DigiScan

User's Guide

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Gatan, Inc.

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Contents

List of Figures

Preface

About this Manual

This *DigiScan User's Guide* provides information and procedures for operating the software that controls the Gatan 688 DigiScan and the Gatan 788 DigiScan II. Hardware setup and specifications for the 788 are described in the *DigiScan II Owner's Manual*.

The following typographical conventions are used for special comments:

NOTE: Used to highlight advice directed at getting the best performance from the equipment.

> ❗ Caution: Precautionary notes and advice to avoid personal injury or damage to the equipment.

The *DigiScan User's Guide* consists of the following chapters and appendices:

Chapter 1, "Getting Started", briefly describes how the DigiScan software works, and how it interacts with the rest of the Gatan Microscopy Suite.

Chapter 2, "Setting Up the DigiScan", describes the initial settings required for optimal use of the equipment.

Chapter 3, "Operating the DigiScan", provides detailed operating procedures and examples.

"Appendix A: Glossary" is a list of terms specific to the DigiScan, and their definitions.

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1. *Getting Started*

1.1   Software Overview

The DigiScan software is a plug-in module for the Digital Micrograph software, the centerpiece of the Gatan Microscopy Suite, that allows operation of the DigiScan controller with most current SEM or STEM units. With the DigiScan hardware and software system, operators have a great deal of flexibility in capturing, displaying, and processing images from the microscope's scan generator. The DigiScan can acquire images up to 8192 x 8192 pixels.

NOTE: Refer to the DigiScan II Owner's Manual for instructions on setting up the 788 hardware.

A typical high-level sequence of steps for operating the DigiScan software might include the following.

1. Check and enter setup parameters using the Setup button and its dialog box.

2. Start an acquisition using the Search button to frame a specimen area and focus the image.

3. Adjust pixel time and rotation as needed.

4. Fine tune focus and signal intensity using the Preview button.

5. Capture an image using the Record button.

6. If desired, save an image on the computer using the File option on the main menu bar of the Digital Micrograph software.

7. If desired, manipulate or process the image using standard tools of the Digital Micrograph software.

1.2   Installing the Software

The following items must have been installed, to operate the DigiScan system:

l   Gatan Microscopy Suite Installation CD, version 1.4 or later

l   Gatan Software License CD

The program CD contains a file titled *GMS installation guide.pdf*. This document can be read with Adobe Acrobat Reader, available on the program CD and from www.adobe.com.

1.3   Starting the Software

To start the system, check that the DigiScan controller is powered on. In the case of the 788 if the power is off, the Digital Micrograph software will display an alert indicating that power is off.

If the DigiScan software plug-in is installed correctly, a display appears similar to Figure 1-1.
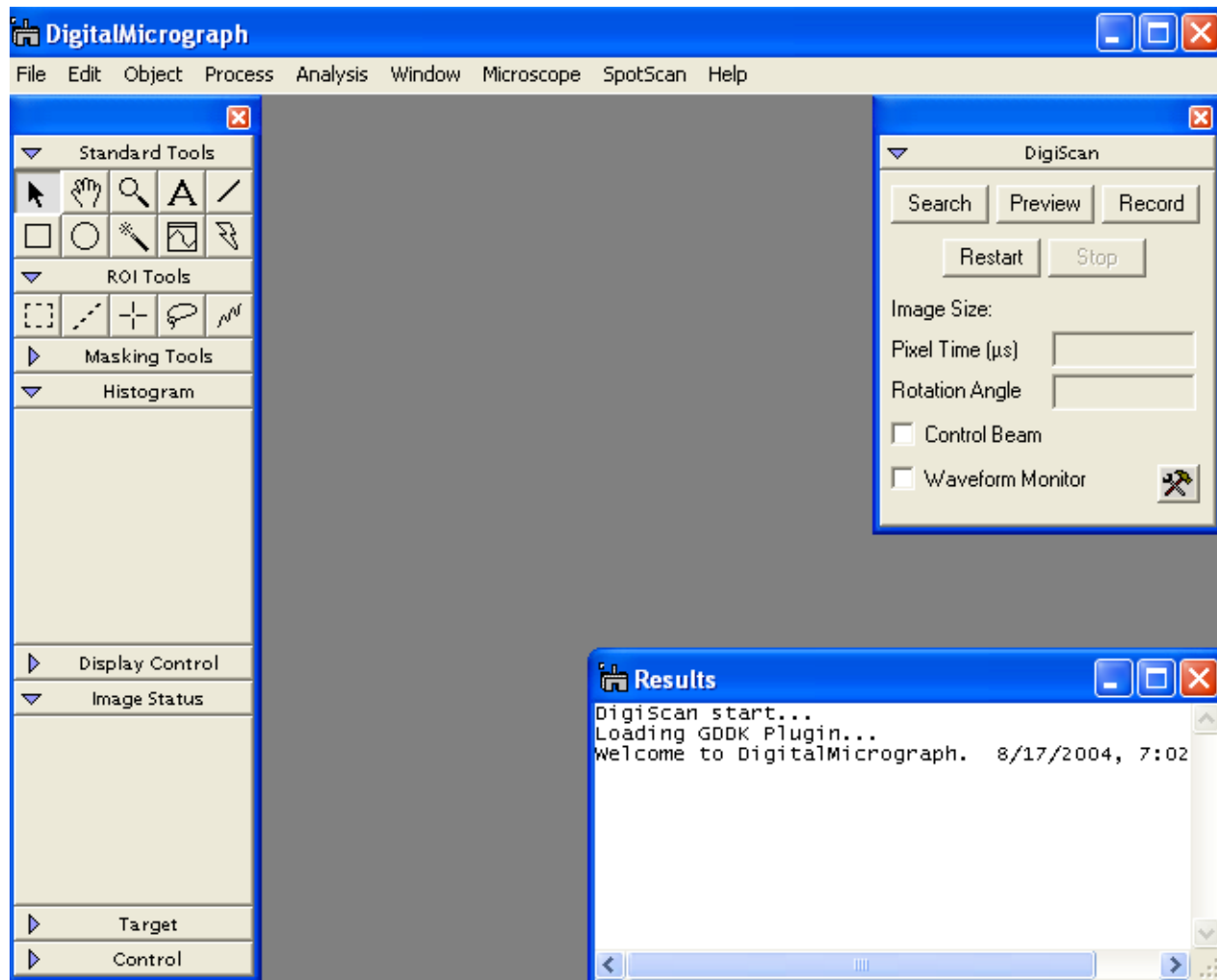
Figure 1-1   Digital Micrograph Software Main Window with DigiScan Installed

