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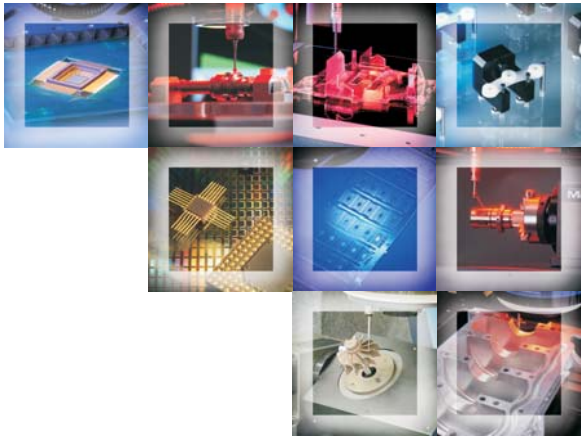

Zoom 12
Optical Configuration Guide

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Section 4: Calibrating the Optics

Section 1

Introduction

This *Optical Configuration Guide* applies to all QVI video metrology systems equipped with 12:1 zoom 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 • Shows the optical components • Shows the optical 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 • Includes information for each optical configuration
3	Re-Configuring the Optical System	• Describes how to change replacement lenses and install attachment lenses • Describes how to change the focus step size
4	Calibrating the Optics	• Describes how to calibrate the optics

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

If You Need Help

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

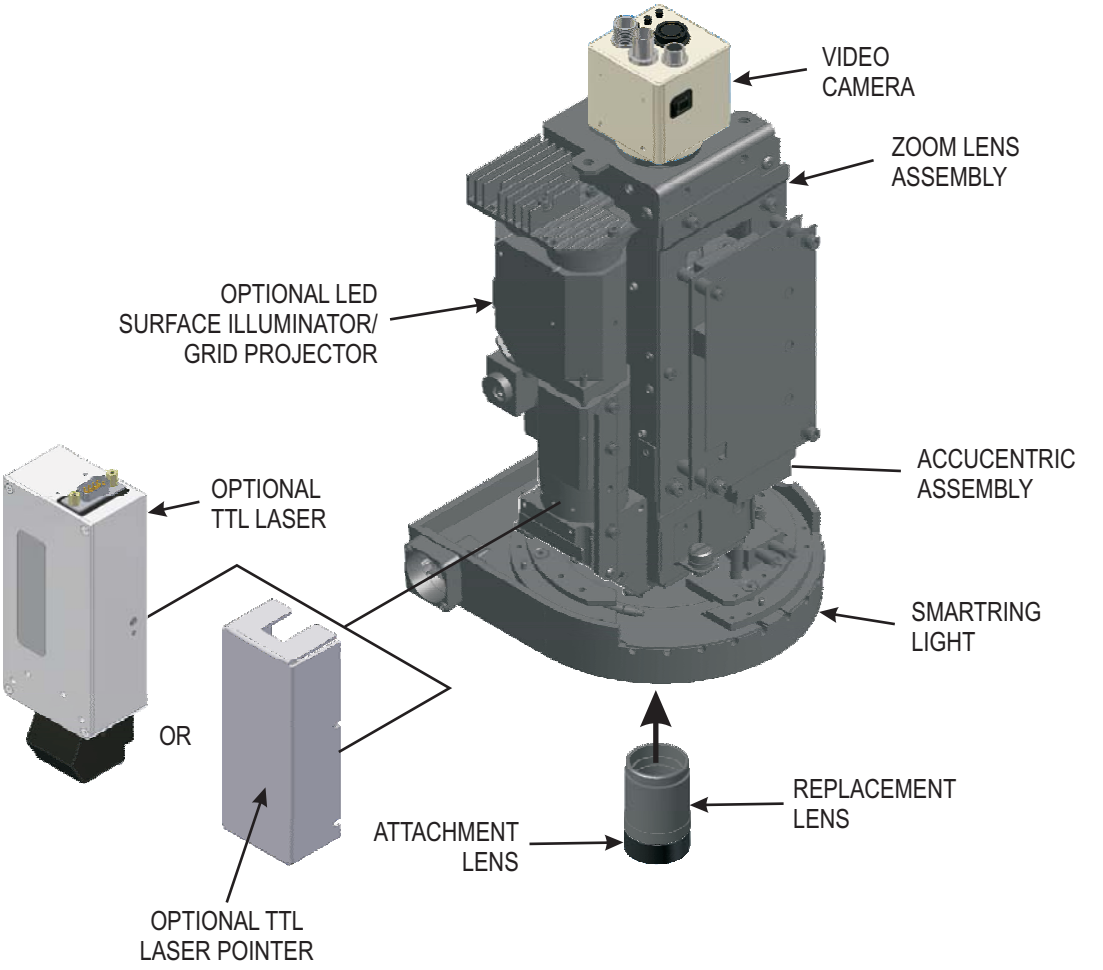

Figure 1-1. Optical Components

Video Camera

The video camera is a high resolution color CCD camera (P/N 036259) or a monochromatic automation camera (P/N 036154). It mounts to the top of the zoom lens assembly and sends a live video image of the part under inspection to the system computer, which displays the image on the system monitor.

Zoom Lens Assembly

The standard 12:1 motorized zoom lens provides 33x to 298x on-screen magnification (on a 15" LCD monitor).

Available Zoom 12 assemblies:

Part Number	Optical Components							
	Color Camera	Mono-chromatic Camera	12X Zoom Lens	AccuCentric Assembly	LED Grid Projector	LED Surface Illuminator	QVI TTL Laser or TTL Laser Pointer	DRX Laser
529020 (standard)	✔		✔	✔		optional		
529019	✔		✔	✔	✔	✔		
531777	✔		✔	✔	✔	✔	✔	
526040	✔		✔	✔				✔
529021		✔	✔			optional		

AccuCentric Assembly

The AccuCentric assembly (P/N 527528) mounts on the right-hand side of the zoom lens assembly and contains an LED reticle that is used to automatically recalibrate the optical system whenever you change the zoom position (magnification).

LED Surface Illuminator

The optional LED surface illuminator (P/N 638852) mounts on the left side of the zoom lens assembly and provides direct, square-on, white light.

LED Surface Illuminator/Grid Projector

The optional LED surface illuminator/grid projector (P/N 529031) mounts on the left side of the zoom assembly and adds the ability to project contrast onto surfaces that have little or no contrast, such as glass. This allows you to perform an autofocus on such surfaces.

SmartRing Light

The SmartRing light mounts below the zoom lens assembly and provides oblique surface illumination. It consists of eight 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 SmartRing 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 a SmartRing light.

Different models are available, depending on which multi-sensor options are installed:

SmartRing Light Model	Part Number
Standard (no probes)	531398
Flexible	532366
For Touch Probe	531397
For Motorized Probe	531395
For Touch Probe & Motorized Probe	531394
For Touch Probe & DRX Laser	531645

The flexible SmartRing light comes with a detachable 1X Fresnel lens (P/N 532370), designed to be used with the 1X replacement lens (no attachment lenses). An interchangeable 0.5X Fresnel lens (P/N 532371) is available for use with the 0.5X attachment lens. Also available is an interchangeable parabolic reflector (P/N 532376), which provides a lower angle of incidence and smaller working distance (10 mm), ideal for measuring relatively flat parts.

