NI Vision

NI Vision Builder for Automated Inspection Tutorial

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Worldwide Technical Support and Product Information

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About This Manual

This manual contains many techniques for using NI Vision Builder for Automated Inspection (Vision Builder AI) to solve visual inspection tasks including inspection, gauging, part presence, guidance, and counting.

Follow the instructions in this manual to familiarize yourself with the Vision Builder AI and perform common inspection tasks.

Conventions

The following conventions appear in this manual:

» — The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.

This icon denotes a tip, which alerts you to advisory information.

This icon denotes a note, which alerts you to important information.

This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.

bold — Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.

italic — Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.

`monospace` — Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

Related Documentation

The following documents contain information that you might find helpful as you read this manual:

- *NI Vision Builder for Automated Inspection Readme*—Contains information about the minimum system requirements, installation instructions, device support, and known issues for NI Vision Builder for Automated Inspection. The *NI Vision Builder for Automated Inspection Readme* is available at **Start»All Programs»National Instruments»Vision Builder AI»Documentation**.
- *NI Vision Builder for Automated Inspection: Configuration Help*—Contains information about using the Vision Builder AI Configuration interface to create a machine vision application. *NI Vision Builder for Automated Inspection: Configuration Help* is available by selecting **Help»Online Help** from the Vision Builder AI Configuration interface.
- *NI Vision Builder for Automated Inspection: Inspection Help*—Contains information about running applications created using Vision Builder AI in the Vision Builder AI Inspection Interface. *NI Vision Builder for Automated Inspection: Inspection Help* is available by selecting **Help»Online Help** from the Vision Builder AI Inspection interface.
- NI Developer Zone—Visit `ni.com/zone` for the latest example programs, tutorials, technical presentations, and a community area where you can share ideas, questions, and source code with developers around the world.
- *NI 17xx Smart Camera User Manual*—Describes the electrical and mechanical aspects of the NI 17*xx* smart camera, troubleshooting guidelines, and information about the LEDs, DIP switches, and connectors on the NI 17*xx*.
- *NI CVS-1450 Series User Manual*—Describes the electrical and mechanical aspects of the NI CVS-1450 Series, troubleshooting guidelines, and information about the LEDs, DIP switches, and connectors on the CVS-1450 device.
- *NI EVS-1464 User Manual*—Describes the electrical and mechanical aspects of the NI EVS-1464 embedded vision system, troubleshooting guidelines, and information about the LEDs, DIP switches, and connectors on the EVS-1464 device.

- *NI Vision I/O Terminal Block and Prototyping Accessory User Guide*—Describes the features of the NI Vision I/O Terminal Block and Prototyping Accessory, what you need to get started, and the installation and operation of the device.
- *NI Smart Camera I/O Accessory User Guide*—Describes the features of the NI Smart Camera I/O Accessory, what you need to get started, and the installation and operation of the device.

Part I

Vision Builder AI Basics

This section provides a series of lessons designed to introduce you to the Vision Builder for Automated Inspection (Vision Builder AI) environment and describe how to perform many common machine vision tasks using Vision Builder AI.

Part I, *Vision Builder AI Basics*, contains the following chapters:

- Chapter 1, *Introduction to Vision Builder AI*, introduces the Vision Builder AI environment and describes how to run an inspection.
- Chapter 2, *Checking for the Presence of a Part*, introduces the **Match Pattern**, **Measure Intensity**, and **Set Coordinate System** steps. Follow the instructions in this chapter to create an inspection that checks for the presence of a spray bottle cap regardless of the bottle position in the inspection images.
- Chapter 3, *Inspecting Objects for Correct Measurements*, introduces image calibration, and the **Detect Objects** and **Geometry** steps. Follow the instructions in this chapter to create an inspection that measures the distance between holes in a gasket to verify that the gasket conforms to manufacturing specifications.
- Chapter 4, *Inspecting for Multiple Correct Instances of an Object*, introduces the **Find Straight Edge**, **Caliper**, and **Decision Making** steps. Follow the instructions in this chapter to create an inspection that measures the distance between the blade connectors of a fuse and checks the integrity of the fuse conductor regardless of the fuse position or whether the fuse is inverted.
- Chapter 5, *Inspecting an Object that Spans Two Image Frames*, introduces the **Select Image** and **Calculator** steps. Follow the instructions in this chapter to create an inspection that measures the width of a wooden plank that spans two images.

- Chapter 6, *Branching and Decision Making*, introduces the inspection state diagram and the **Custom Overlay** step. Follow the instructions in this chapter to create an inspection that checks the image for the presence of a spray bottle and, if a bottle is present, transitions to another state to determine if the bottle has a cap. If there is no spray bottle present in the image, the inspection moves on to the next image.
- Chapter 7, *Looping and Variables*, uses the inspection state diagram to implement a looping inspection and introduces the **Set Variable** and **Index Measurements** steps. Follow the instructions in this chapter to create an inspection that inspects images of electronic components to determine if the distance between pins on the component is within a predetermined range. If the pin is too close or too far away from an adjacent pin, then the inspection fails. The inspection does not need to check every pin on the microchip before failing the inspection. The inspection fails at the first failed pin.

1

Introduction to Vision Builder AI

This chapter introduces the Vision Builder AI environment and describes how to run an inspection.

Figures 1-1 and 1-2 show general instructions for creating a Vision Builder AI inspection. Figure 1-1 describes the basic steps for designing a Vision Builder AI inspection. The *Add Inspection Steps* module of Figure 1-1 is expanded in Figure 1-2.

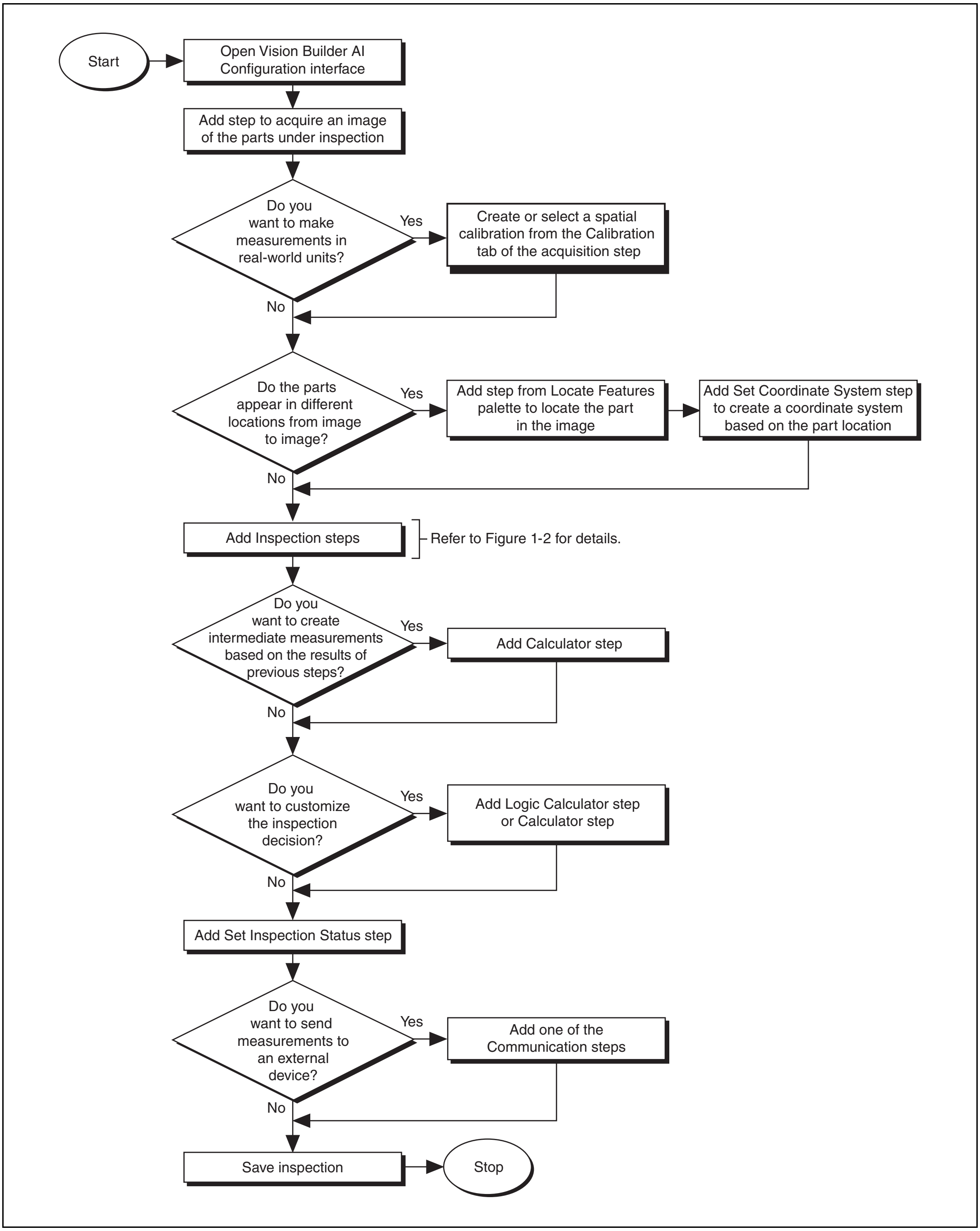


Figure 1-1. Instructions for Creating a Basic Vision Builder AI Inspection

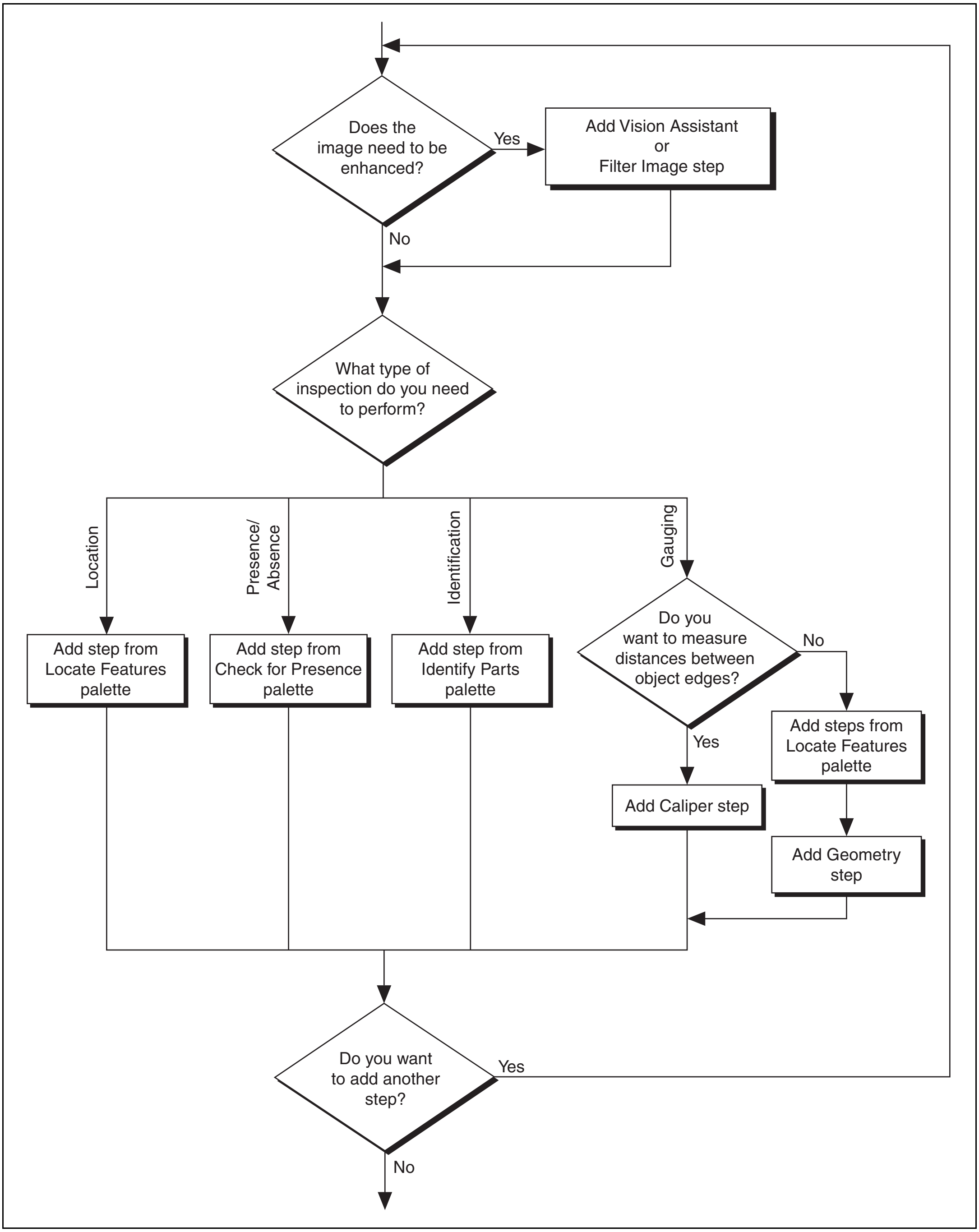


Figure 1-2. Adding Inspection Steps to a Vision Builder AI Inspection

Vision Builder AI Configuration Interface

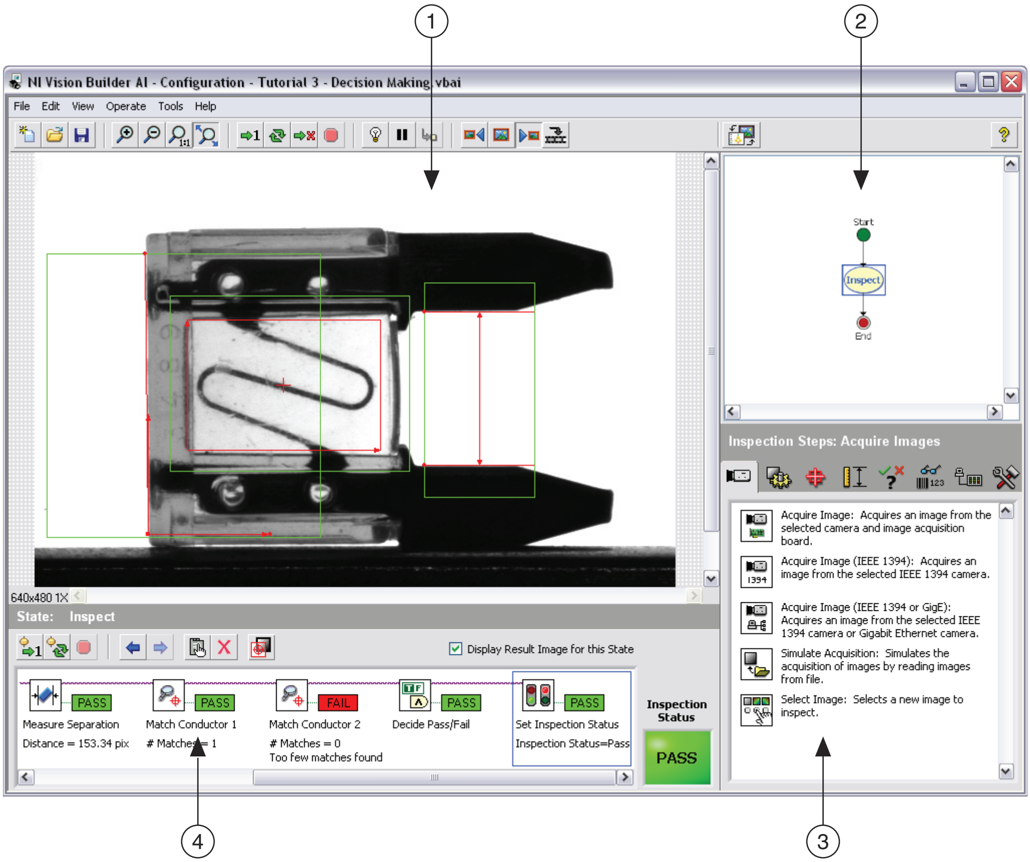
Vision Builder AI has two modes of operation: Configuration and Inspection. Use the Configuration interface to configure and test your inspection. Use the Inspection interface to deploy the software and perform online or offline visual inspection.

Complete the following instructions to open the Vision Builder AI Configuration interface.

1. Select **Start»All Programs»National Instruments»Vision Builder AI** to launch the Vision Builder AI Welcome screen.
2. Click **Configure Inspection**.

Elements of the Configuration Interface

Figure 1-3 shows the Vision Builder AI Configuration interface. The Configuration interface contains four areas: Main window, Overview window, Inspection Steps palette, and State Configuration window.



1	Main Window	3	Inspection Steps Palette
2	Overview Window	4	State Configuration Window

Figure 1-3. Vision Builder AI Configuration Interface

- **Main window**—Displays the image being processed, property pages for some inspection steps, or the state diagram for the inspection. Use the Main window to define regions of interest in an image, configure step parameters for some steps, and create/modify the state diagram for an inspection.
- **Overview window**—Displays a thumbnail view of either the current inspection image or the state diagram for the inspection.
- **Inspection Steps palette**—Lists and describes the steps that you use to create your inspection. When you click on most steps, the palette transforms into the property page for the step.
- **State Configuration window**—Displays the list of steps in the currently selected state in the inspection.

Inspection State Diagram

Vision Builder AI uses a state diagram to define inspections with unique states and transitions that govern the execution flow of the inspection. Simple inspections can be defined using the single-state default inspection, shown in Figure 1-4.

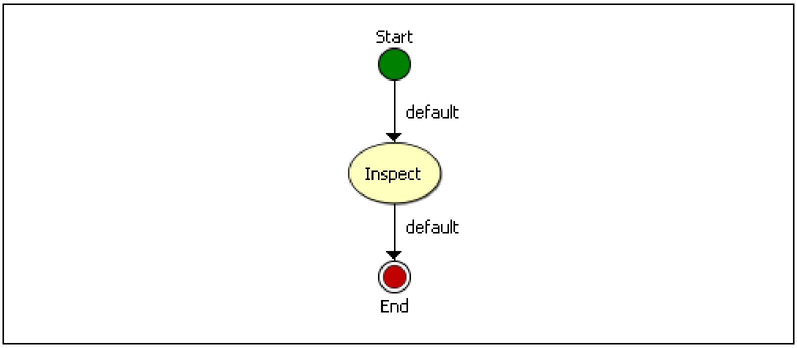


Figure 1-4. Default Inspection State Diagram

More complex inspections can be created by adding additional states and transitions to the default state diagram. Figure 1-5 shows an example of an inspection that uses the state diagram to perform branching and looping in the inspection.

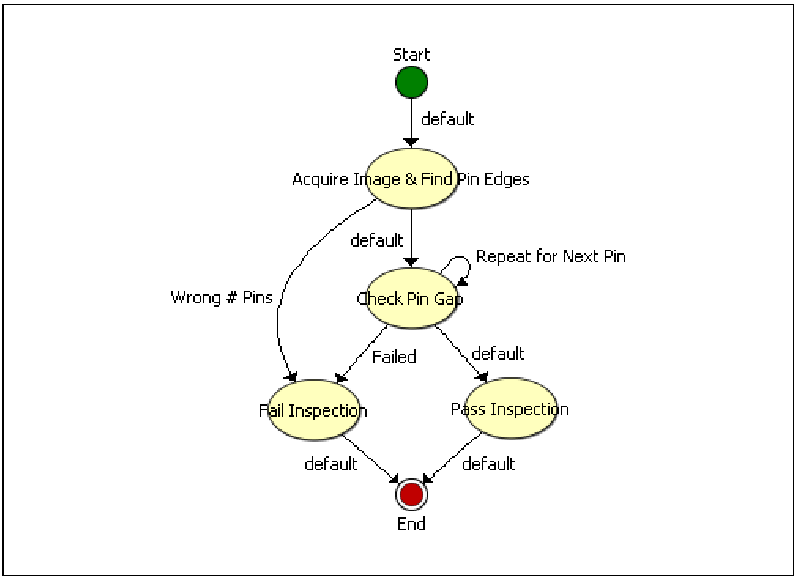


Figure 1-5. Example of a Vision Builder AI Inspection State Diagram

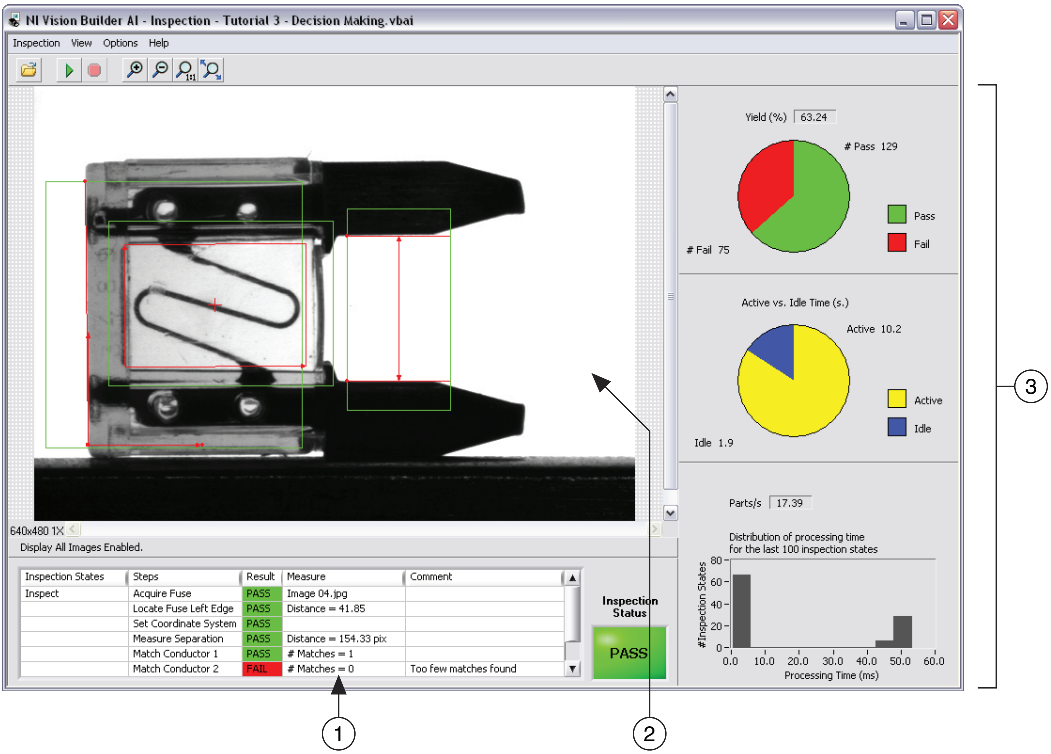
Within a state diagram, each state can lead to one or multiple states or can end the inspection cycle. Each state diagram relies on in-state calculations or user input to determine the next state to execute. Vision Builder AI executes the state diagram continuously from the Start point to the End point.

Each state in an inspection is intended to contain a discrete set of inspection steps. To access the steps contained in a state, select the state on the state diagram. The steps present in the state will appear in the State Configuration window. The currently selected state is highlighted on the state diagram.

Chapter 6, *Branching and Decision Making*, and Chapter 7, *Looping and Variables*, provide examples of using the state diagram.

Vision Builder AI Inspection Interface

As mentioned in the *Vision Builder AI Configuration Interface* section of this chapter, use the Vision Builder AI built-in Inspection Interface to deploy and run an inspection. Figure 1-6 shows the built-in Inspection interface, which has three main areas: the Results panel, the Inspection Statistics panel, and the Display window.



1 Results Panel	2 Display Window	3 Inspection Statistics Panel

Figure 1-6. Vision Builder AI Built-in Inspection Interface

- **Results panel**—Lists the steps in the inspection by name. For each inspection step, Vision Builder displays the step type, result (PASS or FAIL), measurement made, and a comment explaining the reason of a FAIL. **Inspection Status** shows the result of the complete inspection.
- **Display window**—Displays the part under inspection.

- **Inspection Statistics panel**—Contains three indicators that display the yield (ratio between PASS and FAIL), active versus idle time, and processing time of the inspection.

Running an Inspection

Vision Builder AI allows you to run inspections from both the Configuration and Inspection interfaces. The following sections describe the options for running an inspection in Vision Builder AI.

Configuration Interface

Run an inspection from the Configuration interface during development to test and debug inspections. The **Highlight Execution**, **Pause**, and **Single Step** options are useful for debugging inspections. Table 1-1 lists the run options available for the Configuration interface:

Table 1-1. Configuration Interface Run Modes

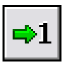
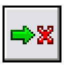
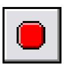
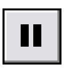
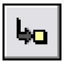
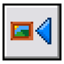
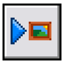
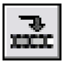
Button	Name	Description
	**Run Inspection Once**	Runs the inspection through one iteration of the state diagram.
	**Run Inspection in Loop**	Runs the inspection continuously.
	**Run Inspection Until Failure**	Runs the inspection until the Inspection Status variable has a value of FAIL.
—	**Run Inspection Multiple Times**	Runs the inspection a specified number of times. This option is available only from the **Operate** menu.
	**Stop Inspection**	Stops the inspection.
	**Highlight Execution**	Highlights the inspection execution when you run the inspection. If the **Highlight Execution** button appears yellow, execution highlighting is enabled.
	**Pause**	Pauses or resumes execution of the inspection. If the **Pause** button appears red, execution is paused.

Table 1-1. Configuration Interface Run Modes (Continued)

Button	Name	Description
	**Single Step**	Steps through the inspection. **Single Step** is only available when the **Pause** button is pressed.
	**Use Previous Image**	Uses the previous inspection image the next time the inspection executes.*
	**Use Current Image**	Uses the current inspection image the next time the inspection executes.*
	**Use Next Image**	Uses the next inspection image the next time the inspection executes.*
	**Select Next Image**	Specifies the inspection image to process the next time the inspection executes.*

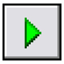
* This button applies only to inspections that either contain a **Simulate Acquisition** step, or have **Smart Camera Emulator**, **Embedded Vision System Emulator**, or **Compact Vision System Emulator** selected as the Execution Target.

Inspection Interface

After an inspection is configured, use the Inspection interface to run the inspection and/or deploy your system. Complete the following instructions to run an inspection from the Inspection interface:

Tip If the Vision Builder AI Configuration interface is already open, select **File»Switch to Inspection Interface** to open the current inspection in the Inspection interface.

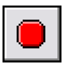
1. Select **Start»All Programs»National Instruments»Vision Builder AI** to launch the Vision Builder AI Welcome screen.
2. Click **Inspect Product**.
3. Open an inspection.



4. Click the **Start Inspection** button. Vision Builder AI begins running the inspection and updating the three areas of the Inspection interface with the most recent inspection data.

   By default, Vision Builder AI displays all the inspection images in the **Display** window. You can change the display settings in the **View** menu to view only images that fail or to have no display. You also can change the magnification of the displayed images in the **Options** menu.

   Notice the performance data displayed in the **Inspection Statistics** panel. This data can help you determine how efficiently your inspection is running. Based on this data, you can make adjustments to improve the inspection speed.



5. Click the **Stop Inspection** button to stop the inspection.

2

Checking for the Presence of a Part

This chapter introduces the **Match Pattern**, **Measure Intensity**, and **Set Coordinate System** steps. Follow the instructions in this chapter to create an inspection that checks for the presence of a spray bottle cap regardless of the bottle position in the inspection images.

Note Launch Vision Builder AI if it is not open. Refer to the *Vision Builder AI Configuration Interface* section of Chapter 1, *Introduction to Vision Builder AI*, for more information.

Creating a New Inspection

Select **File»New**. Vision Builder AI opens a new, blank inspection.

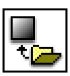
Acquiring Inspection Images

In the Inspection Steps palette, the Acquire Images tab contains several acquisition steps you can use to acquire images from many different types of cameras. The tab also contains a **Simulate Acquisition** step, which simulates image acquisition by loading images from file. The **Select Image** step enables you to switch to a previously acquired image that you need to process later in the inspection.

For simplicity, this tutorial instructs you to use the **Simulate Acquisition** step. However, in your real-world inspection, use one of the other image acquisition steps to acquire images of the object under inspection.

Complete the following instructions to configure a **Simulate Acquisition** step that simulates acquiring images of spray bottles.

1. In the Inspection Steps palette, select the **Acquire Images** tab.



2. Click the **Simulate Acquisition** step. The property page for the step opens.
3. In the **Step Name** control, enter `Acquire Spray Bottle`.