The DigiScan dialog box may appear in the upper right, or it may be attached to other floating windows on the right. If the DigiScan main dialog box does not

appear, select Floating Windows from Window on the main menu bar, and choose DigiScan from the available options (see Figure 1-2).
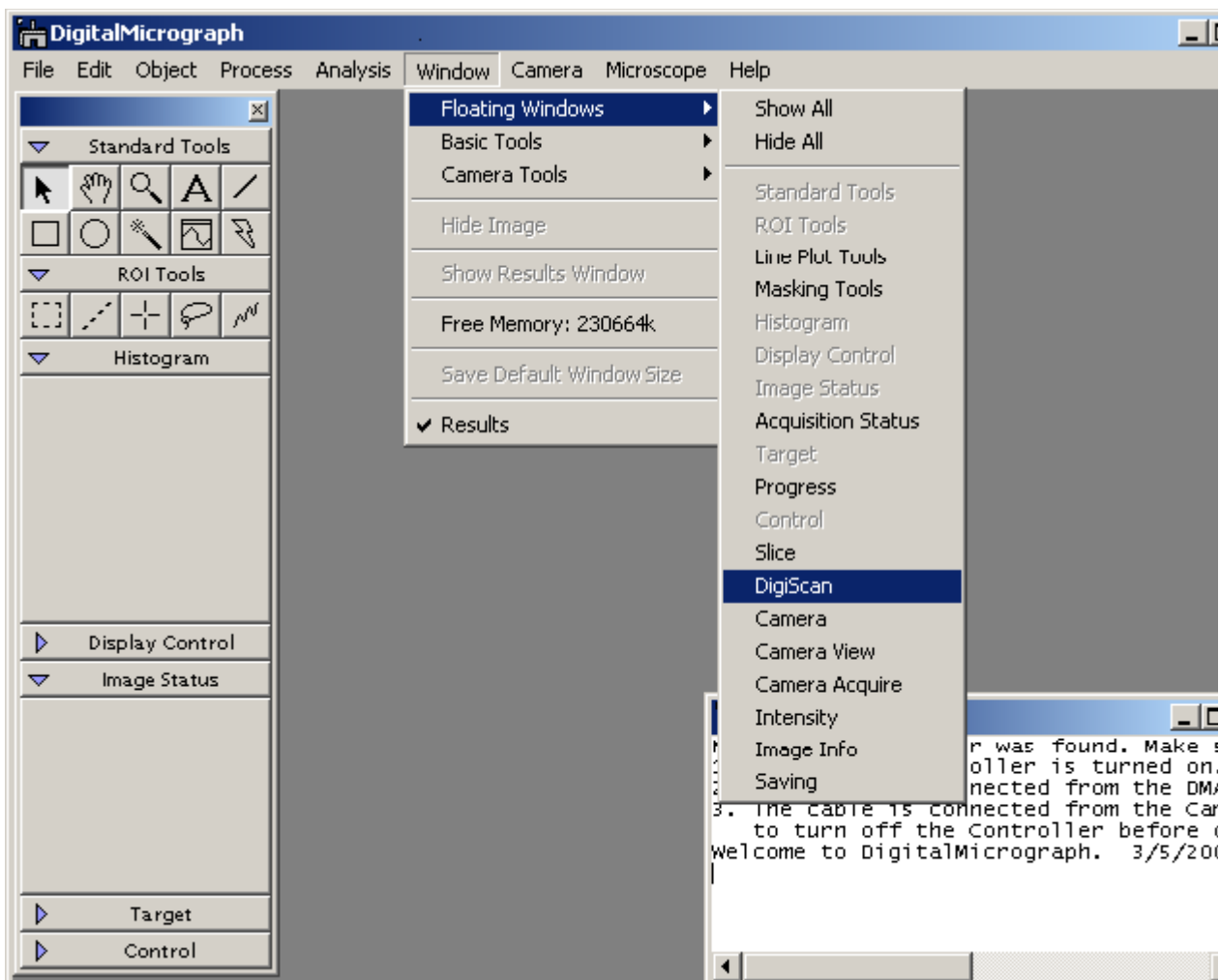
Figure 1-2 Opening DigiScan from Floating Window Menu

> ⚠ **CAUTION:** If you do not see a display similar to the one shown in Figure 1-2, or the DigiScan option is grayed out on the Floating Window menu, contact a Gatan service engineer to complete the software installation properly.

All DigiScan acquisition parameters are entered using the DigiScan main dialog box or its Setup dialog box. None of the other sections of the Digital Micrograph software affect the acquisition parameters. The standard Digital Micrograph software tools work on the images acquired using DigiScan.

