Dual Magnification

Optical System Configuration Guide

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Section 1

Introduction

This *Optical System Configuration Guide* applies to all QVI video metrology systems equipped with dual magnification optics. It explains how to change the magnification range, field of view, working distance, and/or depth of field to meet specific application needs. It is intended for anyone who uses any of these options.

Content

Section	Title	Description
1	Introduction	• Explains the purpose of this manual • Describes the various optical components • Shows the optional configurations • Includes a list of important optical terms
2	Choosing an Optical Configuration	• Provides information to help you choose an optical configuration for your application needs
3	Re-Configuring the Optical System	• Describes how to change replacement lenses • Describes how to change the focus step size
4	Calibrating the Optics	• Describes how to calibrate the optics

Key words: replacement lens, field of view, working distance, depth of field

If You Need Help

For help, contact your local authorized Sales or Service Representative.

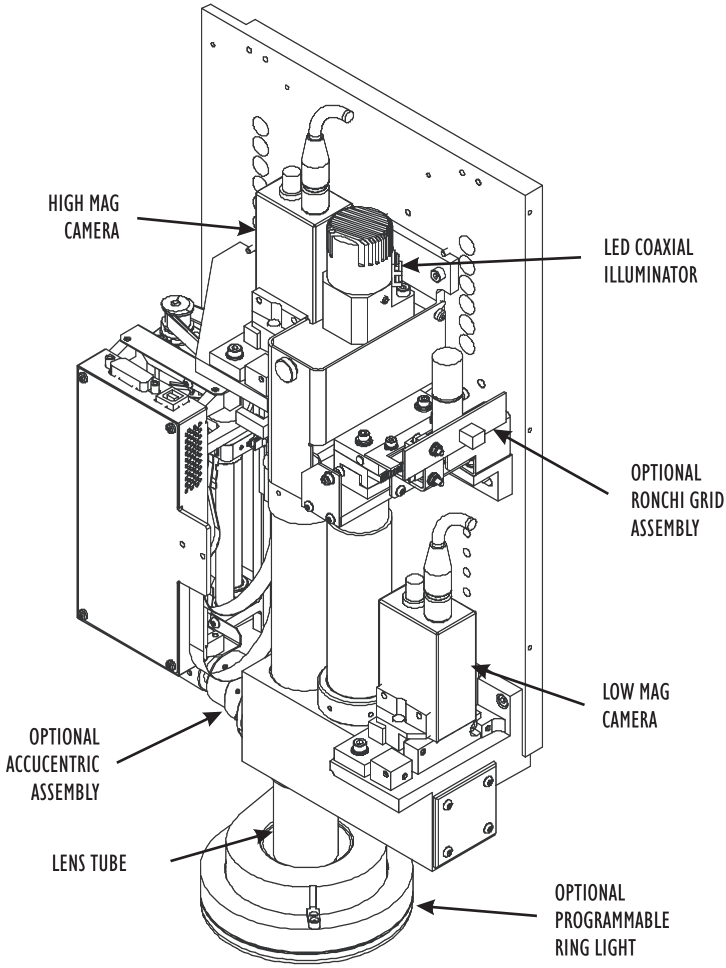

Figure 1-1. Optical Components

Video Cameras

The standard High Mag and Low Mag video cameras (P/N 036473) are high resolution, monochrome, 1/2" format cameras. Each camera mounts on a separate optical path to provide instant magnification switching under software control. Each camera sends a live video image of the part under inspection to the system computer, which displays the selected image on the system monitor.

A 2/3" format extended field of view Low Mag camera (P/N 036474) is available in lieu of the standard 1/2" camera. The 2/3" format camera increases the field of view and on-screen magnification, but does not change the optical magnification.

Note: *The video cameras are factory installed and are not interchangeable. Contact your local Sales or Service Representative for information about changing the Low Mag camera.*

Dual Magnification Optics

The dual magnification, fixed lens optical system provides two internal magnification images. Both magnification images are always present; selecting one camera or the other determines which magnification image is used for measurement. The change from low magnification to high magnification is instantaneous and requires no movement of any optical elements so there is no change in calibration or datum references. This makes for a highly accurate and repeatable system.

Available dual magnification optical systems:

Part Number	Optical Components				
	Dual Path Optics	AccuCentric Assembly	LED Coaxial Illuminator	Ronchi Grid Assembly or LED Surface Illuminator/Grid Projector	Laser-Ready?
529670 (std)	✓		optional	optional	No
529685	✓		optional	optional	Yes
529871	✓	✓	optional	optional	No
529872	✓	✓	optional	optional	Yes

AccuCentric Assembly

The AccuCentric assembly (P/N 529650) mounts on the left-hand side of the dual path beamsplitter and inserts a reticle image into the optical path. This reticle is used to re-calibrate the optical system whenever you switch from high magnification to low magnification, and vice versa. As you switch magnification, the reticle is re-measured to automatically calibrate the position of the optical axis.

LED Coaxial Illuminator

The LED coaxial illuminator (P/N 638876) mounts between the High Mag and Low Mag optical paths and provides direct “square on” light onto the surface of the part where it is reflected up into the optics.

Ronchi Grid Assembly

The optional Ronchi grid assembly (P/N 526880) mounts below the coaxial illuminator and consists of a motorized, three position shuttle and two chrome-on-glass reticles: one for High Mag and another for Low Mag. Light from the coaxial illuminator passes through the selected reticle, projecting a shadow onto the point of focus and creating artificial contrast where none may exist.

LED Surface Illuminator/Grid Projector

The optional LED surface illuminator/grid projector (P/N 532353) mounts in place of the coaxial illuminator and adds the ability to project contrast onto surfaces that have little or no contrast, such as glass, when using high magnification. This allows you to perform an autofocus on such surfaces.

Programmable Ring Light (PRL)

The optional programmable LED ring light (P/N 532023) mounts below the optical assembly and provides an oblique top light. A cone of light projected onto the surface of the part creates a three-dimensional image that highlights heights, depths, and surface imperfections.

The PRL uses multi-color LEDs (red, green, and blue) to illuminate objects that are difficult to resolve using white light alone. Depending on the illumination angle required, the PRL can be positioned up or down on the lens tube to provide variable surface illumination angles of incidence from 10° to 75°.

Note: *The PRL can be used with any replacement lens.*

LED Ring Light

The optional LED ring light (P/N 533605-2) mounts below the optical assembly and provides oblique surface illumination. It consists of six concentric rings that can be split into eight 45° sectors. In the metrology software, you can turn on/off individual rings or sectors as well as adjust the intensity of the illumination to effectively illuminate staged parts with varying incidence and directionality.