Replacement Lenses

Replacement lenses mount to the bottom of the zoom lens assembly. These lenses decrease the field of view, decrease the working distance, and increase the magnification without changing the magnification range. A replacement lens is required for proper system operation.

Replacement Lens	Part Number
1X	634680
2.5X	639050
5X	639051

Note: *A 2X replacement lens (P/N 639184) is available for color camera systems equipped with the QVI TTL laser option. The lens mounts to the bottom of the zoom lens assembly in place of the 1X replacement lens.*

Attachment Lenses

Attachment lenses mount to the bottom of the 1X replacement lens; they are not available with any other replacement lens. These lenses either increase the field of view and decrease the magnification, or decrease the field of view and increase the magnification. They do not change the range of the zoom lens, but they do change the working distance.

Attachment Lens	Part Number
0.5X	638818
0.75X	639143
1.5X	637070
2X	630270

Standard Color Camera Systems

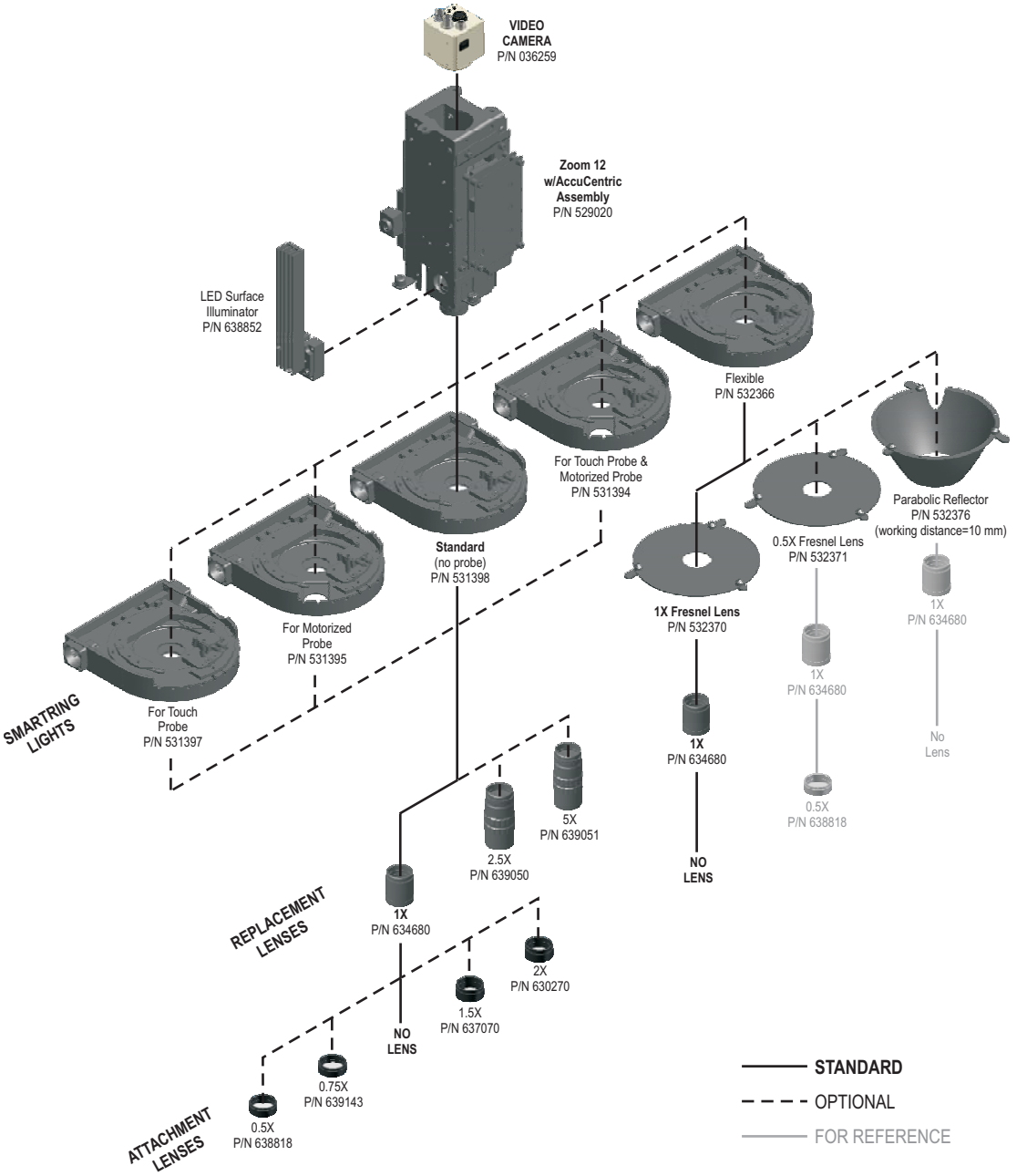

Figure 1-2. Standard Color Camera Systems

Color Camera Systems with Optional LED Surface Illuminator/Grid Projector

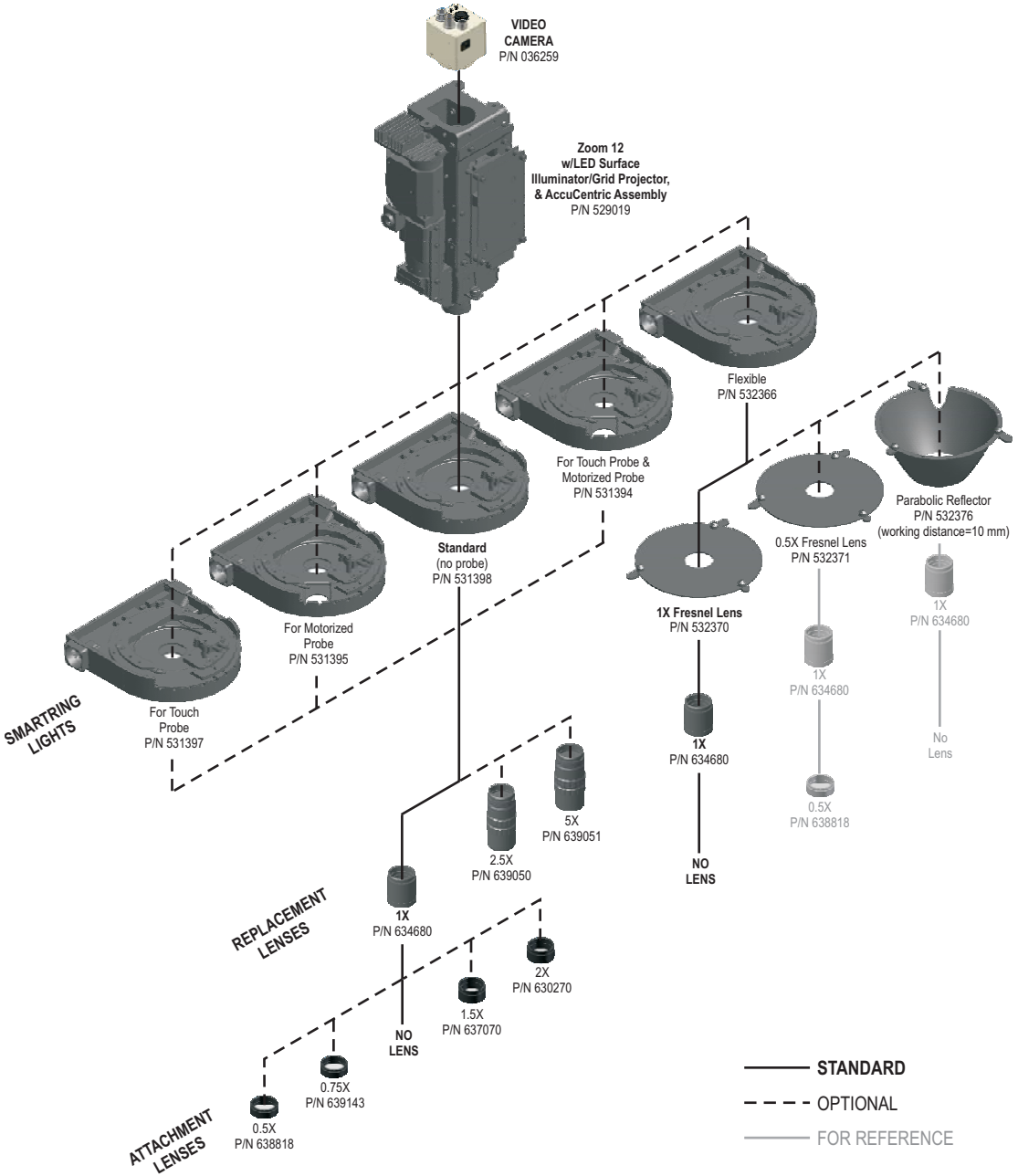

Figure 1-3. Color Camera Systems with Optional LED Surface Illuminator/Grid Projector