4. Click the **Browse** button. The **Select an Image File** dialog box opens.
5. Navigate to <Vision Builder AI>\DemoImg\Tutorial 1, where <Vision Builder AI> is the location where Vision Builder AI is installed.
6. Select the first image, Image 01.jpg, and click **Open**.
7. Make sure the **Cycle Through Folder Images** control is enabled so that Vision Builder AI loads a different simulation image from the folder each time the step is run.
8. Enable the **Cache Images** control if you want to load all of the images into memory when the inspection opens. By default, each image is loaded individually when the step executes.
9. Click **OK** to add the step to the inspection.

Defining a Feature on which to Base a Coordinate System

In a machine vision inspection, you typically limit your inspection and processing to a region of interest (ROI) rather than the entire image for the following reasons:

- To improve your inspection results by avoiding extraneous objects
- To increase inspection speed

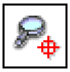
To limit the inspection area, the parts of the object you are interested in must always be inside the ROI you define.

If the object under inspection is fixtured and always appears at the same location and orientation in the images you need to process, defining an ROI is straightforward. However, if the object under inspection appears shifted or rotated within the images, the regions of interest need to shift and rotate with the object under inspection.

For the regions of interest to move in relation to the object, you need to set a *coordinate system* relative to a significant and original feature of the object under inspection. Choose a feature that is always in the *field of view* of the camera despite the different locations that the objects may appear in from image to image. Also, make sure the feature is not affected by major defects that could drastically modify the visual appearance of the feature.

Complete the following instructions to configure a **Match Pattern** step that locates a bottle feature on which you can base a coordinate system.

1. In the Inspection Steps palette, select the **Locate Features** tab.



2. Click the **Match Pattern** step. The NI Vision Template Editor opens.
3. Draw a rectangle around the base of the sprayer, as shown in Figure 2-1. This region becomes the pattern matching template.

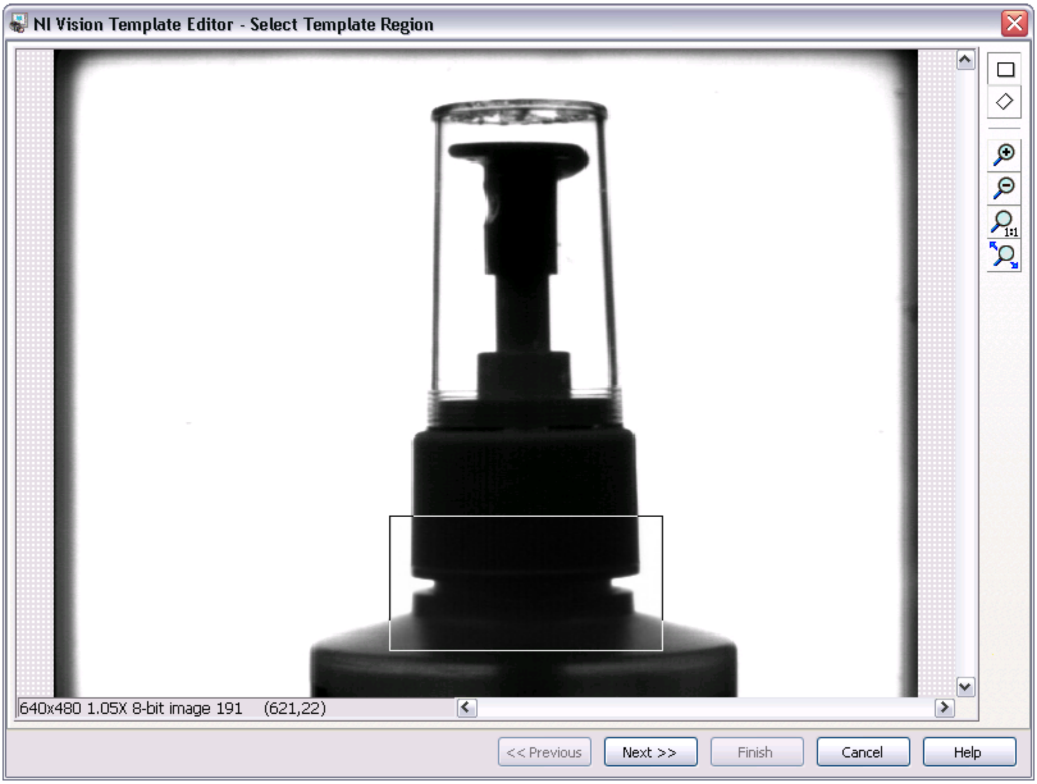


Figure 2-1. Creating a Template Pattern

4. Click **Next**.
5. Click **Finish** to accept the template.
6. On the **Main** tab, enter `Locate Sprayer Base` in the **Step Name** control.

The green ROI specifies the area of the image in which Vision Builder AI tries to locate the template. Assuming that the bottles are fixtured in such a way that they can move only horizontally within the field of view, you can limit the ROI so that it surrounds only the area of the image that may contain a template match during inspection.

7. Redraw or decrease the default green ROI so that it surrounds only the lower portion of the image, as shown in Figure 2-2.

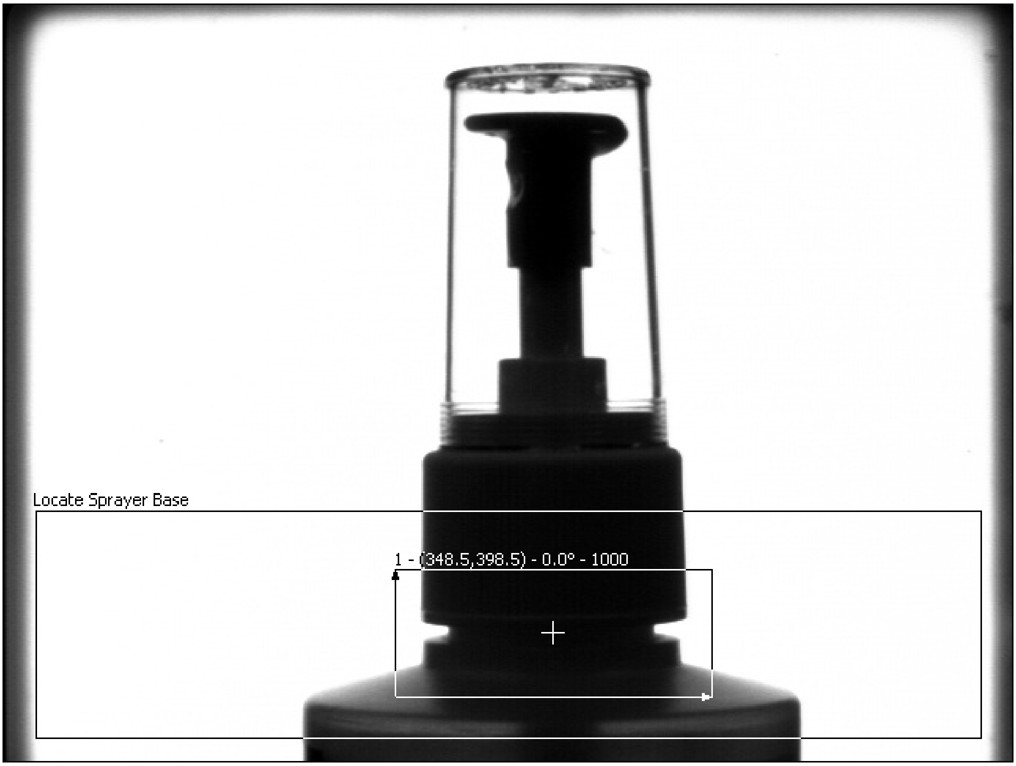
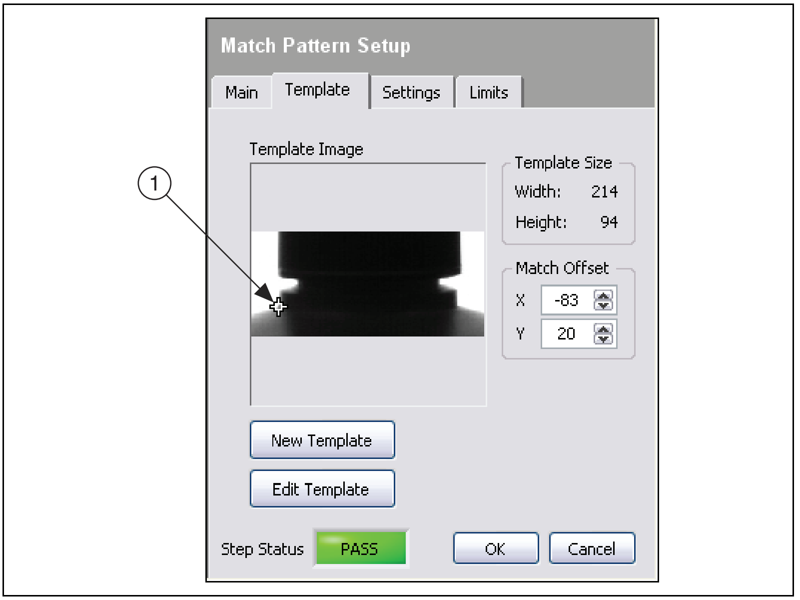


Figure 2-2. Limiting the Search Region

8. On the **Template** tab, drag the red crosshair mark in the template image to the left edge of the sprayer base, as shown in Figure 2-3. This changes the *focal point* of the template.
9. The focal point indicates the part of the template that you want to return as the match location. By default, the focal point is the center of the template. You can modify the focal point by moving the red crosshair or by specifying a **Match Offset**. Later in this inspection, you use the match location as the origin of a coordinate system.



1 Focal Point

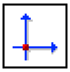
Figure 2-3. Adjusting the Focal Point of the Template

10. On the **Settings** tab, set **Number of Matches to Find** to `1`.
11. On the **Limits** tab, enable the **Minimum Number of Matches** control, and set the value to `1`.
12. Click **OK** to add the step to the inspection.

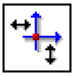
Setting a Coordinate System

Complete the following instructions to configure a **Set Coordinate System** step based on the **Match Pattern** step you configured.

1. In the Inspection Steps palette, select the **Locate Features** tab.



2. Click the **Set Coordinate System** step. The property page for the step opens.
3. On the **Main** tab, enter `Coordinate System` in the **Step Name** control.



4. On the **Settings** tab, select **Horizontal and Vertical Motion** from the **Mode** control because the bottles appear shifted but not rotated from one image to another.

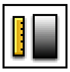
   Notice the **Origin** list. **Match [1]**, the match location of the previous **Locate Sprayer Base** step, is the default origin of the coordinate system because it is the only location point created by previous steps in the inspection.

5. Click **OK** to add the step to the inspection.

Checking for the Cap Using Measure Intensity

The image of the spray bottle was acquired using a backlight. The cap appears dark on the bright background. Complete the following instructions to configure a **Measure Intensity** step to check for the presence of a spray bottle cap.

1. In the Inspection Steps palette, select the **Check for Presence** tab.

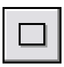


2. Click the **Measure Intensity** step. The property page for the step opens.
3. On the **Main** tab, enter `Check Cap Presence` in the **Step Name** control.
4. Enable the **Reposition Region of Interest** control.

   Enabling this control allows you to link the regions of interest specified in this step to a previously defined coordinate system so that Vision Builder AI can adjust the location and orientation of the ROI from image to image relative to the specified coordinate system.

   The **Reference Coordinate System** list shows all the previously defined coordinate systems. **Coordinate System** is the default reference coordinate system because it is the only **Set Coordinate System** step in the current inspection.

Notice that the **Measure Intensity** step supports a variety of different tools that enable you to draw different shaped regions of interest, such as a point, line, broken line, freehand line, rectangle, ellipse, annulus, polygon, and freehand region. These tools are available in the main menu bar.



5. Using the default **Rectangle Tool**, hold down the <Ctrl> key, and draw three regions of interest that enclose edges of the cap, as shown in Figure 2-4. Pressing the <Ctrl> key enables you to draw multiple regions of interest for the step.

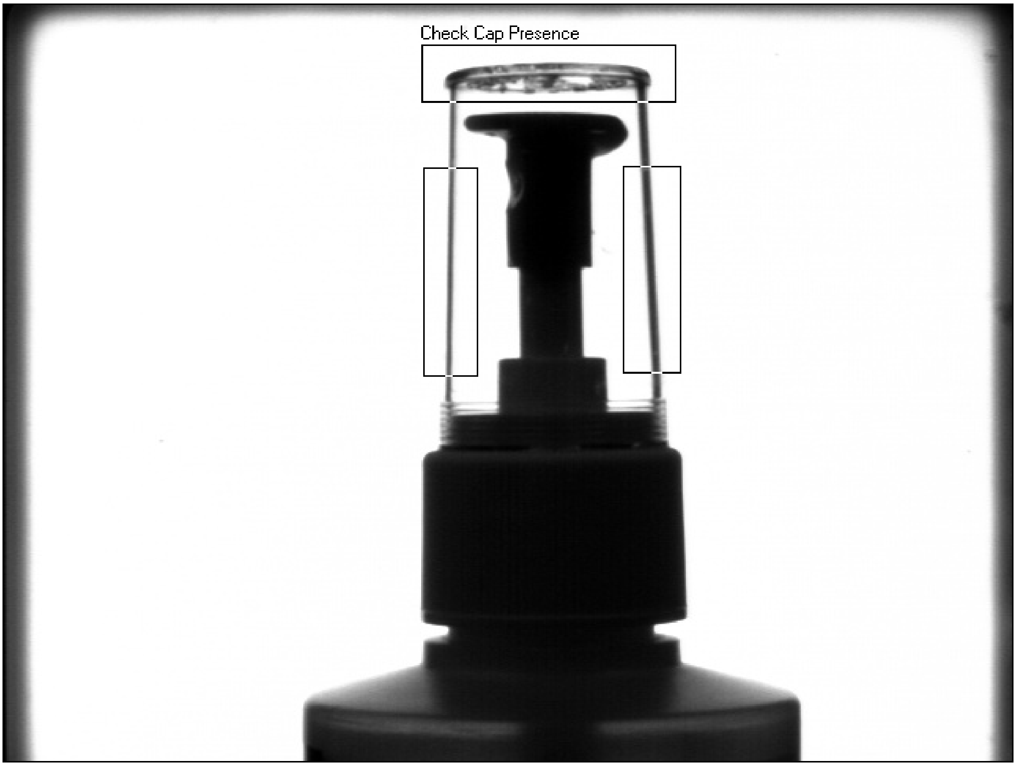


Figure 2-4. Defining Regions in Which to Measure Intensity

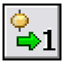
6. Click the **Limits** tab.

   At the bottom of the tabbed page, Vision Builder AI returns the intensity statistics of the pixels inside the regions of interest. Pixel intensities can range from 0–255, where 0 equals black and 255 equals white.

   The **Minimum Intensity** value at the bottom of the page returns the lowest pixel value inside the regions of interest. The backlit edges of the plastic cap appear in silhouette as dark pixels (which have low pixel intensities) on a bright background (which has high pixel intensities).

   Therefore, when the cap is present, the minimum intensity for the regions is low. When the cap is not present, the minimum intensity for the regions is high because the regions contain only bright background pixels.

7. Enable the **Minimum Intensity** control. Set the **Maximum** value to `50.00`.
8. Click **OK** to add the step to the inspection.



9. Click the **Run State Once** button located in the State Configuration window.

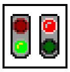
   Vision Builder AI loads the next image, `Image 02.jpg`, from the `<Vision Builder AI>\DemoImg\Tutorial 1` folder and runs the previous inspection steps in the state on the new image.

   Notice that the bottle appears closer to the left edge of the image. Vision Builder AI repositions the regions of interest based on the new location of the bottle. The **Step Status** for the image is PASS because the presence of the cap inside the regions of interest causes the **Minimum Intensity** value to fall within the limits you set.

Setting the Inspection Status

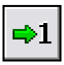
Complete the following instructions to add a **Set Inspection Status** step to determine whether the inspection passes or fails.

1. In the Inspection Steps palette, select the **Use Additional Tools** tab.



2. Click the **Set Inspection Status** step. The property page for the step opens.
3. In the **Inspection Status** control, select the **FAIL if any previous step fails** option.
4. Click **OK** to add the step to the inspection.

Testing the Inspection



Test the remaining images in the `Tutorial 1` folder to make sure the inspection returns the correct results. Click the **Run Inspection Once** button to test the remaining images. Table 2-1 displays the expected results for each image.

Table 2-1. Expected Results for the Spray Bottle Inspection

Image Name	Inspection Status	Explanation
`Image 03.jpg`	PASS	Cap is present.
`Image 04.jpg`	PASS	Cap is present.
`Image 05.jpg`	FAIL	Cap is missing.

Saving the Inspection

Complete the following instructions to save the example inspection.

1. Select **File»Save** or click the **Save** button on the toolbar.
2. Navigate to the location where you want to save the inspection.
3. In the **File Name** control, enter `Tutorial 1.vbai`.
4. Click **Save** to save the inspection.

Tip Select **File»Inspection Properties** to add a short description or comments about the inspection.

3 Inspecting Objects for Correct Measurements

This chapter introduces image calibration, and the **Detect Objects** and **Geometry** steps. Follow the instructions in this chapter to create an inspection that measures the distance between holes in a gasket to verify that the gasket conforms to manufacturing specifications.

Note Launch Vision Builder AI if it is not open. Refer to the *Vision Builder AI Configuration Interface* section of Chapter 1, *Introduction to Vision Builder AI*, for more information.

Creating a New Inspection

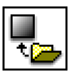
Select **File»New**. Vision Builder AI opens a new, blank inspection.

Acquiring and Calibrating Inspection Images

For simplicity, this tutorial instructs you to use the **Simulate Acquisition** step. However, in your real-world inspection, use one of the other image acquisition steps to acquire images of the object under inspection.

Complete the following instructions to configure a **Simulate Acquisition** step that simulates acquiring images of gaskets.

1. In the Inspection Steps palette, select the **Acquire Images** tab.



2. Click the **Simulate Acquisition** step. The property page for the step opens.
3. In the **Step Name** control, enter `Acquire Gasket`.

4. Click the **Browse** button. The **Select an Image File** dialog box opens.
5. Navigate to `<Vision Builder AI>\DemoImg\Tutorial 2`, where `<Vision Builder AI>` is the location where Vision Builder AI is installed.
6. Select the first image, `Image 01.jpg`, and click **Open**.

7. Make sure the **Cycle Through Folder Images** control is enabled so that Vision Builder AI loads a different simulation image from the folder each time the step is run.

By default, Vision Builder AI returns measurements in pixel units. If you want the inspection to return measurements in real-world units, you need to map pixel units to real-world units through a process called spatial calibration.

8. Click the **Calibration** tab.
9. Click **Create Calibration** to launch the calibration wizard.
10. In the **Calibration Name** control, enter `Gasket Calibration`.
11. Click **Next**.

For this example, assume that the camera that acquired the inspection images is perpendicular to the image plane and lens distortion is negligible. Based on these assumptions, you can use **Simple Calibration** to calibrate your images. **Simple Calibration** transforms a pixel coordinate to a real-world coordinate through scaling in the x (horizontal) and y (vertical) directions.

12. Select the **Simple Calibration** option, and click **Next**.
13. Make sure **Use Current Image** is selected, and click **Next**.
14. Make sure **Pixel Type** is set to **Square** because the camera that acquired the images for this exercise has square pixels.
15. Click **Next**.
16. In the **Specify the Pixel Ratio** step, carefully click the 0 mm and 50 mm markings on the ruler at the bottom of the image, as shown in Figure 3-1.

Tip You may need to use the zoom buttons below the image to accurately click the ruler markings. After zooming in, scroll down to see the ruler at the bottom of the image.

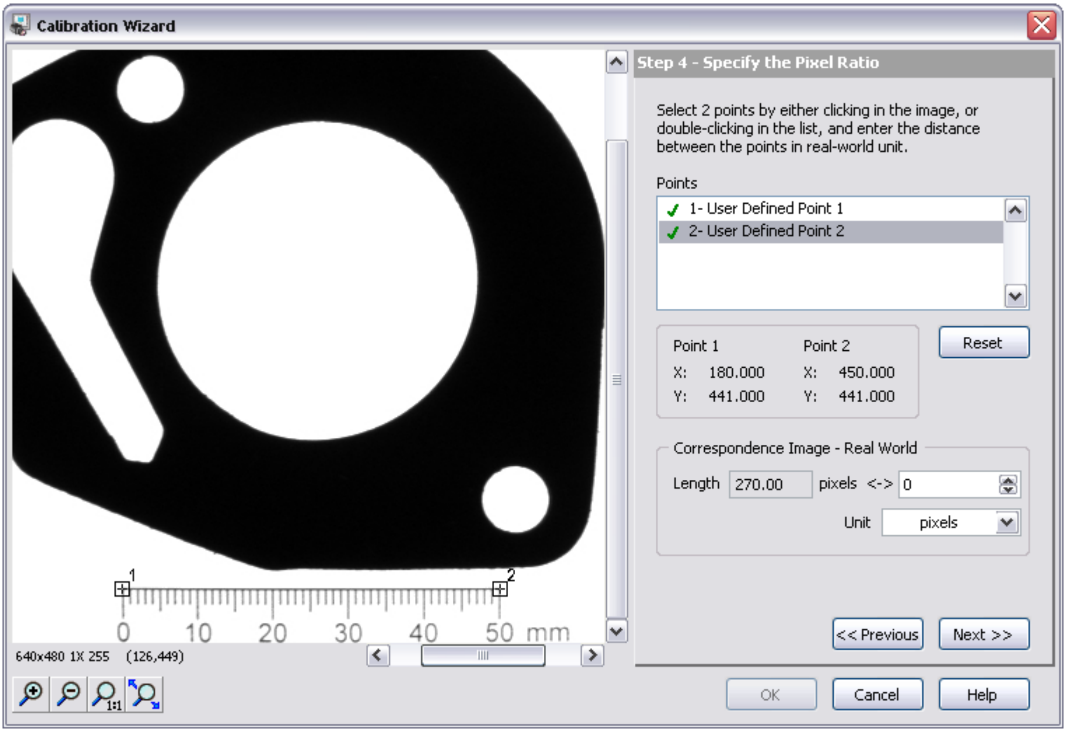


Figure 3-1. Specifying the Pixel Ratio

17. In the **Correspondence Image - Real World** control, enter `50` for the value, and select **millimeter** for the **Unit**.
18. Click **Next**.

In the **Set Calibration Axis** step, you can define the origin and angle of the calibration axis anywhere in the image. By default, the top, left pixel in the image is the calibration axis origin, and the horizontal axis of the image is the calibration axis angle. Use the default calibration axis settings for this exercise.

Tip In some applications, you may want to measure between a fixed reference feature on the part and other features in the image. Setting the origin of the calibration axis to the location of the reference feature simplifies making measurements because the starting point for the measurements becomes 0.

19. Click **OK** to learn the calibration information and exit the calibration wizard.
20. Click **OK** to add the step to the inspection.

Vision Builder AI saves the calibration in the following locations:

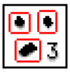
- **Windows XP/2000**—`C:\Documents and Settings\All Users\Application Data\National Instruments\Vision Builder AI\Calibration`
- **Windows Vista**—`C:\ProgramData\National Instruments\Vision Builder AI\Calibration`

Tip You can apply the learned calibration to all images acquired with the same camera at the same resolution.

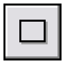
Locating Features to Measure

Complete the following instructions to configure a **Detect Objects** step that finds small holes in the gasket.

1. In the Inspection Steps palette, select the **Check for Presence** tab.



2. Click the **Detect Objects** step. The property page for the step opens.
3. In the **Step Name** control, enter `Detect Small Holes`.



4. Using the default **Rectangle Tool**, draw a region of interest (ROI) around the entire gasket, as shown in Figure 3-2.

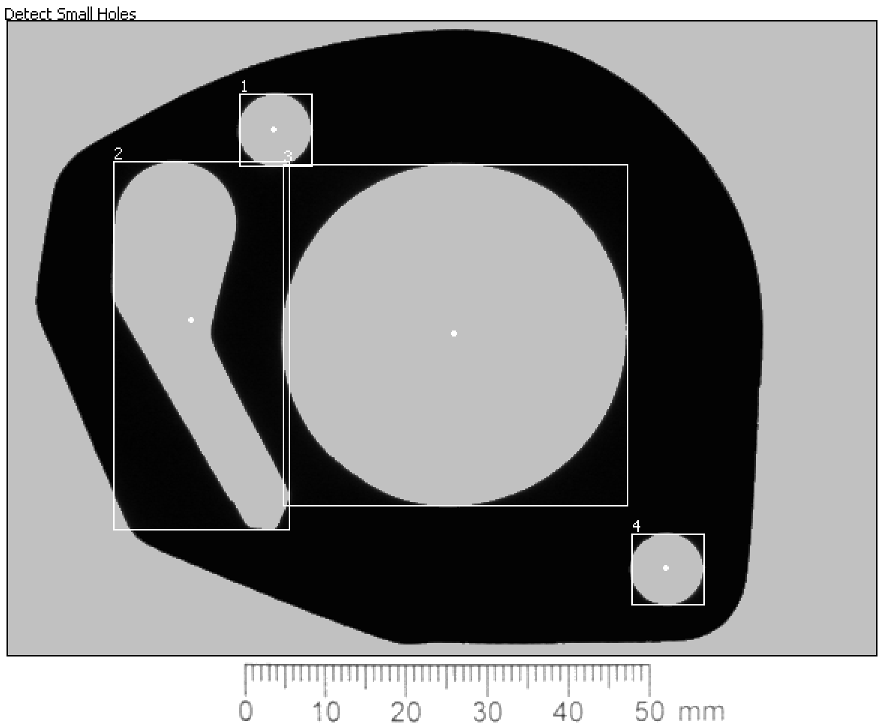


Figure 3-2. Defining the ROI

5. In the **Threshold** tab, select the **Bright Objects** option for the **Look For** control.

   Notice that the blue shading highlights all bright pixels—pixels with high intensity values that fall within the **Threshold Range**—in the ROI. Vision Builder AI groups contiguous highlighted pixels into *objects*, which are depicted by red bounding rectangles.

6. Click the **Settings** tab.

   The step locates four objects, which are listed in Table 3-1. Depending on the location of the user-defined points in the **Calibrate Image** step you previously configured, the values for the **Size (mm^2)** may differ slightly from the values shown in Table 3-1.

Table 3-1. Sizes of Gasket Holes

Object Number	Size (pix^2)	Size (mm^2)
1	1,807	61.97
2	13,351	457.85
3	40,816	1,399.71
4	1,780	61.04

Object 1 and **Object 4** are the small holes of interest in this step. The following steps describe how to use the **Minimum Object Size** and **Maximum Object Size** controls of the **Detect Objects** step to eliminate objects of no interest based on their size.

7. Enable the **Minimum Object Size** and **Maximum Object Size** controls.

   Based on the information in Table 3-1, the small holes have sizes of 61.97 mm^2 and 61.04 mm^2.
8. Set **Minimum Object Size** to `50` and **Maximum Object Size** to `70`.
9. In the **Limits** tab, enable the **Minimum Number of Objects** and **Maximum Number of Objects** controls. Set their values to `2`.
10. Click **OK** to add the step to the inspection.

Complete the following instructions to find the large hole in the gasket.

1. Right-click the **Detect Small Holes** step in the State Configuration window, and select **Copy**.
2. Right-click the **Detect Small Holes** step again.
3. Select **Paste**. A copy of the **Detect Small Holes** step is placed after the original step.

4. Double-click the **Detect Small Holes** copy or click the **Edit Step** button to launch the property page of the step for editing.
5. In the **Step Name** control, enter `Detect Large Hole`.

6. Select the **Settings** tab.

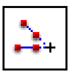
   Based on the information in Table 3-1, the large hole has a size of 1399.71 mm^2.
7. Set **Minimum Object Size** to `1300` and **Maximum Object Size** to `1450`.
8. In the **Limits** tab, enable the **Minimum Number of Objects** and **Maximum Number of Objects** controls. Set their values to `1`.
9. Click **OK** to add the step to the inspection.