2. Setting Up the DigiScan

2.1 Before Operating the DigiScan

2.1.1 Powering On

The DigiScan controller must be turned on before starting the DigitalMicrograph software, in order to load DigiScan software.

The DigiScan controller is normally left on when not in use so that it may be called up by the DigitalMicrograph software at any time. The power mode can be verified on the 788 by the green LED on the front panel. The DigitalMicrograph software may also be left open when not in use.

2.1.2 Using Scanned Images

A scanned image must be present on the microscope monitor at the magnification of interest before image acquisition using the DigiScan. Once image presence is established, the beam control can be passed to the DigiScan and the image displayed in DigitalMicrograph software. The DigitalMicrograph display will aid further image alignment (stigmation and focus). In many microscopes, fine tuning at higher magnification assists in obtaining higher resolution digital images at the lower magnification settings.

2.1.3 Blanking the Monitor Display

The DigiScan may blank the microscope display while it has control of the scan coils. This prevents damage to CRT monitors. If you are unable to detect a SEM/STEM image, check the DigiScan dialog box to verify that the Control Beam box is not checked.

NOTE: If the DigitalMicrograph software is inadvertently shut down by the computer system during DigiScan acquisition, control may not be released to the microscope. In this case, monitor blanking and scan control will be relinquished when the DigitalMicrograph software is restarted or when the DigiScan is powered off.

2.1.4 Calibration

The DigiScan is calibrated during installation to provide the proper range of scan ramps to the microscope.

Another set of calibrations is needed to provide a range of detector signal levels similar to those optimum for SEM/STEM display. This calibration eliminates the need to change detector levels when switching from SEM/STEM display, yet retains the full dynamic range of digital image information. These calibrations are software controlled, and should be performed only by those with adequate training; see the *DigiScan or DigiScan II Service Manual* for more information.

2.1.5 Communicating with the Computer

The DigiScan communicates with the computer via a FireWire connection. If the FireWire cable is not connected, then DigiScan will not appear in the Floating Window menu.

2.2   Setting Up Scan Configuration

In the case of the 788 DigiScan II the scan settings and configuration of the DigiScan are set by the service engineer at the time of installation. Once established, these settings apply to all imaging modes and are saved from one session to the next. They should not need to be altered.

Contact a Gatan service representative if you need to change scan properties or default settings.

3. Operating the DigiScan

3.1   DigiScan Main Dialog Box

The DigiScan main dialog box consists of the following elements, as shown in Figure 3-1.

1. Four acquisition buttons:

    l   Search

    l   Preview

    l   Record

    l   Restart

2. A display of acquisition parameters, including:

    l   Image size

    l   Pixel Time (in µs)

    l   Rotation Angle

    l   Control Beam (enabled or disabled)

    l   Waveform Monitor (enabled or disabled)

3. A setup button (with tool icons, at lower right) to access acquisition parameter settings

4. For service engineers only, in the case of the 788 a Service button will appear on this screen to enable access to scan settings and configuration. See the *DigiScan II Service Manual* for more information.
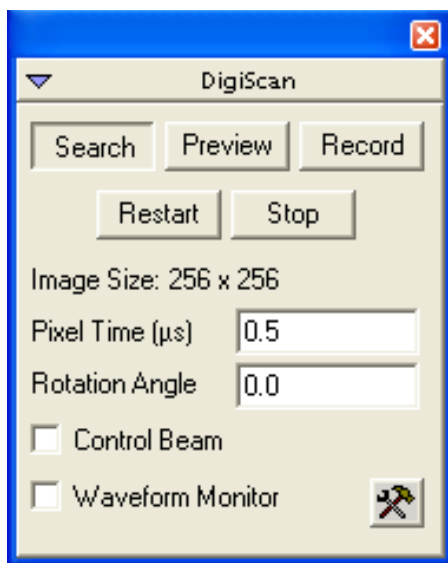
Figure 3-1 DigiScan Main Dialog Box During Search Acquisition

3.1.1 Search, Preview, and Record Acquisition Buttons

Search and Preview are continuous acquisition operations that may be stopped at any time by choosing another acquisition mode, reselecting the same acquisition mode, or pressing the space bar. The user can switch from one acquisition mode to another during acquisition. The image displays will be deleted when a new acquisition mode is started, or updated if the same acquisition mode is restarted. One image will be displayed per input signal and will be continuously updated until stopped. Restart will restart last acquisition with the same parameters.

Use the Record button for single shot acquisitions with longer pixel dwell times and higher quality images. The Record button always opens a new image window.

During data acquisition, the DigiScan takes over beam control from the microscope and blanks the SEM/STEM monitor display. In Search mode, the image will be rescanned until the space bar is pressed. The scan will then continue to the end of the current frame and the display will be updated. The DigiScan will then release the scan and monitor blanking to the SEM/STEM unit, if Control Beam is not checked.

NOTE: If the scan is stopped by clicking the Stop button, the display will be partially updated to the point where the stop took effect. (Pressing the [esc] key has the same effect.)

To Start Image Acquisition

ı   For a high speed, low resolution image acquisition, press the Search button.

ı   To record a longer duration, high resolution image, press the Record button.

To Stop Image
Acquisition

l   Press the Stop button to stop a scan at the current scan position.

l   Press the space bar to stop at the end of the current scan and display a completed image.