A Fresnel lens, mounted to the bottom of the LED ring light, angles the light toward the part surface. Optimal ring light performance occurs when it is approximately 75 mm (3") from the surface under inspection. Systems can be operated without an LED ring light.

Note: *We recommend using the LED ring light with the 0.8X replacement lens.*

Replacement Lenses

Replacement lenses mount to the bottom of the lens tube and either increase the field of view and decrease the magnification, or decrease the field of view and increase the magnification. They also change the working distance. A replacement lens is required for proper system operation.

Replacement Lens	Part Number
0.8X	638685
1.0X	638939
2.5X	638940
5.0X	638941
10X	638942
25X	532186

Optical Configurations

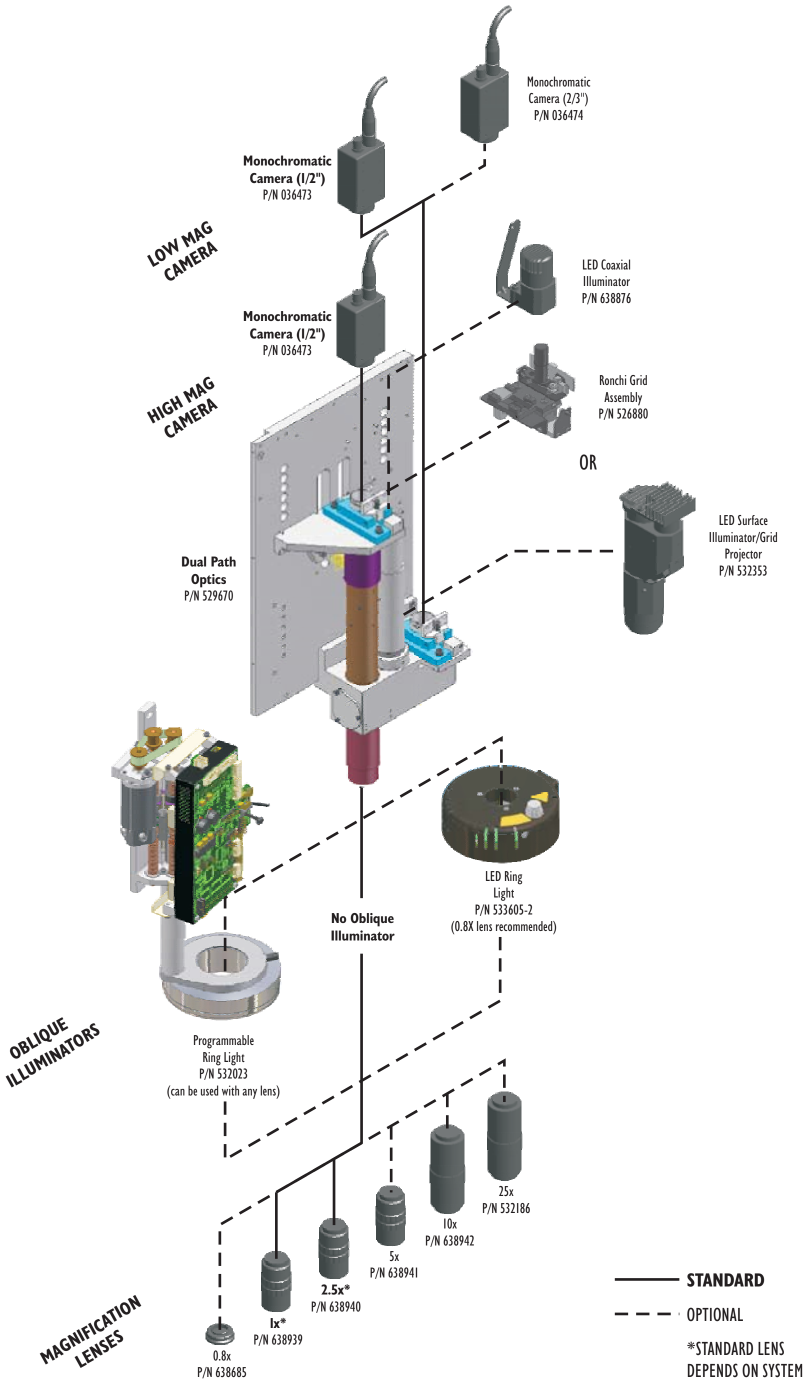

Figure 1-2. Standard Systems (No Laser)