Measuring Parts of the Gasket

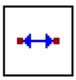
Complete the following instructions to measure the distance from the top small hole to the large hole to inspect whether the distance meets specifications.

Note Vision Builder AI returns the centers of mass for the holes as their locations.

1. In the Inspection Steps palette, select the **Measure Features** tab.



2. Click the **Geometry** step. The property page for the step opens.
3. In the **Step Name** control, enter `Check Top Distance`.



4. In the **Geometric Feature** control, select the **Distance** measurement.
5. Select points **1** and **3** by clicking the points in the image or selecting the points from the **Available Points** list.
6. In the **Limits** tab, enable the **Minimum Distance** control and set it to `32`. Enable the **Maximum Distance** control and set it to `35`.
7. Click **OK** to add the step to the inspection.

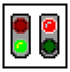
Complete the following instructions to measure the distance from the large hole to the bottom small hole to inspect whether the distance meets specifications.

1. Right-click the **Top Distance** step in the State Configuration window, and select **Copy**.
2. Right-click the **Top Distance** step again.
3. Select **Paste**. A copy of the **Top Distance** step is placed after the original step.
4. Double-click the **Top Distance** copy or click the **Edit Step** button to launch the property page of the step for editing.
5. In the **Step Name** control, enter `Check Bottom Distance`.

6. In the **Geometric Feature** control, select the **Distance** measurement.
7. From the **Available Points** list, select **2** and **3**, which correspond to the bottom small hole and large hole, respectively.
8. In the **Limits** tab, enable the **Minimum Distance** control and set it to `38`. Enable the **Maximum Distance** control and set it to `40`.
9. Click **OK** to add the step to the inspection.

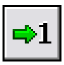
Setting the Inspection Status

Complete the following instructions to add a **Set Inspection Status** step to determine whether the inspection passes or fails.



1. In the Inspection Steps palette, select the **Use Additional Tools** tab.
2. Click the **Set Inspection Status** step. The property page for the step opens.
3. In the **Inspection Status** control, select the **FAIL if any previous step fails** option.
4. Click **OK** to add the step to the inspection.

Testing the Inspection



Test the inspection to make sure it returns the results you expect. Click the **Run Inspection Once** button to run the inspection on each of the test images. Table 3-2 lists the test images, the inspection status to expect for each image, and an explanation of the status.

Table 3-2. Expected Results for the Gasket Inspection

Image Name	Inspection Status	Explanation
`Image 01.jpg`	PASS	All steps passed.
`Image 02.jpg`	PASS	All steps passed.
`Image 03.jpg`	PASS	All steps passed.
`Image 04.jpg`	FAIL	The **Top Distance** step failed because the distance between the holes is too small.
`Image 05.jpg`	FAIL	The **Detect Small Holes** step failed because the bottom hole is missing. The missing hole also caused the **Bottom Distance** step to fail.

Saving the Inspection

Complete the following instructions to save the example inspection.

1. Select **File»Save** or click the **Save** button on the toolbar.
2. Navigate to the location where you want to save the inspection.
3. In the **File Name** control, enter `Tutorial 2.vbai`.
4. Click **Save** to save the inspection.

Tip Select **File»Inspection Properties** to add a short description or comments about the inspection.

4

Inspecting for Multiple Correct Instances of an Object

This chapter introduces the **Find Straight Edge**, **Caliper**, and **Decision Making** steps. Follow the instructions in this chapter to create an inspection that measures the distance between the blade connectors of a fuse and checks the integrity of the fuse conductor regardless of the fuse position or whether the fuse is inverted.

Note Launch Vision Builder AI if it is not open. Refer to the *Vision Builder AI Configuration Interface* section of Chapter 1, *Introduction to Vision Builder AI*, for more information.

Creating a New Inspection

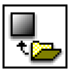
Select **File»New**. Vision Builder AI opens a new, blank inspection.

Acquiring Inspection Images

For simplicity, this tutorial instructs you to use the **Simulate Acquisition** step. However, in your real-world inspection, use one of the other image acquisition steps to acquire images of the object under inspection.

Complete the following instructions to configure a **Simulate Acquisition** step that simulates acquiring images of fuses.

1. In the Inspection Steps palette, select the **Acquire Images** tab.



2. Click the **Simulate Acquisition** step. The property page for the step opens.
3. In the **Step Name** control, enter `Acquire Fuse`.

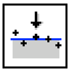
4. Click the **Browse** button. The **Select an Image File** dialog box opens.
5. Navigate to `<Vision Builder AI>\DemoImg\Tutorial 3`, where `<Vision Builder AI>` is the location where Vision Builder AI is installed.
6. Select the first image, `Image 01.jpg`, and click **Open**.

7. Make sure the **Cycle Through Folder Images** control is enabled so that Vision Builder AI loads a different simulation image from the folder each time the step is run.
8. Click **OK** to add the step to the inspection.

Defining a Feature on which to Base a Coordinate System

The fuses can appear shifted horizontally and slightly rotated from one inspection image to another. Complete the following instructions to configure a **Find Straight Edge** step that finds the left edge of the fuse so that regions of interest in subsequent steps can shift with the fuse.

1. In the Inspection Steps palette, select the **Locate Features** tab.



2. Click the **Find Straight Edge** step. The property page for the step opens.
3. In the **Step Name** control, enter `Locate Fuse Left Edge`.
4. Draw a region of interest (ROI) across the left edge of the fuse, as shown in Figure 4-1.

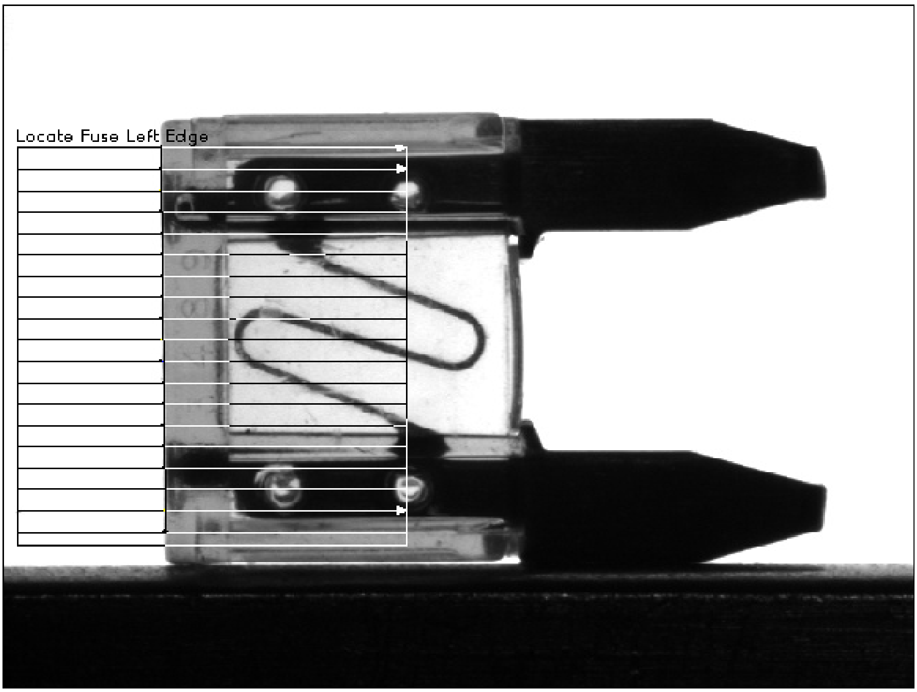


Figure 4-1. Finding a Straight Edge

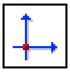
Notice that the ROI contains blue search lines. The step searches along the search lines for sharp transitions in pixel intensities, which usually represent object edges. The step fits a straight line through the individual detected edge points of each search line to determine the left edge of the fuse.

5. Click **OK** to add the step to the inspection.

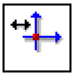
Setting a Coordinate System

Complete the following instructions to configure a **Set Coordinate System** step based on the **Find Straight Edge** step you configured.

1. In the Inspection Steps palette, select the **Locate Features** tab.



2. Click the **Set Coordinate System** step. The property page for the step opens.
3. In the **Main** tab, enter `Set Coordinate System` in the **Step Name** control.



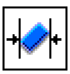
4. In the **Settings** tab, select **Horizontal Motion** from the **Mode** control.

   Notice the **Origin** list. **Point 1**, the first point of the straight line detected by the **Locate Fuse Left Edge** step, is the default origin of the coordinate system. In this exercise, the location of the origin does not affect the measurement you need to make. Therefore, use the default origin.
5. Click **OK** to add the step to the inspection.

Measuring the Separation between Connectors

Complete the following instructions to configure a **Caliper** step that measures the distance between the blade connectors of the fuse.

1. In the Inspection Steps palette, select the **Measure Features** tab.



2. Click the **Caliper** step. The property page for the step opens.
3. In the **Main** tab, enter `Measure Separation` in the **Step Name** control.
4. Enable the **Reposition Region of Interest** control.

5. Draw an ROI across the blade connectors, as shown in Figure 4-2.

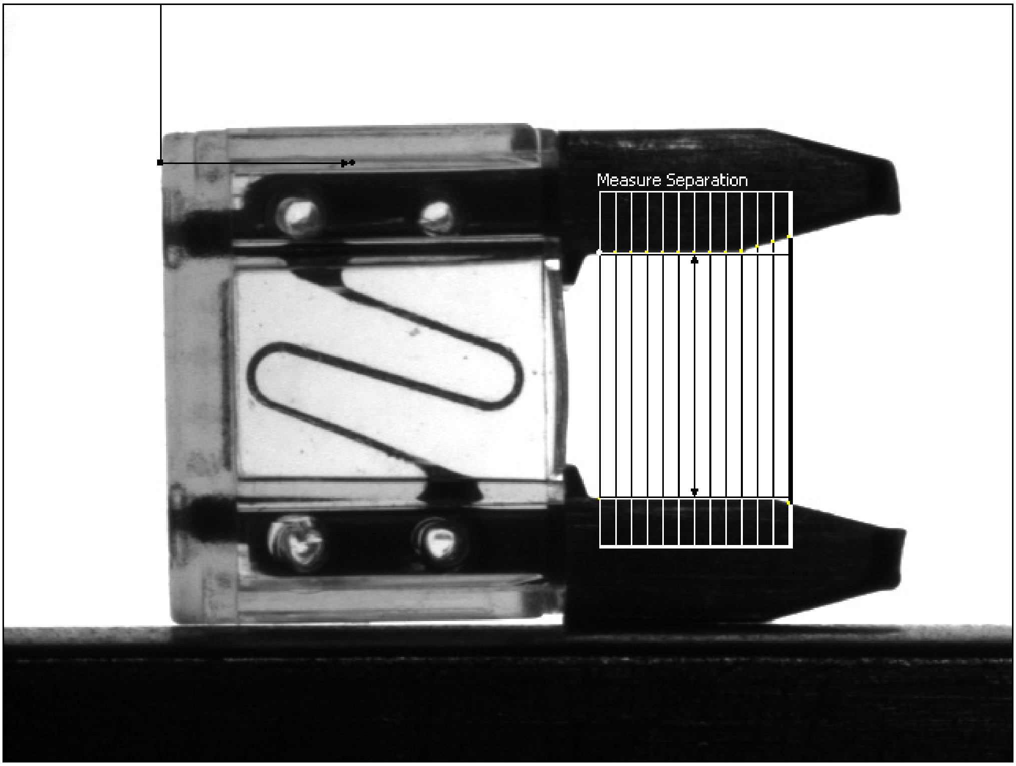
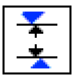


Figure 4-2. Measuring the Distance Between Two Edges

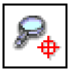


6. In the **Settings** tab, select the **Process** named **Vertical Min Caliper** to change the direction and orientation of the caliper search lines.
7. In the **Limits** tab, enable the **Minimum Distance** control and set the value to `150`. Enable the **Maximum Distance** control and set the value to `160`.
8. Click **OK** to add the step to the inspection.

Inspecting the Fuse Conductor

Complete the following instructions to configure **Match Pattern** steps that inspect the integrity of the fuse conductor.

1. In the Inspection Steps palette, select the **Locate Features** tab.



2. Click the **Match Pattern** step. The NI Vision Template Editor opens.
3. Draw an ROI around the conductor, as shown in Figure 4-3. This region becomes the pattern matching template.

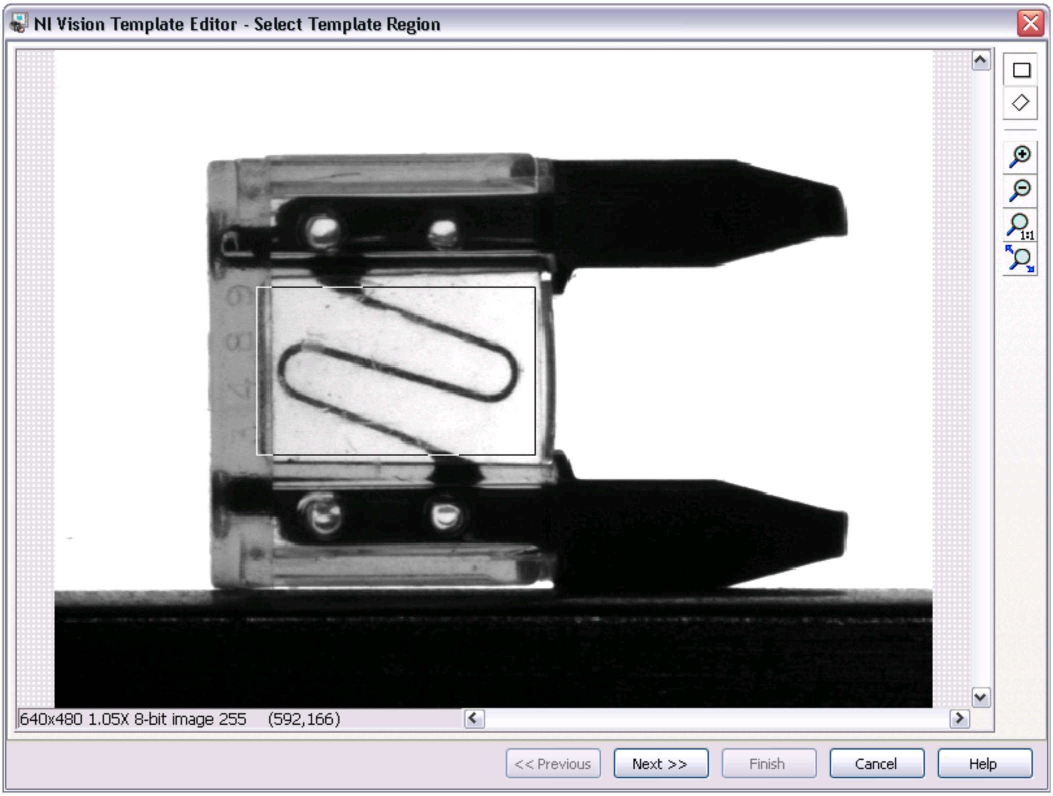


Figure 4-3. Creating a Template Pattern

4. Click **Next**.
5. Click **Finish** to accept the template.
6. On the **Main** tab, enter `Match Conductor 1` in the **Step Name** control.
7. Make sure the **Reposition Region of Interest** control is enabled.

8. Redraw or decrease the default green ROI so that it surrounds an area slightly larger than the template, as shown in Figure 4-4.

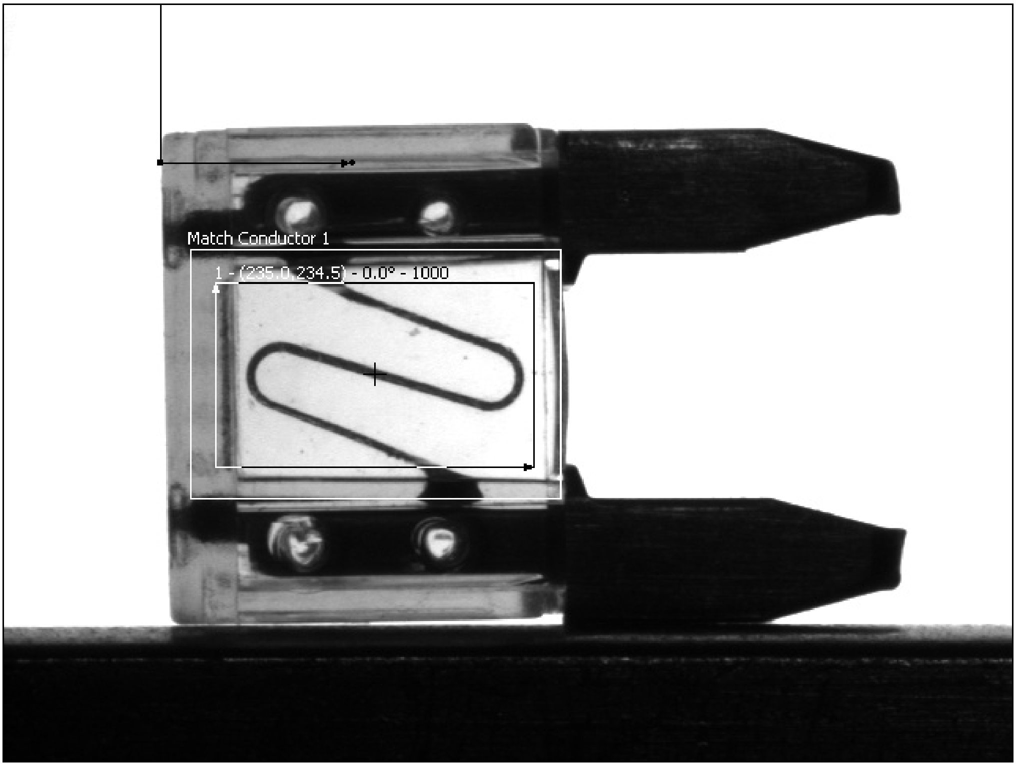
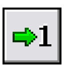


Figure 4-4. Limiting the Search Region

9. In the **Settings** tab, set **Number of Matches to Find** to `1`.
10. Enable the **Search for Rotated Patterns** control.
11. Set the **Angle Range +/– (degrees)** control to `10` to enable the step to locate the best match possible within ±10° of the learned template angle.
12. In the **Limits** tab, enable the **Minimum Number of Matches** control and set the value to `1`.
13. Click **OK** to add the step to the inspection.



14. Click the **Run Inspection Once** button *twice* so that `Image 03.jpg` becomes the active image.

Note The name of the active image is displayed in the **Acquire Fuse** step in the State Configuration window.

A fuse may be inverted when Vision Builder AI acquires an image of the fuse. This inversion causes the conductor to look different than the template, shown in Figure 4-5a. To prevent a good but inverted fuse from failing inspection, you need to learn a pattern matching template for the inverted instances of the conductor as well, shown in Figure 4-5b.

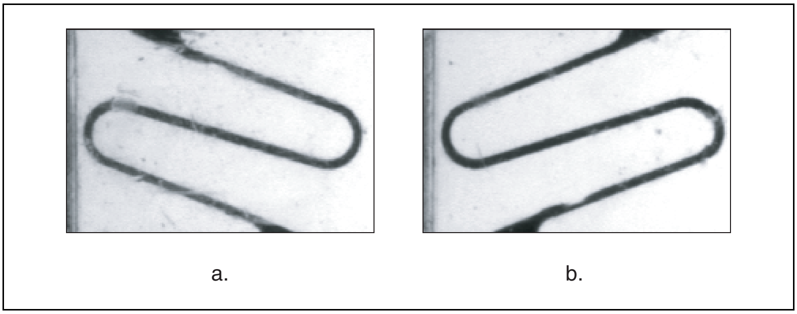


Figure 4-5. Valid Templates for the Conductor

15. In the Inspection Steps palette, select the **Locate Features** tab.
16. Click the **Match Pattern** step. The **Select a template in the image** dialog box opens.
17. Draw an ROI around the conductor, similar to the region you drew in step 3.
18. Click **OK** to learn the inverted template.
19. In the **Step Name** control, enter `Match Conductor 2`.
20. Set the **Region of Interest** control to **Match Conductor 1**. This configures the **Match Conductor 2** step to use the same ROI that you previously defined for the **Match Conductor 1** step.
21. In the **Settings** tab, set **Number of Matches to Find** to `1`.
22. Enable the **Search for Rotated Patterns** control.
23. Set the **Angle Range +/– (degrees)** control to `10` to enable the step to locate the best match possible within ±10° of the learned template angle.
24. In the **Limits** tab, enable the **Minimum Number of Matches** control and set the value to `1`.
25. Click **OK** to add the step to the inspection.

Making Logical PASS/FAIL Decisions

In the previous lessons, the inspection would fail if any of the steps in the inspection failed. In this lesson, because the conductor under inspection can match only one of the patterns you specified, one of the **Match Pattern** steps always fails. If you were to set the Inspection Status to fail if any of the steps in the inspection fail, the entire inspection will always fail because one of the **Match Pattern** steps always fails.

Using the **Logic Calculator** step, you can create a Boolean result that is based on the results of the previous inspection steps. The Set Inspection Status step can use this Boolean result to determine the Inspection Status.

Complete the following instructions to configure a **Logic Calculator** step that causes the inspection to pass when the conductor matches either the template in **Match Conductor 1** or **Match Conductor 2**, and when the **Measure Separation** step passes.

1. In the Inspection Steps palette, select the **Use Additional Tools** tab.

2. Click the **Logic Calculator** step. The property page opens in the Main window.
3. In the **Step Name** control, enter `Decide Pass/Fail`.
4. In the **First Operand** frame, set **Source** to **Measure Separation**. Set **Measure** to **Step Status**.

   Current Value displays the value of the measurement based on the current image.
5. Make sure **Second Operand** is set to **Constant**, and **Constant** is set to **True**.
6. Click **Add** to add this expression to the **Expression** table.
7. In the **First Operand** frame, set **Source** to **Match Conductor 1**. Set **Measure** to **Step Status**.
8. Make sure **Second Operand** is set to **Constant**, and **Constant** is set to **True**.
9. Click **Add** to add this expression to the **Expression** table.

   Notice the default binary operator **AND** in the last column of the **Expression** table.
10. In the **First Operand** frame, set **Source** to **Match Conductor 2**. Set **Measure** to **Step Status**.
11. Make sure **Second Operand** is set to **Constant** and **Constant** is set to **True**.

12. Click **Add** to add this expression to the **Expression** table.
13. Select the second expression in the Expression table, and click **AND/OR** to change the binary operator to **OR**.
14. Hold down the <Shift> key, and select the second and third expressions in the **Expression** table.
15. Click **( )** to group the expressions.

The **Logic Calculator** property page should resemble Figure 4-6.

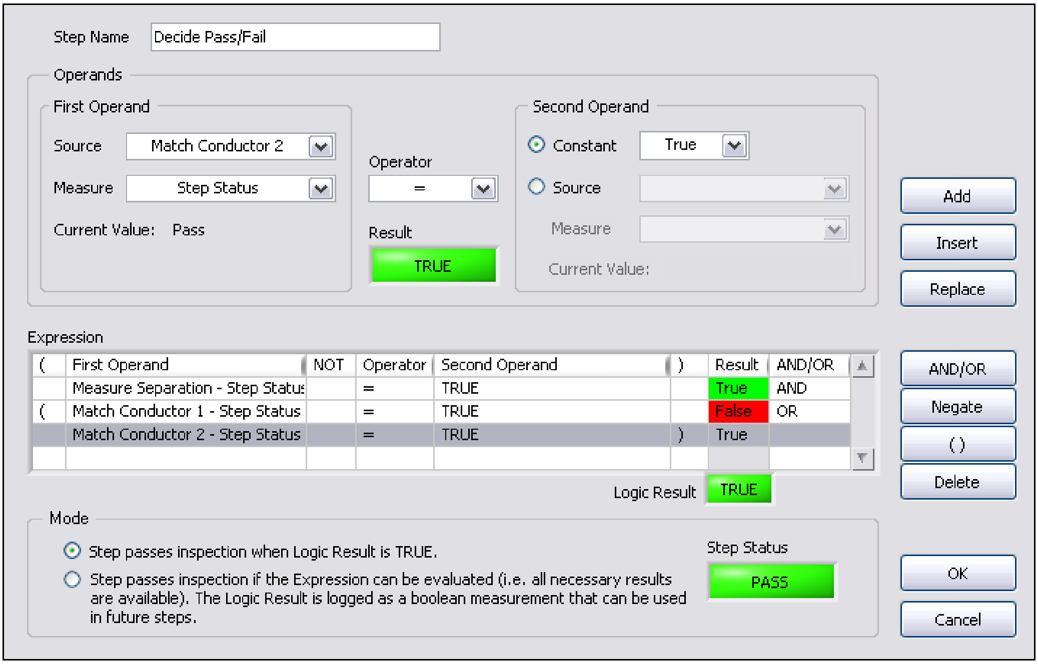
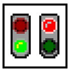


Figure 4-6. Logic Calculator Property Page

16. Click **OK** to add the step to the inspection.

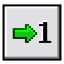
Setting the Inspection Status

Complete the following instructions to configure Vision Builder AI to pass the inspection when the **Logic Calculator** step passes, regardless of the results of individual steps in the inspection.



1. In the Inspection Steps palette, select the **Use Additional Tools** tab.
2. Click the **Set Inspection Status** step. The property page for the step opens.
3. In the **Step Name** control enter `Set Inspection Status`.
4. In the Inspection Status control select the **Equals specified measurement** option, and select **Decide Pass/Fail - Step Status** for the value.
5. Make sure the **Update Number of Parts Inspected** control is enabled.
6. Click **OK** to add the step to the inspection.

Testing the Inspection



Test the inspection to make sure it returns the results you expect. Click the **Run Inspection Once** button to test the remaining images. Table 4-1 lists the test images, the inspection status to expect for each image, and an explanation of the status.

Table 4-1. Expected Results for the Fuse Inspection

Image Name	Inspection Status	Explanation
`Image 01.jpg`	PASS	All steps pass but one **Match Pattern** step.
`Image 02.jpg`	PASS	All steps pass but one **Match Pattern** step.
`Image 03.jpg`	PASS	All steps pass but one **Match Pattern** step.
`Image 04.jpg`	PASS	All steps pass but one **Match Pattern** step.
`Image 05.jpg`	PASS	All steps pass but one **Match Pattern** step.
`Image 06.jpg`	FAIL	The **Measure Separation** step fails because the blade connectors are too close together.
`Image 07.jpg`	FAIL	Both **Match Pattern** steps fail because the conductor is blown.
`Image 08.jpg`	FAIL	Both **Match Pattern** steps fail because the conductor is melted.

Saving the Inspection

Complete the following instructions to save the example inspection.

1. Select **File»Save** or click the **Save** button on the toolbar.
2. Navigate to the location where you want to save the inspection.
3. In the **File Name** control, enter `Tutorial 3.vbai`.
4. Click **Save** to save the inspection.

Tip Select **File»Inspection Properties** to add a short description or comments about the inspection.

5

Inspecting an Object that Spans Two Image Frames

This chapter introduces the **Select Image** and **Calculator** steps.

Assume that you need to measure the width of a wide wooden plank with high accuracy. The only cameras available for the application have low pixel resolutions.

To measure the width of a plank, you need to locate its left and right edges. If you were to set up the imaging system so both edges of a plank fit within an available camera's field of view, the resulting image detail would be too low to yield accurate measurements. Because the required image detail exceeds the pixel resolution capability of a single camera, two cameras per plank are needed—one camera to acquire an image of the left edge and one camera to acquire an image of the right edge.

Follow the instructions in this chapter to create an inspection that measures the width of a wooden plank that spans two images.

Note Launch Vision Builder AI if it is not open. Refer to the *Vision Builder AI Configuration Interface* section of Chapter 1, *Introduction to Vision Builder AI*, for more information.

Creating a New Inspection

Select **File»New**. Vision Builder AI opens a new, blank inspection.

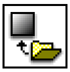
Acquiring Inspection Images from Two Cameras

For simplicity, this tutorial instructs you to use the **Simulate Acquisition** step. However, in your real-world inspection, use one of the other image acquisition steps to acquire images of the object under inspection.

Acquiring and Calibrating the Image of the Left Edge

Complete the following instructions to configure **Simulate Acquisition** steps that simulate acquiring an image of the left section of the wooden plank and calibrating the image.

1. In the Inspection Steps palette, select the **Acquire Images** tab.



2. Click the **Simulate Acquisition** step. The property page for the step opens.
3. In the **Step Name** control, enter `Acquire Plank (Left)`.

