before making a map, make sure the size and location of the map are set, the sample is in focus and the illumination level is sufficient, otherwise you will not get a good image. When ready, click Make and wait for the process to complete. While the process is underway, you can click Make again (its caption will have changed to Stop) to stop the process. The status line at the bottom of the window will show the progress of the map build.

Once the process has completed, you can click on the map to move the stages to a location. Click OK to close the map window and the map will be displayed in the sample map box on the main window.

Saving a Map in a File

Sample maps can be saved for reuse. By default, they are saved in the Maps subdirectory of the folder where the program was installed (usually C:/Program Files/Merchantek EO/Laser Ablation/Maps). A sample map is saved as a *Windows* bitmap file (.BMP) and can be pulled into most graphics and word-processing programs.

> *NOTE: Sample maps contain position information encoded into the first few pixels of the image, so if you view the image with another program, you may see some strange colors in the first few pixels -- don't edit these pixels or you will not be able to recall the map into the ablation software.*

Recalling a Map

A map can be recalled and reused. The map is restored at the same X, Y stage position as when it was made, so it is important that the sample be loaded into the sample chamber in the same position as when the map was made.

Installing Drill Bits

In order to accurately set the depth to drill a scan, the system must know the position of the tip of the drill bit. This is done by using the drill Z sensor to determine the Z position of the drill bit.

Click on the appropriate button in the Setup Checklist, the Setup Toolbar or click Drill Setup → Load a New Drill Bit to initiate the load procedure. The program will then guide you through the procedure.

Mounting a Sample

In order to mill a scan on a sample, the samples must be securely mounted to the round sample plate. Typically this is done by removing the plate from the MicroMill Sampling System, melting some wax on it, placing the sample on the melted wax then allowing the wax to cool and harden. The plate can be placed on a hot plate to warm it up. If placed on an aluminum surface or metal table it will cool rapidly.

The sample can also be affixed with hot-glue, double-sticky tape, or any other type of suitable adhesive.

Defining the Sample Thickness

The thickness of the sample is defined as the Z distance from the top surface of the sample holder plate to the top surface of the sample. This value is used by the program to place the surface of the sample at the focus of the microscope/video, and to position the drill at the proper depth when milling. Anytime a new sample is loaded, the thickness must be specified. The surface can be defined two ways:

(1) as a flat surface (one that is parallel to the sample mounting plate), or
(2) as a tilted surface that is tilted at an angle with respect to the sample plate surface.

Flat Surface

A flat surface will have the same Z coordinate (height) at any location on the sample, so all milling will use the same Z position. The height is measured by simply bringing the bit down until it contacts the surface and trips the Z axis sensor.
The program will remember the last value that was entered, so you can accept the default value if you have not changed the sample.

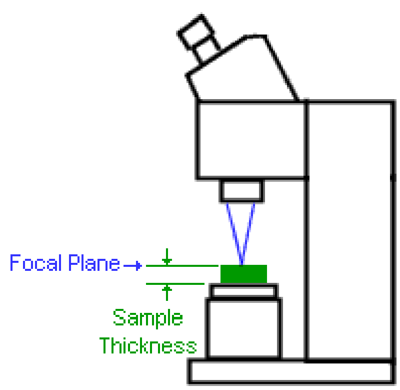


Figure 4-21: Sample Thickness

To specify a thickness, click on the appropriate button in the Setup Checklist, or select Position →Sample Thickness →Flat Surface. The program will allow you to either edit or use the default value, or measure a new value. The MicroMill Sampling System can measure the thickness by positioning the sample under the drill and moving the drill down until the drill Z sensor is activated.

Titled Sample Surface For a tilted surface, the height of the sample varies depending on the XY location. The software models a tilted surface as a plane, tilted about the X and Y axes. Three points are needed to define the plane, and this is done by placing three reference marks on the sample, and then measuring the height of the sample at each point. Click Position → Sample Thickness →Tilted Surface and the software will guide you through the process.