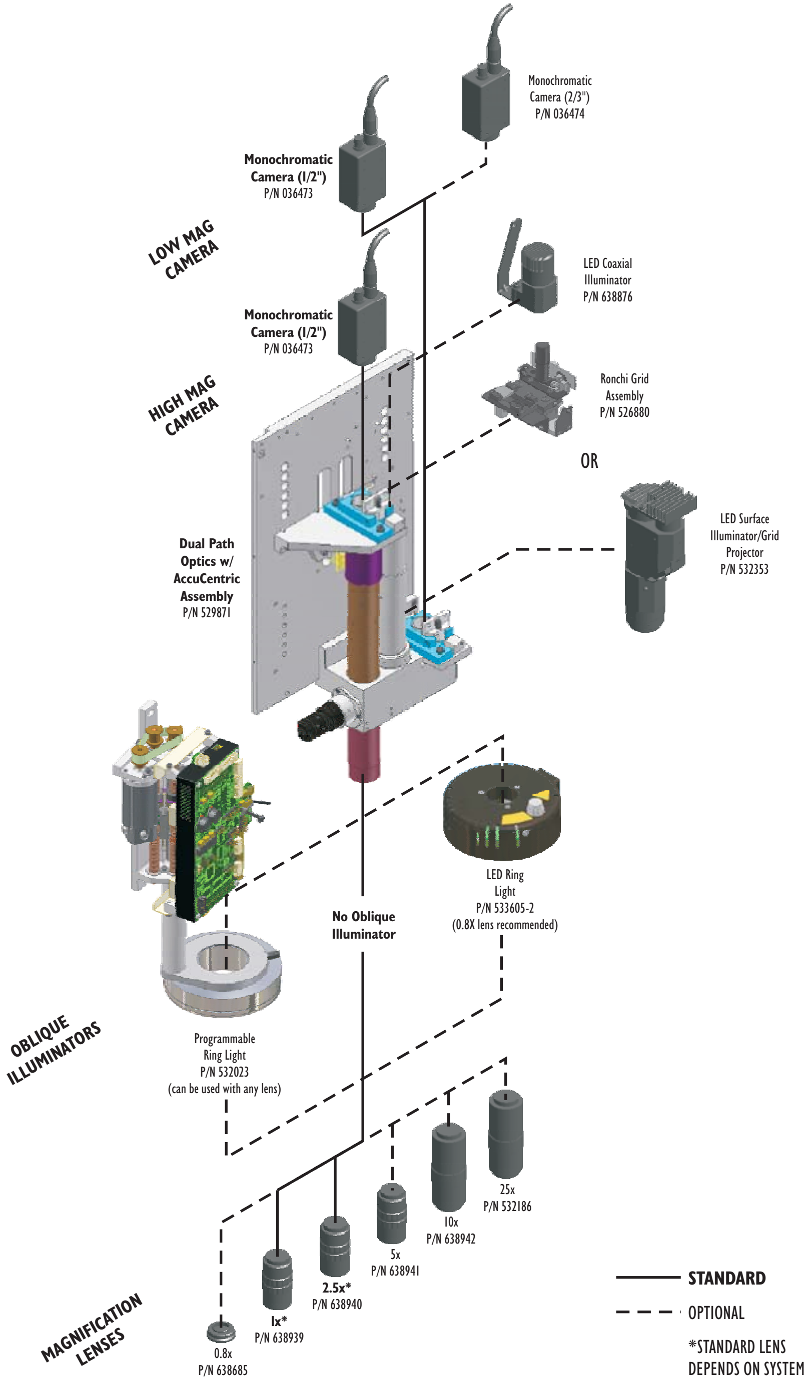

Figure 1-3. Systems Equipped with AccuCentric Assembly (No Laser)