3.1.2 Parameter Display

The main DigiScan dialog box displays the following acquisition parameters:

l   Image size

l   Pixel time

l   Rotation angle

NOTE: Current acquisition parameters appear when the cursor is positioned over one of the acquisition buttons, as shown in Figure 3-2, without pressing the button. Pressing the acquisition button begins the acquisition; parameters may be updated during acquisition.
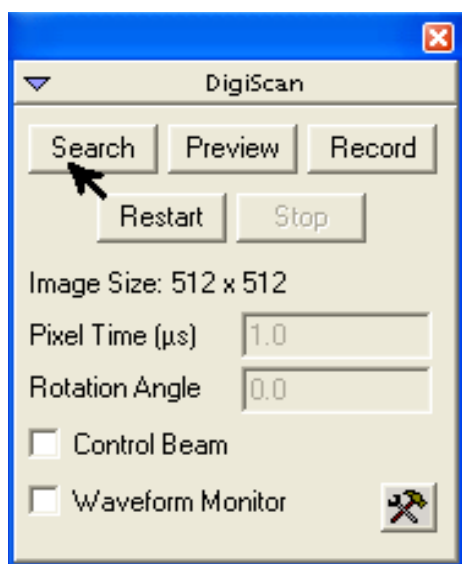
***Figure 3-2 DigiScan Main Dialog Box Before Acquisition***

Pixel time and rotation can be edited on the main dialog box during Search and Preview acquisitions. To change the initial values for these parameters, or to set a different image size, see Section 3.2, "Editing Acquisition Parameters".

When an acquisition is stopped, the parameters are saved along with the image in DigitalMicrograph software. These parameters revert to their default setup values at the start of each new image acquisition.

3.1.3 Checkboxes

3.1.3.1 Control Beam

The Control Beam option is used to position the beam on a previously acquired scanned image. When the Control Beam box is checked, the DigiScan assumes control over the beam and blanks the SEM/STEM monitor display. After acquisition is complete, a "beam" indicator tool will appear on the DigitalMicrograph software image(s) (see Figure 3-3).
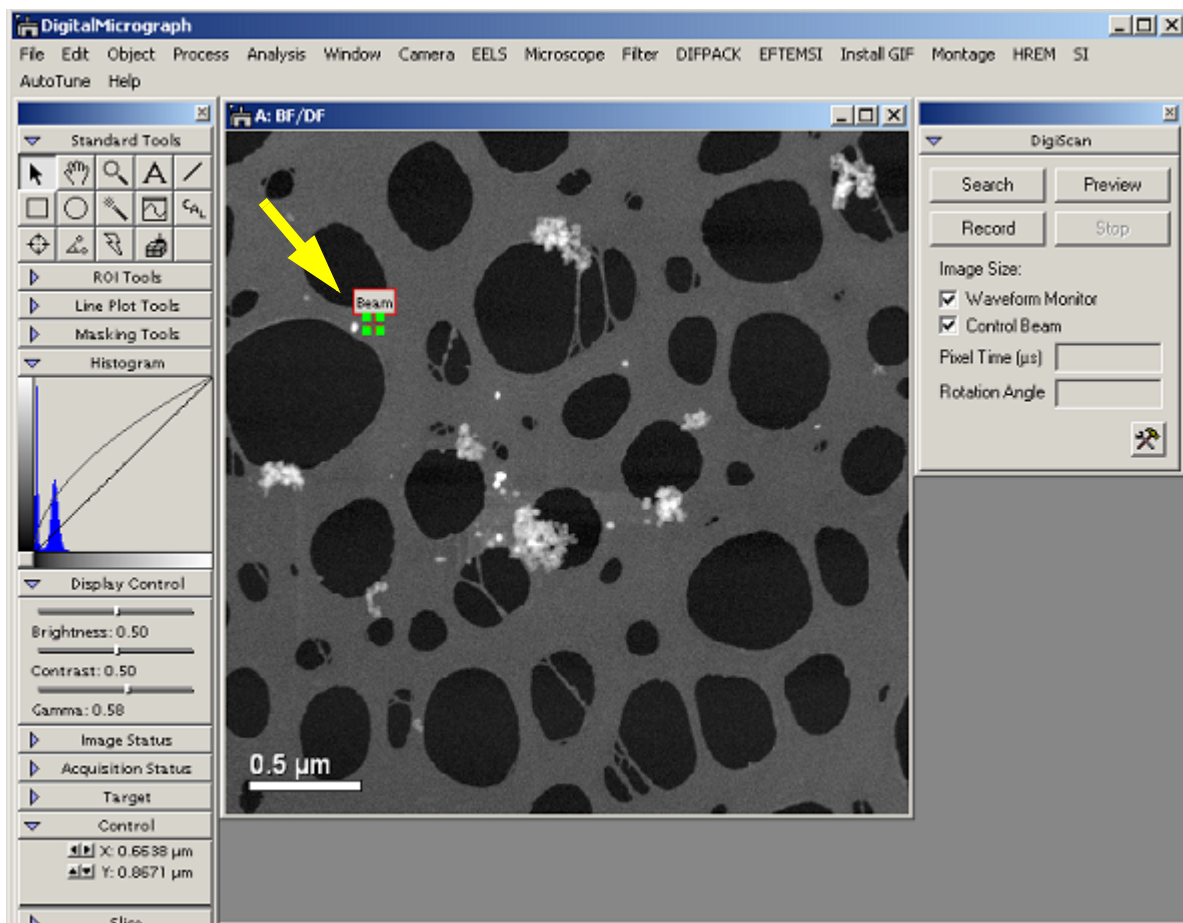
Figure 3-3 Control Beam Display

When the control beam indicator is selected, green boxes appear surrounding the position of the beam. If two images are acquired simultaneously, the beam position marker follows on the second image.