Using the Drill

When not running scans, you can manually run the drill by using the Drill Control Toolbar. From the toolbar, you can set the drill speed and turn it on and off. When scans are being run, the system controls the drill for you, using the settings specified by the scan properties.

Figure 4-22: Defining the drill speed

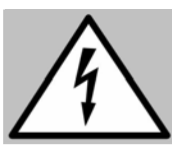
Drill Speed Control Sets the speed of the drill. The drill speed is set in percentage of its maximum speed, 0% = slowest, 100% = fastest. This control is only active while manually drilling. When running scans, the drill speed is controlled by the scan pattern properties.

Drill On/Off Button Turns the drill on and off when in manual mode. When running scans, the drill is automatically controlled.

Interlock Indicator Indicator that lights up red when one of the safety interlocks is tripped. Click on the indicator to display the Interlock Failure Window to see more detailed information.

Safety Interlocks

Because the drill and motorized stages can be dangerous to the operator or can be damaged if not operated under proper conditions, the MicroMill Sampling System is equipped with a set of safety interlocks. The software continuously monitors all interlocks and will take the appropriate action when an interlock is tripped. When this happens, an Interlock indicator on the Drill Control toolbar will turn red -- click on the indicator to bring up the Interlock Failure window:



Never defeat an interlock and continue working with the MicroMill Sampling System. Defeating any safety interlock and continuing to operate this tool may cause severe personal injury or may damage the system.

Figure 4-23: Failed Interlock screen

The indicator lights on the left will light up to show which interlocks have been tripped. When an interlock is tripped, the software will automatically take the appropriate action to insure that the system remains in a safe condition -- often this means shutting down the drill, or stopping the stages. Following is a list of the interlocks with a description of why the interlock is tripped and how the drill will respond:

Sample Slide Interlock

Cause: The sliding stage that the sample is mounted on is not in the Drill position (all the way to the left). It is normal for this interlock to be activated when the sample is in the microscope view position.
Result: The drill is disabled. The video view is switched to the microscope when the slide is not in the Drill position, and is switched back to the drill video when the slide is returned to the Drill position.

Drill Overload Interlock

Cause: The drill motor current limit has been exceeded.
Result: The drill is disabled.

Drill Z Sensor Interlock

Cause: The drill has moved up (vertically) due to pressure on the bit.
Result: The drill is disabled.

Stop Button Interlock

Cause: The Stop button (on the front of the MicroMill Sampling System) has been pressed.
Result: The drill and stages are disabled.
Click Interlock Failure → Stop indicator to clear the indicator and re-enable the stages and drill.

Placing Scans

Once the system is calibrated, a sample is mounted and the sample thickness is defined, you are ready to place scans.

1) Position a sample under the microscope by selecting the microscope video view -- the sample slider should be all the way to the right if it isn't already:

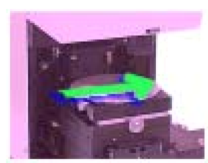


Figure 4-24: Placing scans

2) Select the proper tool from the scan toolbar. You can right-click on the scan toolbar button and set the default properties (speed, depth etc.) for the patterns you are about to place.
3) Click on the video image of the sample and define the endpoints of the scan. As you place scans, they are added to the scan pattern list, which is displayed just to the left of the video image. You can right-click on any pattern in the list to edit its properties, or press the Properties button below the list.

Some scans, such as lines and rasters, require you to define multiple endpoints. You can press Escape or right mouse to end placing a scan -- if enough endpoints have been defined, then the scan is added to the list.

Line scans can have a virtually unlimited number of endpoints -- each set of endpoints defines a line segment. Every time you click, a new endpoint is defined; press Escape, or right click to end the current line.

Scan Toolbar

The Scan Toolbar contains the "tools" you use to place and manipulate scans. When a tool is selected, its corresponding button will appear depressed on the toolbar, and the mouse cursor will change to reflect the tool selection as well. (The mouse cursor will only be changed while the mouse is over the live video window).