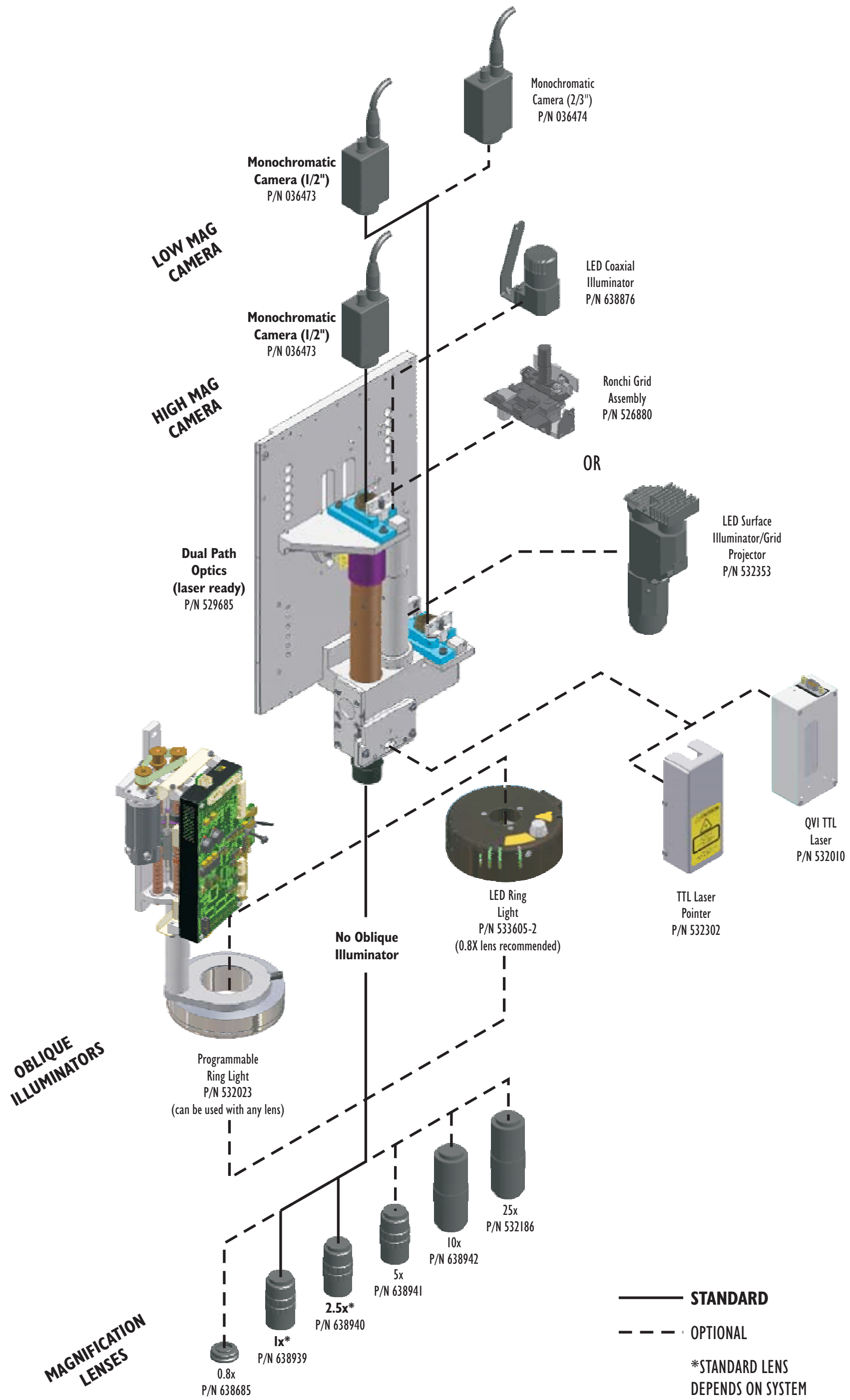

Figure 1-4. Laser Ready Systems

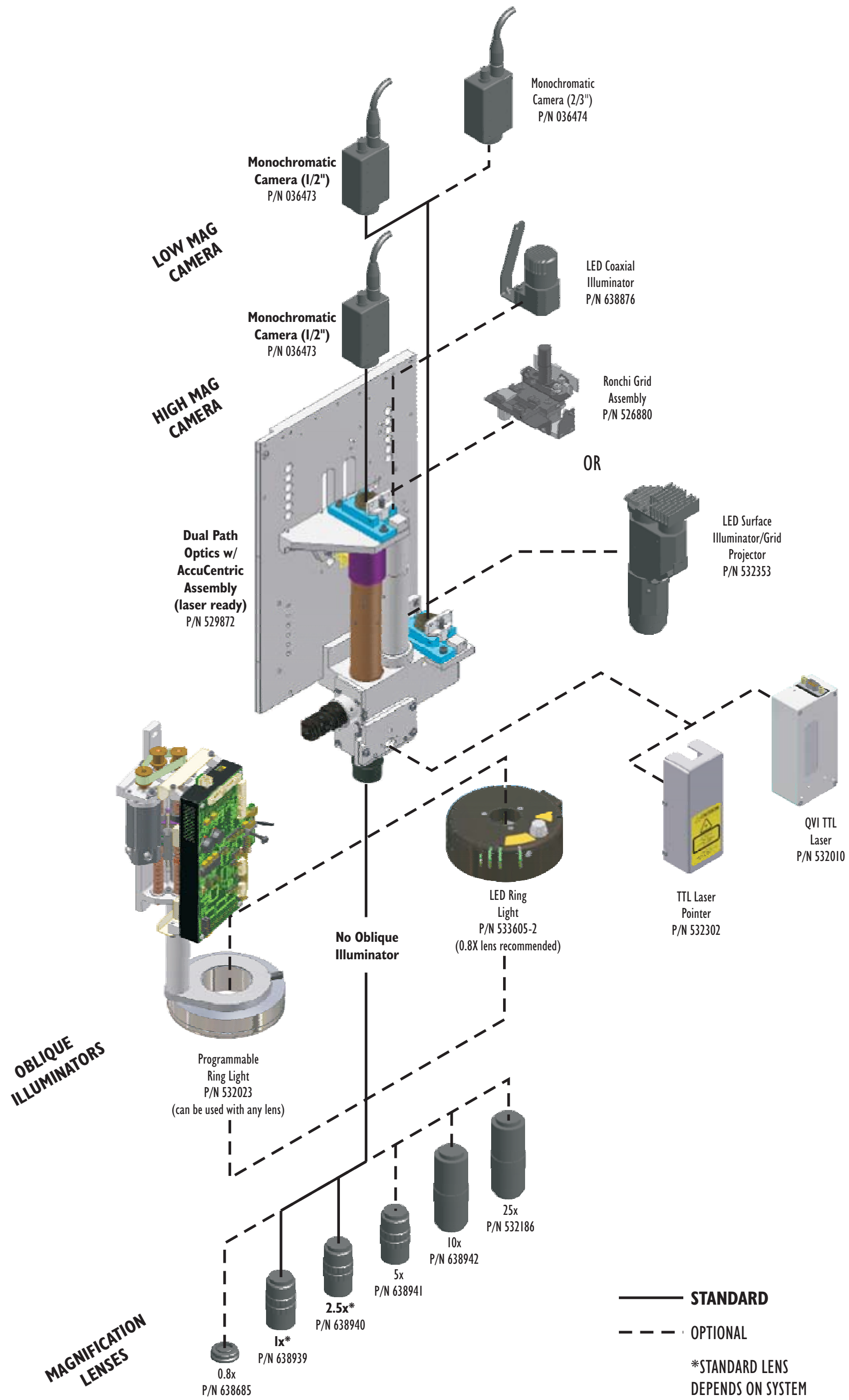

Figure 1-5. Laser Ready Systems Equipped with AccuCentric Assembly

Important Optical Terms

Astigmatism	• A lens aberration that results in horizontal features being in focus at a different plane than vertical features. Images in one axis are in focus across the entire field of view while images in the other axis are not, and appear "fuzzy." This source of imaging error is corrected by lens combinations.
Beamsplitter	• An optical device that divides one beam of light into two or more separate beams. An uncoated piece of glass at a 45° angle to the incident beam will reflect approximately 8% of the light at a 90° angle, and pass approximately 92%.
Depth of Field	• Distance along the optical axis over which an object will remain in focus. Depth of Field is larger at lower magnifications, and smaller at higher magnifications.
Distortion	• A general term used when an image does not fully represent an object. There are many types of distortion; pin cushion and barrel are common.
Field of View (FOV)	• Maximum area that the system can see at one time (usually expressed as a diagonal measurement). The field of view increases when the magnification decreases.
Fresnel Lens	• As used in the LED ring light, a Fresnel lens is a spherical lens that is cut into narrow rings and flattened, without the thickness of material that would be required in a conventional lens design. It focuses the LEDs to a spot.
Hot Spot	• An area near the center of an FOV of above average light intensity.
Parfocalization	• Condition where the part image stays in focus through the full magnification range.
Step Size	• The distance traveled in Z, between video frames during an autofocus. (The step size is an approximate representation of the depth of field at any given magnification when multiplied by four.)
TTL Laser	• A laser that emits and collects light produced from a laser through the replacement lens.
Working Distance	• The distance from the closest surface of a lens system to the area of the sample being imaged when properly focused.

Section 2

Choosing an Optical Configuration

The optical system can be re-configured in different ways to meet specific application needs. This section will help you choose the right optical configuration for a particular application.

Lenses can be changed at any time, which can provide different performance characteristics. For example, a lower magnification lens enlarges the field of view to see more of the part or to measure a large feature. To measure small features or fine detail, use a higher magnification lens.

Changing the replacement lens has the following effects:

Lens	Effect
Lower magnification lens	Working Distance ↑
	FOV ↑
	Measurement Accuracy ↓
Higher magnification lens	Working Distance ↓
	FOV ↓
	Measurement Accuracy ↑

Key:

- ↑ increase
- ↓ decrease

Helpful Hints

- Always allow sufficient working distance for your application. Consider clearances of the optics and PRL/LED ring light for areas on parts and fixtures **not** being measured.
- Consider the size of the feature you want to measure when choosing an optical configuration. Typically, larger features require a large field of view and smaller features require higher magnification. Recognize that the larger the field of view, the lower the measurement resolution, and vice versa. In other words, enlarging the field of view will let you see more of the part, but you may not be able to resolve surface detail as well.
- If your part has large variations in surface height, choose an optical configuration that provides a large depth of field.
- Any optical configuration change will change magnification, requiring an optics recalibration (described in Section 4).
- For higher accuracy, use higher magnification. This generally produces better results when measuring features that appear in good focus and have well-defined edges and surfaces.