4. Click the **Browse** button. The **Select an Image File** dialog box opens.
5. Navigate to `<Vision Builder AI>\DemoImg\Tutorial 4 Left`, where `<Vision Builder AI>` is the location where Vision Builder AI is installed.
6. Select the first image, `Image 01.jpg`, and click **Open**.
7. Make sure the **Cycle Through Folder Images** control is enabled so that Vision Builder AI loads a different simulation image from the folder each time the step is run.
8. Click the **Calibration** tab.
9. Click **Create Calibration** to launch the calibration wizard.
10. In the **Calibration Name** control, enter `Plank Calibration (Left)`.
11. Click **Next**.

For this example, assume that the camera that acquired the inspection images is perpendicular to the image plane and lens distortion is negligible. Based on these assumptions, you can use **Simple Calibration** to calibrate your images. **Simple Calibration** transforms a pixel coordinate to a real-world coordinate through scaling in the x (horizontal) and y (vertical) directions.

12. Select the **Simple Calibration** option, and click **Next**.
13. Make sure **Use Current Image** is selected, and click **Next**.
14. Make sure **Pixel Type** is set to **Square** because the camera that acquired the images for this exercise has square pixels.

15. Click **Next**.
16. In the **Specify the Pixel Ratio** step, carefully click the 1 cm and 5 cm markings on the ruler at the bottom of the image, as shown in Figure 5-1.

Tip You may need to use the zoom buttons below the image to accurately click the ruler markings. After zooming in, scroll down to see the ruler at the bottom of the image.

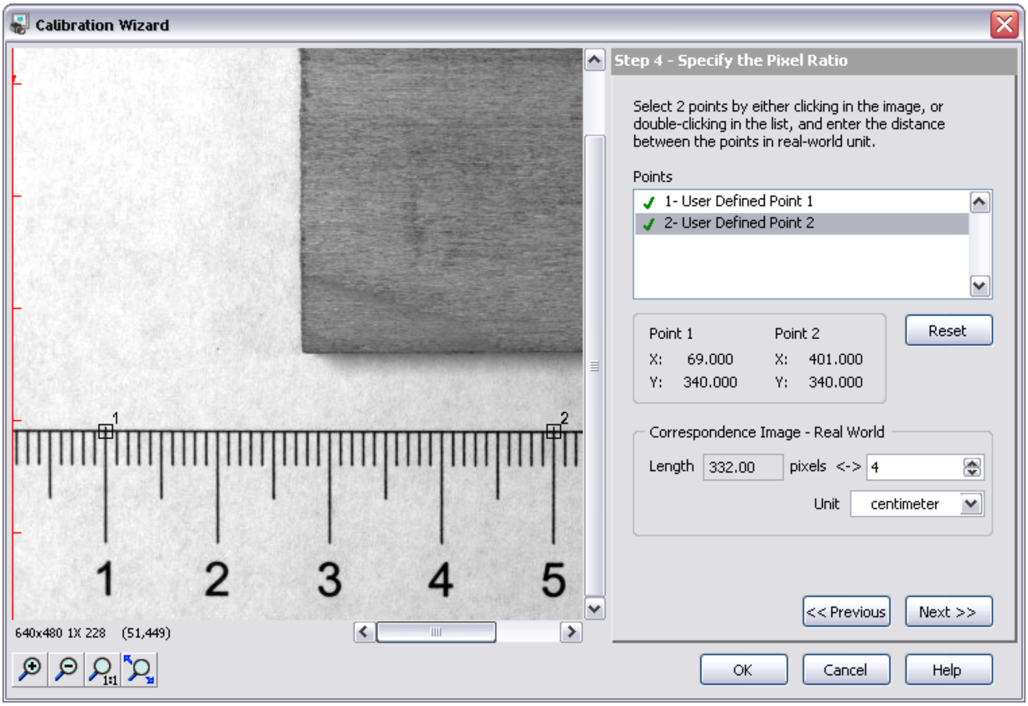


Figure 5-1. Defining the Pixel to Real-World Ratio

17. In the **Correspondence Image - Real World** control, enter 4 for the value, and select **centimeter** for the **Unit**.
18. Click **Next**.

19. In the **Set Calibration Axis** step, click the 1 cm marking to define it as the origin of the calibration axis. Draw a line horizontally and to the right along the edge of the ruler to define the angle of the calibration axis, as shown in Figure 5-2.

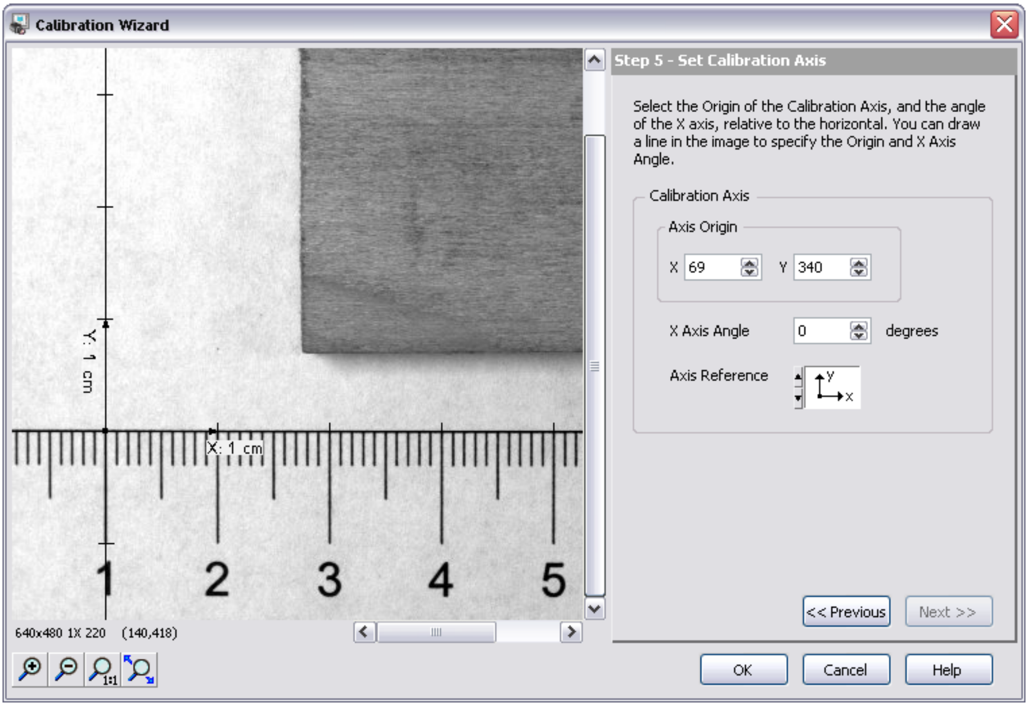


Figure 5-2. Defining the Origin and Angle of the Calibration Axis

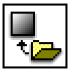
20. Set the **Axis Reference** control to **Direct**.
21. Click **OK** to learn the calibration information and exit the calibration wizard.
22. Click **OK** to add the step to the inspection.

Acquiring and Calibrating the Image of the Right Edge

This section simulates acquiring an image of the right section of the wooden plank. Because the simulated acquisition represents a second camera, you cannot reuse the calibration that you created for the first camera.

Complete the following instructions to configure **Simulate Acquisition** steps that simulate acquiring an image of the right section of the wooden plank and calibrating the image.

1. In the Inspection Steps palette, select the **Acquire Images** tab.



2. Click the **Simulate Acquisition** step. The property page for the step opens.
3. In the **Step Name** control, enter `Acquire Plank (Right)`.

4. Click the **Browse** button. The **Select an Image File** dialog box opens.
5. Navigate to `<Vision Builder AI>\DemoImg\Tutorial 4 Right`, where `<Vision Builder AI>` is the location where Vision Builder AI is installed.
6. Select the first image, `Image 01.jpg`, and click **Open**.
7. Make sure the **Cycle Through Folder Images** control is enabled so that Vision Builder AI loads a different simulation image from the folder each time the step is run.
8. Click the **Calibration** tab.
9. Click **Create Calibration** to launch the calibration wizard.
10. In the **Calibration Name** control, enter `Plank Calibration (Right)`.
11. Click **Next**.

Again, assume that the camera that acquired the inspection images is perpendicular to the image plane and lens distortion is negligible.

12. Select the **Simple Calibration** option, and click **Next**.
13. Make sure **Use Current Image** is selected, and click **Next**.
14. Make sure **Pixel Type** is set to **Square** because the camera that acquired the images for this exercise has square pixels.
15. Click **Next**.

16. In the **Specify the Pixel Ratio** step, carefully click the 38 cm and 42 cm markings on the ruler at the bottom of the image, as shown in Figure 5-3.

Tip You may need to use the zoom buttons below the image to accurately click the ruler markings. After zooming in, scroll down to see the ruler at the bottom of the image.

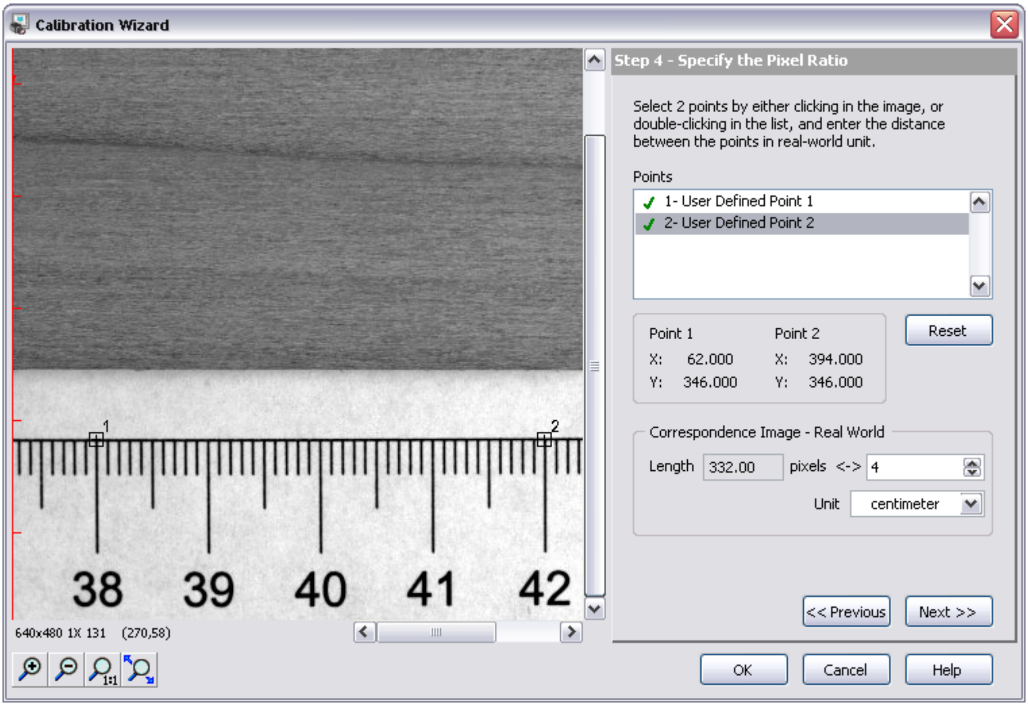


Figure 5-3. Defining the Pixel to Real-World Ratio

17. In the **Correspondence Image - Real World** control, enter 4 for the value, and select **centimeter** for the **Unit**.

18. Click **Next**.

19. In the **Set Calibration Axis** step, click the 38 cm marking to define it as the origin of the calibration axis. Draw a line horizontally and to the right along the edge of the ruler to define the angle of the calibration axis, as shown in Figure 5-4.

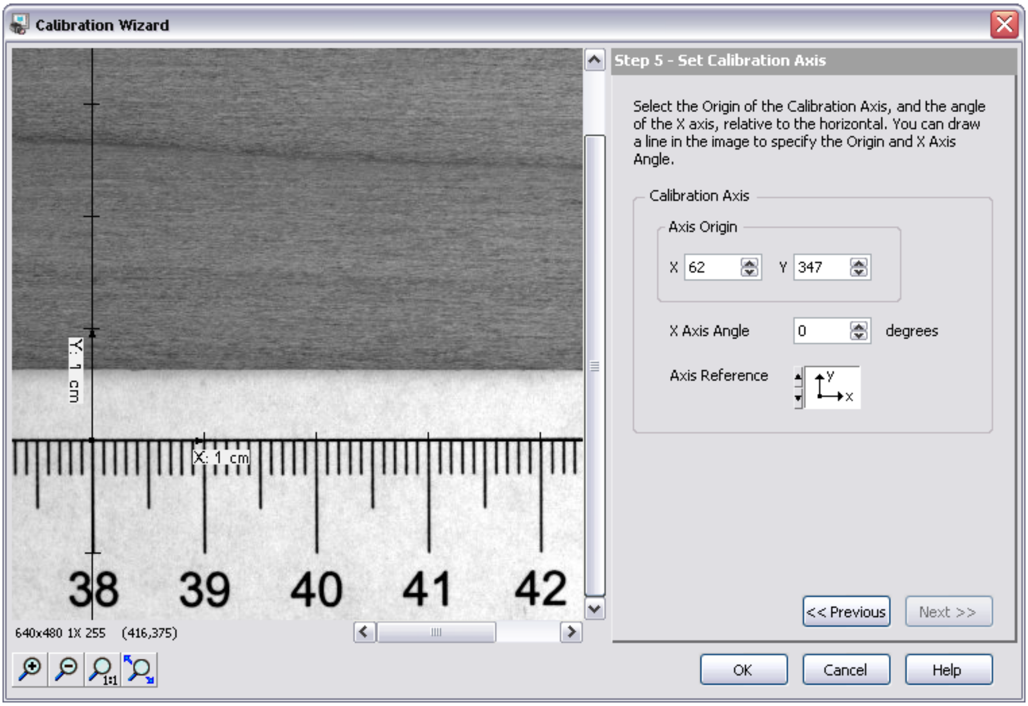


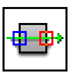
Figure 5-4. Defining the Origin and Angle of the Calibration Axis

20. Set the **Axis Reference** control to **Direct**.
21. Click **OK** to learn the calibration information and exit the calibration wizard.
22. Click **OK** to add the step to the inspection.

Locating the Right Edge of the Part

Complete the following instructions to configure a **Find Edges** step that locates the right edge of the part.

1. In the Inspection Steps palette, select the **Locate Features** tab.



2. Click the **Find Edges** step. The property page for the step opens.
3. In the **Step Name** control, enter `Find Right Edge`.

4. Draw a line across the right edge of the part going from right to left, as shown in Figure 5-5.

Tip Pressing the <Shift> key while drawing a line constrains the line tool to only draw horizontal or vertical lines.

5. Click the **Settings** tab.
6. In the **Look for** control, select **First Edge**.
7. In the **Edge Polarity** control, select **Bright to Dark Only**.

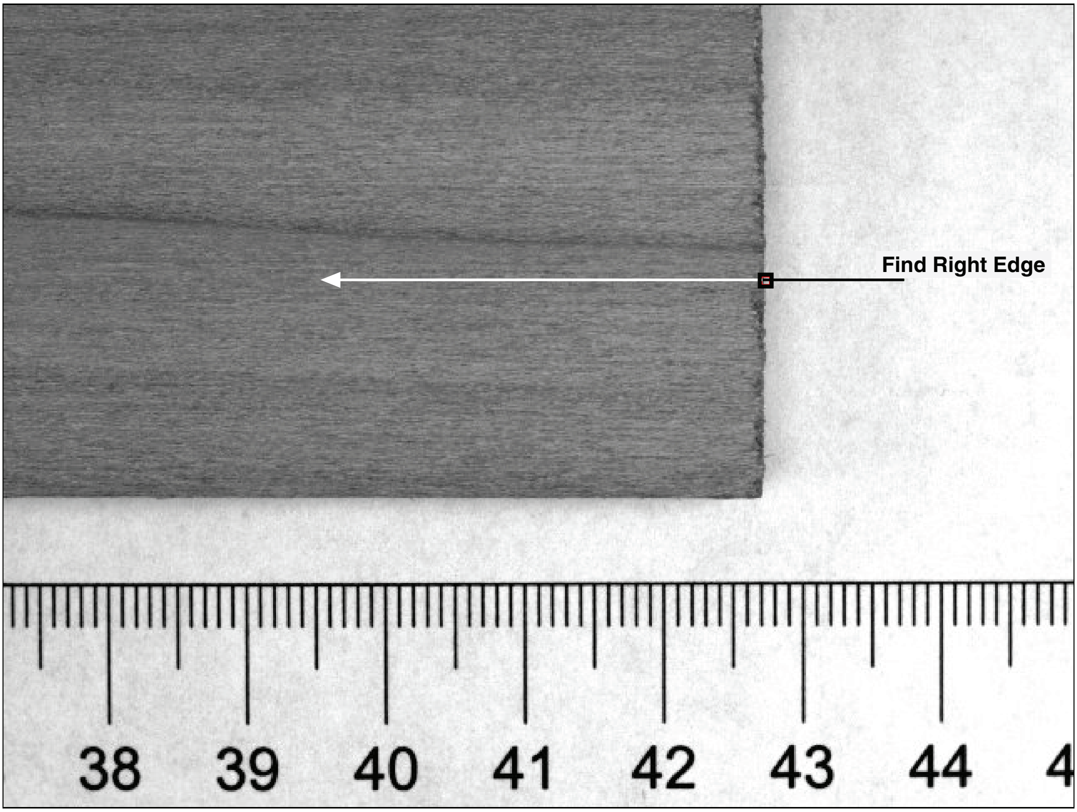


Figure 5-5. Finding the Right Edge of the Plank

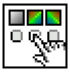
Notice the red square on the search line. The step searches along the search line for a sharp transition in pixel intensities, which usually represents an object edge. The red square marks the location of the right edge of the part.

8. Click **OK** to add the step to the inspection.

Switching Images

Now that you have configured the inspection to locate the right edge of the wooden plank, you need to switch to the image of the left side of the plank. Complete the following instructions to configure a **Select Image** step that makes the image of the left side of the plank active for processing.

1. In the Inspection Steps palette, select the **Acquire Images** tab.



2. Click the **Select Image** step. The property page for the step opens.
3. In the **Step Name** control, enter `Switch to Left Side`.
4. In the **Image Selection** list, select **Acquire Plank (Left)**. The image of the left side of the part appears in the **Main** window.
5. Click **OK** to add the step to the inspection.

Locating the Left Edge of the Part

Complete the following instructions to configure a **Find Edges** step that locates the left edge of the part.

1. In the Inspection Steps palette, select the **Locate Features** tab.
2. Click the **Find Edges** step. The property page for the step opens.
3. In the **Step Name** control, enter `Find Left Edge`.
4. Hold down the <Shift> key and draw a line across the left edge of the part going from left to right, as shown in Figure 5-6.
5. Click the **Settings** tab.
6. In the **Look for** control, select **First Edge**.
7. In the **Edge Polarity** control, select **Bright to Dark Only**.

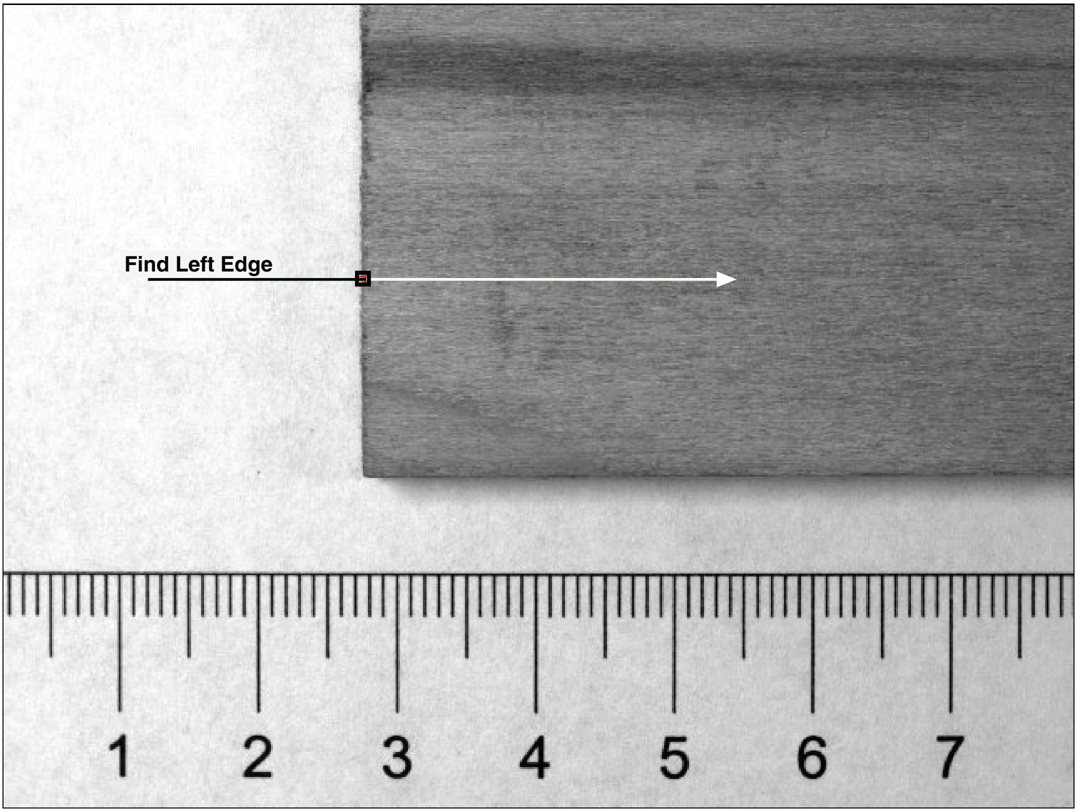


Figure 5-6. Finding the Left Edge of the Plank

The step searches along the search line and marks the location of the left edge with a red square.

8. Click **OK** to add the step to the inspection.

Calculating the Width of the Part

Now that you have located the right edge of the part in one image and the left edge of the part in another image, you need to combine the measurements from the two images to determine the width of the part. Use the **Calculator** step to combine the two measurements and compute the width.

Refer to the following equations as you configure the step.

$$Right\ (LC) = Right\ (RC) + (Origin\ R - Origin\ L) \tag{5-1}$$

$$Part\ Width = Right\ (LC) - Left\ (LC) \tag{5-2}$$

where *Right (LC)* = The x position of the right edge in the calibration axis of the left edge.

Right (RC) = The x position of the right edge in the calibration axis of the right edge. This corresponds to the calibrated x position result of the Find Right Edge step.

Origin R = The x position of the origin in the calibration axis of the right edge.

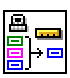
Origin L = The x position of the origin in the calibration axis of the left edge.

Left (LC) = The x position of the left edge in the calibration axis of the left edge. This corresponds to the calibrated x position result of the Find Left Edge step.

Setting Calculator Step Inputs and Outputs

Complete the following instructions to configure a **Calculator** step to select the input measurements from the previous **Find Right Edge** and **Find Left Edge** steps, and create output results for the calculated values.

1. In the Inspection Steps palette, select the **Use Additional Tools** tab.



2. Click the **Calculator** step. The Calculator Setup Wizard opens.
3. Click **Next** to proceed with the wizard.

Notice the **Input Measurements** list. The list contains all of the measurable data from each of the previous steps in the inspection.

4. Select the following measurements from the **Input Measurements** list:
   - **Find Right Edge»Edge [1].X Position (Calibrated)**
   - **Find Left Edge»Edge [1].X Position (Calibrated)**
5. Click **Next**.
6. Click **Add New Output Result**. A new output appears in the **Output Results** list.
7. In the **Name** control, enter `Part Width`. This output will contain the results of Equation 5-2.
8. Make sure **Type** is set to **Numeric**.
9. Click **Add New Output Result** again.
10. In the **Name** control, enter `Right (LC)`. This output will contain the results of Equation 5-1.
11. Make sure **Type** is set to **Numeric**.
12. Click **Finish** to close the Calculator Setup Wizard.

The **Main** window now displays a diagram with the measurement inputs and result outputs you specified in the Calculator Setup Wizard, as shown in Figure 5-7. The diagram also contains a default Boolean result named **Step Result**. You can connect the result of a computation to **Step Result**, which changes the status of the **Calculator** step to the result of the computation. Refer to the *Making Logical PASS/FAIL Decisions with the Calculator Step* section of this chapter for more information about **Step Result**.

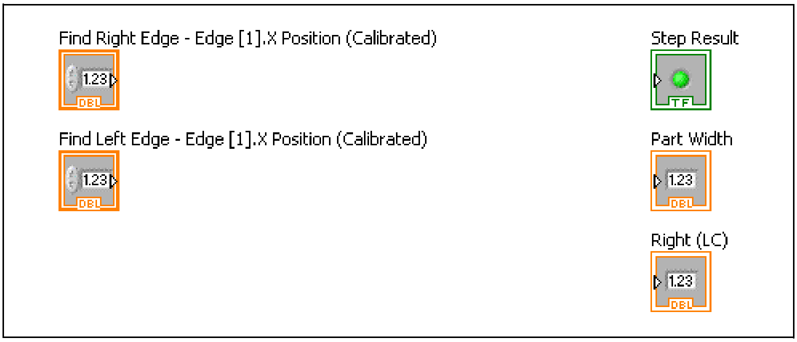


Figure 5-7. Calculator Diagram Elements

Notice that the inputs and outputs are framed with color and have codes at the bottom of their frames. These colors and codes visually group inputs and outputs into their respective *data types*—numerics, Booleans, or strings.

13. To simplify the process of connecting the diagram elements later in this chapter, arrange the elements into the configuration shown in Figure 5-8 by dragging them to their new positions.

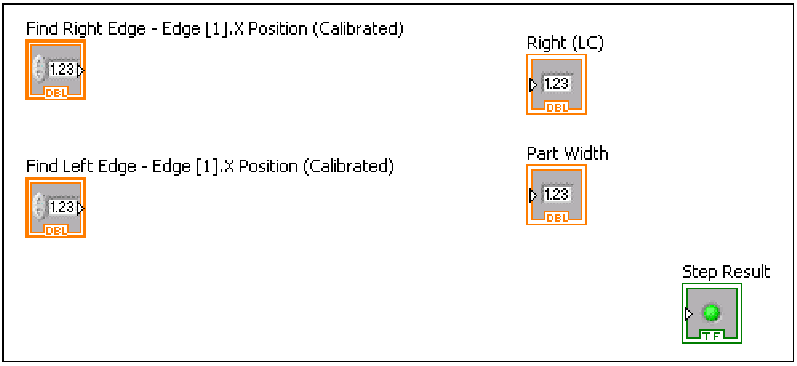


Figure 5-8. Arranging Diagram Elements

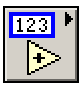
Adding Operators and Constants

Earlier in this chapter, you used the Calibration Wizard to set calibration axis origins for the right and left sides of the part. These origins are the only elements of Equations 5-1 and 5-2 not yet represented in the Calculator diagram: (*Origin R* and *Origin L*).

In step 19 of the *Acquiring and Calibrating the Image of the Right Edge* section of this chapter, you set the origin of the right side to the 38 cm marking of the imaged ruler. In step 19 of the *Acquiring and Calibrating the Image of the Left Edge* section of this chapter, you set the origin of the left side to the 1 cm marking of the imaged ruler. Therefore,

$$(Origin\ R - Origin\ L) = 38 - 1 = 37.$$

The distance between the calibration axis origins is a constant value. Add a constant with the value `37` to the Calculator diagram.



1. In the Functions palette, click **Numeric**.
2. Click the **Num Const** operator. Click inside the Calculator diagram below the **Find Right Edge - Edge [1].X Position (Calibrated)** input measurement to place the numeric constant on the Calculator diagram.

3. Double-click the numeric constant and type `37` to set the value of the constant.

4. Click the **Add** operator in the Functions palette. Click inside the Calculator diagram to the right of the **Find Right Edge - Edge [1].X Position (Calibrated)** input measurement.

Tip Place the **Add** operator close enough to the **Find Right Edge - Edge [1].X Position (Calibrated)** input so that the **Calculator** step automatically connects the two elements with a wire.