The beam position indicator can be dragged to any position, or the keyboard arrow keys can be used to move the beam position in any direction. The pixel coordinates are indicated in the Control floating window. The Control floating

window can be added to the left-hand menu of floating windows by selecting Control from the Floating Windows menu.

In Figure 3-3, the X row position is 0.66 µm from the left, and the Y column position is 0.86 µm from the top. The pointer buttons in the Control window can also be used to position the Control Beam. Positional coordinates outside the image boundaries may not represent the actual beam position.

If the beam position is inside the image boundary, it will return to the same position after the next acquisition. If the beam position is outside the image boundary, it will snap back to the image center after the next acquisition.

To Position the Control Beam
Use the mouse to select the beam indicator tool and drag it to any desired position on the image. The beam can be moved slightly off the scan area, as indicated by the position in the control window. If the beam indicator is moved too far outside the image boundaries, the beam indicator will snap back to the middle of the scanned area.

3.1.3.2   Waveform Monitor

The Waveform Monitor display only works when an acquisition is active. When the Waveform Monitor box on the main DigiScan dialog box is checked, the intensity of raster lines over the lower part of the image is displayed, as shown by the sloped line in Figure 3-4.
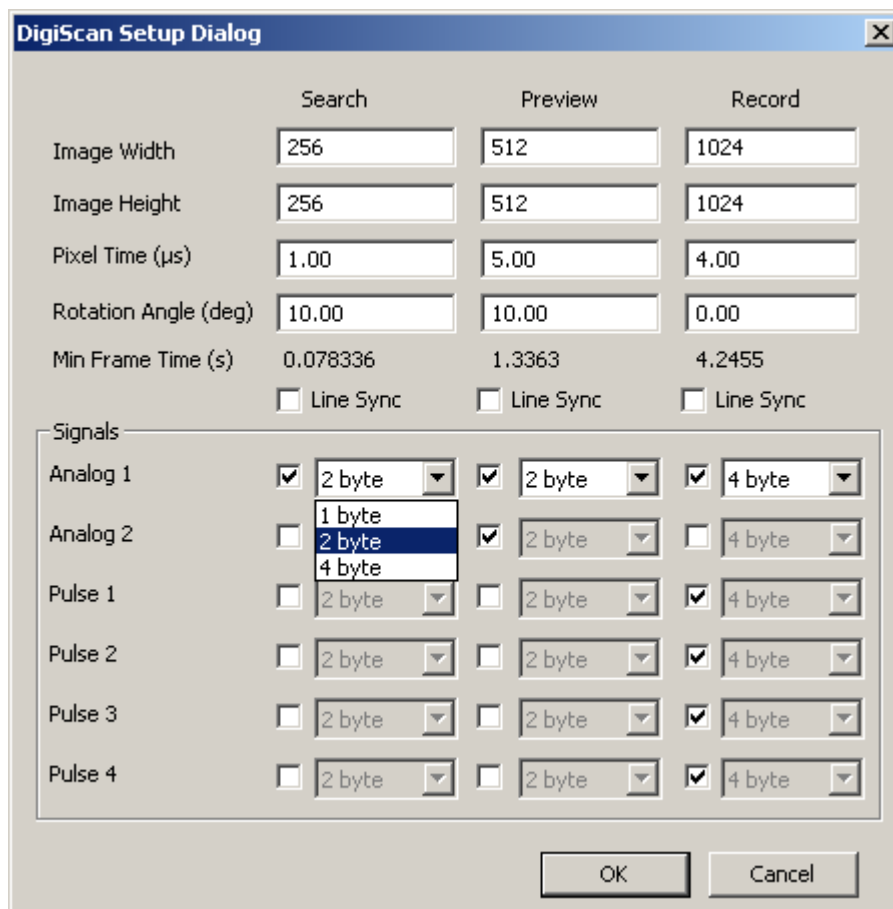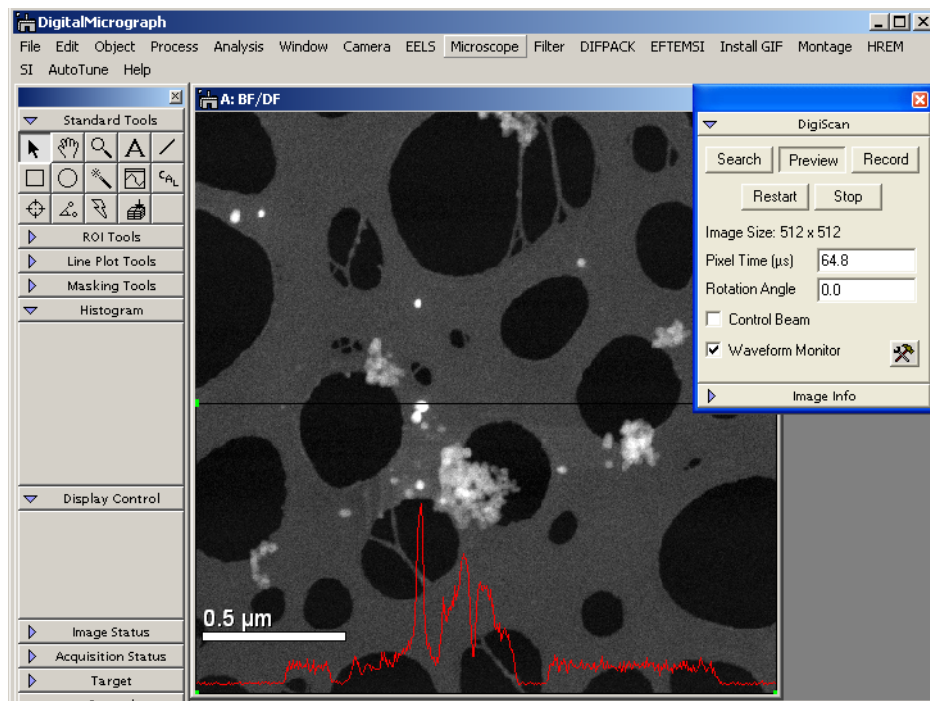

Figure 3-4 Waveform Monitor Display

Detector gain and offset should be adjusted so that the minimum and maximum intensity measurement of the waveform span the full waveform range. This set-

ting should be consistent with the microscope brightness and contrast. See the Service Manual for more information on adjusting gain and offset.