Optical Configuration Data

The table on the next page lists the following optical configuration data:

- Magnification
- Field of view
- Effective pixel size
- Working distance
- Depth of field

Optical Configurations								Specifications						
Objectives						Low Mag Camera		Optical Magnification		FOV (mm)		Effective Pixel Size (µm)		Working Distance (mm)
0.8x	1x	2.5x	5x	10x	25x	1/2"	2/3"	Low	High	Low	High	Low	High	
✓						✓		0.8x	3.2x	8.34 x 6.23	1.91 x 1.43	5.99	1.38	110
	✓					✓		1x	4x	6.46 x 4.82	1.59 x 1.19	4.64	1.15	34
		✓				✓		2.5x	10x	2.78 x 2.07	0.64 x 0.48	1.99	0.46	34
			✓			✓		5x	20x	1.35 x 1.01	0.31 x 0.23	0.97	0.22	33.5
				✓		✓		10x	40x	0.69 x 0.52	0.16 x 0.12	0.50	0.11	20
					✓	✓		25x	100x	0.28 x 0.21	0.06 x 0.05	0.20	0.04	13
✓							✓	0.8x	3.2x	11.58 x 8.65	2.70 x 2.02	8.32	1.94	110
	✓						✓	1x	4x	9.63 x 7.20	2.24 x 1.68	6.92	1.61	34
		✓					✓	2.5x	10x	3.85 x 2.88	0.90 x 0.67	2.77	0.64	34
			✓				✓	5x	20x	1.92 x 1.44	0.45 x 0.33	1.38	0.32	33.5
				✓			✓	10x	40x	0.96 x 0.72	0.22 x 0.17	0.69	0.16	20
					✓		✓	25x	100x	0.38 x 0.29	0.09 x 0.07	0.28	0.06	13

Table 2-1. Optical Configuration Data for 1.4MP Digital Cameras (1/2" & 2/3")

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Section 3

Re-Configuring the Optical System

This section describes how to:

- Re-configure the optical system
- Change the replacement lens
- Remove the LED ring light
- Install the LED ring light
- Change the focus step size (MeasureMind 3D systems)

Re-Configuring the Optical System

Use the following flowchart as a guide to re-configure the optical system:

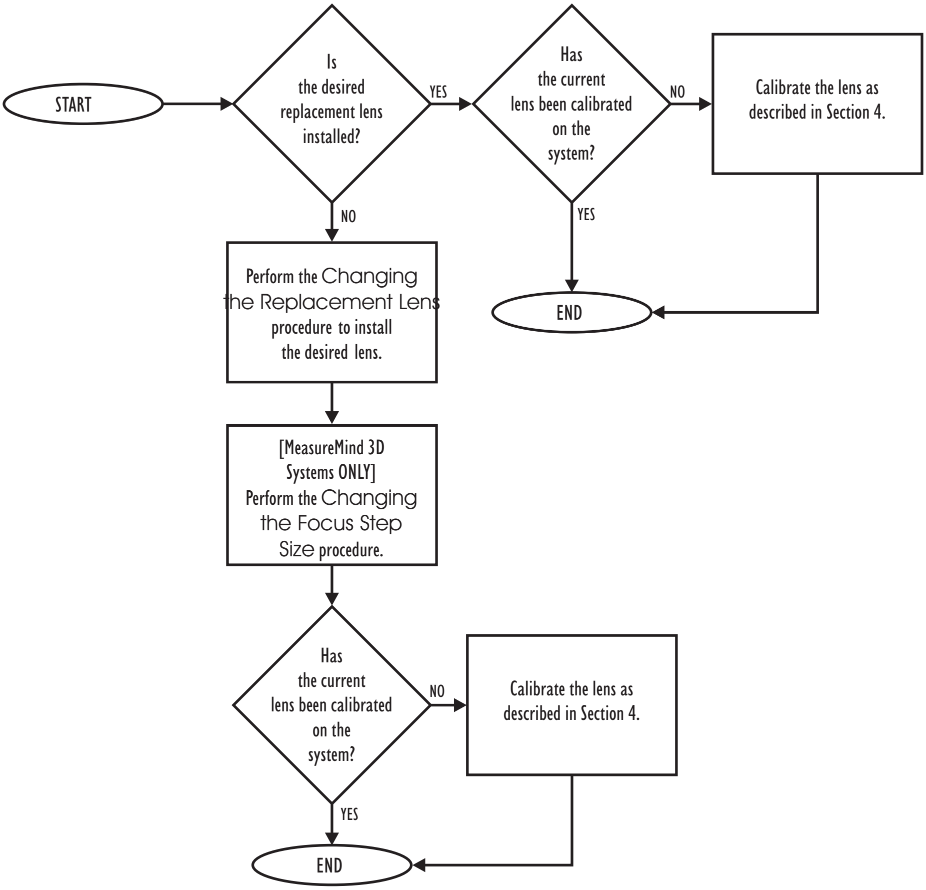


Figure 3-1. Re-Configuring the Optical System

Changing the Replacement Lens

Note: *No tools are required to change the replacement lens, and it is not necessary to remove the front cover.*

Note: *This procedure assumes that there are no parts, fixtures, or other objects on the worktable.*

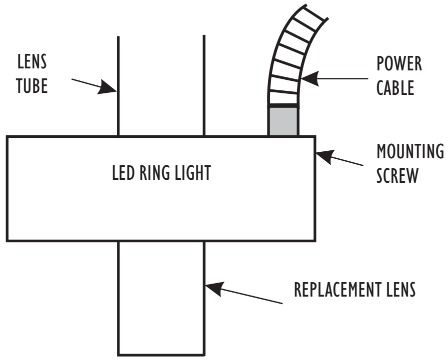
1. Use the joystick to lower the optical assembly so the lens is accessible.
2. If the Programmable Ring Light is installed, move it to the **0** setting (from within the metrology software). This provides access to the lens.
3. Unscrew (counterclockwise) the replacement lens from the lens tube and carefully set the lens aside.
4. Install the desired replacement lens by screwing it (clockwise) into the threaded opening in the bottom of the lens tube.
5. [VMS Systems] Select **Setup / Lens Calibration** and apply the lens calibration values.

   If the lens has never been calibrated on the system, perform the Lens Calibration procedure on page 4-4.
6. [MeasureMind 3D Systems] Select **System / Configuration** ⇒ **Optics** and select the current lens configuration. Then click **OK**.

   If the lens has never been calibrated on the system, perform the Optics Calibration procedure on page 4-6.