Color Camera Systems with Optional TTL Laser Pointer

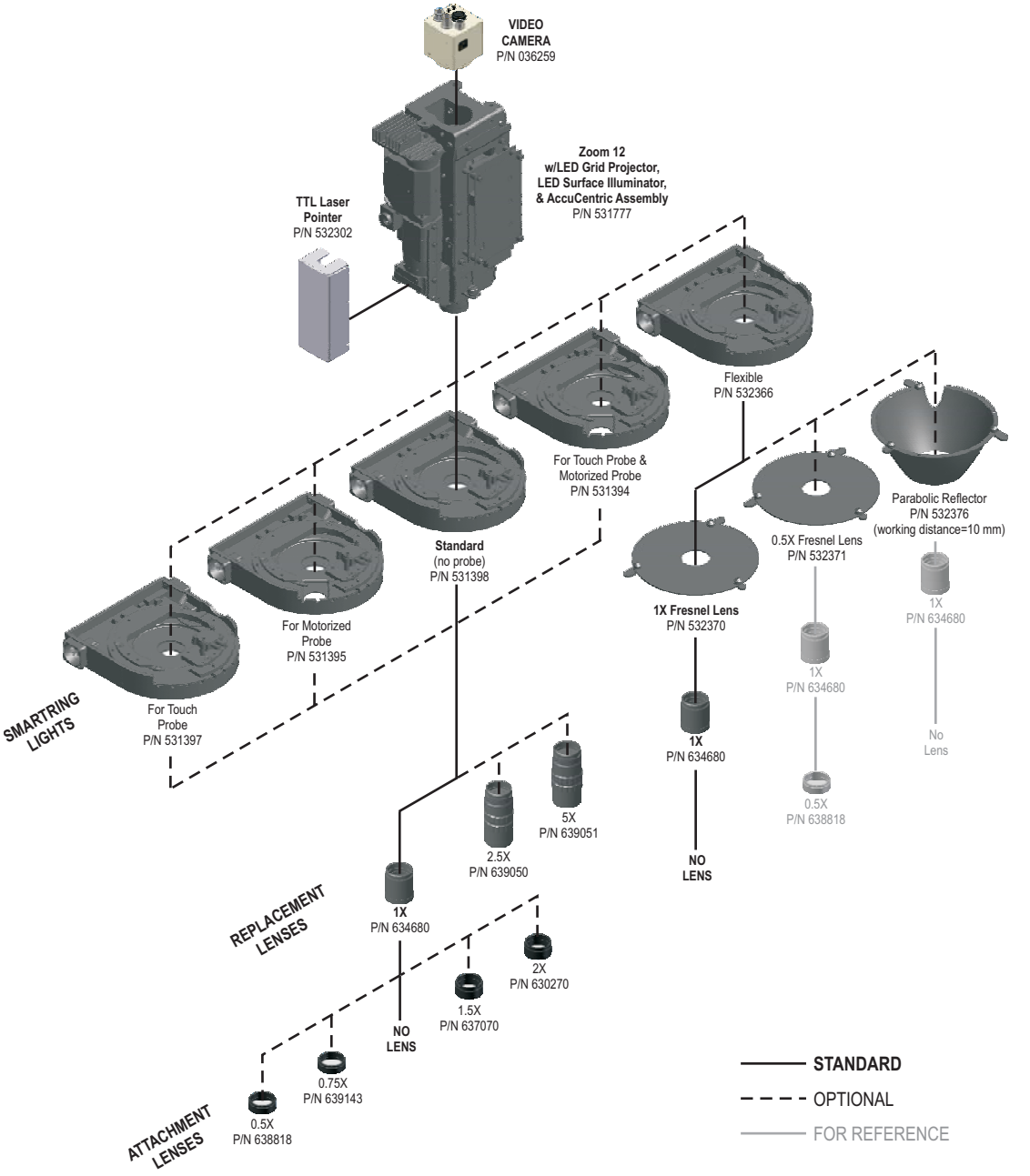

Figure 1-4. Color Camera Systems with Optional Laser Pointer

Color Camera Systems with Optional QVI TTL Laser

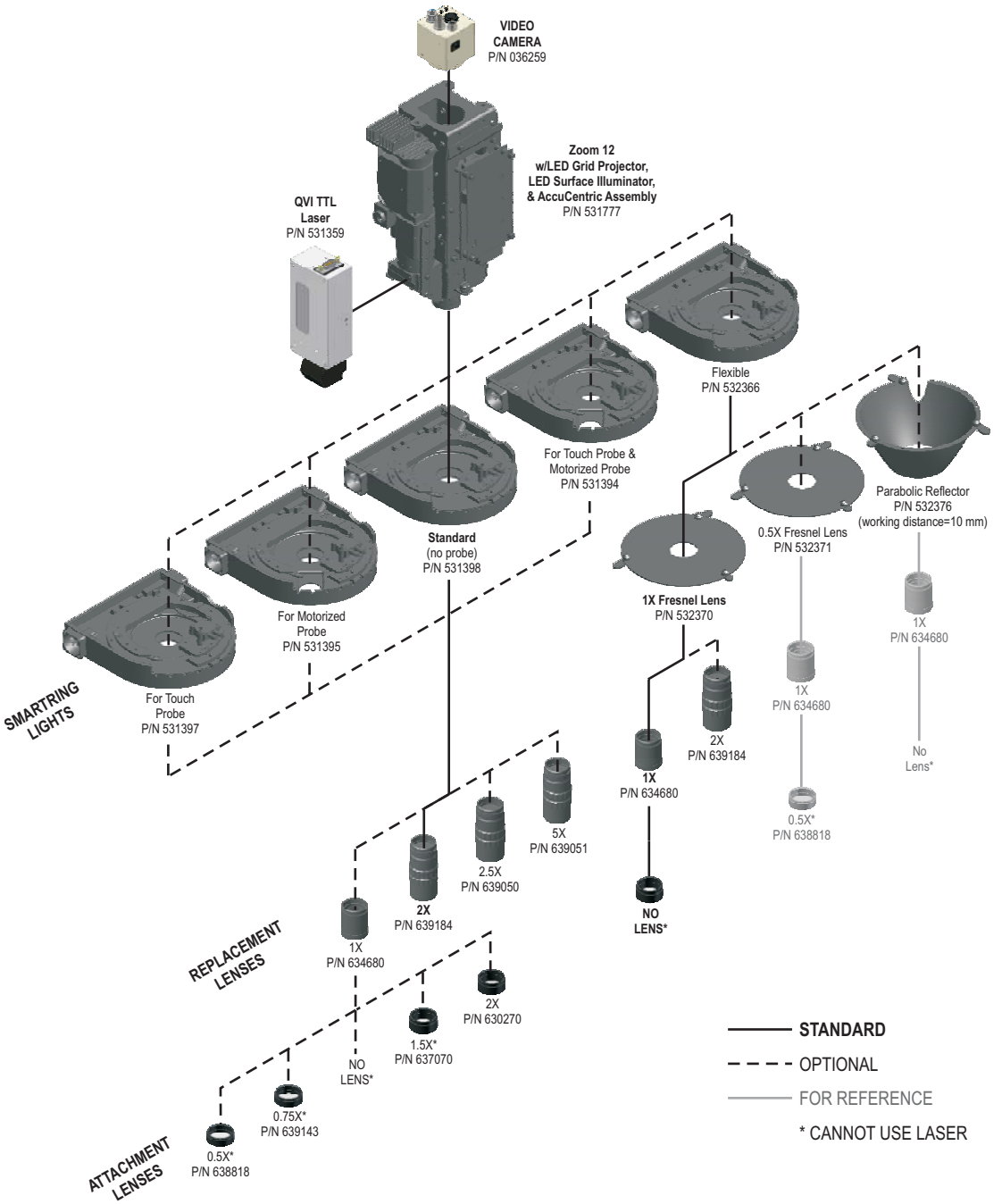

Figure 1-5. Color Camera Systems with Optional QVI TTL Laser

Color Camera Systems with Optional DRX Laser

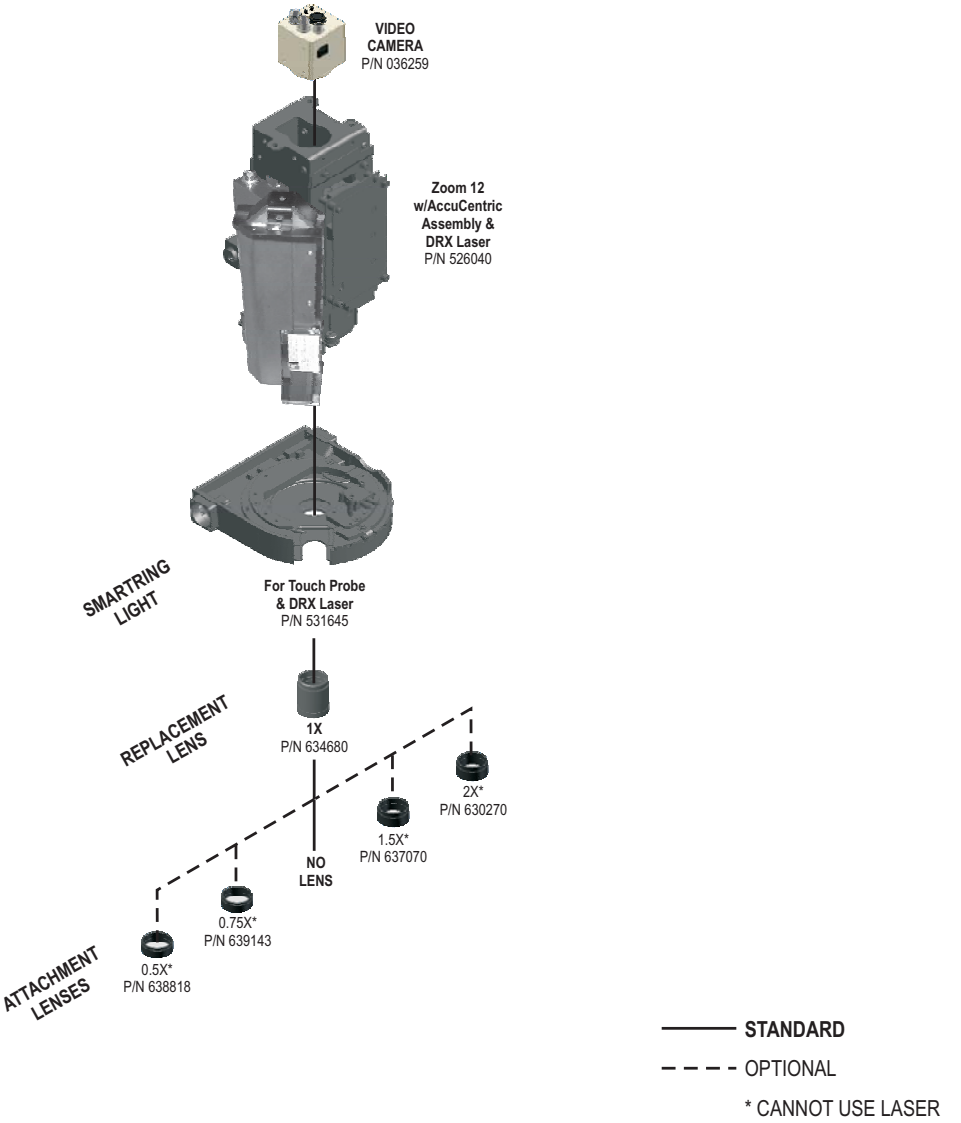

Figure 1-6. Color Camera Systems with Optional DRX Laser

Monochromatic Camera Systems

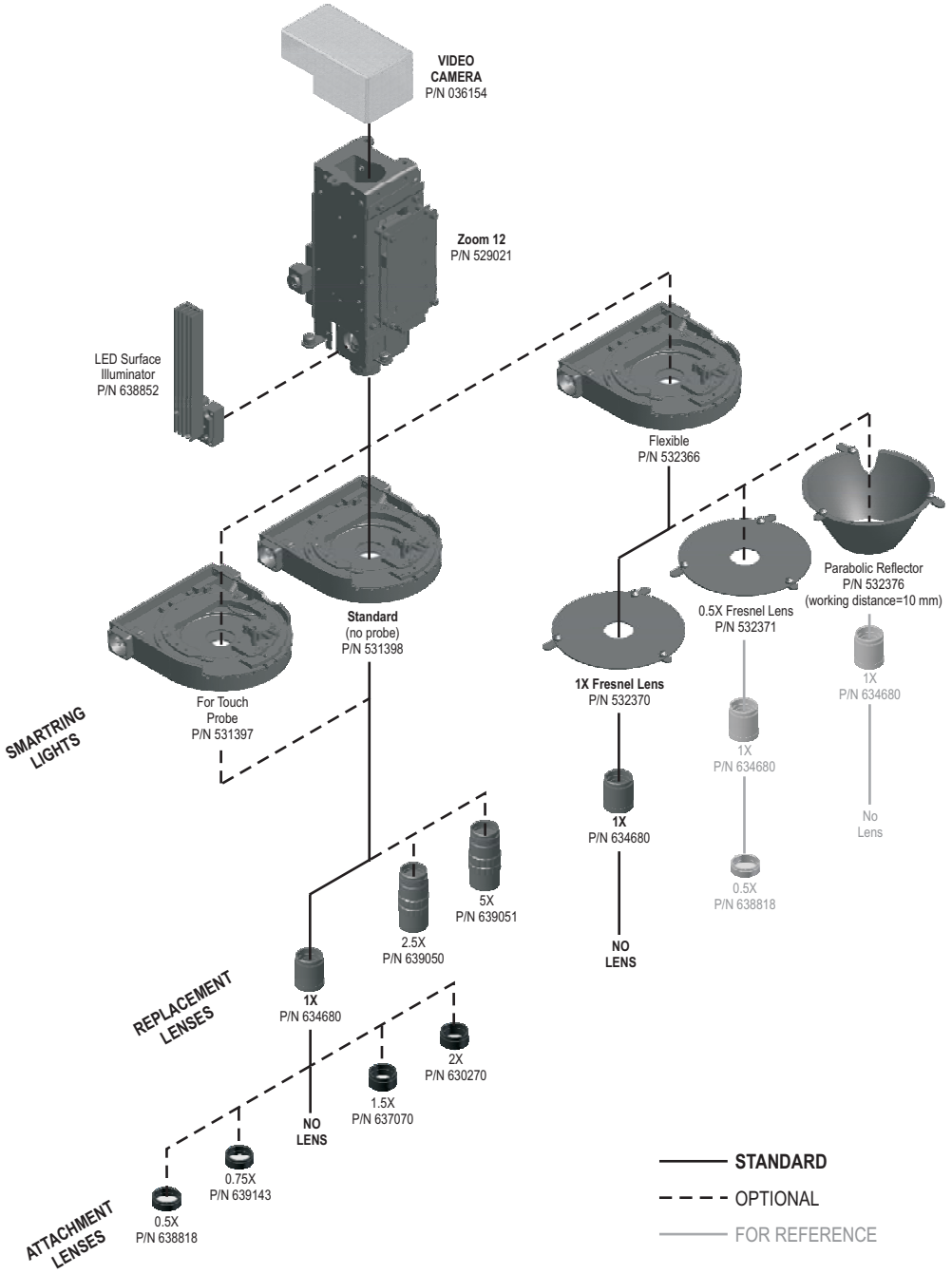

Figure 1-7. Monochromatic Camera Systems

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 SmartRing 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 front 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 lens has the following effects:

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

Key:

- ↑ increase
- ↓ decrease

Helpful Hints

- Always allow sufficient working distance for your application. Consider clearances of the optics and SmartRing 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.