5. Click the **Show Help Window** button on the **Main** tab of the **Calculator** step to launch the Help window, or click the **Help** button in the Calculator diagram toolbar. When you move your cursor over certain elements within the Calculator diagram, information about that item shows in the **Help** window.
6. Place your cursor over the **Add** operator. Notice in the Help window that the operator has an **x** input terminal, **y** input terminal, and **x+y** output terminal.

7. Click the **Subtract** operator in the Functions palette. Click inside the Calculator diagram to the right of the **Find Left Edge - Edge [1].X Position (Calibrated)** input measurement.

Your Calculator diagram should look similar to the diagram shown in Figure 5-9.

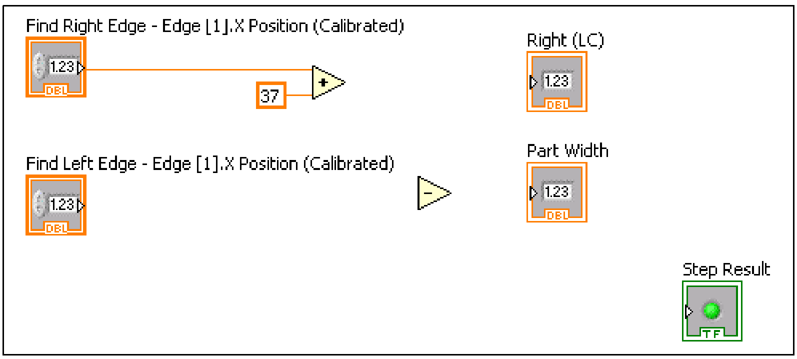
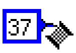


Figure 5-9. Unconnected Diagram Elements

Connecting the Equation Elements

Complete the following instructions to wire the diagram elements together such that they form Equation 5-1: *Right (LC)* = *Right (RC)* + (37).



1. Place your cursor on the small, triangular terminal located on the right side of the numeric constant. The cursor changes into a Wiring tool.

2. Use the Wiring tool to click the terminal and release the mouse. As you move the cursor across the Calculator diagram, the **Calculator** step draws a wire between the terminal and the Wiring tool as though the wire were unwinding from a spool.
3. Without holding down the mouse button, move the cursor to the **y** input terminal of the **Add** operator. The **y** input terminal blinks. Use the Wiring tool to click the **y** input terminal and complete the connection.
4. Click the output terminal of the Add operator, and connect it to the input terminal of **Right (LC)**.

Tip If you do not terminate a wire correctly, the wire is broken and appears as a dashed black line with a red X in the middle. Click **Remove Broken Wires** in the **Main** tab to remove broken wires.

Complete the following instructions to wire the diagram elements together such that they form Equation 5-2: *Part Width = Right (LC) – Left (LC)*.

1. Place the cursor on the wire that connects the **Add** operator to **Right (LC)**. The cursor changes into the Wiring tool.
2. Click the wire, and connect it to the **x** input terminal of the **Subtract** operator.
3. Click the **Find Left Edge - Edge [1].X Position (Calibrated)** output terminal, and connect it to the **y** input terminal of the **Subtract** operator.
4. Click the output terminal of the **Subtract** operator, and connect it to the input terminal of **Part Width**.

Your connected Calculator diagram should look similar to the diagram shown in Figure 5-10.

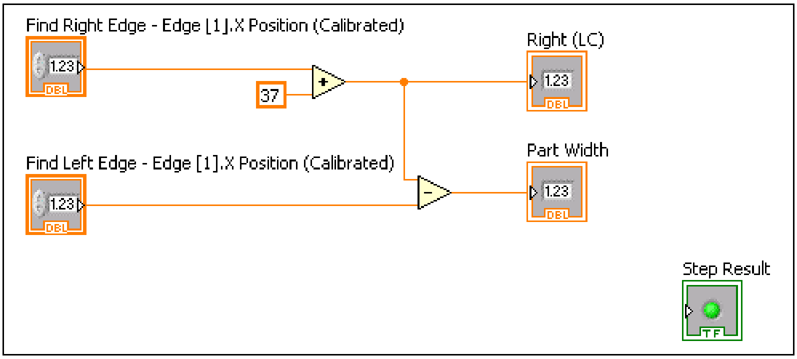


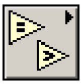
Figure 5-10. Connected Elements of Calculator Diagram

5. In the **Calculator** step property page, click the **Measurements** tab.
6. Click **Compute Results** to see the results of the calculation thus far.

Making Logical PASS/FAIL Decisions with the Calculator Step

Now that you have a created a diagram to measure the width of the part, you need a way to verify that the width meets manufacturing specifications. Complete the following instructions to add diagram elements that compare the measured width to minimum and maximum width tolerances and decide whether the plank passes inspection.

1. Click the up arrow in the Functions palette to return to the main palette.



2. Select the **Comparison** palette.
3. Click the **Less?** operator in the Comparison palette. Click inside the Calculator diagram below **Part Width**.
4. Connect the wire between **Subtract** and **Part Width** to the **x** input of the **Less?** operator.
5. Click the up arrow in the Functions palette to return to the main palette.
6. Select the **Numeric** palette.
7. Click the **Num Const** operator in the Numeric palette.
8. Click close enough to the **y** input of **Less?** to automatically wire the numeric constant and **y** input together.
9. Type `40.5` to set the maximum width a plank can be to pass the inspection.
10. Click the up arrow in the Functions palette to return to the main palette.
11. Select the **Comparison** palette.
12. Click the **Greater?** operator. Click inside the Calculator diagram below the **Less?** operator.
13. Connect the wire between **Subtract** and **Part Width** to the **x** input of the **Greater?** operator.
14. Click the up arrow in the Functions palette to return to the main palette.
15. Select the **Numeric** palette.
16. Click the **Num Const** operator.
17. Click close enough to the **y** input of **Greater?** to automatically wire the numeric constant and **y** input together.
18. Type `39.5` to set the minimum width a plank can be to pass the inspection.
19. Click the up arrow in the Functions palette to return to the main palette.

20. Select the **Boolean** palette.
21. Click the **And** operator. Click close enough to the left side of **Step Result** to wire the two elements together.
22. Connect the **Less?** output to the **x** input of **And**.
23. Connect the **Greater?** output to the **y** input of **And**.

Your completed Calculator diagram should look similar to the diagram shown in Figure 5-11.

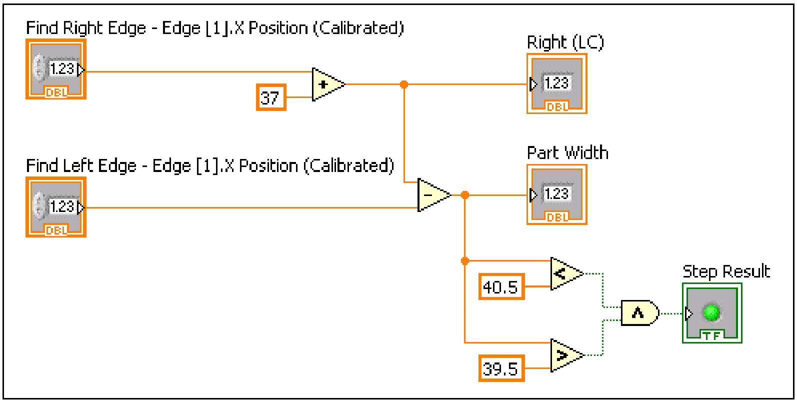


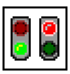
Figure 5-11. Calculator Diagram with Decision-Making Abilities

24. In the **Calculator** step property page, click the **Limits** tab.
25. Enable the **Step Result is True** checkbox.
26. Click **OK** to add the step to the inspection.

Setting the Inspection Status

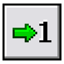
Complete the following instructions to add a **Set Inspection Status** step to determine whether the inspection passes or fails.

1. In the Inspection Steps palette, select the **Use Additional Tools** tab.



2. Click the **Set Inspection Status** step. The property page for the step opens.
3. In the **Inspection Status** control, Select the **FAIL if any previous step fails** option.
4. Click **OK** to add the step to the inspection.

Testing the Inspection



Test the inspection to make sure it returns the results you expect. Click the **Run Inspection Once** button to test the remaining images. Table 5-1 lists the test images, the inspection status to expect for each image, and an explanation of the status.

Note Results may vary slightly based on the accuracy of the calibration and the edge detection location.

Table 5-1. Expected Results for the Plank Inspection

Image Name	Part Width	Inspection Status
`Image 01.jpg`	40.00 cm	PASS
`Image 02.jpg`	40.16 cm	PASS
`Image 03.jpg`	40.28 cm	PASS
`Image 04.jpg`	39.27 cm (too short)	FAIL
`Image 05.jpg`	40.90 cm (too long)	FAIL

Saving the Inspection

Complete the following instructions to save the example inspection.

1. Select **File»Save** or click the **Save** button on the toolbar.
2. Navigate to the location where you want to save the inspection.
3. In the **File Name** control, enter `Tutorial 4.vbai`.
4. Click **Save** to save the inspection.

Tip Select **File»Inspection Properties** to add a short description or comments about the inspection.

6

Branching and Decision Making

This chapter introduces the inspection state diagram and the **Custom Overlay** step. Follow the instructions in this chapter to create an inspection that checks the image for the presence of a spray bottle and, if a bottle is present, transitions to another state to determine if the bottle has a cap. If there is no spray bottle present in the image, the inspection moves on to the next image.

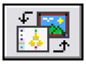
Note Launch Vision Builder AI if it is not open. Refer to the *Vision Builder AI Configuration Interface* section of Chapter 1, *Introduction to Vision Builder AI*, for more information.

Creating a New Inspection

Select **File»New** to load a new, blank Vision Builder AI inspection.

Creating the Inspection State Diagram

The configurable process model in Vision Builder AI is represented by a state diagram. Complete the following instructions to create a state diagram to define the inspection.



1. Click the **Toggle Main Window View** button on the toolbar to bring the state diagram to the Main window.

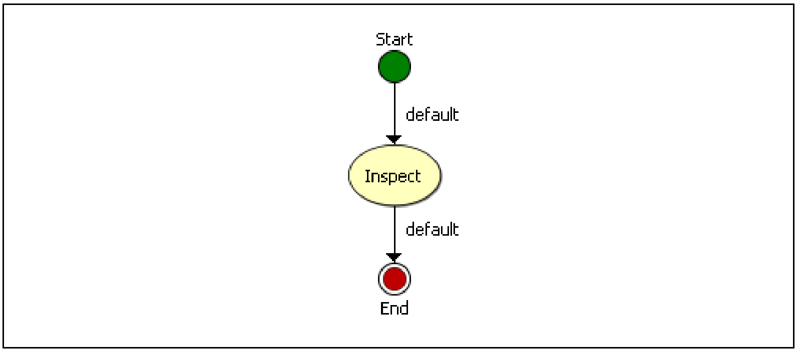


Figure 6-1. Default Inspection State Diagram

2. Double-click the **Inspect** state to launch the Edit State Name dialog box.
3. In the State Name control, enter `Check Part Presence`, and click **OK**.
4. Right-click an open area on the state diagram and select **Create New State** to add a new state to the inspection, as shown in Figure 6-2. The Edit State Name dialog box opens.

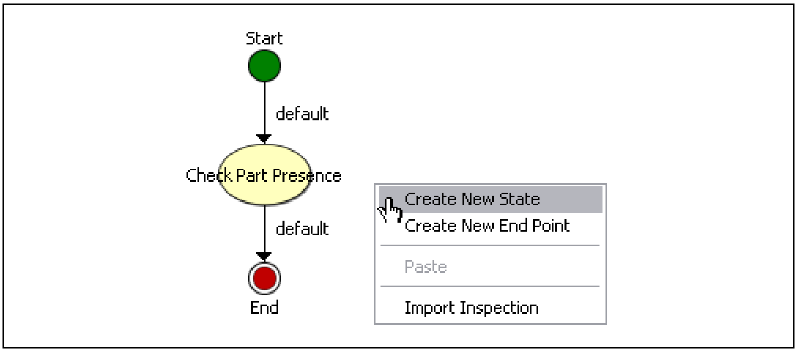


Figure 6-2. Creating a New Inspection State

5. In the **State Name** control, enter `Inspect Part`.

6. Create two more states named `Fail Part` and `Pass Part`. The state diagram should now resemble the state diagram shown in Figure 6-3.

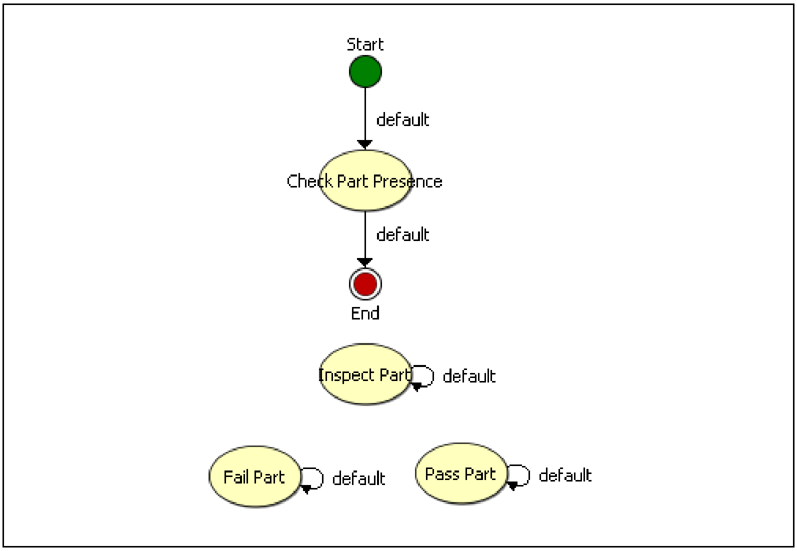


Figure 6-3. Adding New States to the Inspection

Next, you will create transitions between the various inspection states. Notice that every state has a default transition. You can also create additional transitions between states based on measurement results or variable values.

Note The default transition occurs if the transition requirements for other possible transitions are not met.

7. Click the arrow of the Check Part Presence **default** transition and drag it back to the Check Part Presence state. This creates a loop that will run the steps in the Check Part Presence State until a part is detected.
8. Click the **End** point and drag it to the bottom of the state diagram.
9. Click the Inspect Part **default** transition and drag it to the Fail Part state.
10. Click the Fail Part **default** transition and drag it to the End point.
11. Click the Pass Part **default** transition and drag it to the End point.

The state diagram should now resemble the state diagram shown in Figure 6-4.

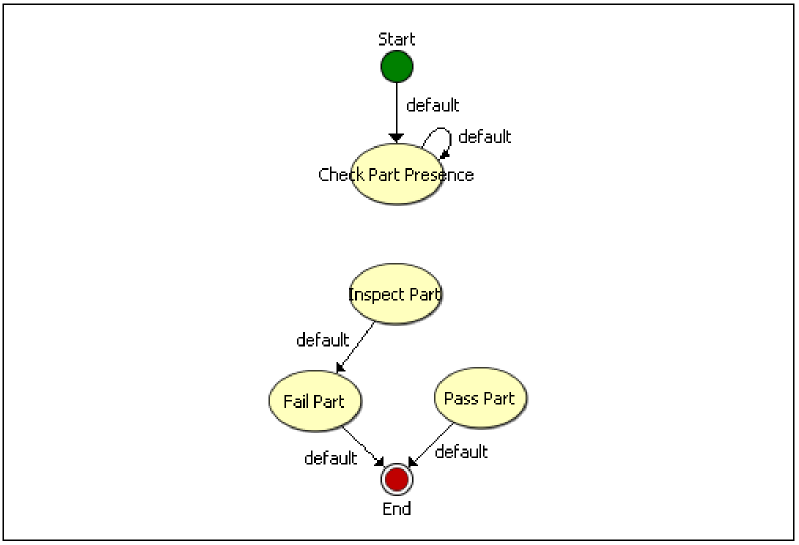


Figure 6-4. Configuring the Default Transitions

12. Right-click the **Check Part Presence** state and select **Create New Transition**.
13. Click the **Inspect Part** state to create a transition between the Check Part Presence and Inspect Parts states, as shown in Figure 6-5.

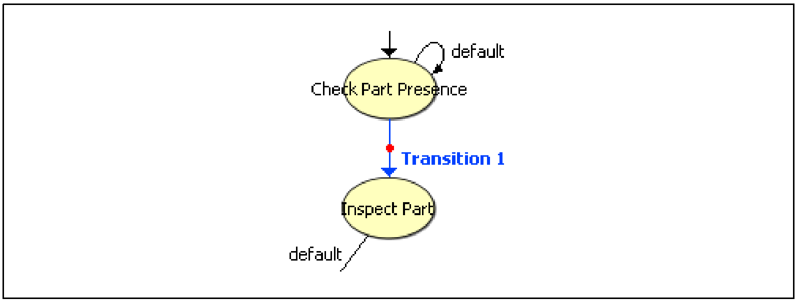


Figure 6-5. Creating a New Transition

You can change the shape of the transition by dragging the anchor point at the center of the transition. You can move the location of the transition label by clicking the label and dragging it to the new location.

Tip When drawing a transition, click once on the state diagram to set the anchor point for the transition. The anchor point allows you to draw an arc instead of a straight line to represent the transition.

14. Double-click the transition to launch the Edit Transition dialog box, which is used to configure the transition.
15. In the **Transition Name** control, enter `Part Detected`, and click **OK**.
16. Create another transition named `Part OK` between the **Inspect Part** and **Pass Part** states.

The state diagram should now resemble the state diagram shown in Figure 6-6.

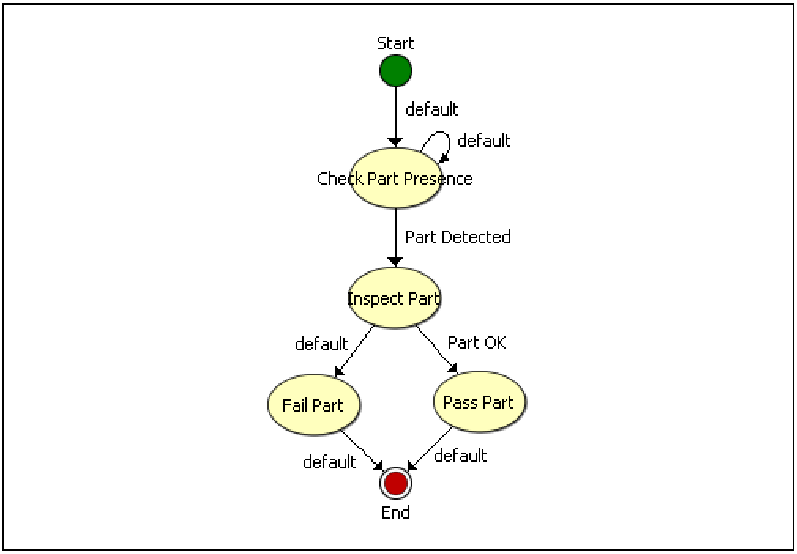


Figure 6-6. Completed State Diagram for the Inspection

Note You can remove a state or transition from the inspection by selecting the object you want to remove and pressing the <Delete> key.

Note You cannot rename or remove the default transition of a state.

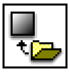
Each state in an inspection is intended to contain a separate set of inspection steps. To access the functions in a state, click the state in the state diagram. The currently selected state is highlighted in blue on the state diagram.

Acquiring Inspection Images

For simplicity, this tutorial instructs you to use the **Simulate Acquisition** step. However, in your real-world inspection, use one of the other image acquisition steps to acquire images of the object under inspection.

Complete the following instructions to configure a **Simulate Acquisition** step that simulates acquiring images of spray bottles.

1. On the state diagram, click the **Check Part Presence** state.
2. In the Inspection Steps palette, select the **Acquire Images** tab.



3. Click the **Simulate Acquisition** step. The property page for the step opens.

Note When the property page for an inspection step opens, if the state diagram is displayed in the Main window, the state diagram switches from the Main window to the Overview window to allow you to use the current inspection image to configure the step.

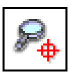
4. In the **Step Name** control, enter `Acquire Image`.

5. Click the **Browse** button. The **Select an Image File** dialog box opens.
6. Navigate to `<Vision Builder AI>\DemoImg\Tutorial 5`, where `<Vision Builder AI>` is the location where Vision Builder AI is installed.
7. Select an image containing the entire spray bottle, such as `Image 00480.jpg`, and click **Open**.
8. Make sure the **Cycle Through Folder Images** control is enabled so that Vision Builder AI loads a different simulation image from the folder each time the step is run.
9. Click **OK** to add the step to the inspection.

Checking for a Spray Bottle in the Image

Complete the following instructions to configure a **Match Pattern** step to check for the presence of a spray bottle in the image.

1. In the Inspection Steps palette, select the **Locate Features** tab.



2. Click the **Match Pattern** step. The NI Vision Template Editor opens.
3. Draw a region of interest (ROI) around the bottom left edge of the bottle. This region becomes the pattern matching template.
4. Click **Next**.

5. Click **Finish** to accept the template.
6. On the **Main** tab, enter `Locate Bottle` in the **Step Name** control.
7. Adjust the default green ROI so that it only surrounds the area of the image that could contain the bottom left edge of a spray bottle, as shown in Figure 6-7.

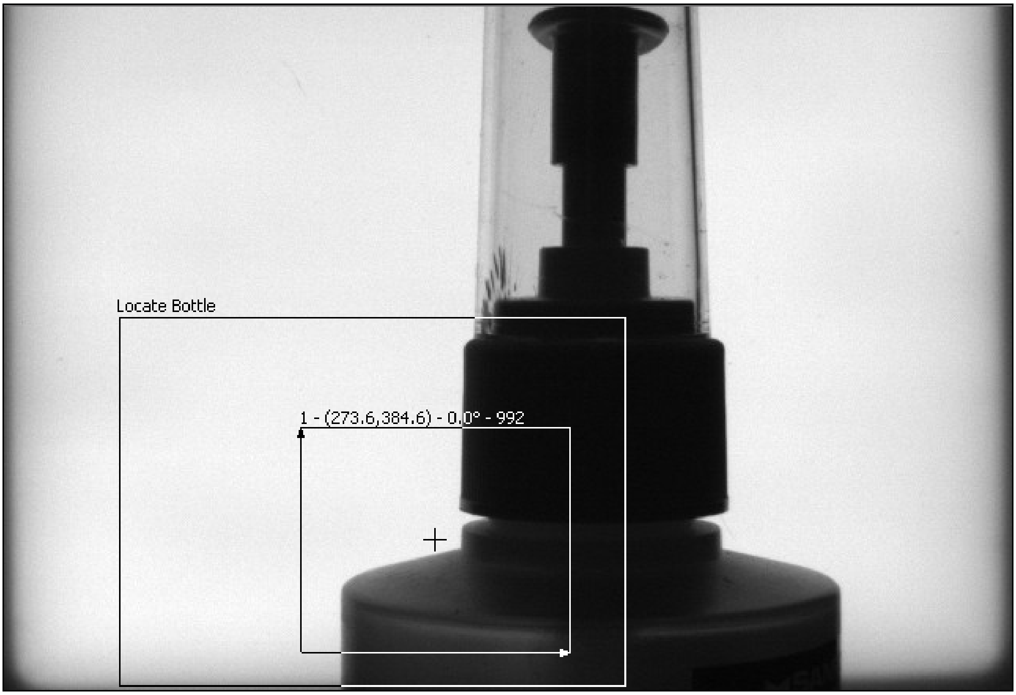


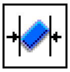
Figure 6-7. Adjusting the Search Region

8. On the **Settings** tab, set the **Number of Matches to Find** control to `1`.
9. On the **Limits** tab, enable the **Minimum Number of Matches** control, and set the value to `1`.
10. Click **OK** to add the step to the inspection.

Checking for the Cap Using the Caliper

You can check for the presence of the cap on a spray bottle by using the **Caliper** step to find two edges where the cap is supposed to be and measuring the distance between them. Complete the following instructions to configure a **Caliper** step to check for the presence of the spray bottle cap.

1. In the Overview window, click the **Inspect Part** state on the state diagram.
2. In the Inspection Steps palette, select the **Measure Features** tab.



3. Click the **Caliper** step. The property page for the step opens.
4. In the **Step Name** control, enter `Check Cap Presence`.
5. Draw an ROI around the area in the image where a cap should appear, as shown in Figure 6-8.

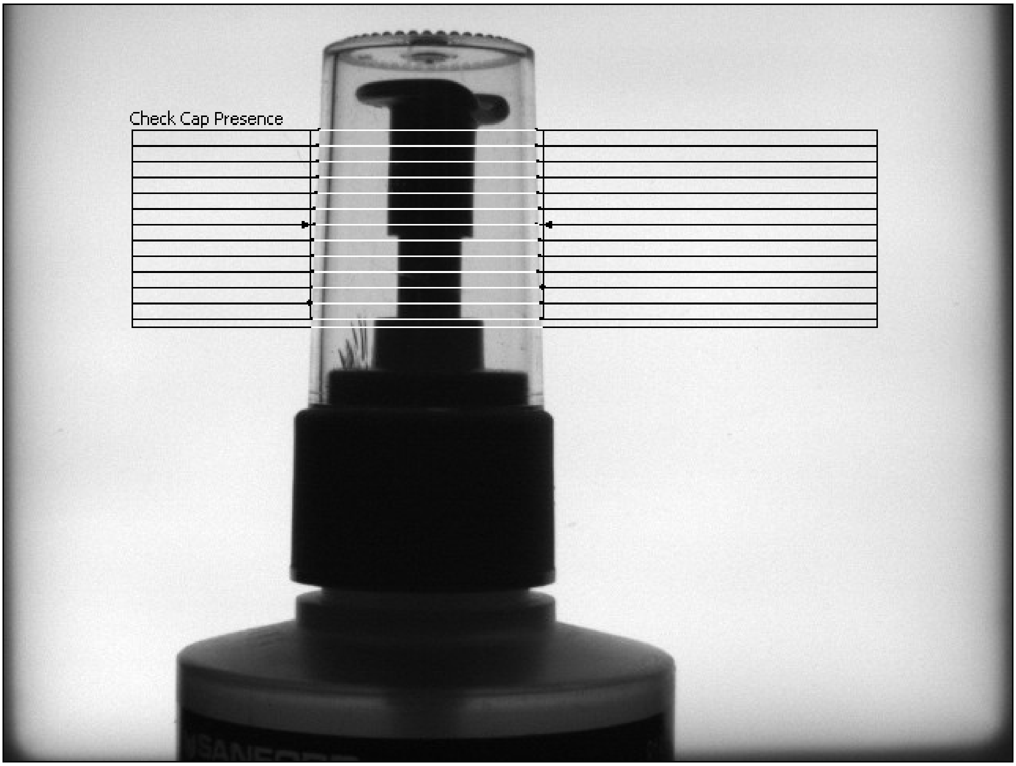
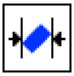


Figure 6-8. Checking for Cap Presence

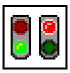


6. On the **Settings** tab, select the **Process** named **Horizontal Max Caliper** to change the direction and orientation of the caliper search lines.
7. Set the **Gap** control to `10`, **Edge Strength** to `40`, and **Smoothing** to `12` to ensure that the step correctly detects the edges of the cap.
8. On the **Limits** tab, enable the **Minimum Distance** control, and set the value to `140`.
9. Enable the **Maximum Distance** control, and set the value to `160`.
10. Click **OK** to add the step to the inspection.

Setting the Inspection Status

Complete the following instructions to add a **Set Inspection Status** step to determine whether the inspection passes or fails.

1. In the Inspection Steps palette, click the **Use Additional Tools** tab.



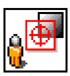
2. Click the **Set Inspection Status** step. The property page for the step opens.
3. In the **Inspection Status** control, select the **FAIL if any previous step fails** option.
4. Click **OK** to add the step to the inspection.

Creating Custom Overlays for Inspection

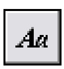
Use the **Custom Overlay** step to create custom overlays that display whether the inspection passed or failed.

Complete the following steps to create an overlay to display when the inspection fails.

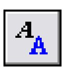
1. In the Overview window, click the **Fail Part** state on the state diagram.
2. In the Inspection Steps palette, select the **Use Additional Tools** tab.



3. Click the **Custom Overlay** step. The property page for the step opens.
4. In the **Step Name** control, enter `Overlay Results`.



5. On the **Custom Overlay** tab, select the **Text** tool and click a point in the image near the bottom of the spray nozzle of the bottle.
6. In the **Text** Control, enter `Missing Cap!`.