Removing the LED Ring Light (If Equipped)

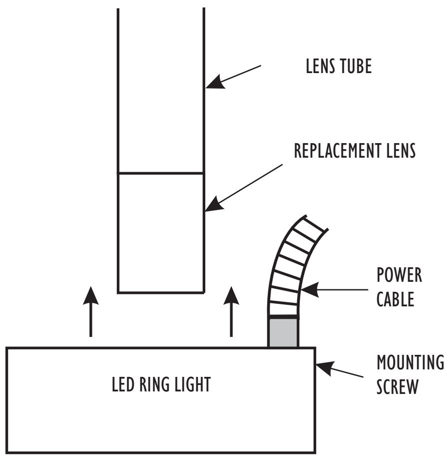
Note: *This procedure assumes that there are no parts, fixtures, or other objects on the stage.*



1. Use the joystick to lower the optical assembly so the LED ring light is accessible.
2. Exit the metrology software.
3. Shut down Windows™ and power down the system.
4. Disconnect the power cable from the top of the LED ring light. (Do not disconnect the cable with power applied, which may damage the LED ring light.)
5. Use a 3 mm Allen wrench to remove the mounting screw.
6. Remove the LED ring light and carefully set it aside.

Installing the LED Ring Light (If Equipped)

Note: *This procedure assumes that there are no parts, fixtures, or other objects on the stage.*



1. Use the joystick to lower the optical assembly so the lens is accessible.
2. Exit the metrology software.
3. Shut down Windows and power down the system.
4. Slide the LED ring light onto the lens tube and hold it in position.
5. Use a 3 mm Allen wrench to tighten the mounting screw.
6. Connect the power cable to the top of the LED ring light. (Do not connect the cable with power applied, which may damage the LED ring light.)

Changing the Focus Step Size (MeasureMind 3D)

After making changes to the optical system, it may be necessary to change the focus step size in the metrology software.

Note: *The step size, in microns, is the distance traveled in Z, between video frames during an autofocus.*

To Change the Step Size (MeasureMind 3D Systems - Rev 13 or Higher):

1. Enable calibration mode (see *Enabling Calibration Mode with ENABLE.CAL* on page 4-2).
2. Select **System / Diagnostics**.
3. Select the **Focus Graphics** check box and then click the **Save** button to close the window.
4. Place and secure a part with a fine ground aluminum surface on the stage. For the best results, we recommend using the QVI Focus Artifact (P/N 531900)
5. Move the stage so the surface appears in the Image window.
6. Adjust the surface illumination to approximately 40-50%.
7. Use the Zoom slider to select the desired camera (High Mag or Low Mag) and manually focus on the surface; adjust the lighting if necessary.
8. Click  in the toolbox to select the Advanced Focus target.
9. Click the **Reset** button in the Advanced Focus Settings window. Then click the **Advanced** button.
10. Click the **Slow Scan** radio button and then click **OK** to close the window.
11. Click anywhere in the Image window to perform an autofocus.

    Focus results, including the calculated step size and the current magnification, are displayed in the Image window.
12. Note the calculated step size and the current magnification.
13. Press **F8** and open **fzdual1x.CFG**.
14. Enter the new step size value for the current magnification.
15. Save and close the file.

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Section 4

Calibrating the Optics

This section describes how to calibrate a magnification lens.

Enabling Calibration (MeasureMind 3D Systems)

In order to perform the Optics Calibration on a system equipped with the MeasureMind 3D software, you must enable calibration mode by changing the positions of jumpers JP401 and/or JP402 on the DSP Multi Axis Board. See your system hardware documentation for information about accessing the DSP board.

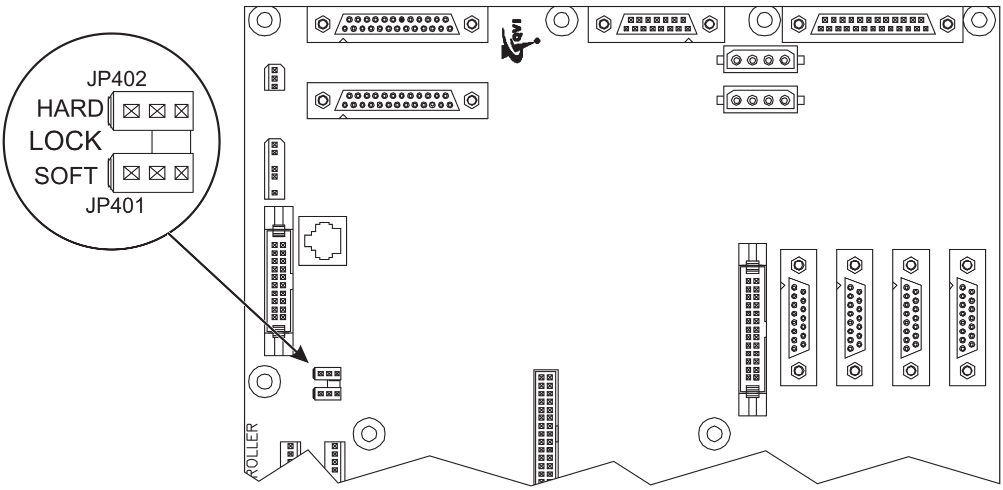
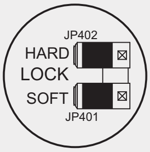
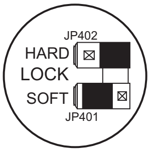
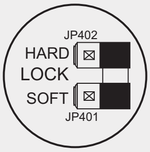


Figure 4-1. Location of Jumpers JP401 and JP402

Note: *JP402 performs the lock/unlock function and JP401 performs the complete/partial lock function. The table on the next page summarizes the jumper positions and corresponding calibration mode access.*

Jumper Positions

Calibration Access	Jumper Position	Description
Full Access		You can access and change any calibration parameter. This mode is only recommended for authorized personnel.
Partial Access		You can only access and change calibration parameters with an ENABLE.CAL file. This is the recommended mode.
No Access		You cannot access or change any of the calibration parameters.

Accessing Calibration Mode with ENABLE.CAL

1. Set the Calibration Mode to Partial Access as shown in the previous table.
2. Create a file with the filename **ENABLE.CAL**. You can create the file any way you want—you can copy another file or create a new blank file. The contents of the file are unimportant, but its filename must be **ENABLE.CAL**.
3. Copy the newly-created **ENABLE.CAL** file to a USB drive.
4. To enable calibration mode, plug the USB drive described in Step 3 into an available USB connector on the system controller.

   The system searches for a file named **ENABLE.CAL** on the USB drive. If the system finds the filename, it enables calibration mode. You can now access and change calibration parameters and settings.