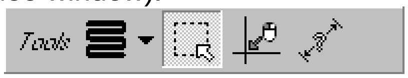
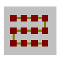


Figure 4-25: Scan Toolbar

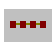
Scan Pattern Tool

Selects which type of pattern will be created. You select the type of pattern by clicking on the small down arrow and choosing from the list that appears. The following scan patterns are available:


Raster Scan - a rectangular area with rows of horizontal lines through it. The vertical spacing between the lines is adjustable. During milling, the drill will follow the path of the lines.


Grid of Spots - a rectangular area with sets of spots arranged in rows and columns. The spacing between the rows and columns is adjustable. During milling, the drill will move to each spot location and drill for a specified amount of time.


Line - one of more connected line segments.


Line of Spots - spots placed along a line segment at a specified spacing. During milling, the drill will move to each spot location and drill for a specified amount of time.


Spot - a single spot location. The drill will move to the spot and drill for the specified amount of time.


Reference Point - used to mark a reference location on the sample. No milling will take place at the reference point. Reference points are used primarily for locating landmarks when doing recoordination. See Recoordinating Scan Positions on page 41 for details.

Setting the Default Scan Properties

Right-click Scan Pattern tool to edit the default properties for new scans -- any new scans you lay down will then use these properties.

Selection Tool

Used to select a pattern or a group of patterns for editing. You can also use the selection tool to click and drag entire patterns or just single endpoints. This tool has several different modes that are explained in detail in Selecting and Dragging Scans on page 38. When a scan is selected it is drawn in a different color on the video window, and is shown highlighted in the Scan Pattern List.

Centering Tool

Used to center a location on the video screen. Click on a location in the video window and the stages will move to bring that point to the center of the window, aligned with the crosshairs.

Measuring Tool

Used to measure distances on the screen. Click on two locations in the video window and the distance between them will be shown in the status line at the bottom of the screen.

Selecting and Dragging Scans

After you have placed a scan, you can delete it, cut and paste it or drag it to a new position using Scan Toolbar → Scan Selection tool. The selection tool is quite powerful and has several modes of operation -- the mouse cursor will change to indicate which mode is active. Its behavior is based on the way similar tools behave in graphics and CAD programs.

When a scan is selected, it is drawn on the video window in a different color, and is highlighted in the Scan Patter List on the left side of the screen.

Selecting an Entire Scan

There are two ways to select an entire scan -- you can click directly on the scan (anywhere but at an endpoint), or you can click to define a rectangle around an area to select any patterns that are completely inside that area.

If you want to select more than one scan, SHIFT + click-- any patterns that are already selected will remain so, and any newly selected patterns will be highlighted. If you do not hold down the SHIFT key, any patterns previously selected will be unselected and only the newly selected patterns will be highlighted.

Dragging a Scan

Click and drag a scans borderline (anywhere BUT an endpoint) to a new position to move the scan. The cursor will change to a hand as you are dragging the scan. Holding the Shift key and dragging will choose all the scans.
When scans are dragged, only their X and Y coordinates are changed, the Z positions stay the same.

Note that you can also use the Translate/Rotate menu (accessed from the Scan Pattern List) to move scans around by a specific amount.

Dragging an Endpoint

Click and drag an endpoint to a new position.
When you drag an endpoint, its XY position is changed to the new position, and <u>the Z coordinate is changed to the current Z axis position</u>. This allows you to move endpoints "up and down" in Z by moving the Z axis up or down and dragging the endpoint.

You can also click Scan Pattern List → Edit Endpoints menu to change the positions of an endpoint.

Cut, Copy and Paste Scans If you have a scan selected, right-click in the video window to access the Cut, Copy and Paste menus.

Copy Scans Right-click in the video window and select the Copy menu to put a copy of all selected scan patterns into the copy buffer. No scans are removed from the display.

Cut (Delete) Scans Cut will delete all selected scans from the display and place them in the copy buffer.

Paste Scans Paste will place a copy of each scan in the copy buffer on the display, at the current mouse position. You can use paste multiple times to make as many copies of a scan (or scans) as you wish -- the copy buffer is not emptied until the program is terminated, so once a pattern is in the buffer, it stays there.