The full scale of the Waveform Monitor is automatically adjusted to reflect the maximum counts possible for a particular integration time. (For a 2-byte display the maximum will vary between 32,000 and 64,000 counts.)

3.2 Editing Acquisition Parameters

To set up acquisition parameters, or to change the acquisition parameters displayed, press the Setup button at the lower right on the main DigiScan dialog box. A DigiScan Setup Dialog box appears, as shown in Figure 3-5.

Figure 3-5 DigiScan Setup Dialog Box

Acquisition parameters are entered separately for each of the acquisition modes:

l   Search

l   Preview

l   Record

3.2.1 Acquisition Mode Settings

3.2.1.1 Search

Search settings are normally intended for use with small image sizes and high speed, low resolution acquisition, so the number of pixels is normally set lower, with corresponding smaller pixel time. Pixel time is frequently increased while in Search mode.

3.2.1.2 Preview

Preview settings are intended to be used for fine focus or detector brightness and contrast adjustment just before recording. A larger number of pixels may be used but the pixel time must be set fast enough to view updates. This mode may also be used to select images (e.g., at high magnification) that appear to be undergoing dynamic processes. Preview mode settings are typically similar to Record mode settings to verify intensity and image resolution.

3.2.1.3 Record

Record settings provide the highest resolution and are intended for one-shot, long time-duration acquisition. Record mode always opens a new image window for each signal input, without deleting previous recorded images.

3.2.2 Parameter Settings

NOTE: Use the [Tab] key to move from one field to the next in the DigiScan II Setup Dialog box. Pressing the [Enter] key will be interpreted as hitting the [OK] button, which accepts your changes and closes the dialog box.

3.2.2.1 Image Width and Height

The DigiScan uses a scan space that is typically calibrated to span the minimum axis of the STEM display (usually the vertical axis). To allow for 45 degree scan rotation, the scan *area* is further restricted to about 70% of the scan *space*. There-fore, the scan area is a fixed size dependent on the SEM/STEM magnification.

The image *width* is the number of image pixels (up to 8192) that span the scan area in the horizontal direction.

The image *height* is the number of image pixels (up to 8192) that span the scan area in the vertical direction.
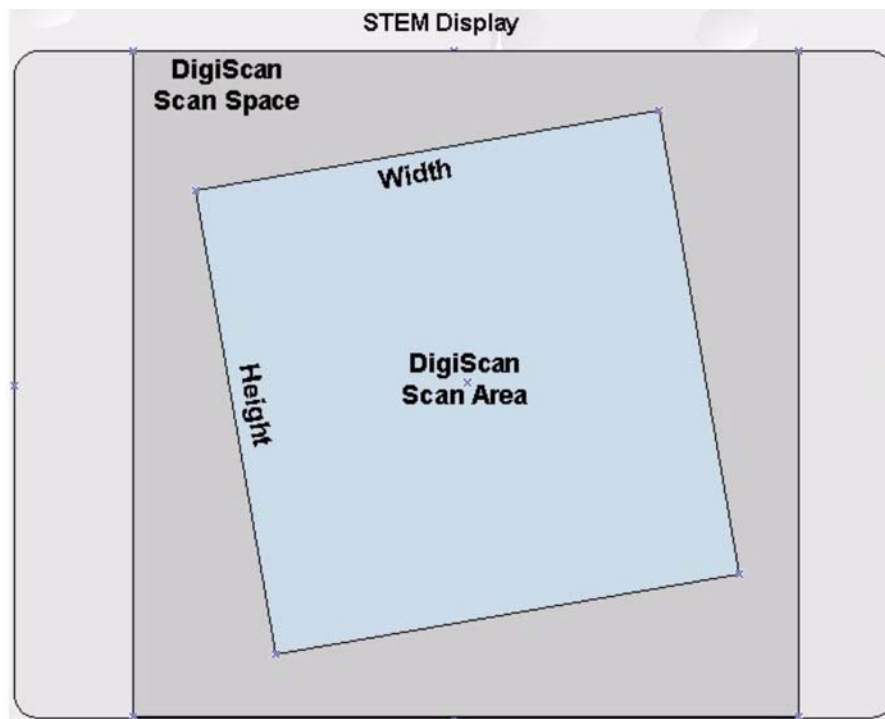
Figure 3-6 DigiScan Scan Area

To Set Image Width and Height   Enter values for the image width and height for each acquisition mode. The width must be a multiple of 8, starting with a minimum of 16 pixels. The height must be at least 1 pixel. Any invalid entry will be automatically updated to the nearest valid value.

3.2.2.2   Pixel Time

The pixel time is the number of µseconds that a beam waits, per pixel, ranging from 0.5 µseconds to 400,000 µseconds (0.4 seconds per pixel).

The minimum pixel time depends on the number of bytes per pixel, image size, and number of detectors. The pixel time display will correct to the minimum allowed pixel time if a lesser value is entered.