Tools and Materials Required

- QVI Alignment Reticle (P/N 623970)
- Factory Data Backup disc for your system (MeasureMind 3D systems)

Calibration Procedures

Procedure	Purpose
Lens Calibration (VMS Systems)	Calibrate the field of view for the lens that is currently installed
Optics Calibration (MeasureMind 3D Systems)	Align the system computer graphics with the video image from the video camera
Autofocus Calibration (MeasureMind 3D Systems)	Minimize the effect of any residual optical astigmatism errors

Note: *The procedures described in this section assume that there are no parts, fixtures, or other obstructions on the stage. If there are, remove them before performing any of the procedures.*

Important: *You only need to calibrate lenses that are installed for the first time. You do not need to do this whenever you change lenses (use the same lens again).*

Important: *When you install a metrology software update, we strongly recommend that you calibrate each lens being used.*

Lens Calibration (VMS Systems)

Note: *You need the QVI Alignment Reticle (P/N 623970) or a sharp, square corner on any chrome glass reticle to perform the Lens Calibration.*

1. Place the QVI Alignment Reticle (P/N 623970) on the stage.
2. Secure the reticle to the stage so it will not move when the stage moves.
3. Adjust the backlight illumination to approximately 50%.
4. Click  to select the Crosshair Finder.
5. Align the bottom edge of the reticle square to the Crosshair Finder and use the joystick to move the stage from left to right along the X axis.
6. Adjust the rotation of the reticle until there is no vertical movement in the video image when you move the bottom edge of the reticle square from side to side along the X axis.

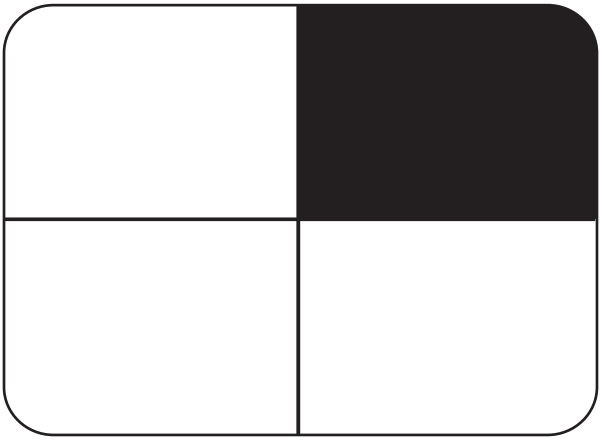
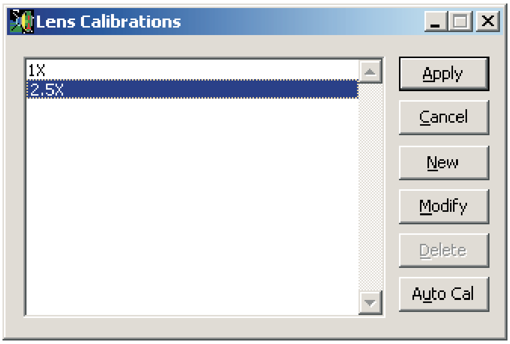


Figure 4-2. Edge, Not Skewed

7. Use the joystick to move the stage so the lower-left corner of the reticle square appears in the Video window.
8. Select the High Mag camera and manually focus on the lower-left corner of the reticle square; adjust the lighting if necessary.

9. Select **Setup / Calibration**.

   The following appears:

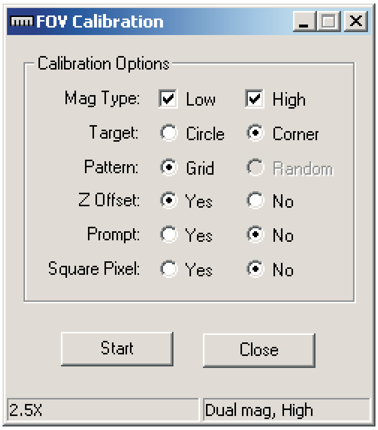


10. Select the lens that is installed.

Note: *If the lens you want to calibrate is not listed, click the **New** button and define the new lens by selecting the type of lens and entering a descriptive name for the lens (for example, 1X).*

11. Click the **Auto Cal** button.

    The following appears:



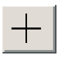
12. Click the **No** Square Pixel radio button.
13. Click the **Start** button and then click **OK** in response to the displayed prompt.

    The system automatically performs the lens calibration and displays the FOV Calibration window when finished.

14. Click the **Close** button in the FOV Calibration window.
15. Click the **Apply** button in the Lens Calibrations window.
16. Click the **Close** button in the Lens Calibrations window.

Optics Calibration (MeasureMind 3D Systems)

Note: *You need the Factory Data Backup disc and the QVI Alignment Reticle (P/N 623970) or a sharp, square corner on any chrome glass reticle to perform the Optics Calibration.*

1. Insert the Factory Data Backup disc into the system controller to “unlock” the calibration files.
2. Place the QVI Alignment Reticle (P/N 623970) on the stage.
3. Secure the reticle to the stage so it will not move when the stage moves.
4. Adjust the backlight illumination to approximately 50%.
5. Use the joystick to move the stage so the upper-right corner of the reticle square appears in the Image window.
6. Move the Zoom slider to the far right to select the High Mag camera and manually focus the reticle square; adjust the lighting if necessary.
7. Click  in the toolbox to select the Basic Focus target.
8. Click in the Image window to focus on the upper-right corner of the reticle square.
9. Click  in the toolbox to select the Crosshair target.
10. Align the top edge of the reticle square to the Crosshair target and use the joystick to move the stage from left to right along the X axis.
11. Adjust the rotation of the reticle until there is no vertical movement in the video image when you move the top edge of the reticle square from side to side along the X axis.

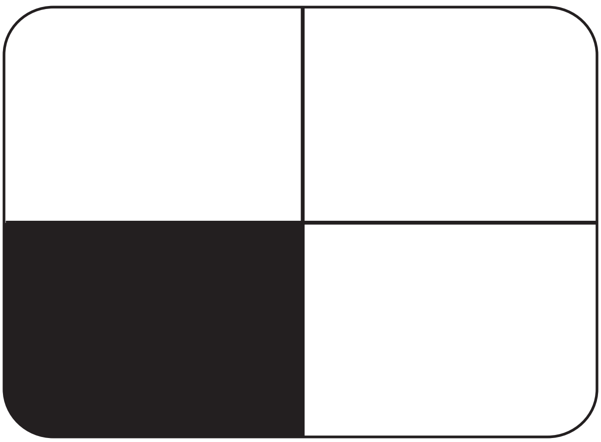


Figure 4-3. Edge, Not Skewed

12. Select **System / Calibration** ⇒ **Optics**.

- If the system is equipped with the AccuCentric assembly, a calibration circle (image of the LED reticle) appears in the Image window. Go to Step 13.
- If the system is not equipped with the AccuCentric assembly, go to Step 14 on the next page.