Saving and Recalling Scans Scans can be saved in files for archival use and reuse. You can also recall saved scans and import scans from other file formats.

File Formats

Scans can be saved and recalled in two formats:

- **MicroMill Experiments Files (.MME)** - a binary file format that is small, fast and saves all the scan locations and parameters. This format cannot be read by other programs, but is the most efficient way to save scans.
- **ASCII Text Files** - a special text format which can save the type and location of the scans, but not the scan properties. ASCII files can be edited with most any word processing program or editor. See the ASCII File Format on page 50 in the Appendix for details.

In addition, scans can be imported from DXF files.

Saving Files Click File → Save Experiment to save scans. You can choose to save files in either MME or ASCII format. By default, experiments are saved in the C:/Program Files/Merchantek EO/MicroMill/Data directory.

Recalling Files Select File → Open Experiment to read in scans from a file. Any scans read in will be added to those already defined, thus allowing you to "merge" scans saved in multiple files. If you want to get rid of all currently defined scans, select *New Experiment* from the *File* menu.

Recoordinating Scan Positions See Recoordinating Scan Positions on page 39 for details on how to make imported data line match up with the sample.

Manipulating Scans Click Options (located just below the Scan Patterns list) to access a set of menus that can be used to move and duplicate scans.

Duplicating Scans Click Duplicate Scans to make multiple copies of each selected scan pattern (selected scans are highlighted in the list and on the video window). You can specify how many copies to make, and how far apart to space them. Each copy will be offset from the original scan by the specified distance.

Translating and Rotating Scans Click Translate/Rotate Scans to move all selected scans by a specified distance, or rotate them a certain angle. You can specify whether to do the translation first or the rotation first.

Editing Endpoints Click Edit Endpoints to edit the XYZ coordinates of the individual endpoints of a scan. A small calculator icon appears in the lower-left corner of the Edit Endpoints dialog box -- click on a coordinate value, then click on the calculator icon to activate a pop-up calculator window that lets you easily perform mathematical operations on the value. Click the check mark on the calculator and the result will be entered in the endpoint coordinate.

Interpolating Between Scans Another way of creating scans is to select two existing line scans and have the software generate a set of new scans, equally spaced between the original scans. This is explained in detail in the next section.

Interpolating Between Scans

You can define a set of new scans which are equally spaced between two sets of line scans by selecting <u>two</u> line scan patterns from the Scan Pattern List, and then right-click, or click Options → Interpolate Between Scans menu. <u>The two selected scans must be line scans with the same number of segments.</u> The following screen will be displayed:

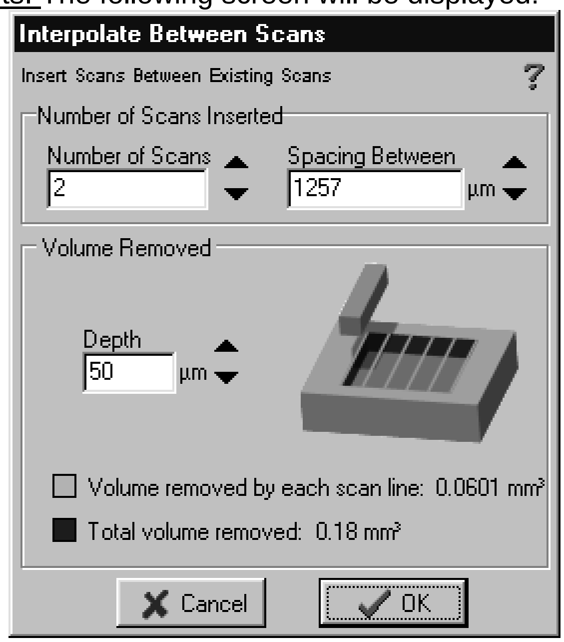


Figure 4-26: Interpolate Between Scans

Number and Spacing of Interpolated Scans There are two ways of defining how many scan lines are generated when interpolating between existing scans. You can either specify how many scans are to be made, or you can specify the maximum spacing between the scans, in which case the program will then calculate the number of scans for you.