In the case of the 788 DigiScan II the analog data is digitized at a rate of 40 per µsecond so that pixel times are "quantized" by 25 nsecond digitization periods. For pixel times greater than 1600 µseconds, the length of the digitization periods increase; however, signal averaging occurs during the digitization period so that signal-to-noise ratio will continue to improve.

To Set Pixel Time   Enter an approximate pixel time to be used for each acquisition mode. The pixel time display will automatically update to the closest usable pixel time. If line synchronization is used, the minimum pixel time will depend on the line frequency.

To Change Pixel Time With Arrow Keys

The up and down arrows on the keyboard will increase or decrease pixel time by a factor of two during the continuous display. Each time these keys are used, the scan re-starts before completion. It may be necessary to reselect the image, by clicking on the upper half, to enable use of arrow keys for changing pixel time.

To Change Pixel Time By Typing

With the cursor in the Pixel Time text box, type in a new value. This will cause a change in the current continuous mode acquisition time but will not affect future acquisitions.

3.2.2.3   Rotation Angle

Rotation angle defaults to 0 degrees. Rotation angle can be updated during continuous acquisition, but not before acquisition begins, by using the arrow keys on the keyboard or by typing in a new value. However, the rotation angle will return to the default value when a new acquisition is started. To change the default rotation angle, see the Service Manual.

The actual rotation step is limited by the pixel size in the DigiScan space. For a 1024 by 1024 image, the rotation step size is 2.5°.

To Change Rotation Angle With Arrow Keys

The keyboard arrow keys can be used to modify the rotation angle by plus (right arrow) or minus (left arrow) 5° during continuous acquisition. Holding down the [Alt] key while using the left and right arrow keys causes rotation to decrement or increment by 0.1°. It may be necessary to reselect the image, by clicking on the upper half, to enable use of arrow keys for changing rotation angle.

To Change Rotation Angle By Typing

With the cursor in the Rotation Angle text box, type in a new value. This will cause a change in the current continuous mode acquisition offset but will not affect future acquisitions.

3.2.2.4   Line Synchronization

Line synchronization enables the start of each scan line to be synchronized by the mains AC signal, in case stray fields at mains frequency cause interference with the scan signal. It can only be used with longer pixel times (approximately 50 μseconds or longer) since the combined period of delay and scan must be a multiple of 16 or 20 milliseconds, depending on line frequency. Frame time could be extended by up to 16 seconds for a 1024 line image.

To Enable Line Synchronization

A check mark in the Line Sync box for an acquisition mode turns on line synchronization for all image acquisition performed in that mode.

3.2.2.5   Analog Signals

Typical DigiScan input signals are analog, provided by the secondary, backscattered bright field or annular dark field electron detectors. These signals are converted to digital signals by a 40 MHz analog-to-digital converter (788) or 10MHz analog-to-digital converter (688). The digital intensities are scaled such that the maximum allowed signal within a dwell period will be near a maximum number

determined by the number of bytes in the display. If pixel time is exactly doubled then the maximum intensity remains the same.

1 byte, 2 byte, and 4 byte settings are available, referring to the maximum number of bytes per pixel in the image. Increasing byte settings may increase the ability to detect a greater range of intensities in an image, but usually noise limits reasonable resolution per pixel to a maximum of about 1 in 64,000. This resolution can be displayed with the 2 byte setting. The amount of memory required to store images is proportional to the number of bytes per pixel.

3.2.2.6   Pulse Signals

Pulse signals are commonly used when fewer imaging electrons, x-rays or photons are being counted. These individual signal pulses are typically discriminated from noise by pulse analyzers using electronic level discriminators before being sent to the DigiScan. The maximum number of counts displayed per pixel will depend on the pixel time and the frequency of pulses. The DigiScan pulse electronics limit the frequency to less than 40 MHz.

The number of bytes must be constant within an acquisition mode, but can be independently set at 1, 2, or 4 bytes for each mode. In pulse mode, the intensity is not scaled to the maximum number of bytes selected, so if the pixel time is doubled, the number of counts will also double.

To Set Signal Bytes (Analog or Pulse)

ι   Under the appropriate acquisition mode, click in the checkbox to enable the appropriate signal type.

ι   Use the pull-down menu to select the number of bytes to be used to determine resolution for that acquisition mode. All selected signals are acquired with the same number of bytes.

3.2.2.7   Frame Time

Frame time is the time for one image acquisition to be complete, before the next one is started. This time is slightly greater than the result of multiplying pixels by pixel time, to allow for set-up time between images. This is not a user-editable field, and is shown for information only.

Appendix A: Glossary

BF/DF Bright field/dark field

CL, EL Cathodoluminescence

DDC DigiScan Differential Converter, provides signal I/O and signal relays.

DM DigitalMicrograph, the core software application of the Gatan Microscopy Suite for control and analysis of TEM data.

EDS Energy Dispersive X-ray Spectrometer

Flyback time Period of time required to allow the scan beam to return from the end of the line to the first pixel.

Frame time The time required from starting one image acquisition to starting the next one. This is slightly greater than the calculated number of pixels x pixel time, because of additional setup time between images.

GMS Gatan Microscopy Suite, complete set of interconnected applications and plug-ins for control and analysis of TEM data.

Pixel time The number of µseconds that a beam waits, per pixel, ranging from 0.4 µseconds to 400,000 µseconds (0.4 seconds per pixel).

Scan space The amount of the total STEM display that is included in the scan, usually equal to the minimum axis of the SEM/STEM display.

Scan area A percentage of the scan space (usually about 70%, depending on SEM/STEM magnification) to allow for 45 degree scan rotation.