13. Select three points on the largest complete circle that fits in the Image window (see Figure 4-4). Make sure the points are equally spaced.

The system measures the circle diameter and determines the precise relative magnification.

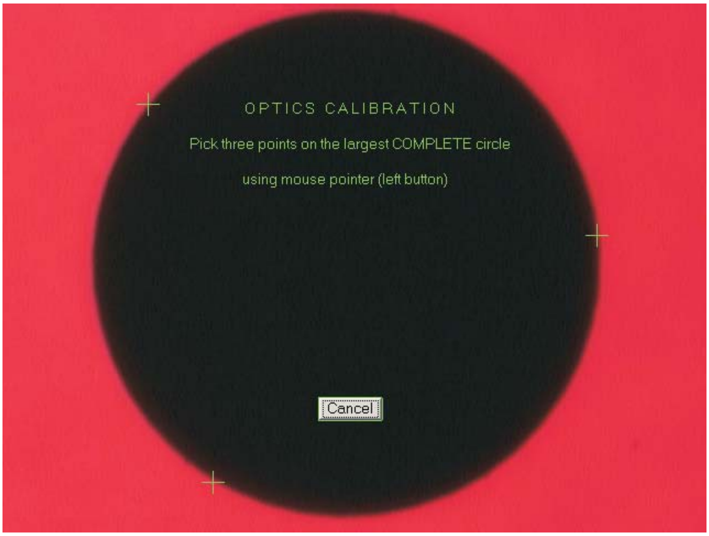


Figure 4-4. Image of LED Reticle

14. Make sure the upper-right corner of the QVI Alignment Reticle square is approximately centered in the Image window as shown in Figure 4-5.

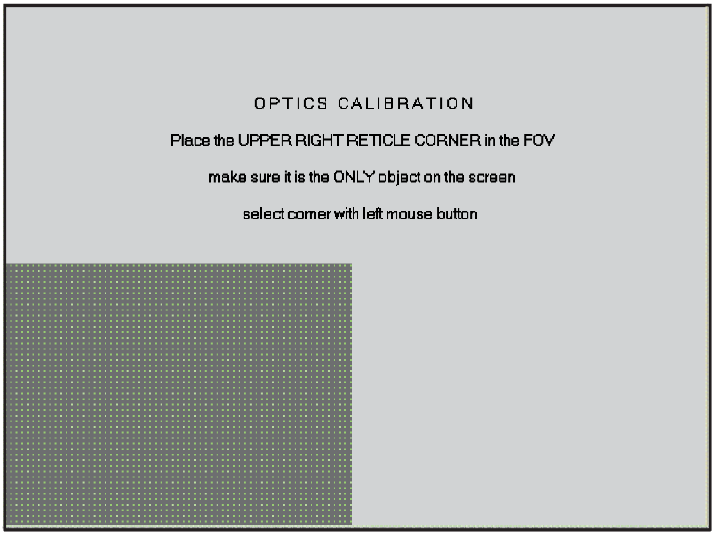


Figure 4-5. Optics Calibration Screen

15. Click the left mouse button to start the calibration.

The system automatically calibrates the field of view and optics.

If the Optics Calibration Fails…

Occasionally, the Optics Calibration may fail if:

- The image shown in Figure 4-5 is out of focus, offset from center, or does not appear at all
- The alignment reticle is dirty
- The contrast level is set too high—To compensate for high contrast, try selecting the strong edge finder target, and move the contrast slider to 0%

Repeat the Optics Calibration for any new lenses. Calibration files are retained in the system and can be recalled whenever you change a lens.

Autofocus Calibration (MeasureMind 3D Systems)

Note: *You need the Factory Data Backup disc and the QVI Alignment Reticle (P/N 623970) to perform the Autofocus Calibration.*

1. Insert the Factory Data Backup disc into the system controller to “unlock” the calibration files.

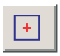
2. Place the QVI Alignment Reticle (P/N 623970) on the stage.

3. Secure the reticle to the stage so it will not move when the stage moves.

4. Adjust the backlight illumination to approximately 50%.

5. Use the joystick to move the stage so the reticle dot appears in the Image window.

6. Use the Zoom slider to select the desired camera (High Mag or Low Mag) and manually focus the reticle dot; adjust the lighting if necessary.

7. Click  in the toolbox to select the Basic Focus target.

8. Click in the Image window to focus on the reticle dot.

9. Select **System / Calibration** ⇒ **Auto Focus**.

10. Carefully select three points on the circumference of the reticle dot (as shown).

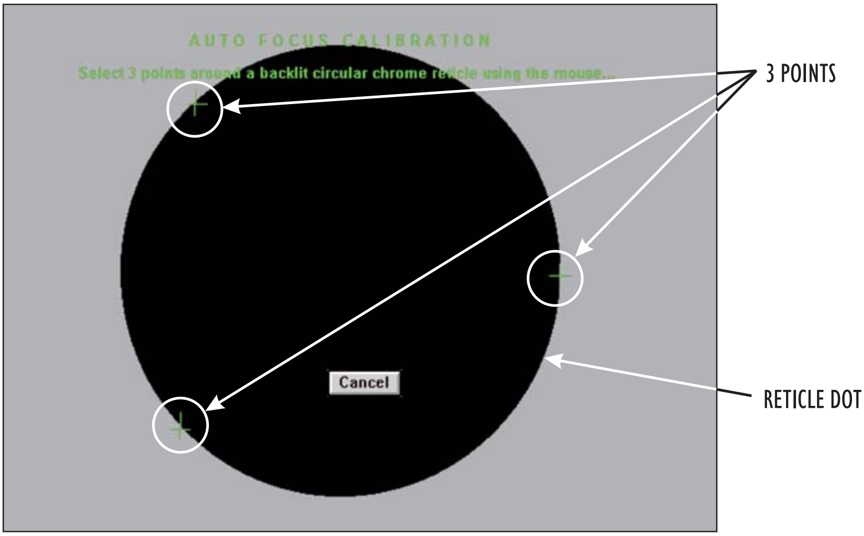


Figure 4-6. Select Three Points

The system performs the calibration for the current magnification.

Note: *The reticle dot does not have to fit entirely in the field of view. You can select a point on a larger dot, move the stage, select another point, move the stage again, and select the third point.*

11. If the calibration is successful, the system generates or updates the autofocus correction factors in the CONFIG directory and displays calibration results in the Image window. Click **Done** to complete the calibration.

    If the calibration fails, an error message is displayed. Click **OK** and perform the calibration again.

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