Depth of Interpolated Scans Sets the drilling depth for the interpolated scans. It also sets the depth of the original scans (the ones enclosing the interpolated scans). This number will affect the calculation of the volume removed.

Volume Removed The volume removed calculation assumes that the interpolation function is used to remove all of the material between the two original scan lines to the depth of those lines. Based on this assumption, two numbers are displayed:

- Volume Removed by each Scan Line – This calculation divides the total volume between the original two scan lines by the total number of scan lines programmed and does not take into account overlap between adjacent scan lines. It is a function of scan geometry, drill depth and the interpolated line spacing.
- Total Volume Removed – This calculation displays the total volume between the original two scan lines. It is a function of scan geometry and drill depth. The actual volume removed will exceed the calculated figure by the volume of one scan line since the calculation doesn't take into account the width of the drill bit.

In both of these calculations, factors like the shape and size of the drill bit, and overlap between scans are not considered.

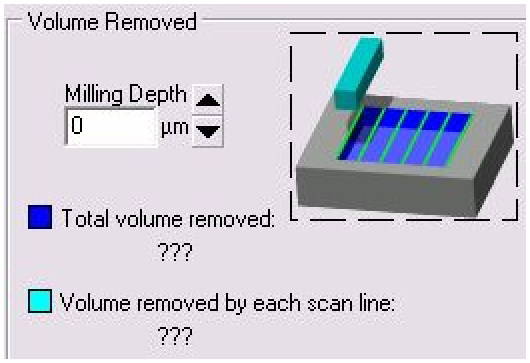


Figure 4-27: Volume Removed

Recoordinating Scans Often when recalling saved scans, or importing scans from another source, you will want to "recoordinate" the data so that it matches up with the proper locations on the sample.

Scan Recoordination allows you to recall previously saved scan patterns and position them in their original location on the sample surface, even if the sample has been rotated or mounted in a different location. Recalled files can be either MicroMill Experiment files (.MME) or ASCII format files. Recoordination relies on reference points that must be included in the file being recalled. In addition, you must be able to move the stages and center the crosshairs on the locations on the sample where the reference points where originally placed. For this reason, you should place your reference points on easily recognizable "landmarks" or features on the sample.

The recoordination procedure will prompt you to move the crosshairs to the landmark locations on the sample that corresponds to each of the reference points. Then by comparing the original location of the reference points (as stored in the file) with the new location of the reference points, the scans can be "recoordinated" and moved to their new locations.

There are two types of recoordination are supported - 2D and 3D.

Two Dimensional (2D) Recoordination

2D recoordination will correct for any rotation and/or translation of the sample since the points were originally saved. Only 2 reference points are required.

Three Dimensional (3D) Recoordination

3D recoordination will correct for rotation, translation AND tilting of the sample. It requires 3 reference points, and the three points must NOT be collinear (in a line). It also requires that you focus precisely on each location in order to accurately determine the Z position -- for this reason it is recommended that you set the video view to maximum zoom when focusing since the depth of focus is less when zoomed in.

The Scan Pattern List

Located on the left side of the main program window, the Scan Pattern List displays a listing of all the currently defined patterns. Below the list are a set of buttons that are used to access various options for manipulating the scans

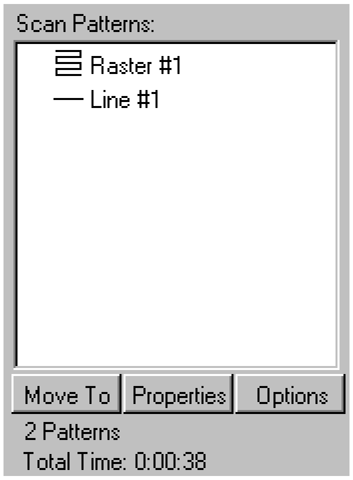


Figure 4-28: Scan Patterns Screen

Each scan is shown in the list with a small icon next to it indicating the type of the scan pattern (raster, line etc.). Each scan is also labeled with a name and number - you can rename any of the scans by right-clicking on the scan list and selecting Rename.