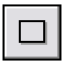


7. Click the **Text Properties** button. The Text Properties dialog box opens.

8. In the **Desired Font** control, select **User-Specified Font**.
9. Specify a **Font Name** and **Size** to use for the overlay.
10. In the **Horizontal Alignment** control, select **Center**. This centers the text around the point you selected using the Text tool.
11. Click **OK** to save the Text Properties settings and close the dialog box.
12. Click **OK** to add the step to the inspection.

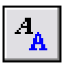
Next, you need to create an overlay to display if the inspection passes. Complete the following steps to create an overlay to display when the inspection passes.

1. In the Overview window, click the **Pass Part** state on the state diagram.
2. In the Inspection Steps palette, select the **Use Additional Tools** tab.
3. Click the **Custom Overlay** step. The property page for the step opens.
4. In the **Step Name** control, enter `Overlay Results`.



5. On the **Custom Overlay** tab, select the **Rectangle** tool and draw a rectangle in the upper-left corner of the image.
6. Click the **Stroke** control, and select black.
7. Click the **Fill** control, and select a bright green color.

8. On the **Custom Overlay** tab, select the **Text** tool, and click a point just below the center of the rectangle overlay.
9. In the **Text** control, enter `Part OK`.
10. Click the **Text** color control, and select black.



11. Click the **Text Properties** button. The Text Properties dialog box appears.
12. In the **Desired Font** control, select **User-Specified Font**.
13. Specify a **Font Name** and **Size** to use for the overlay.
14. In the **Horizontal Alignment** control, select **Center**.
15. Click **OK** to save the Text Properties settings and close the dialog box.
16. Click **OK** to add the step to the inspection.

Figure 6-9 shows the overlays for both Pass and Fail images.

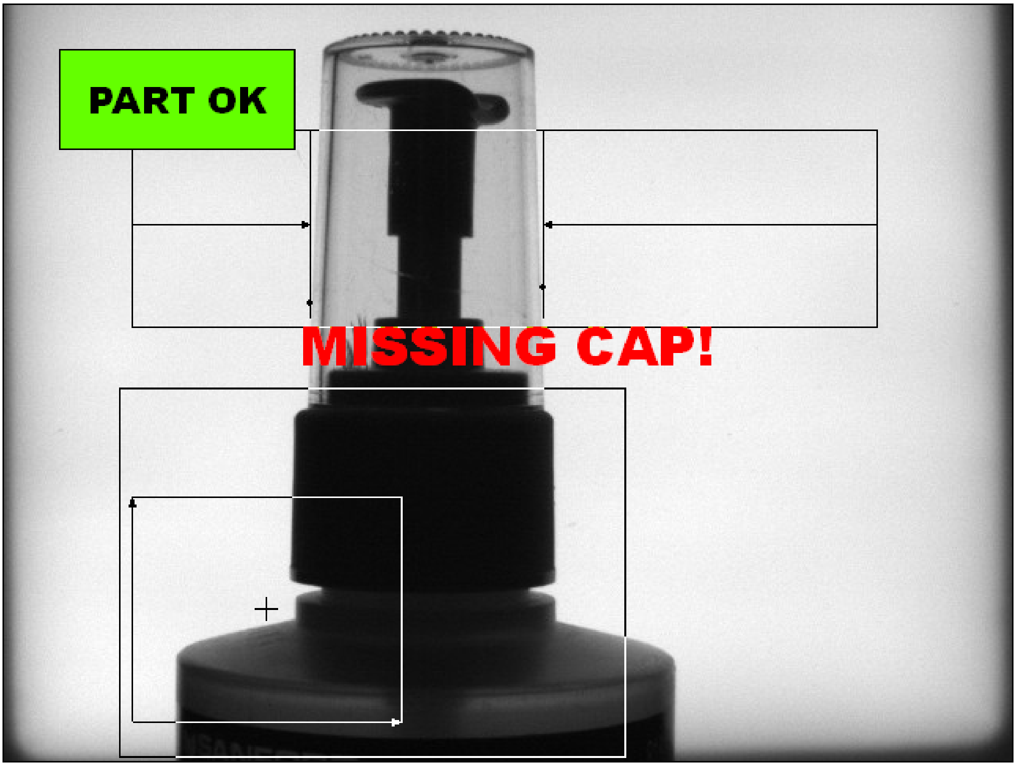
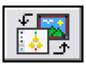


Figure 6-9. Creating Custom Overlays for Images that Pass and Fail

Configuring State Transitions

Once you have configured all of the states in the inspection and created transitions between the states, you need to define the conditions that trigger a transition between inspection states. Complete the following instructions to define the transitions between inspection states.



1. Click the **Toggle Main Window View** button to display the state diagram in the Main window.
2. Double-click the **Part Detected** transition to launch the Edit Transition dialog box, which is used to configure the transition.

3. In the Edit Transition dialog box, modify the controls to transition when **Locate Bottle - # Matches** is **Equal** to `1`, as shown in Figure 6-10.

Figure 6-10. Configuring the Part Detected Transition

4. Click **OK** to close the Edit Transition dialog box.
5. Double-click the **Part OK** transition. The Edit Transition dialog box opens.

6. In the Edit Transition dialog box, modify the controls to transition when **Check Cap Presence - Step Status** is **Pass**, as shown in Figure 6-11.

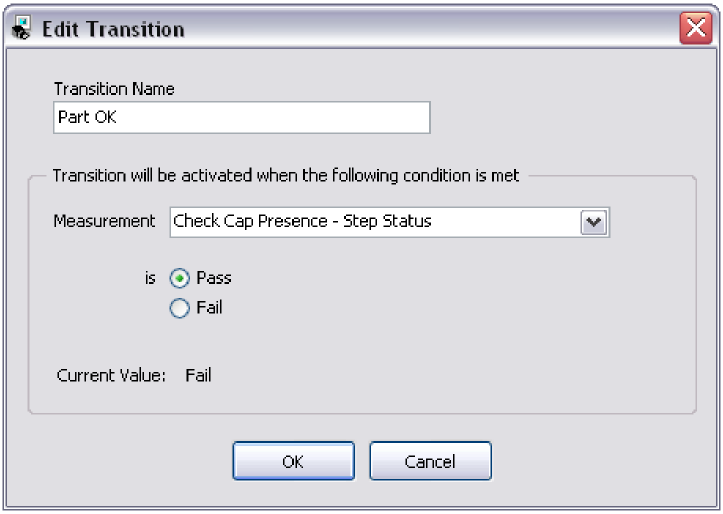
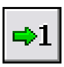


Figure 6-11. Configuring the Part OK Transition

7. Click **OK** to close the Edit Transition dialog box.

Testing the Inspection



Test the images in the `Tutorial 5` folder to make sure the inspection returns the correct results. Click the **Run Inspection Once** button to test the remaining images. Table 6-1 displays the expected results for each image.

Table 6-1. Expected Results for the State Diagram Branching Inspection

Image Name	Inspection Status	Explanation
`Image 00480.jpg`	PASS	Cap is present.
`Image 01710.jpg`	PASS	Cap is present
`Image 03450.jpg`	FAIL	Cap is missing.
`Image 04200.jpg`	PASS	Cap is present.

Saving the Inspection

Complete the following instructions to save the example inspection.

1. Select **File»Save** or click the **Save** button on the toolbar.
2. Navigate to the location where you want to save the inspection.
3. In the **File Name** control, enter `Tutorial 5.vbai`.
4. Click **Save** to save the inspection.

Tip Select **File»Inspection Properties** to add a short description or comments about the inspection.

7

Looping and Variables

This chapter uses the inspection state diagram to implement a looping inspection and introduces the **Set Variable** and **Index Measurements** steps. Follow the instructions in this chapter to create an inspection that inspects images of electronic components to determine if the distance between pins on the component is within a predetermined range. If the pin is too close or too far away from an adjacent pin, then the inspection fails. The inspection does not need to check every pin on the microchip before failing the inspection. The inspection fails at the first failed pin.

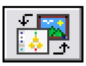
Note Launch Vision Builder AI if it is not open. Refer to the *Vision Builder AI Configuration Interface* section of Chapter 1, *Introduction to Vision Builder AI*, for more information.

Creating a New Inspection

Select **File»New** to load a new, blank Vision Builder AI inspection.

Creating the Inspection State Diagram

Complete the following instructions to create a state diagram to define the inspection.



1. Click the **Toggle Main Window View** button on the toolbar to bring the inspection state diagram to the Main window.
2. Double-click the **Inspect** state to launch the Edit State Name dialog box.
3. In the **State Name** control, enter `Acquire Image & Find Pin Edges`.

4. Right-click an open area on the state diagram and select **Create New State** to add a new state to the inspection, as shown in Figure 7-1. The Edit State Name dialog box opens.

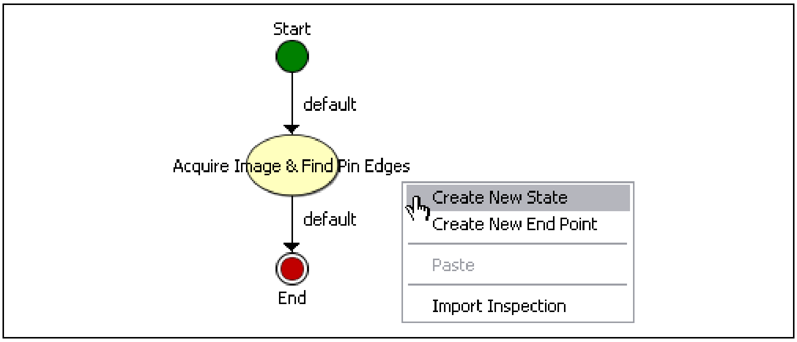


Figure 7-1. Creating a New Inspection State

5. In the **State Name** control, enter `Check Pin Gap`.
6. Create two more states named `Fail Inspection` and `Pass Inspection`. The state diagram should now resemble the state diagram shown in Figure 7-2.

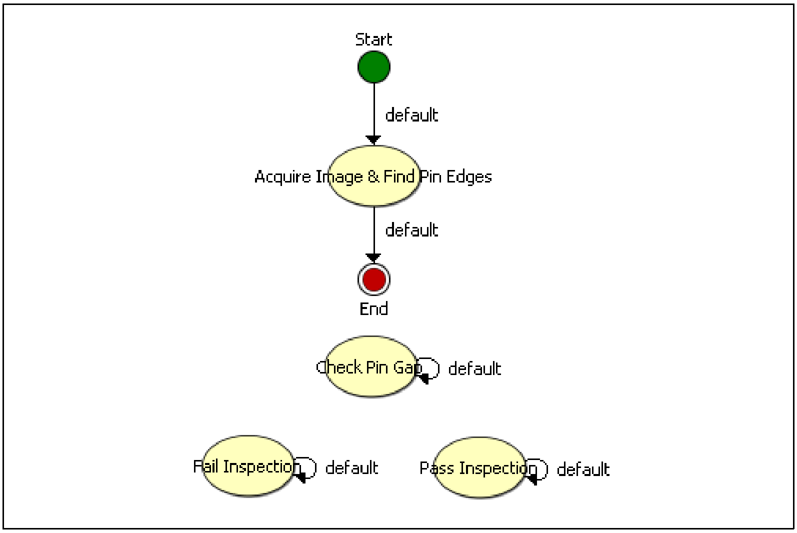


Figure 7-2. Adding New States to the Inspection

Next, you will define transitions between the various inspection states. Notice that every state has a default transition. You can also create additional transitions between states based on measurement results or variable values.

Note The default transition occurs if the transition requirements for other possible transitions are not met.

7. Click the Acquire Image & Find Pin Edges **default** transition and drag it to the Check Pin Gap state.
8. Click the **End** point and drag it to the bottom of the state diagram.
9. Click the Check Pin Gap state **default** transition and drag it to the Pass Inspection state.
10. Click the Fail Inspection **default** transition and drag it to the End point.
11. Click the Pass Inspection **default** transition and drag it to the End point.

The state diagram should now resemble the state diagram shown in Figure 7-3.

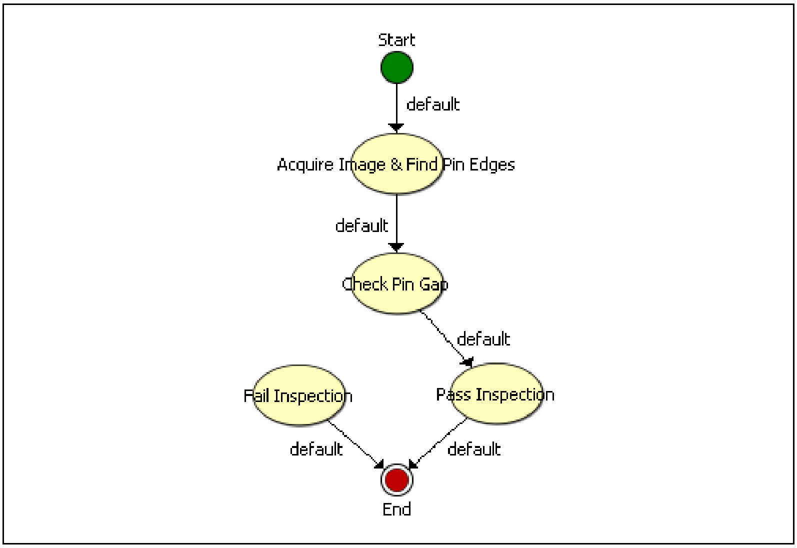


Figure 7-3. Configuring the Default Transitions

12. Right-click the **Acquire Image & Find Pin Edges** state and select **Create New Transition**.

13. Click the **Fail Inspection** state to create a transition between the Acquire Image & Find Pin Edges state and the Fail Inspection state, as shown in Figure 7-4.

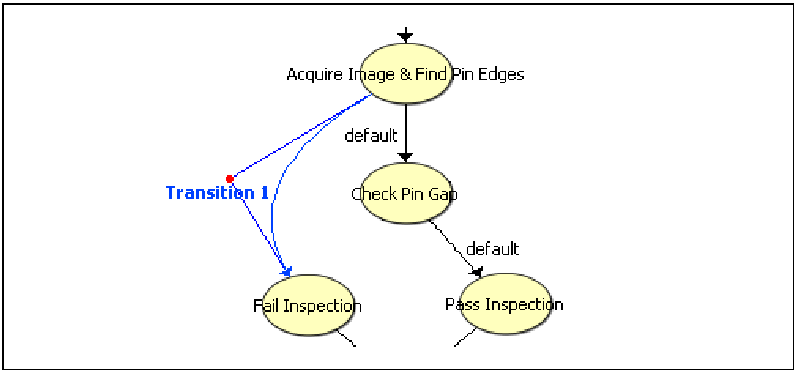


Figure 7-4. Creating a New Transition

You can change the shape of the transition by dragging the anchor point at the center of the transition. You can move the location of the transition label by clicking the label and dragging it to the new location.

Tip When drawing a transition, click once on the state diagram to set the anchor point for the transition. The anchor point allows you to draw an arc instead of a straight line to represent the transition.

14. Double-click the transition to launch the Edit Transition dialog box.
15. In the **Transition Name** control, enter `Wrong # Pins`, and click **OK**.
16. Create a transition from the **Check Pin Gap** state that loops back to the **Check Pin Gap** state named `Repeat for Next Pin`.
17. Create a transition named `Failed` between the **Check Pin Gap** and **Fail Inspection** states.

The state diagram should now resemble the state diagram shown in Figure 7-5.

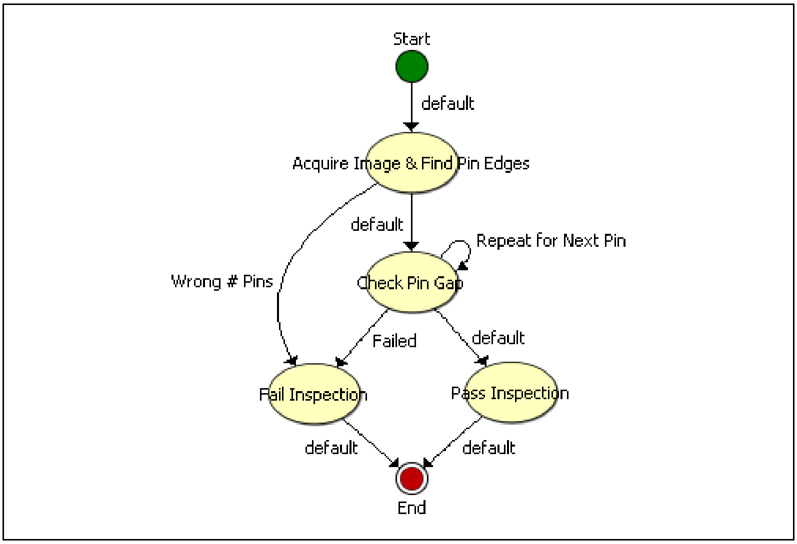


Figure 7-5. Completed State Diagram for the Inspection

Creating a Variable

Since the same inspection needs to be performed on each set of pins, creating a loop in the inspection eliminates the need to configure separate steps to inspect each set of pins. Use the Variable Manager to configure a variable to keep track of the number of times the loop executes.

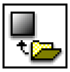
1. Select **Tools»Variable Manager** to launch the Variable Manager.
2. On the Inspection Variables tab of the Variable Manager, click **Add** to launch the Add Inspection Variable dialog box.
3. In the **Name** control, enter `Counter`.
4. In the **Type** control, select **Numeric**.
5. In the **Initial Value** control, enter `1`.
6. Click **OK** to create the variable.
7. Click **OK** to close the Variable Manager.

Acquiring Inspection Images

For simplicity, this tutorial instructs you to use the **Simulate Acquisition** step. However, in your real-world inspection, use one of the other image acquisition steps to acquire images of the object under inspection.

Complete the following instructions to configure a **Simulate Acquisition** step that simulates acquiring images of the pins on electronic components.

1. On the state diagram, select the **Acquire Image & Find Pin Edges** state.
2. In the Inspection Steps palette, select the **Acquire Images** tab.



3. Click the **Simulate Acquisition** step. The property page for the step opens.

Note When the property page for an inspection step opens, if the state diagram is displayed in the Main window, the state diagram switches from the Main window to the Overview window to allow you to use the current inspection image to configure the step.

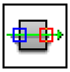
4. In the **Step Name** control, enter `Acquire Pins`.

5. Click the **Browse** button. The Select an Image File dialog box opens.
6. Navigate to `<Vision Builder AI>\DemoImg\Tutorial 6`, where `<Vision Builder AI>` is the location where Vision Builder AI is installed.
7. Select `image 01.jpg`, and click **Open**.
8. Make sure the **Cycle Through Folder Images** control is enabled so that Vision Builder AI loads a different simulation image from the folder each time the step is run.
9. Click **OK** to add the step to the inspection.

Finding Pin Edges

Complete the following instructions to configure a **Find Edges** step to find the edges of the pins and determine if the microchip has the correct number of pins.

1. In the Inspection Steps palette, select the **Locate Features** tab.



2. Click the **Find Edges** step. The property page for the step opens.
3. In the **Step Name** control, enter `Find Pin Edges`.

4. Hold down the <Shift> key and draw a line from left to right across the width of the image where the pins are located, as shown in Figure 7-6.

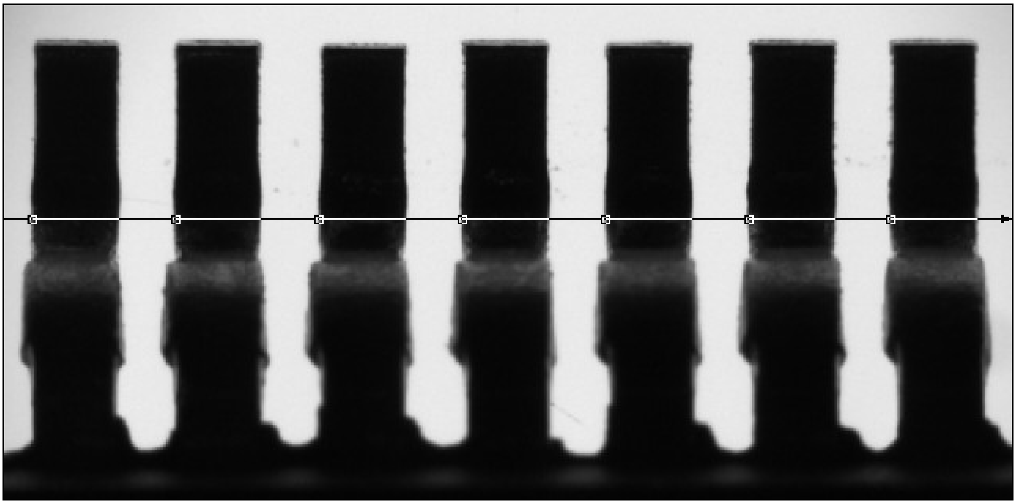


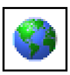
Figure 7-6. Locating the Edges of the Pins of a Microchip

5. In the **Look for** control, select **All Edges**.
6. In the **Edge Polarity** control, select **Bright to Dark Only**.
7. On the **Limits** tab, enable the **Minimum Number of Edges** control and set the value to `7`.
8. Enable the **Maximum Number of Edges** control and set the value to `7`.
9. Click **OK** to add the step to the inspection.

Initializing the Variable

Use the **Set Variable** step to set the value of user-defined variables. Complete the following instructions to configure a **Set Variable** step to initialize the Counter variable.

1. In the Inspection Steps palette, select the **Use Additional Tools** tab.



2. Click the **Set Variable** step. The property page for the step opens in the Main window.
3. In the **Step Name** control, enter `Initialize Counter`.

4. In the **Operation** control, select the **Set to Constant** option and enter `1` for the value.
5. Click **OK** to add the step to the inspection.

Indexing Measurements

Complete the following instructions to configure an **Index Measurements** step to select the x and y position of the *i*th edge found by the **Find Pin Edges** step in the Acquire Image & Find Pin Edges state, where *i* is the value of the Counter variable.

1. In the Overview window, click the **Check Pin Gap** state on the state diagram.
2. In the Inspection Steps palette, select the **Use Additional Tools** tab.

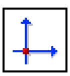
3. Click the **Index Measurements** step. The property page for the step opens.
4. In the **Step Name** control, enter `Get Edge Position`.
5. In the **Measurements** control, select **Edge [i].X Position** and **Edge [i].Y Position**.
6. In the **Index** control, select **Inspection Variable - Counter** from the drop-down listbox.
7. Click **OK** to add the step to the inspection.

In the *Updating the Variable* section of this tutorial, you will set the Counter variable to increment by one each time the Check Pin Gap state is run. This ensures that a different set of pins is inspected each time the **Index Measurements** step is run.

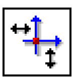
Setting a Coordinate System

Complete the following instructions to configure a **Set Coordinate System** step based on the **Find Pin Edges step** you configured.

1. In the Inspection Steps palette, select the **Locate Features** tab.



2. Click the **Set Coordinate System** step. The property page for the step opens.

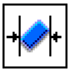


3. On the **Settings** tab, in the **Mode** control, select **Horizontal Motion** because the pins may shift horizontally from one image to another.
4. Click **OK** to add the step to the inspection.

Checking the Pin Gap

Complete the following instructions to measure the gap between two pins and determine if it is within a certain range.

1. In the Inspection Steps palette, select the **Measure Features** tab.



2. Click the **Caliper** step. The property page for the step opens.
3. In the **Step Name** control, enter `Measure Gap`.
4. Enable the **Reposition Region of Interest** control and verify that **Set Coordinate System** is selected for the **Reference Coordinate System** control.
5. Draw an ROI over the gap between the first two pins, as shown in Figure 7-7.

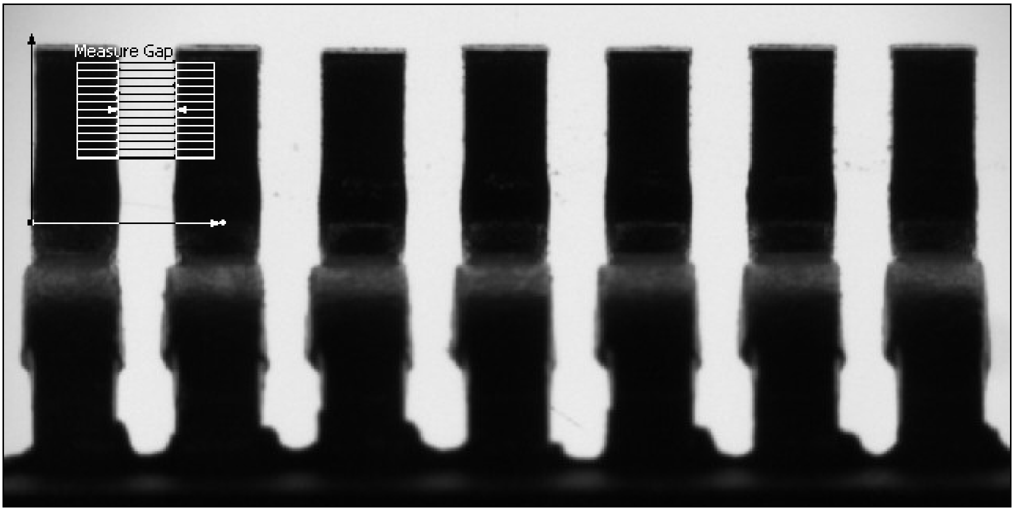
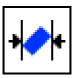


Figure 7-7. Measuring the Distance Between Pins



6. In the **Settings** tab, select the **Process** named **Horizontal Max Caliper** to change the direction and orientation of the caliper search lines.
7. On the **Limits** tab, enable the **Minimum Distance** control and set the value to `30.00`. Enable the **Maximum Distance** control and set the value to `46.00`.
8. Click **OK** to add the step to the inspection.

Updating the Variable

After you have measured the gap between two pins, you must increment the Counter variable so that the next time the state is executed the next set of pins is inspected. Complete the following instructions to use a **Set Variable** step to increment the value of the Counter variable.

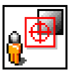
1. In the Inspection Steps palette, select the **Use Additional Tools** tab.

2. Click the **Set Variable** step. The property page for the step opens in the Main window.
3. In the **Step Name** control, enter `Update Counter`.
4. In the **Operation** control, select the **Increment** option.
5. Click **OK** to add the step to the inspection.

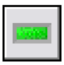
Identifying Failed Pins

Complete the following instructions to create an overlay to identify a failed pin using the **Custom Overlay** step.

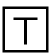
1. In the Inspection Steps palette, select the **Use Additional Tools** tab.



2. Click the **Custom Overlay** step. The property page for the step opens.
3. In the **Step Name** control, enter `Overlay Failed Gap`.



4. On the **Custom Overlay** tab, select the **Indicator** tool and draw a small indicator on the image.
5. In the **Top Left Point** control, select **Get Edge Position - Edge [i]**. This aligns the top left point of the indicator overlay with the *i*th edge found by the **Get Edge Position** step.
6. In the **X Offset** control, enter `35`. In the **Y Offset** control, enter `28`. This positions the indicator overlay over the gap between two pins.
7. In the **Value** control, select **Measure Gap - Step Status** to set the indicator overlay to display the Step Status for the **Measure Gap** step in the inspection.

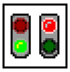


8. Delete the text in the **True Text** control since the overlay is only displayed if the inspection fails. Set the **Fill** to transparent.
9. In the **False Text** control, enter `FAIL`. Set the **Fill** to red.
10. Click **OK** to add the step to the inspection.

Setting the Inspection Status

Complete the following instructions to set the Inspection Status for the inspection.

1. In the Overview Window, click the **Fail Inspection** state on the state diagram.
2. In the Inspection Steps palette, select the **Use Additional Tools** tab.



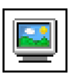
3. Click the **Set Inspection Status** step. The property page for the step opens.
4. In the **Step Name** control, enter `Set Inspection Status`.
5. In the Inspection Status control, select the **FAIL** option.
6. Enable the **Update Number of Parts Inspected** checkbox.
7. Click **OK** to add the step to the inspection.

8. In the Overview Window, click the **Pass Inspection** state on the state diagram.
9. In the Inspection Steps palette, select the **Use Additional Tools** tab.
10. Click the **Set Inspection Status** step. The property page for the step opens.
11. In the **Step Name** control, enter `Set Inspection Status`.
12. In the Inspection Status control, select the **PASS** option.
13. Enable the **Update Number of Parts Inspected** checkbox.
14. Click **OK** to add the step to the inspection.