- For applications requiring the SmartRing light, choose a configuration that provides a working distance closest to 75 mm (3").
- Any optical configuration change will change magnification, which may require an optics recalibration (described in Section 4).
- Increasing the depth of field reduces the need to refocus, but also reduces the autofocus accuracy.
- 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 range (optical and on-screen)
- Field of view range
- Working distance
- Depth of field
- Distortion at low magnification
- Hot spot at low magnification
- Step size for the highest magnification (see *Changing the Focus Step Size* on page 3-5 for information about changing the step size)

Optical Configurations								Specifications							
Replacement Lenses			Attachment Lenses					Mag Range		FOV Range (mm)	Working Distance (mm)	Depth of Field (mm)	Distortion (Low Mag) (µm)	Hot Spot** (Low Mag)	Step Size (at highest zoom position)
1X	2.5X	5X	NONE	0.5X	0.75X	1.5X	2X	Optical	On-Screen*						
✔			✔					0.8x - 7.0x	33.2x - 298x	10.08 - 1.13	64	2.3	2.44	21%	31.12
✔				✔				0.5x - 3.9x	18.4x - 163x	18.22 - 2.05	95	4.6	4.84	36%	74.99
✔					✔			0.6x - 5.5x	25.7x - 229x	13.30 - 1.45	73	3.6	3.75	28%	41.62
✔						✔		1.2x - 10.2x	47.9x - 426x	7.01 - 0.78	39	1.5	2.30	15%	15.62
✔							✔	1.5x - 13.3x	62.5x - 558x	5.37 - 0.60	30	1.3	1.42	20%	11.74
	✔							1.9x - 16.7x	78.4x - 700x	4.28 - 0.48	35	0.8	1.03	32%	11.99
		✔						3.8x - 33.5x	157x - 1404x	2.13 - 0.24	32	0.2	0.57	22%	3.62

* Magnification on a 15" LCD monitor

** Indicates the approximate light intensity difference between the corners of the FOV and the center of the FOV

Table 2-1. Optical Configuration Data

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Section 3

Re-Configuring the Optical System

This section describes how to:

- Re-configure the optical system
- Install an attachment lens
- Change the replacement lens
- Change the focus step size

Re-Configuring the Optical System

After choosing an optical configuration, use the following flowchart as a guide to re-configure the optical system:

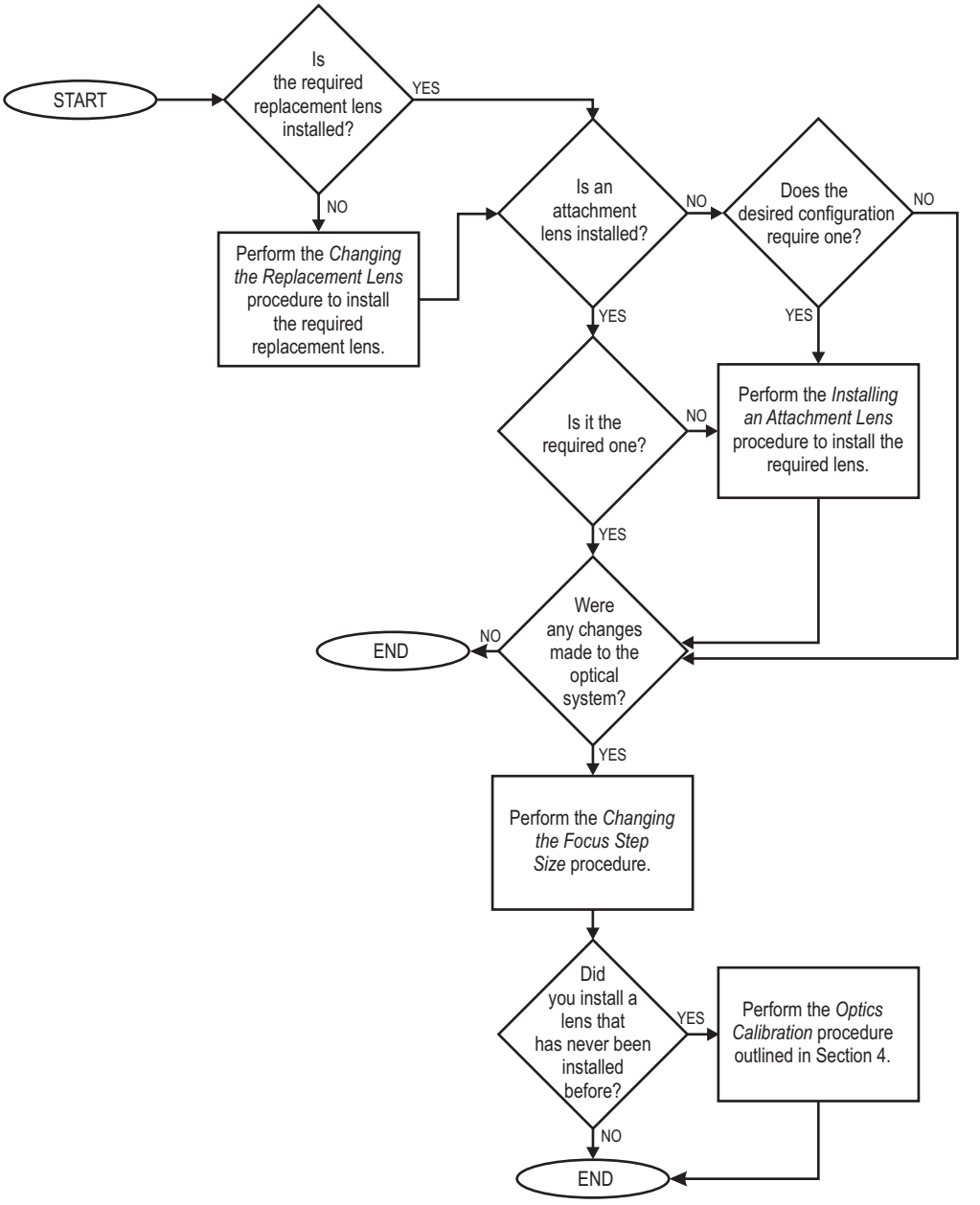


Figure 3-1. Re-Configuring the Optical System

Installing an Attachment Lens

Note: *No tools are required to install an attachment lens, and it is not necessary to remove the optics cover.*

Note: *This procedure assumes the 1X replacement lens is installed. If necessary, perform the Changing Replacement Lenses procedure to install the 1X replacement lens.*

1. Use the joystick to raise the optical assembly to the upper limit of travel.
2. If an attachment lens is already installed, unscrew it (counterclockwise) and set it aside.
3. Install the desired attachment lens by screwing it (clockwise) into the threaded opening in the bottom of the replacement lens until it stops.
4. Select **System / Configuration** ⇒ **Optics** and select the lens configuration that is currently installed on the system.
5. Click **OK**.
6. Perform the *Optics Calibration* on page 4-4 if this lens has never been installed on the system or if it has not been installed since the last metrology software update.

Changing Replacement Lenses

1. Use the joystick to raise the optical assembly to the upper limit of travel.
2. If necessary, remove the SmartRing light (refer to your system *Service and Maintenance Manual*):
   - Exit the metrology software, shut down Windows, and power down the system. (Do not remove the SmartRing light with power applied, which may damage the SmartRing light.)
   - Remove the optics cover.
   - Grasp the SmartRing light by its outside edges and fully loosen the three thumbscrews securing the SmartRing light to the optical assembly.
   - Unplug the connector from the back of the SmartRing light and gently set it on the stage.
3. Unscrew (counterclockwise) the currently installed replacement lens and set it aside.
4. Install the desired replacement lens by screwing it (clockwise) into the threaded opening in the bottom of the zoom lens assembly until it stops.
5. If you removed the SmartRing light, re-install it by reversing the procedure in Step 2. Then power up the system and launch the metrology software.
6. Select **System / Configuration** ⇒ **Optics** and select the lens configuration that is currently installed on the system.
7. Perform the *Optics Calibration* on page 4-4 if this lens has never been installed on the system or if it has not been installed since the last metrology software update.

Changing the Focus Step Size

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

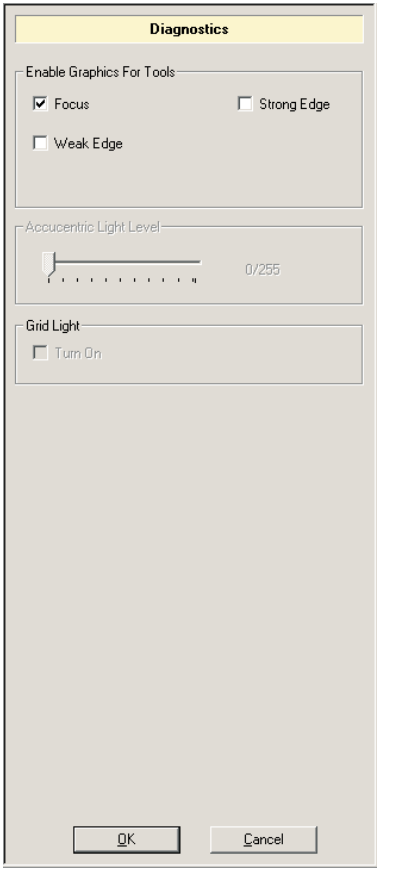
1. Enable calibration mode (see *Enabling Calibration Mode with ENABLE.CAL* on page 4-2).
2. Select **System / Diagnostics**.
3. Select the **Focus Graphics** check box and then click the **Save** button to close the window.
4. Place and secure a part with a fine ground aluminum surface on the stage. 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 zoom to the desired magnification 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 zoom position, are displayed in the Image window.
12. Note the calculated step size and the current zoom position.
13. Press **F8** and open **FTEN_1X.CFG**.
14. Enter the new step size value for the current zoom position.
15. Save and close the file.

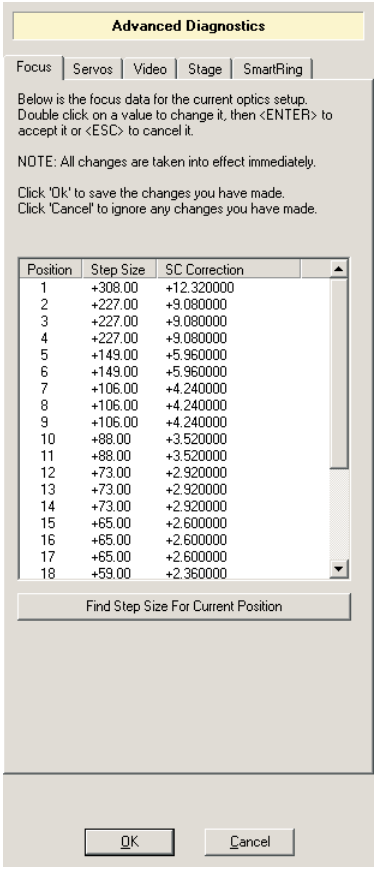
To Determine the Correct Step Size (Measure-X Systems):

Note: *If you already know the recommended step size for the desired zoom position, you do not need to perform this procedure; perform the procedure on page 3-8 to change the step size.*

1. Insert the system options disk into the system disk drive.
2. Select **System / Diagnostics** ⇒ **Basic**.
3. Select the **Focus** check box and click the **OK** 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 zoom to the desired magnification and manually focus on the surface; adjust the lighting if necessary.