Following are actions you can perform:

- Click on an item to select it. The item will be highlighted in the list, and it will be displayed in a different color in the video window.
- Hold down the SHIFT key and click on an item to select a range of patterns.
- Hold down the CTRL key and click the individual pattern(s) you want to select.

- Press Delete to delete the selected patterns.
- Right click, or click Options button to access the Scan Pattern Options menu for the selected patterns.

Move To — This will move the stages so that the crosshairs are centered on the selected pattern. If more than one pattern is selected in the list, then the stages are moved to the first selected one.

Properties Button — This allows access to the pattern properties edit box -- from here you can set the scan parameters for the selected scan or scans. Parameters such as the stage speed, the output level and spot size all set from here. See Setting the Default Scan Properties on page 37 for more details.

Options Button — Displays a menu of options for manipulating the selected pattern(s). There are options for duplicating scans, translating/rotating scans and more.

Scan Properties — You can access the Scan Properties edit box by right-clicking on the Scan Pattern List box and selecting Properties, or clicking Properties (located underneath the Pattern List). From here you set the parameters that will be used when running scans. Each individual scan pattern has its own copy of the scan properties, so you can have different settings for each scan.

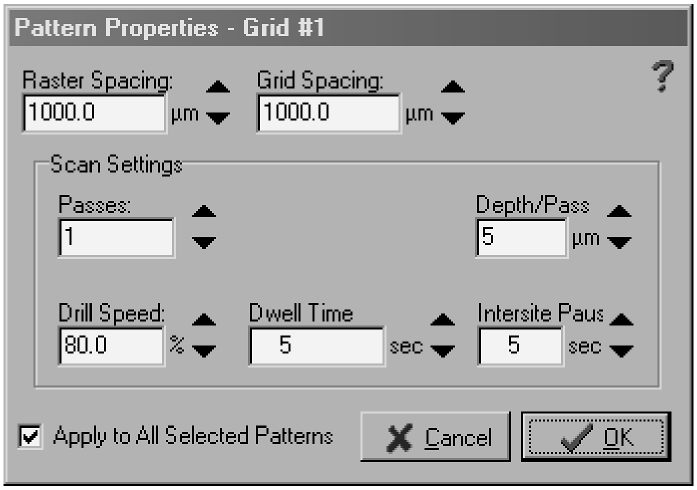


Figure 4-29: Pattern Properties - Grid #1

The exact options that are shown in the properties box depends on the type of scan selected -- for instance, Raster Spacing only applies to raster scans.

Grid Spacing, Raster Spacing	Applies to Rasters, Grid of Spots and Line of Spots. When setting the properties for a Raster or a Grid of Spots, you can adjust the Y axis spacing between rows of spots or lines by changing the raster spacing. If you are setting the properties for a Grid of Spots, or a Line of Spots, then you can adjust the X axis spacing between spots with the Grid Spacing property. Changing the spacing will change the number of lines or spots that will be milled.
Number of Passes, Depth per Pass	Sets how many times the drill will traverse over the pattern. If set to more than one, the drill will reverse when the drill and traverse back over the pattern in the opposite direction. If the Depth per Pass setting is not 0 (zero), then the Z axis will also be moved down by the specified amount at the end of each pass. This is useful for "drilling" down into a sample by removing a layer of material on each pass.
Scan Speed	Applies to Rasters and Line scans only. Sets the speed at which the stages will move while milling.
Dwell Time	Applies to Spots, Grid of Spots and Line of Spots only. Sets how long in seconds the drill will be on at each spot.
Drill Speed	The sets the drill speed that will be used when running the scan. You may need to experiment with different drill and scan speeds to find out what works best for a given material.
Applying Properties to Multiple Scan Patterns	If more than one scan is selected in the Scan Pattern List, then you can apply the current scan properties to ALL the selected scans by checking the Apply to All Selected Scans box. All the current scan properties will then be copied to all the selected scans.