Displaying the Current Inspection Image

Complete the following instructions to use a **Display Image** step to display the current inspection image.

1. In the Overview Window, click the **Fail Inspection** state on the state diagram.
2. In the Inspection Steps palette, select the **Use Additional Tools** tab.



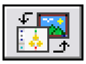
3. Click the **Display Image** step. The property page for the step opens.
4. In the **Step Name** control, enter `Display Image`.
5. In the **Display Images** control, select the **Always** option.
6. Click **OK** to add the step to the inspection.

7. In the Overview window, click the **Pass Inspection** state on the state diagram.
8. In the Inspection Steps palette, select the **Use Additional Tools** tab.
9. Click the **Display Image** step. The property page for the step opens.
10. In the **Step Name** control, enter `Display Image`.
11. In the **Display Images** control, select the **Always** option.
12. Click **OK** to add the step to the inspection.

Configuring State Transitions

After you have created the state diagram and configured all of the steps in the inspection, you must specify when you want transitions from one state to another state to occur. Complete the following sets of instructions to configure the transitions for the inspection.

If an image has an incorrect number of pins, the inspection should transition to the Fail Inspection state. Complete the following instructions to define the Wrong # Pins transition.



1. Click the **Toggle Main Window View** button on the toolbar to bring the inspection state diagram to the Main window.
2. Double-click the **Wrong # Pins** transition on the state diagram to launch the Edit Transition dialog box.
3. In the Edit Transition dialog box, modify the controls to transition when **Find Pin Edges - Step Status** is **Fail**.
4. Click **OK** to close the dialog box.

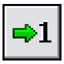
Since the same inspection needs to be performed on each set of pins on the electronic component, the Repeat for Next Pin transition creates a loop in the inspection that eliminates the need to configure separate steps to inspect each set of pins. Complete the following instructions to configure the Repeat for Next Pin transition.

1. Double-click the **Repeat for Next Pin** transition.
2. In the Edit Transition dialog box, modify the controls to transition when **Get Edge Position - Remaining Objects** is **Greater** than `1`.
3. Click **OK** to close the dialog box.

The final transition that must be defined for the inspection is the transition between the Check Pin Gap and Fail Inspection states that occurs when the pins on the component fail inspection. Complete the following instructions to configure the Failed transition.

1. Double-click the **Failed** transition.
2. In the Edit Transition dialog box, modify the controls to transition when **Measure Gap - Step Status** is **Fail**.
3. Click **OK** to close the dialog box.

Testing the Inspection



Test the images in the `Tutorial 6` folder to make sure the inspection returns the correct results. Click the **Run Inspection Once** button to test the remaining images. Table 7-1 displays the expected results for each image.

Table 7-1. Expected Results for the State Diagram Looping Inspection

Image Name	Inspection Status	Explanation
`Image 01.jpg`	PASS	All pins are present and straight.
`Image 02.jpg`	PASS	All pins are present and straight.
`Image 03.jpg`	PASS	All pins are present and straight.
`Image 04.jpg`	FAIL	Third pin is bent.
`Image 05.jpg`	PASS	All pins are present and straight.
`Image 06.jpg`	FAIL	Fifth pin is bent.
`Image 07.jpg`	PASS	All pins are present and straight.
`Image 08.jpg`	FAIL	Seventh pin is bent.

Saving the Inspection

Complete the following instructions to save the example inspection.

1. Select **File»Save** or click the **Save** button on the toolbar.
2. Navigate to the location where you want to save the inspection.
3. In the **File Name** control, enter `Tutorial 6.vbai`.
4. Click **Save** to save the inspection.

Tip Select **File»Inspection Properties** to add a short description or comments about the inspection.

Part II

Using Vision Builder AI with Remote Targets

This section provides lessons about using Vision Builder AI with NI Vision remote targets, such as NI 17xx Smart Cameras or NI CVS-1450 Series Compact Vision Systems.

NI Smart Cameras combine an image sensor and a high-performance processor to return inspection results instead of images. While a typical industrial camera acquires and transmits images through a standard camera bus for processing on another device, the smart camera performs both acquisition and processing operations directly on the smart camera.

NI CVS-1450 Series devices are easy-to-use, distributed, real-time imaging systems that acquire, process, and display images from external IEEE 1394 cameras conforming to the *IIDC 1394-based Digital Camera Specification, Version 1.30*.

An Ethernet connection between the remote target and a development computer allows you to display measurement results and status information and to configure the remote target settings. When configured, the remote target can run applications without a connection to the development computer.

Part II, *Using Vision Builder AI with Remote Targets*, contains the following chapters:

- Chapter 8, *Acquiring an Image with the NI 17xx Smart Camera*, introduces using Vision Builder AI with the NI Smart Camera to perform a basic image acquisition.
- Chapter 9, *Acquiring an Image with the NI CVS-1450 Compact Vision System*, introduces using Vision Builder AI with the NI CVS-1450 Series Compact Vision System to perform a basic image acquisition.
- Chapter 10, *Performing a Triggered Acquisition Using the NI CVS-1450 Compact Vision System*, introduces using Vision Builder AI and the NI CVS-1450 Series Compact Vision System to perform a triggered image acquisition.
- Chapter 11, *Inspection Selection*, introduces using Vision Builder AI running on a remote target to switch between multiple inspections based on an I/O result.

8

Acquiring an Image with the NI 17xx Smart Camera

This chapter introduces using Vision Builder AI with the NI 17xx Smart Camera to perform a basic image acquisition. Follow the instructions in this chapter to learn how to connect and configure the smart camera to acquire an image using Vision Builder AI.

Refer to the *NI 17xx Smart Camera User Manual* for additional information about specific features and specifications of the smart camera. Select **Start»All Programs»National Instruments»Vision» Documentation»NI-IMAQ** to access the *NI 17xx Smart Camera User Manual* after configuring the smart camera using the procedures described in this chapter.

Hardware

The following hardware is necessary to complete this lesson.

- ❑ NI 17xx Smart Camera
- ❑ 5-position lighting connector (additional/replacement plugs for use with the lighting connector are available from NI, part number 780260-01)
- ❑ One or two CAT 5 10/100Base-TX or CAT 5e or CAT 6 1000Base-T Ethernet cables. One Ethernet cable is required to connect the smart camera directly to the development computer. Two Ethernet cables are required to connect the smart camera to the development computer through a network.

Note A CAT 5e or CAT 6 1000Base-T Ethernet cable is required to achieve maximum 1,000 Mbps (Gigabit) Ethernet performance. CAT 5e and CAT 6 Ethernet cables adhere to higher electrical standards required for Gigabit Ethernet communication. CAT 5 cables are not guaranteed to meet the necessary electrical requirements. While CAT 5 cables may appear to work in some installations at 1,000 Mbps, CAT 5 cables are likely to cause increased bit errors resulting in degraded or unreliable network performance.

- ❑ One of the following power supply options:

Caution Use the smart camera only with a 24 VDC, UL listed, limited power source (LPS) supply. The power supply will bear the UL listed mark, LPS. The power supply must also meet any safety and compliance requirements for the country of use.

  - NI desktop power supply (part number 780237-01) and power supply cord. Refer to `ni.com` for the power supply cord part number specific to your region and ordering information.
  - Any 24 VDC, +20%/–15% (IEC 1311) power supply and one of the following cable options for connecting to the power supply and I/O.
    - 15-pin D-SUB pigtail cable, 5 m (part number 197818-05)
    - 15-pin D-SUB to 15-pin D-SUB cable, 2 m (part number 197817-02) or 5 m (part number 197817-05), and a 15-pin D-SUB terminal block

- ❑ Standard C-mount lens
- ❑ Development computer running Windows Vista/XP/2000

To complete the *Triggered Acquisitions* section of this lesson the following additional hardware is necessary.

- ❑ Trigger source such as a proximity sensor or other device to generate a trigger signal.

Connecting the Lens and Lighting

Complete the following steps to connect a standard C-mount lens and external lighting accessories to the NI Smart Camera.

1. Remove the lens cover from the smart camera.
2. Gently align the threads on the base of the lens with the threads on the sensor opening, and twist clockwise until the lens is secure.

The lens is now attached to the smart camera.

Lighting

The NI Smart Camera offers two options for controlling a light—a Direct Drive internal lighting controller, or 5 V TTL or 24 V external strobe generation for use with a third-party lighting controller. Refer to the *NI 17xx Smart Camera User Manual* for information about using the smart camera with a light.

Note The Direct Drive lighting controller is not available on NI 1722 smart cameras. NI 1722 smart cameras support only 5 V TTL or 24 V external strobe generation.

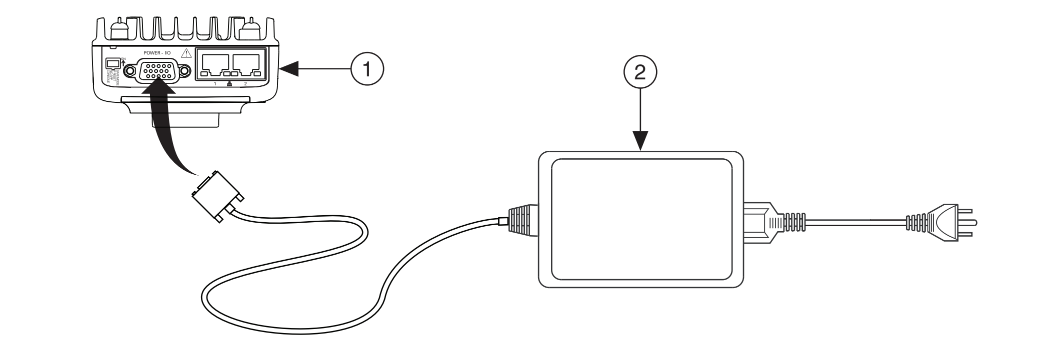
Connect the Power Supply and I/O

To connect a power supply to the NI Smart Camera, complete the steps listed in one of the following sections. Refer to the *Power Only* section to connect the NI desktop power supply directly to the smart camera with no additional I/O. Refer to the *Power with Additional I/O* section to connect a third-party power supply or if your application requires I/O, such as a trigger signal.

Caution Use the smart camera only with a 24 VDC, UL listed, limited power source (LPS) supply. The power supply will bear the UL listed mark, LPS. The power supply must also meet any safety and compliance requirements for the country of use.

Power Only

Refer to Figure 1 while completing the following steps to connect the NI desktop power supply to the NI Smart Camera with no additional I/O.



1 NI Smart Camera	2 Power Supply

Figure 8-1. Connecting the NI Smart Camera to the NI Desktop Power Supply

1. Connect and secure the 15-pin D-SUB connector on the NI desktop power supply to the POWER-I/O connector on the smart camera.
2. Plug the power supply power cord into the power supply.
3. Plug the power supply into an outlet.

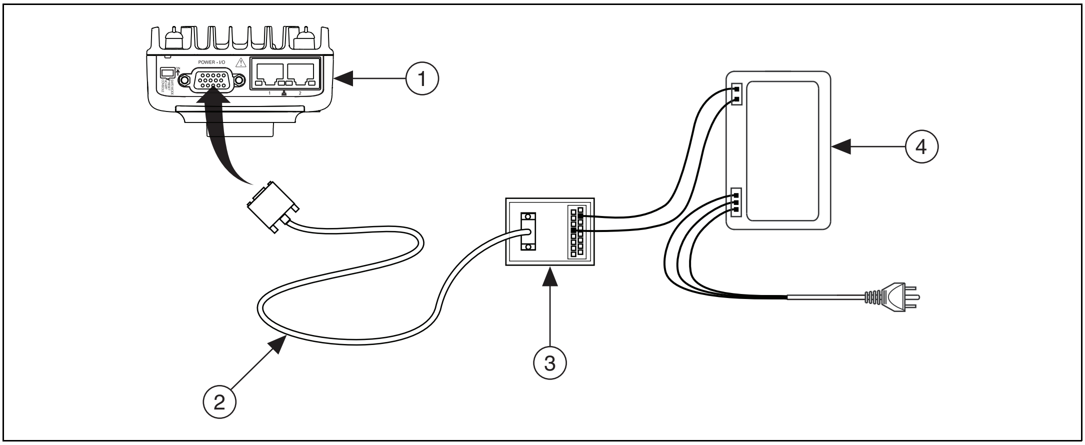
When power is first applied to the smart camera, the POWER LED flashes red for one second while internal systems power up. The POWER LED then lights green when power is correctly wired to the smart camera.

Power with Additional I/O

National Instruments provides the following two cable options for connecting a third-party power supply and I/O to the NI Smart Camera.

- Terminal block with a 15-pin D-SUB connector, such as the NI Smart Camera I/O Accessory, and a 15-pin D-SUB to 15-pin D-SUB cable
- 15-pin D-SUB pigtail cable

Refer to Figure 2 while completing the following steps to connect a third-party power supply and I/O to the smart camera using either a terminal block or the pigtail cable.



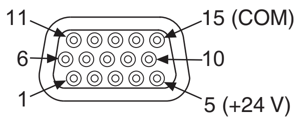
1	NI Smart Camera	3	Optional Terminal Block
2	15-Pin D-SUB to 15-Pin D-SUB Cable	4	Power Supply

Figure 8-2. Connecting the NI Smart Camera to a Third-Party Power Supply

1. Connect and secure the 15-pin D-SUB connector on your cable to the POWER-I/O connector on the smart camera.
2. If you are using a terminal block, connect the cable to the terminal block.
3. Connect the +24 V signal from the cable or terminal block to the corresponding signal on the power supply.

Table 3 shows the pin locations for the POWER-I/O connector and lists the signal names and pin numbers. The table also lists wire colors for the National Instruments 15-pin D-SUB pigtail cable. Cables from another vendor may have different wire colors.

Table 8-1. NI Smart Camera POWER-I/O Connector Signal Descriptions

Connector Diagram	Signal Name	Pin Number	Wire Color
	+ 24 V	5	Red
	COM	15	Black
	RS_232TXD	10	Pink
	RS_232RXD	14	Black/White
	TrigIn+ IsoIn(0)+	2	Brown
	IsoIn(1)+	8	Orange
	TrigIn– IsoIn(0)– IsoIn(1)–	12	Light Green
	IsoOut(0)+	6	Yellow
	IsoOut(0)–	1	Green
	IsoOut(1)+	11	Light Blue
	IsoOut(1)–	7	Gray
	PhaseA+	3	Blue
	PhaseA–	13	Brown/White
	PhaseB+	9	Purple
	PhaseB–	4	White

4. Connect the COM signal from the cable or terminal block to the corresponding signal on the power supply.
5. Connect any additional I/O signals necessary for your application to the appropriate signal on the cable or terminal block. Refer to Table 3 for pin information.
6. If necessary, connect the power cord to the power supply.
7. Plug the power supply into an outlet.

When power is first applied to the smart camera, the POWER LED flashes red for one second while internal systems power up. The POWER LED then lights green when power is correctly wired to the smart camera.

Connecting to the Development Computer

The NI Smart Camera can connect to the development computer directly or through a network using an Ethernet cable. The smart camera provides automatic MDI/MDI-X correction, so you can use either a standard Ethernet cable or a crossover Ethernet cable to connect to the development computer. If the development computer is configured on a network, you must configure the smart camera on the same network subnet as the development computer to connect through the network.

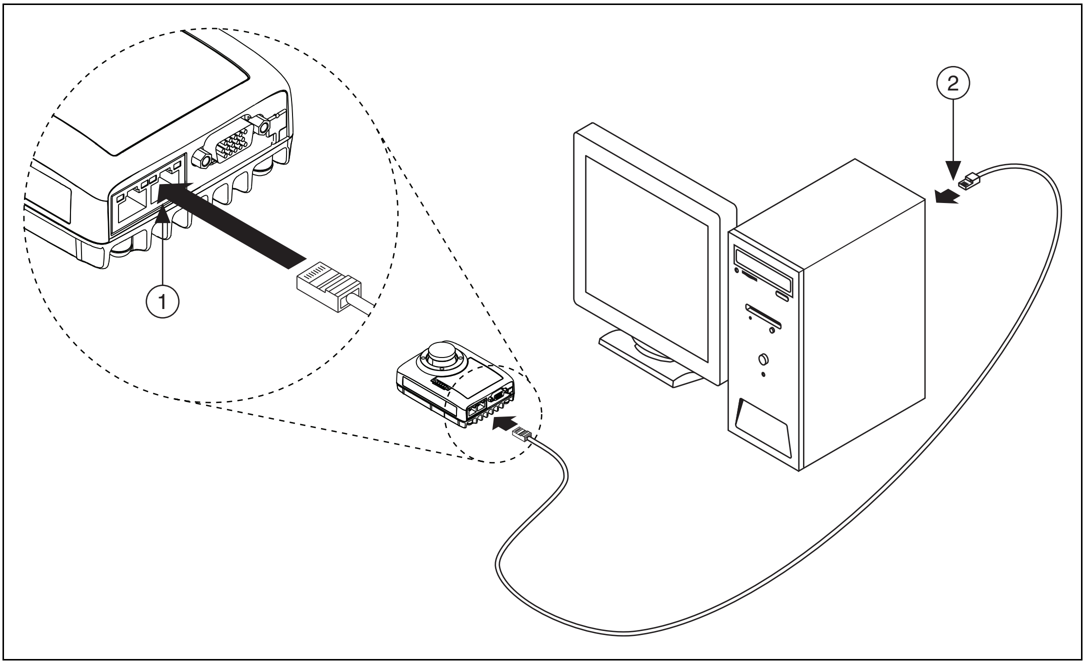
Caution To prevent data loss and to maintain the integrity of your Ethernet installation, do *not* use a cable longer than 100 m. National Instruments recommends using a shielded twisted pair Ethernet cable for maximum signal integrity.

Firewall Configuration

If your firewall is controlled remotely or you are unsure about configuring the firewall, contact your network administrator. Refer to Appendix B, *Troubleshooting*, of the *NI 17xx Smart Camera User Manual* to troubleshoot network configuration issues.

Direct Connection

To connect the NI Smart Camera directly to the development computer, refer to Figure 8-3 and complete the following steps.



1	Connecting an Ethernet Cable to Port 1 on the NI Smart Camera
2	Connecting an Ethernet Cable to an Ethernet Port on the Development Computer

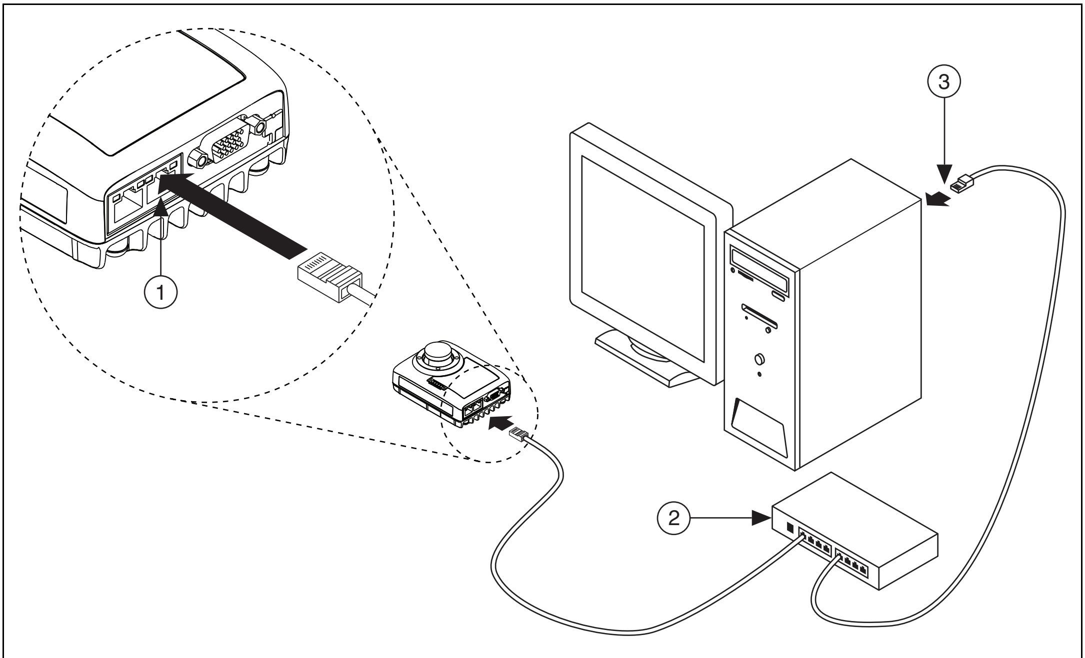
Figure 8-3. Connecting the NI Smart Camera Directly to the Development Computer

1. Use an Ethernet cable to connect from the Ethernet port on the development computer to Ethernet port 1 on the smart camera.
2. Configure the network card on the development computer to use a static IP address. Refer to your network card documentation for information about configuring a static IP address.

The smart camera is now connected directly to the development computer.

Network Connection

To connect the NI Smart Camera to the development computer through a network, refer to Figure 8-4 and complete the following steps.



1	Connecting an Ethernet Cable to Port 1 on the NI Smart Camera
2	Ethernet Hub or Other Network Port
3	Connecting an Ethernet Cable to an Ethernet Port on the Development Computer

Figure 8-4. Connecting the NI Smart Camera Through a Network

1. Verify that the development computer is connected to the network and powered on.
2. Using an Ethernet cable, connect from an Ethernet hub or other network port to Ethernet port 1 on the smart camera.
3. Using another Ethernet cable, connect from the Ethernet hub or other network port to the Ethernet port on the development computer.

The smart camera is now connected to the development computer through a network.

Subnet Considerations

To configure the NI Smart Camera, it must reside on the same subnet as the development computer. Once the smart camera is configured, other subnets can be used to access it.

To use the smart camera on a subnet other than the one on which the development computer resides, first connect and configure the smart camera on the same subnet as the development computer. Next, physically move the smart camera to the other subnet. Contact your network administrator for assistance in setting up the development computer and smart camera on the same subnet.

Configuring the IP Address

Complete the following steps to configure an IP address for the NI Smart Camera.

1. Launch Vision Builder AI.
2. On the Vision Builder AI startup screen, expand the **Execution Target** listbox, and click **Select Network Target**.

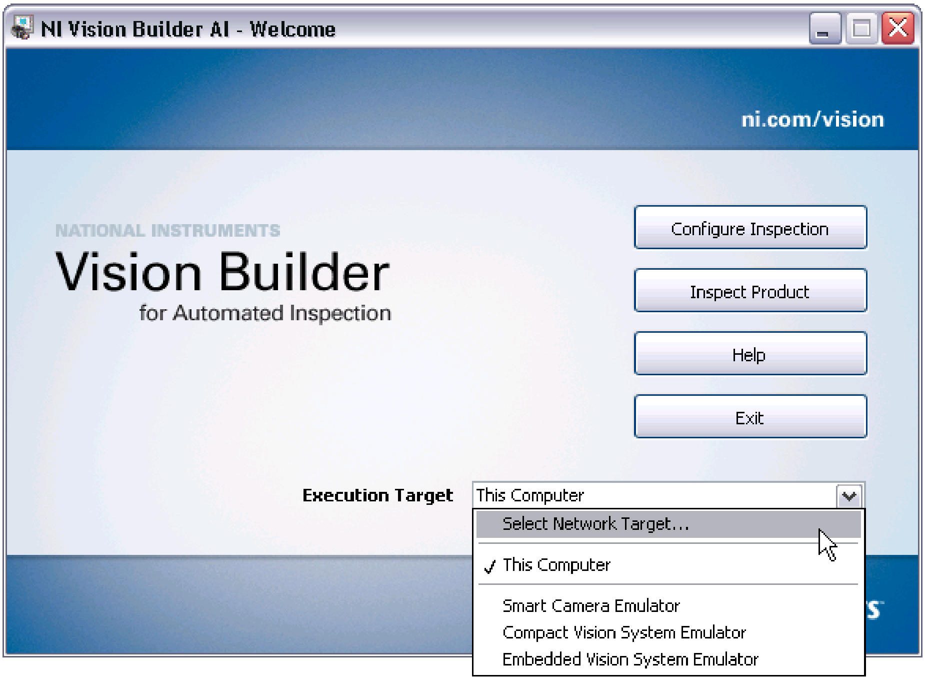


Figure 8-5. Vision Builder AI Welcome Screen

3. In the Select Remote Target dialog box, select the smart camera with a MAC address that corresponds to the MAC address on the label of the smart camera you want to configure.

   Refer to the *Subnet Considerations* section of this document and Appendix B, *Troubleshooting*, of the *NI 17xx Smart Camera User Manual* for information about subnets and troubleshooting smart camera configuration issues.

4. Click **Configure**. The Remote Target Configuration Wizard launches in a new window.

5. In the **Name** field, enter a name for the smart camera. Use the **Description** field to enter any additional information or a brief description of the smart camera.

   Device names are limited to 31 characters with no spaces or special characters, except hyphens. The first and last characters must be alphanumeric.

6. Click **Next**.

7. If the network is configured to issue IP addresses using DHCP, select **Obtain IP address from DHCP server**. Otherwise, configure the IP address manually by selecting **Edit the IP settings** and clicking **Suggest Values**.
8. If you want to prevent other users from configuring the smart camera, select **Enable Password** and click **Set Password** to set up password protection for the smart camera.
9. Click **Next**.

Installing Software on the NI Smart Camera

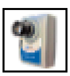
Complete the following steps to install software from the development computer to the NI Smart Camera.

1. In the Remote Target Configuration Wizard, enable the **Update Target Software** checkbox.
2. Click the **Browse** button next to the **Software Image to Install on the Target** control.
3. Navigate to the Vision Builder AI software image you want to use, and click **OK**. Software images provided by National Instruments are installed to the <Vision Builder AI>\RT Images directory, where <Vision Builder AI> is the location where Vision Builder AI is installed.
4. Click **OK** to apply the IP configuration settings and download software to the smart camera.
5. Click **OK** to close the Remote Target Configuration Successful dialog box.

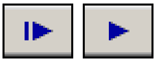
Acquiring an Image

Complete the following steps to acquire an image using Vision Builder AI.

1. In the **Select Remote Target** dialog box, select your configured NI Smart Camera, and click **OK**.
2. On the Vision Builder AI Welcome screen, click **Configure Inspection**.
3. In the Inspection Steps palette, select the **Acquire Images** tab.



4. Click the **Acquire Image (Smart Camera)** step. The property page for the step opens.



5. Click the **Acquire Single Image** button to acquire a single image, or click the **Acquire Continuous Images** button to acquire continuous images.
6. Use the controls on the **Main**, **Trigger**, **Lighting**, and **Advanced** tabs to configure any additional settings necessary for your application.
7. Click **OK** to add the step to the inspection.

The smart camera is now configured and acquiring images. Use Vision Builder AI to add and configure additional inspection steps to create your application.

Saving the Inspection

Complete the following instructions to save the inspection.

1. Select **File»Save** or click the **Save** button on the toolbar.
2. In the **Inspection Name** control, enter a name for the inspection.
3. Click **Save** to save the inspection.

Tip Select **File»Inspection Properties** to add a short description or comments about the inspection.

Triggered Acquisitions

To configure the NI Smart Camera for a triggered acquisition, complete the steps listed in the following sections.

Connecting the Trigger Signal

Complete the following steps to connect a trigger signal to the NI Smart Camera.

1. Close Vision Builder AI.
2. Disconnect the 15-pin D-SUB connector from the POWER-I/O connector on the smart camera.
3. Connect the TrigIn(0)+ and TrigIn(0)– signals from the POWER-I/O connector on the smart camera to the trigger output signal you want to use on the trigger source. Refer to Table 8-1 for pinout information and signal descriptions for the POWER-I/O connector. Refer to the *NI 17xx Smart Camera User Manual* for specific information about connecting to an the isolated input trigger signal on the smart camera.

4. Connect the COM signal from the POWER-I/O connector on the smart camera to the common or ground signal on the trigger source.
5. Connect the 15-pin D-SUB connector from your cable to the POWER-I/O connector on the smart camera.

Configuring the Acquisition

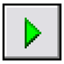
Complete the following steps to configure an **Acquire Image (Smart Camera)** step for a triggered acquisition.