SEM Scanning Electron Microscope

STEM Scanning Transmission Electron Microscope

TEM Transmission Electron Microscope

WDS Wavelength Dispersive X-ray Spectrometer

Index

Gatan Product Warranty

Gatan warrants that products manufactured by Gatan shall be free of defects in materials and workmanship for the warranty period, which commences at date of shipment. Gatan tests the performance of a unit as part of its final test procedure, prior to shipment from its factory. Gatan warrants that the unit meets Gatan's published specifications at time of shipment from its factory. All product warranties provide, for a period of one year after shipment to customer, parts (excluding all normal consumable, wear, and maintenance items) and labor. For Specimen Preparation Equipment and Specimen Holders, Gatan will correct any defects in the instrument either by repair in our facility or replacing the defective part, with the shipping party responsible for shipping costs. For products which attach to the column (Cameras, DigiScan, GIF, and PEELS), travel of up to 100 miles from a Gatan authorized repair center (Pleasanton, CA; Warrendale, PA; Munich, GmbH; and Corby, UK) is included. Travel expenses for service beyond 100 miles will be charged for.

Instruments, parts, and accessories not manufactured by Gatan will be warranted by Gatan for the specific items and periods in accordance with and provided by the warranty received by Gatan from the Original Equipment Manufacturer. All such accessory warranties extended by Gatan are limited in accordance with all the terms, conditions, and other provisions stated in this Original Equipment Manufacturer warranty. Gatan makes no warranty whatsoever concerning products or accessories not of its manufacture, except as noted above.

Customer Responsibilities

The customer bears the following responsibilities with regard to maintaining the warranty. The customer shall:

1. Perform the routine maintenance and cleaning procedures at the required intervals as specified in Gatan's operating manuals. Failure to perform specified maintenance will automatically void warranty.
2. Use Gatan replacement parts. Failure to use the specified replacement parts will automatically void warranty.
3. Use Gatan or Gatan-approved consumables.
4. Provide Gatan authorized service representatives access to the products during normal Gatan working hours during the coverage periods to perform service.
5. Provide adequate and safe working space around the products for servicing by Gatan authorized service representatives.
6. Provide access to, and use of, all information and facilities determined necessary by Gatan to service and/or maintain the products. (Insofar as these items may contain proprietary or classified information, the customer shall assume full responsibility for safe-guarding and protecting them from wrongful use.)

Repairs and Replacements

Gatan will, at its option, either repair or replace defective instruments or components with conforming goods. Repair or replacement of products or parts under warranty does not extend the original warranty period. With the exception of consumable and maintenance items, the replacement parts or products used on instruments out of warranty are themselves warranted to be free of defects in materials and workmanship for 90 days.

Any products, part, or assembly returned to Gatan for examination or repair shall have Gatan's prior approval, with the customer requesting a Returned Material Authorization (RMA) approval. This RMA and the associated RMA number may be obtained through Gatan Service or directly from Gatan's Warrendale facility at 724-776-5260. If the item is not under warranty, to obtain an RMA, the customer must provide a Purchase Order (PO) for the repair. If the item is under warranty and the customer is requesting an expedited exchange, as may be the case for a printed circuit board, a PO will be required. A credit against this PO will be issued by Gatan upon receipt of the item as returned in accordance with the RMA instructions. The returned item should be shipped prepaid by the customer with the RMA number clearly marked on the exterior of the shipping container and on the enclosed shipping documents. If the returned item is under warranty, return transportation will be prepaid by Gatan. If the returned item is not under warranty, return transportation will be charged to the customer.

Warranty Limitations

The warranty does not cover:

1. Parts and accessories which are expendable or consumable in the normal operation of the instrument.
2. Any loss, damage, and/or instrument malfunction resulting from shipping or storage, accident (fire, flood, or similar catastrophes normally covered by insurance), abuse, alteration, misuse, neglect, or breakage or abuse of parts by User.
3. Operation other than in accordance with correct operational procedures and environmental and electrical specifications.
4. Performance to specifications or safety of use (including X-ray emissions) if the unit is physically installed on, used in conjunction with, or used as part of a third party's equipment and is not installed by a Gatan service engineer.
5. Performance to specifications or safety of use (including X-ray emissions) as a result of the use of Gatan's equipment with that of a third party due to the third party's product design.
6. Modification of, or tampering with, the system.
7. Improper or inadequate care, maintenance, adjustment, or calibration by User.
8. User-induced contamination or leaks.
9. Any loss, damage, and/or instruments malfunction resulting from use of User-supplied software, hardware, interfaces, or consumables other than those specified by Gatan.

Warranty Exclusions

In the course of normal use and maintenance, certain parts have finite lifetimes. For this reason, the consumables, wear, and maintenance parts as specified in Gatan's operating manuals carry a 90-day warranty unless otherwise specified.

Post Warranty Period Support and Product Obsolescence

After the expiration of the warranty period described above, Gatan will provide service support for Gatan manufactured products at Gatan's service labor rates and parts pricing in effect at the time of the repair. Gatan will continue to provide billable service support for the products for a period of three years after discontinuance or design obsolescence by Gatan. After this three year period, service support will be offered at the sole discretion of Gatan.

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This warranty is in lieu of and excludes all other expressed or implied warranties, including (but not limited to) warranties of merchantability of fitness for a particular purpose. Under no circumstances will Gatan Inc. or Gatan International be liable for any direct, indirect, special, incidental or consequential damages (including lost profit) or loss of any kind, whether based on warranty, contract, tort, or any other legal theory. The limits of Gatan liability in any dispute shall be the price received from the purchaser for the specific equipment at issue. The laws of the state of Pennsylvania apply to all aspects of this warranty.