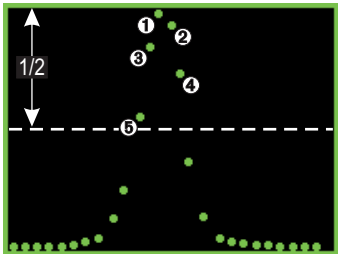
8. Select **System / Diagnostics ⇒ Advanced**.
9. Click the **Focus** tab.
10. Click the **Find Step Size For Current Position** button and observe whether or not the step size value for the current zoom position changes.
    - If the value changes, advance to Step 13.
    - If the value remains the same, continue with the next step.
11. Double-click on the **Step Size** value for the current zoom position and change the value.
12. Repeat Steps 10 and 11 until the step size value for the current zoom position changes when you click the Find Step Size For Current Position button.



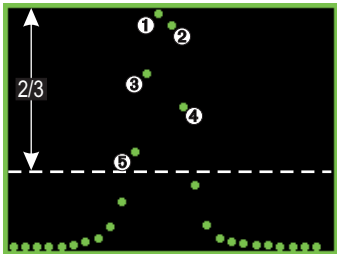
13. Click  in the toolbox and focus on the same surface that you focused on in Step 7.

    Focus graphics appear in the Image window. Note the contrast curve displayed in the lower-right corner of the Image window. The peak of the bell-shaped curve and two points on either side should occupy the upper 2/3 of the curve (as shown below).

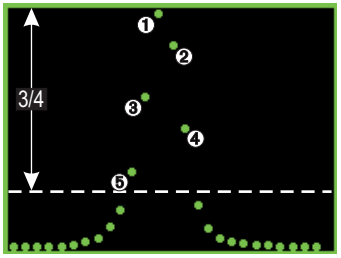
    - If the points only occupy the upper 1/2 of the curve or less, the step size is too small (see example below).
    - If the points occupy the upper 3/4 of the curve or more, the step size is too large (see example below).



STEP SIZE TOO SMALL



STEP SIZE CORRECT



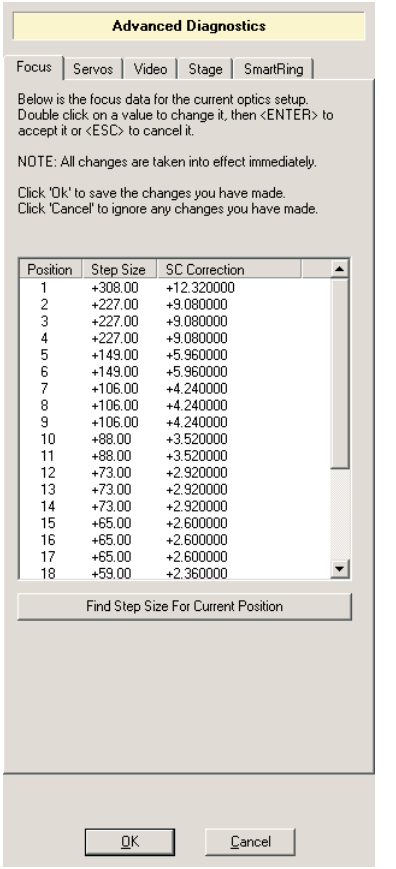
STEP SIZE TOO LARGE

14. If necessary, change the step size (as described in Step 11) for the current zoom position so the peak of the curve and two points on either side occupy the upper 2/3 of the curve.
15. Click the **OK** button to save the changes (or click **Cancel** to ignore the changes).

To Change the Step Size (Measure-X Systems):

Note: *Perform this procedure if you already know the step size. If you do not know the step size, perform the procedure on page 3-6 to determine the correct step size.*

1. Insert the system options disk into the system disk drive.
2. Select **System / Diagnostics** ⇒ **Advanced**.
3. Click the **Focus** tab.
4. Double-click on the desired **Step Size** value to edit the value.
5. Type the new value.
6. Press **Enter** to accept the change (or press **Esc** to cancel).
7. Click the **OK** button to save the changes (or click **Cancel** to ignore the changes).



Section 4

Calibrating the Optics

This section describes how to calibrate the optics after changing the optical configuration.

Enabling Calibration

In order to perform the Optics Calibration, 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.

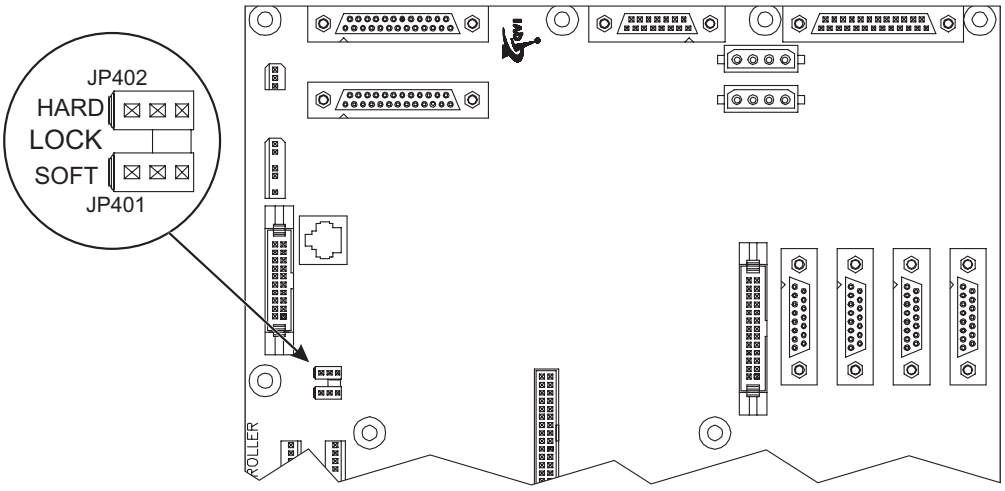
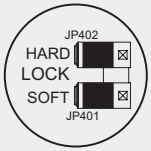
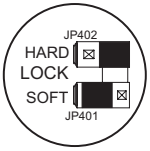
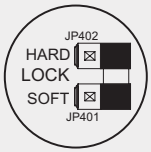


Figure 4-1. Location of Jumpers JP401 and JP402

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. Insert a formatted, blank floppy disk into the system floppy drive. Then, copy the newly-created ENABLE.CAL file onto the disk.
4. To enable calibration mode:
   - Insert the floppy disk created in Step 3 into the system floppy drive.
   - Access any calibration function from the **System / Calibration** menu.