Running Scans

Once a set of scan patterns are placed, you can click Run Scans to start a sample run. While scans are being run, the stages and the drill are under computer control and will use the parameters that you've set up in the scan properties. The system will continue to monitor the safety interlocks, so should one be tripped, the scan run will be aborted and the drill and stages will be shut down. You can also press the Stop button on the front of the MicroMill Sampling System at any time to shut down the drill and abort a scan.

When you click Run Scans, a dialog box will appear with a set of options for controlling the scan run:

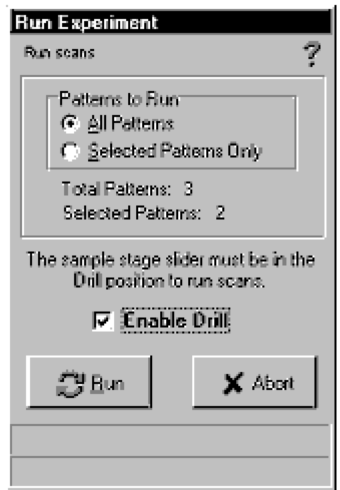


Figure 4-30: Run Experiments Screen

Patterns to Run

You can choose to run all defined patterns, or only the ones which are selected (selected patterns are drawn on the screen in a different color and are highlighted in the Scan Pattern List). See Selecting and Dragging Scans on page 38 for more details.

Enable Drill During Scans

Check this box to enable running the drill when running scans. If this box is unchecked, then the system will go through all the stage movements when running the scans, but the drill will remain inactive. This is useful for double-checking the scan setups before actually milling.

Run and Abort Buttons

Click Run to start a sample run, click Abort to stop. While a run is in progress you will be unable to use the software to control the drill or stages, and if a joystick control is installed, it will be disabled. Once the sample run is complete, or you end it by pressing the Abort button, control will be returned to you.

Chapter Five

Maintenance and Troubleshooting

There are no Maintenance or Troubleshooting instructions.

Chapter Six

Appendices

ASCII File Format The ASCII file format is useful for importing scan positions to and from other programs, such as spreadsheets or digitizers. ASCII files only store the type and position information of the scans -- the scan properties are not stored, so you will need to set those manually.

> *Note: When importing ASCII files, the current default scan settings are used. See Scan Toolbar for instructions on setting the default properties.*

Format Details The file format consists of multiple lines of ASCII text, each line terminated with a carriage return and/or line feed character. The file can contain data on many different scans; each scan is defined by a header line, and then is followed by one or more lines and endpoint data.

<SCAN TYPE HEADER>
X, Y, Z
X, Y, Z
" " "
" " "
X, Y, Z

Where
SCAN TYPE HEADER - indicates the type of scan.
X, Y, Z - coordinates of endpoints*, separated by commas; all values in **millimeters**.

> **NOTE: The Z coordinate is optional and need not be present. If no Z is specified, then the system will use the current Z stage position.*

Scan Type Header

Several different scan types are supported:

Scan Type Description
- **REF** Reference Point, each one has one endpoint.
- **LINE** Line, can have from 2 to 5000 endpoints.
- **RASTER** Raster pattern, each one has 2 endpoints -- the upper-left and lower-right corners.
- **SPOTGRID** Grid of spots over a rectangular area, each one has 2 endpoints -- the upper-left and lower-right corners.
- **SPOTLINE** Line of spots, has from 2 to 5000 endpoints.
- **SPOT** Single spot, each one has one endpoint.

You do not need to have a header for each new scan. You can define multiple scans by including more than the normal number of vertices under one scan header. For instance, by including 4 sets of vertices under one REF header, 4 separate Reference Points will be defined.