Tools and Materials Required

- QVI Alignment Reticle (P/N 623970)
- Options disk for your system

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 either procedure.*

Calibration Procedures

Procedure	Purpose
Optics Calibration	Align the system computer graphics with the video image from the video camera
Autofocus Calibration	Minimize the effect of any residual optical astigmatism errors

Note: *See the Calibration and Alignment Manual for your system for additional optical calibration and alignment procedures and laser alignment procedures.*

Important: *You only need to perform the Optics Calibration when you install a lens 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 perform the Optics Calibration for each lens being used.*

Optics Calibration

The Optics Calibration ensures that an edge can be detected anywhere within the field of view.

Note: *You need the system options disk 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 system options disk into the system floppy disk drive—this "unlocks" 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. Use the Zoom slider to zoom to the *highest* magnification 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.

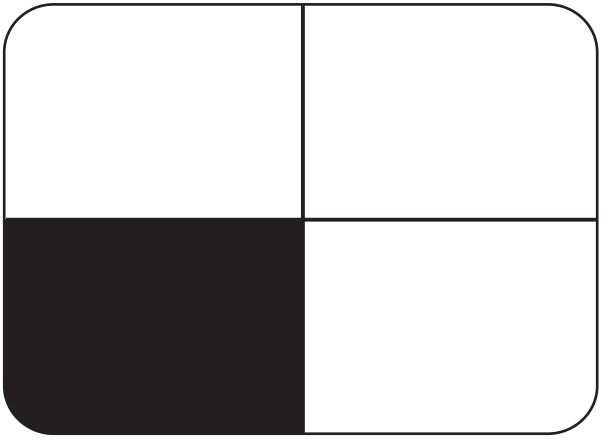


Figure 4-2. Edge, Not Skewed

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 4-3). Make sure the points are equally spaced.

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

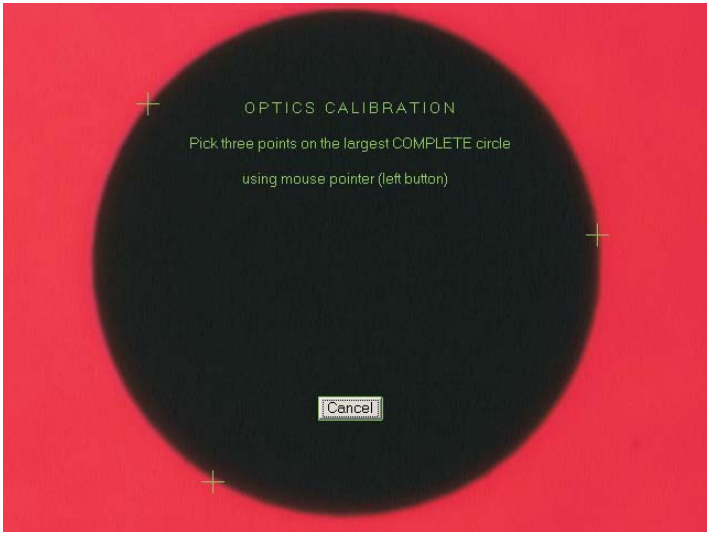


Figure 4-3. Image of LED Reticle

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

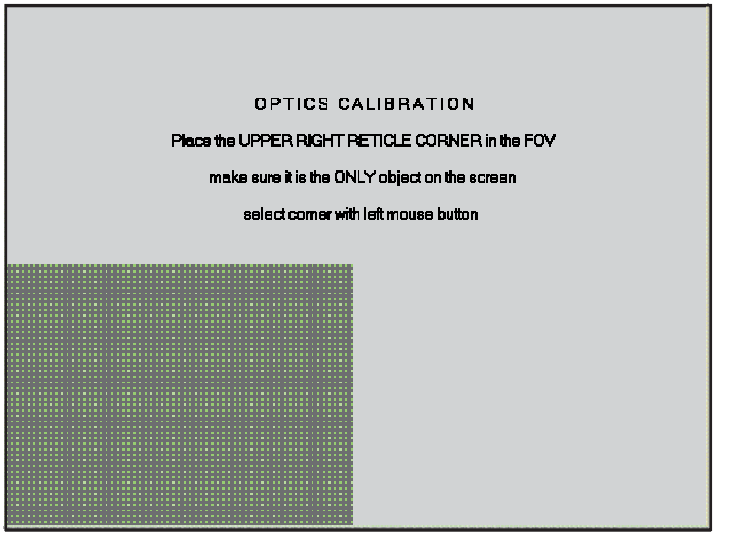


Figure 4-4. Optics Calibration Screen

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

The system automatically calibrates the field of view and zoom lens at each zoom position. The length of time depends on the number of steps in the zoom range.

If the Optics Calibration Fails…

Occasionally, the Optics Calibration may fail if:

- The image shown in Figure 4-4 is out of focus, offset from the center, or does not appear at all
- 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

The Autofocus Calibration minimizes the effect of any residual optical astigmatism errors.

Note: *You need the system options disk and the QVI Alignment Reticle (P/N 623970) to perform the Autofocus Calibration.*

1. Insert the system options disk into the system floppy disk drive—this "unlocks" 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 zoom to the desired magnification and manually focus the reticle dot; adjust the lighting if necessary.
7. Click  in the toolbox to select the Basic Focus target.
8. Position the Basic Focus target over an edge of the reticle dot and click in the Image window to perform an autofocus.
9. Center the reticle dot in the Image window and select **System / Calibration** ⇒ **Autofocus**.

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

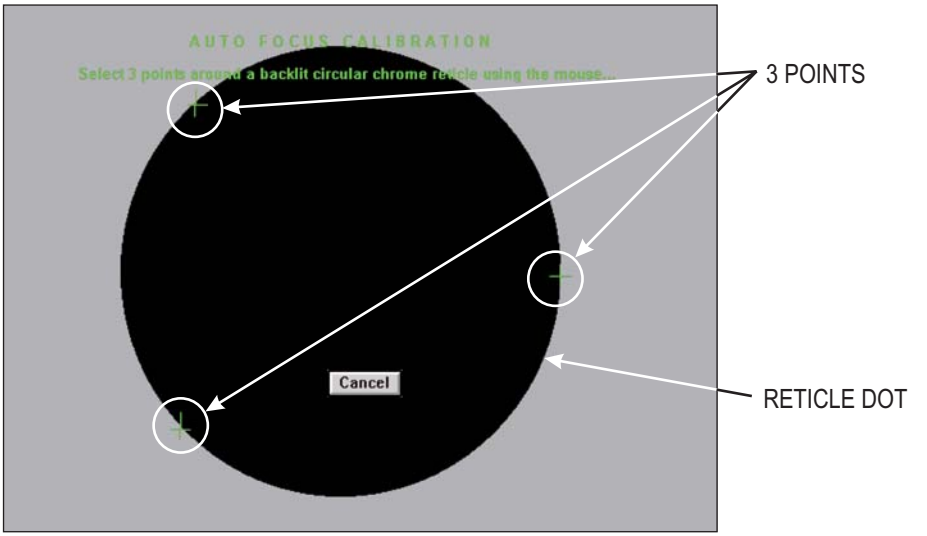


Figure 4-5. Select Three Points

The system performs the calibration for the current zoom position.

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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