Table 6-1: Scan line example

Example: The following is an example containing a line scan (with 5 segments with 6 endpoints), a raster, and 2 reference points.

```
LINE
31.750,12.255
36.496,12.255
36.496,13.217
31.750,13.217
31.750,14.825
36.238,14.825

RASTER
31.492,16.945
36.109,16.945

REF
36.109,16.945
35.000,20.002
```

Using a Joystick

A joystick can be used to control various parts of the MicroMill Sampling System, such as stage motion and illumination level. The joystick can be configured within the software to customize the joystick controls -- you can assign different joystick buttons to different actions, and specify what happens when the joystick is moved.

System Requirements

To use a joystick, it must be connected to the computer system and have a *Windows*-compatible driver installed. Joysticks are typically attached to the computer's game port, but can also be connected to a serial port, USB or other interface. Refer to your joystick manufacturer's instructions for information on how to install a joystick.

> *Note: The software relies on the Windows joystick driver. The joystick must be installed and calibrated from the Windows control panel or it will not work properly.*

When the MicroMill Sampling System software recognizes that a joystick is installed, a button will appear on the Stage Position Toolbar:

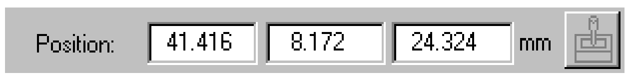


Figure 6-1: Joystick Recognition

If you do not see this button, the joystick driver is not installed, or the joystick is not connected properly.

Enabling the Joystick

For safety reasons, the MicroMill Sampling System software starts up with joystick disabled -- you need to explicitly enable it by choosing Stage Position Toolbar → joystick. The button will appear depressed when the joystick is enabled.

Configuring the Joystick

If you right-click on the joystick button in the stage position toolbar, a dialog box will appear allowing you to customize the joystick settings:

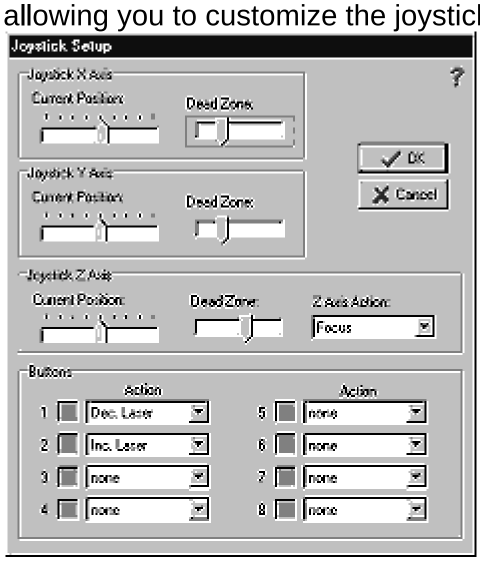


Figure 6-2: Joystick Setup Screen

Joystick XYZ Axis Setup

If your joystick only has two axes (X and Y), then the Z axis controls will be disabled. There are two slider bars displayed for each axis:

- **Current Position** - shows the current position of the joystick axis.
- **Dead Zone** - This adjusts the sensitivity of the joystick. If the Current Position indicator is jittering, then slide this adjuster to the right until the jitter is eliminated.

Z Axis Action

The X and Y axes can only be used to control the X and Y stages. However, the Z axis can be configured to control one of the following:

- **Focus** - moving the joystick Z axis moves the focus (Z stage) up and down.
- **Light Level** - moving the joystick Z axis adjusts the output of the current active light source.
- **Drill Speed** - moving the joystick Z axis adjusts the drill speed.
- **None** - moving the joystick Z axis has no effect.

Joystick Buttons

Up to 8 joystick buttons can be used to control various options. Each button can be mapped to a different action. The available options are:

- **Jog Z Down** - the Z axis stage (focus) is moved in the down direction for as long as the button is held down.
- **Jog Z Up** - the Z axis stage (focus) is moved in the up direction for as long as the button is held down.
- **Dec. Light** - the current light source output is decreased for as long as the button is held down.
- **Inc. Light** - the current light source output is increased for as long as the button is held down.
- **Drill On/Off** - toggles the drill on and off.
- **Place Scan** - places a scan endpoint at the current crosshair location. You must have a scan placement tool selected.

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