1. Launch Vision Builder AI.
2. In the **Select Remote Target** dialog box, select your configured NI Smart Camera, and click **OK**.
3. On the Vision Builder AI Welcome screen, click **Configure Inspection**.
4. In the Inspection Steps palette, select the **Acquire Images** tab.
5. Click the **Acquire Image (Smart Camera)** step. The property page for the step opens.
6. In the **Step Name** control, enter `Acquire Image`.
7. On the **Trigger** tab, enable the **Triggered Acquisition** checkbox.
8. In the **Trigger Polarity** control, specify whether to begin the acquisition on the rising or falling edge of the trigger signal.
9. In the **Exposure Delay** and **Delay Units** controls, specify the amount of time the smart camera waits after a trigger signal is received before it acquires an image.
10. In the **Trigger Timeout** control, specify the amount of time the smart camera waits to receive a trigger before the acquisition times out.
11. Use the controls on the Main, Trigger, Lighting and Advanced tabs to configure any additional settings necessary for your application.
12. Click **OK** to add the step to the inspection.
13. Add and configure additional inspection steps to complete your application.
14. Save the inspection.

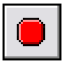
Acquiring images

Complete the following steps to test your trigger configuration and acquire images.

1. Select **File»Switch to Inspection Interface** to launch the Inspection Interface.



2. Click the **Start Inspection** button to run the inspection.



3. Click the **Stop Inspection** button to stop the inspection.

If the triggered acquisition is configured correctly, an image is acquired only when the NI Smart Camera receives a trigger signal. If the smart camera does not receive a trigger signal before the specified trigger **Timeout** elapses, the smart camera returns a timeout error.

Preventing an Acquisition Timeout

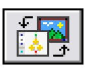
While testing the acquisition, you may have noticed that sometimes the **Acquire Image (Smart Camera)** step status changes from Pass to Fail. This behavior occurs when the acquisition step does not receive a trigger within the **Timeout** period specified on the property page of the acquisition step. If a timeout occurs, any processing steps in the inspection that occur after the acquisition step will also fail because there is no image available to process.

Ideally you would set the acquisition step **Timeout** to an infinite value to ensure that a timeout never occurs. However, since Vision Builder AI allows only finite values for the timeout period, you must use another method to achieve the desired behavior. Instead of setting an infinite timeout, you can use the inspection state diagram to configure Vision Builder AI to only run the image processing steps in an inspection when an image has been acquired.

Creating the Inspection State Diagram

Complete the following instructions to implement the behavior of an infinite timeout in Vision Builder AI.

1. Select **File»Switch to Configuration Interface** to switch to the Vision Builder AI Configuration Interface.



2. Click the **Toggle Main Window View** button on the toolbar to bring the inspection state diagram to the Main window.

3. Right-click an open area on the state diagram and select **Create New State** to add a new state to the inspection, as shown in Figure 8-6. The Edit State Name dialog box opens.

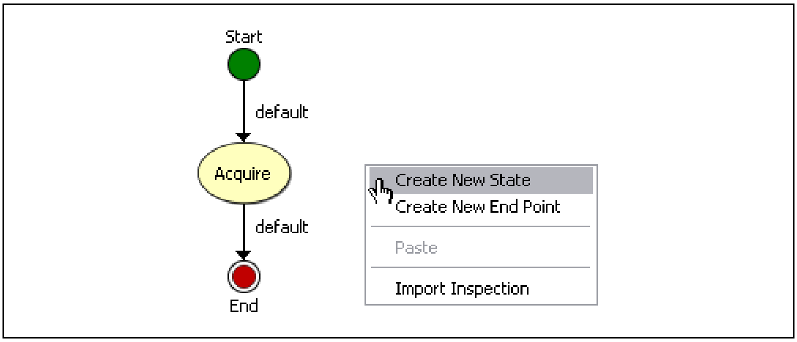


Figure 8-6. Creating a New Inspection State

4. In the **State Name** control, enter `Inspect`.

Next, you will define transitions between the inspection states. Notice that every state has a default transition. You can also create additional transitions between states based on measurement results or variable values.

Note The default transition occurs when the transition requirements for other possible transitions are not met.

5. Click the Acquire state **default** transition and drag it so that the transition loops back to the Acquire state.
6. Click the Inspect state **default** transition and drag it to the End point.

The state diagram should now resemble the state diagram shown in Figure 8-7.

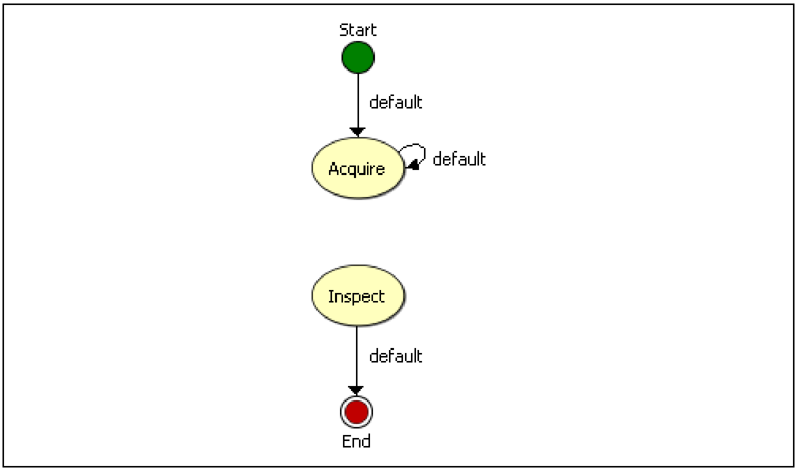


Figure 8-7. Configuring the Default Transitions

7. Right-click the **Acquire** state and select **Create New Transition**.
8. Click the **Inspect** state to create a transition between the Acquire state and the Inspect state.
9. Double-click the transition to launch the Edit Transition dialog box.
10. In the **Transition Name** control, enter `Image Acquired`.
11. In the **Measurement** control, configure the transition to occur when **Acquire Image - Timeout** is **False**.
12. Click **OK** to close the dialog box.

The state diagram should now resemble the state diagram shown in Figure 8-8.

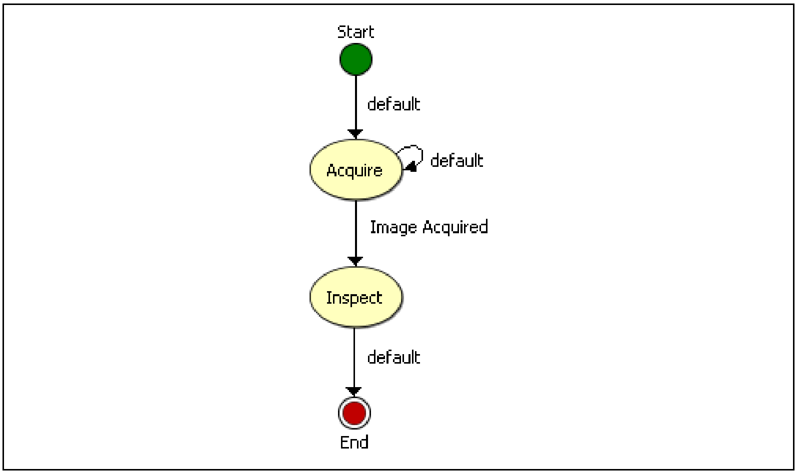


Figure 8-8. Completed State Diagram for the Inspection

13. Add and configure additional steps in the Inspect state to complete your application.
14. Save the Inspection.
15. Switch to the Inspection Interface and run the inspection.

When you run the inspection, notice that when a timeout occurs, the inspection simply loops back to the Acquire state and resumes waiting for a trigger. A timeout no longer affects the rest of the steps in the inspection.

Tip Set the **Acquire Image (Smart Camera)** step **Acquisition Mode** to **Immediate** to prevent the inspection from missing triggers that may occur when the inspection transitions between states.

9

Acquiring an Image with the NI CVS-1450 Compact Vision System

This chapter introduces using Vision Builder AI with an NI CVS-1450 Series Compact Vision System to perform a basic image acquisition.

Follow the instructions in this chapter to learn how to connect and configure an NI CVS-1450 device to acquire an image using Vision Builder AI.

Hardware

The following hardware is necessary to complete this lesson.

- ❑ NI CVS-1450 Series Compact Vision System
- ❑ Development computer running Windows Vista/XP/2000
- ❑ DCAM-compliant IEEE 1394 camera
- ❑ IEEE 1394 jackscrew-to-latch cable (part number 778796-01) or any standard IEEE 1394 cable. You can use a 4-pin to 6-pin converter cable with cameras that have their own external power supply and do not require power from the IEEE 1394 bus
- ❑ NI desktop power supply (part number 778794-01) or any 24 VDC ±10%, 50 W power supply
  - – Power supply cord—Connects the NI desktop power supply to an outlet. Refer to `ni.com` for the part number specific to your region and ordering information
  - – 4-position power connector—Required if you do not use the NI desktop power supply
- ❑ Two 10 m standard CAT 5 10/100Base-T Ethernet cables (part number 189174-10)

Connecting a Camera and Monitor

Before connecting a camera and monitor to the NI CVS-1450 device, make sure that all NI CVS-1450 device DIP switches are in the **OFF** position.

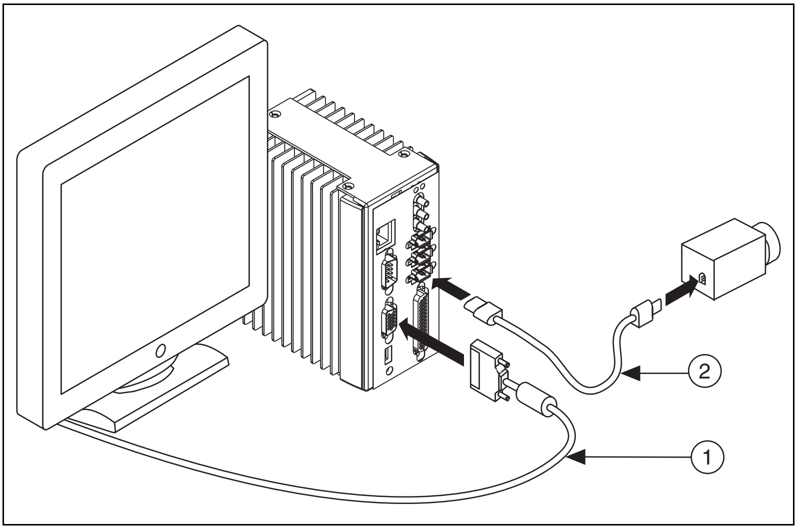
To connect an IEEE 1394 camera and a monitor to the NI CVS-1450 device, refer to Figure 9-1 while completing the following steps:

1. Connect the VGA cable from the monitor to the VGA port on the NI CVS-1450 device.
2. Plug the IEEE 1394 cable into one of the IEEE 1394a ports on the NI CVS-1450 device. Plug the other end of the cable into the IEEE 1394 port on the camera.

   If your camera requires an external power supply, connect it to the camera, and verify that the camera is powered on.

Note To maintain signal integrity, the IEEE 1394 cable length must be no longer than 4.5 m.

3. Plug in and power on the monitor.



1 VGA Cable	2 IEEE 1394 Cable

Figure 9-1. Basic Hardware Setup

Connecting a Power Supply

This section describes how to connect the NI desktop power supply. For instructions on how to connect a separate main supply, refer to the *Connecting to a Third-Party Power Supply* section.

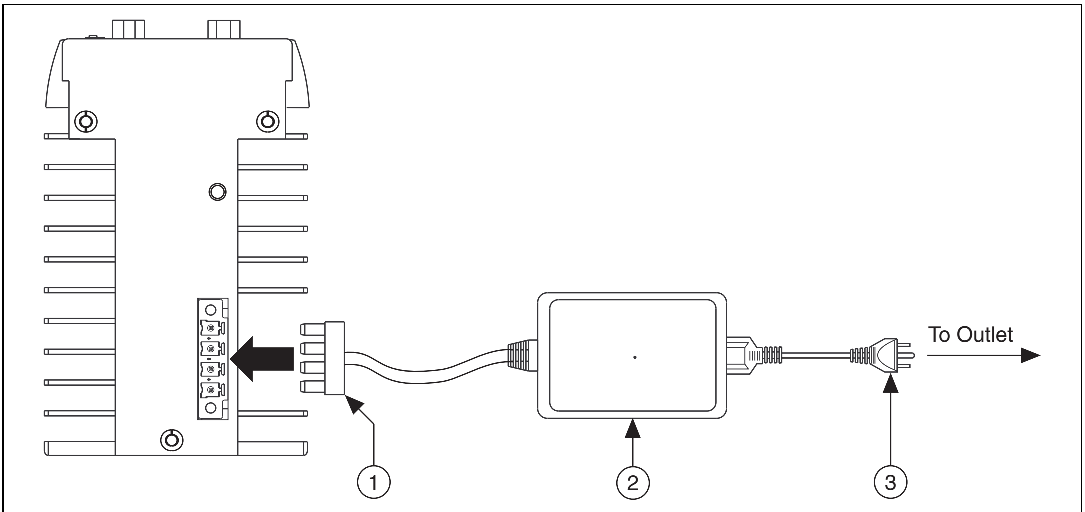
Caution Do *not* connect the NI CVS-1450 device main power to a source other than 24 VDC ±10%. Do *not* connect the NI CVS-1450 device isolated power to a source less than 5 VDC or greater than 30 VDC. Doing so could damage the NI CVS-1450 device.

To connect power to the NI CVS-1450 device, refer to Figure 9-2 while completing the following steps:

1. Plug the 4-position connector from the power supply into the power receptacle on the NI CVS-1450 device.
2. Plug the power cord into the power supply.
3. Plug the power cord into an outlet.

The NI CVS-1450 device ships with a factory-installed startup program that, when the NI CVS-1450 device is connected to a camera and powered on, acquires images and displays them on the monitor.

If the images from the camera display on the monitor, continue to the *Connecting to a Network* section. If the images from the camera are not displayed on the monitor, refer to the *NI CVS-1450 Series User Manual* for troubleshooting information.



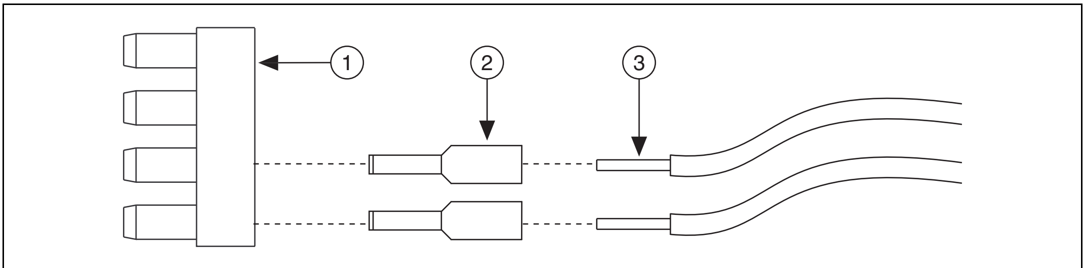
1 4-Position Power Connector	2 NI Desktop Power Supply	3 Power Supply Cord (to Outlet)

Figure 9-2. Wiring Power to the NI CVS-1450 Device

Connecting to a Third-Party Power Supply

If you use a power supply other than the NI desktop power supply, follow the instructions in this section to connect power to the NI CVS-1450 device.

Note If you are not using the NI desktop power supply, use 0.75 mm^2, 18 AWG ferrules according to manufacturer specifications to terminate the wires leading to the 4-position power connector, as shown in Figure 9-3. Ferrules are available from Phoenix Contact (part number 3200519).



1 4-Position Power Connector	2 Ferrule	3 Power Supply Wires

Figure 9-3. Wiring a Third-Party Power Supply to the 4-Position Power Connector

Caution Do *not* connect the NI CVS-1450 device main power to a source other than 24 VDC ±10%. Do *not* connect the NI CVS-1450 device isolated power to a source less than 5 VDC or greater than 30 VDC. Doing so could damage the NI CVS-1450 device.

The NI CVS-1450 device ships with a 4-position power connector that plugs directly into the power input connector on the NI CVS-1450 device. To wire power to the 4-position connector, complete the following steps:

1. Wire the voltage output of the 24 VDC ±10% power supply to the main voltage input, labeled V, on the 4-position connector.
2. Wire the common-mode signal (ground) output of the power supply to the common-mode signal input, labeled C, on the 4-position connector.

If you are using a separate power supply for the NI CVS-1450 device isolated outputs, connect the voltage output on the power supply to the isolated power (V_{iso}) on the 4-position connector. Connect the common-mode signal on the power supply to the isolated common-mode signal (C_{iso}) on the connector.

Note If you do not require a separate power supply for the NI CVS-1450 device isolated outputs, you can daisy-chain the V to the V_{iso} and the C to the C_{iso} on the connector.

For information about grounding the NI CVS-1450 device chassis to earth ground, refer to the *NI CVS-1450 Series User Manual*.

Connecting to a Network

Use a standard CAT 5 or CAT 6 Ethernet cable to connect the NI CVS-1450 device to a network.

If the development computer is already configured on a network, you must configure the NI CVS-1450 device on the same network. If the development computer is not connected to a network, you can connect the development computer and the NI CVS-1450 device directly using a CAT 5 or CAT 6 Ethernet crossover cable.

Caution To prevent data loss and to maintain the integrity of your Ethernet installation, do *not* use a cable longer than 100 m. If you are using a 100 Mbps Ethernet, National Instruments recommends using a CAT 5 or CAT 6 shielded twisted-pair Ethernet cable.

Subnet Considerations

To configure the NI CVS-1450 device, it must reside on the same subnet as the development computer. Once the NI CVS-1450 device is configured, other subnets can access and use it.

To use the NI CVS-1450 device on a subnet other than the one on which the development computer resides, first connect and configure the NI CVS-1450 device on the same subnet as the development computer. Next, physically move the NI CVS-1450 device to the other subnet and reassign an IP address. Contact your network administrator for assistance in setting up the development computer and NI CVS-1450 device on the same subnet.

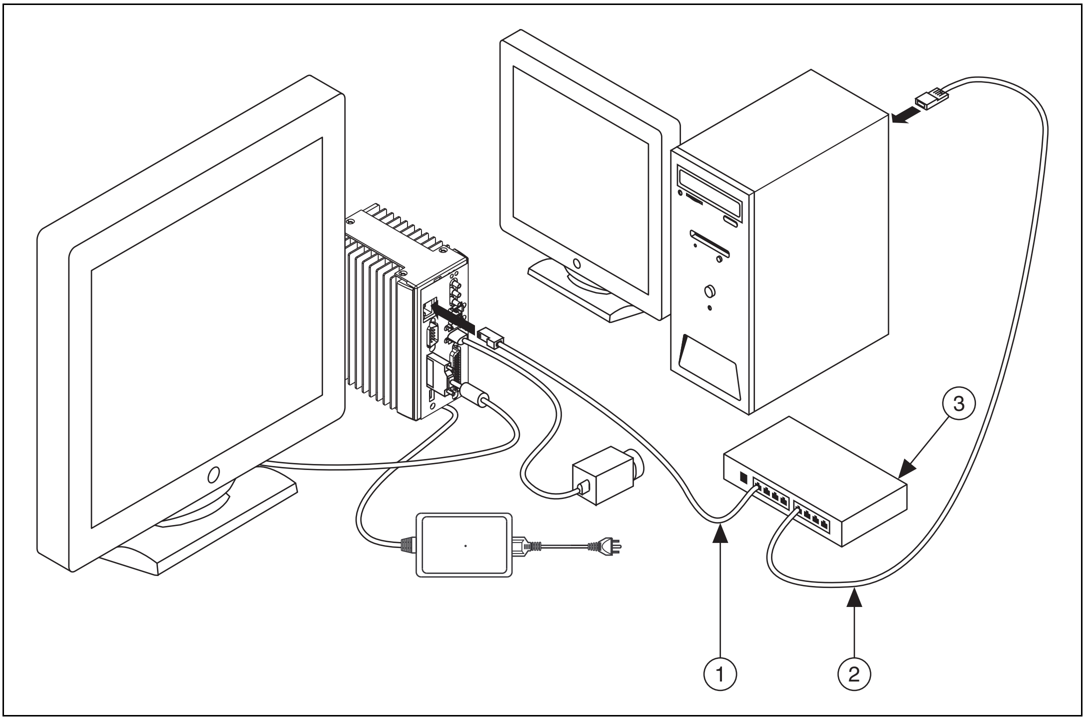
Connecting to a Development Computer

The development computer communicates with the NI CVS-1450 device over an Ethernet connection. Use a standard Ethernet cable to connect from the network port to the NI CVS-1450 device.

Note If you are not connecting through a network, use an Ethernet crossover cable to connect the NI CVS-1450 device directly to the development computer.

To connect the NI CVS-1450 device to the development computer, refer to Figure 9-4 while completing the following steps:

1. Verify that the development computer is connected to the network and is powered on.
2. Using a standard Ethernet cable, connect from the network port to the Ethernet port on the NI CVS-1450 device.
3. Using a standard Ethernet cable, connect from the network port to the Ethernet port on the development computer.



1	Standard Ethernet Cable Connecting from the NI CVS-1450 Device to an Ethernet Hub
2	Standard Ethernet Cable Connecting from an Ethernet Hub to the Development Computer
3	Ethernet Hub or Other Network Port

Figure 9-4. Ethernet Connection

Configuring an IP Address

Complete the following steps to assign an IP address to the NI CVS-1450 device.

1. Launch Vision Builder AI
2. On the Vision Builder AI Welcome screen, shown in Figure 9-5, expand the **Execution Target** listbox, and select **Select Network Target**.

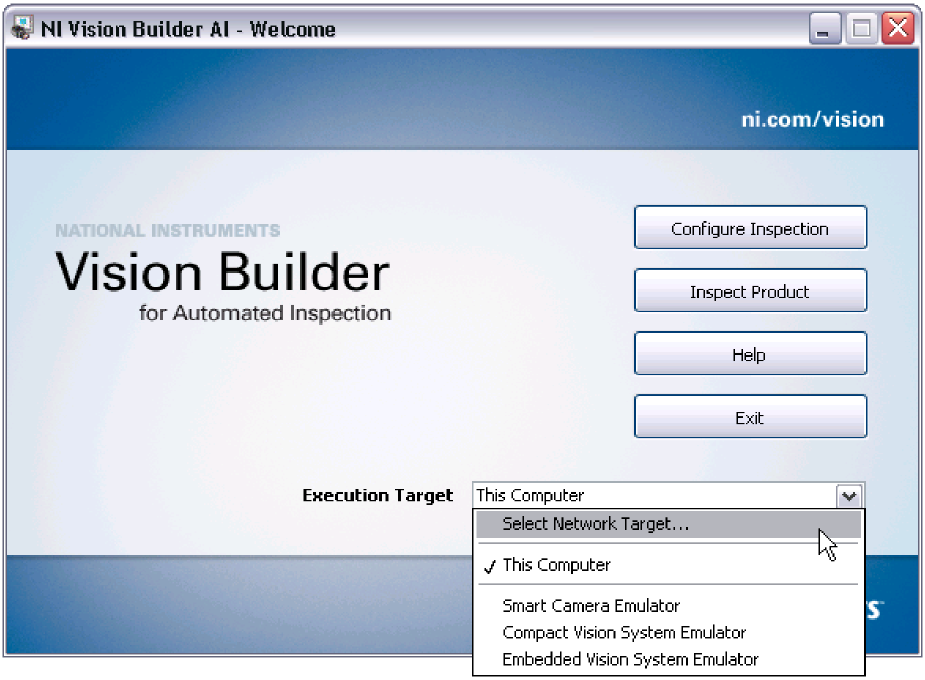


Figure 9-5. Vision Builder AI Welcome Screen

3. In the Select Remote Target dialog box, select the NI CVS-1450 device with a MAC address that corresponds to the MAC address on the label of the NI CVS-1450 device you want to configure.
4. Click **Configure**. The Remote Target Configuration Wizard launches in a new window.

5. In the **Name** field, enter a name for the device. Use the **Description** field to enter any additional information or a brief description of the device.

   Device names are limited to 31 characters with no spaces or special characters, except hyphens. The first and last characters must be alphanumeric.
6. Click **Next**.
7. If the Network is configured to issue IP addresses using DHCP, select **Obtain IP Address for DHCP Server**.

   Otherwise, set the IP address manually by selecting **Edit IP Settings**, **Suggest Values**, and **OK**.
8. Click **Next**.

Installing Software to the NI CVS-1450 Device

Once you have configured the NI CVS-1450 device on the network, you must install software from the host computer to the NI CVS-1450 device. Complete the following instructions to install software to the NI CVS-1450 device.

1. Enable the **Update Target Software** checkbox.

2. Click the **Browse** button next to the **Software Image to Install on the Target** control. The Open dialog box opens.
3. Navigate to the Vision Builder AI software image you want to use, and click **OK**.
4. Click **OK** to install the software on the NI CVS-1450 device.

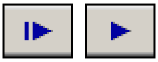
Acquiring an Image

Complete the following instructions to acquire an image in Vision Builder AI using the NI CVS-1450 device.

1. Launch Vision Builder AI.
2. On the Vision Builder AI Welcome screen, expand the **Execution Target** listbox, and select **Select Network Target**.
3. Select the NI CVS-1450 device you configured, and click **OK**.

4. On the Vision Builder AI Welcome screen, click **Configure Inspection** to launch the Configuration Interface.

5. On the **Acquire Images** tab of the Inspection Steps palette, click the **Acquire Image (IEEE 1394)** step. The property page for the step opens.



6. Click the **Acquire Single Image** button to acquire a single image, or click the Acquire **Continuous Images** button to acquire continuous images.
7. Click **OK** to add the step to the inspection.

Now that you have configured an acquisition from the NI CVS-1450 device, you may continue to develop the inspection by adding additional steps from the Inspection Steps palette.

Saving the Inspection

Complete the following instructions to save the inspection.

1. Select **File»Save** or click the **Save** button on the toolbar.
2. In the **Inspection Name** control, enter a name for the inspection.
3. Click **Save** to save the inspection.

Tip Select **File»Inspection Properties** to add a short description or comments about the inspection.

10

Performing a Triggered Acquisition Using the NI CVS-1450 Compact Vision System

This chapter introduces using the NI CVS-1450 Series Compact Vision System and Vision Builder AI to perform a triggered image acquisition.

The following signal names are used throughout this chapter to describe the I/O signals used in a triggered acquisition. The actual name of the signal will depend on your camera and system configuration.

Table 10-1. I/O Signal Descriptions

Signal Name	Description	Available Signals
Camera Trigger In	Input on the camera that receives an external trigger	Camera-specific, refer to your camera documentation
CVS Trigger Out	Output on the NI CVS-1450 device that generates a trigger to the camera	TRIG 1 TRIG 2 TTL OUTPUT 1 TTL OUTPUT 2 TTL OUTPUT 3 TTL OUTPUT 4
CVS Trigger In	Input on the NI CVS-1450 device that receives a signal from an external device, such as a proximity sensor	TRIG 0 TTL INPUT 0 TTL INPUT 1 ISO INPUT 5 ISO INPUT 8

Hardware

The following hardware is necessary to complete this lesson.

- ❑ NI CVS-1450 Series Compact Vision System
- ❑ Development computer running Windows Vista/XP/2000
- ❑ DCAM-compliant IEEE 1394 camera
- ❑ IEEE 1394 jackscrew-to-latch cable (part number 778796-01) or any standard IEEE 1394 cable. You can use a 4-pin to 6-pin converter cable with cameras that have their own external power supply and do not require power from the IEEE 1394 bus
- ❑ NI desktop power supply (part number 778794-01) or any 24 VDC ±10%, 50 W power supply
  - Power supply cord—Connects the NI desktop power supply to an outlet. Refer to `ni.com` for the part number specific to your region and ordering information
  - 4-position power connector—Required if you do not use the NI desktop power supply
- ❑ Two 10 m standard CAT 5 10/100Base-T Ethernet cables (part number 189174-10)
- ❑ Recommended—NI Vision I/O Terminal Block and Prototyping Accessory (part number 779166-01)

Connecting the Hardware

Before you complete the instructions in the following sections, complete the instructions described in Chapter 9, *Acquiring an Image with the NI CVS-1450 Compact Vision System*, to connect the power supply and camera to the NI CVS-1450 device, and connect the NI CVS-1450 device to a development computer.

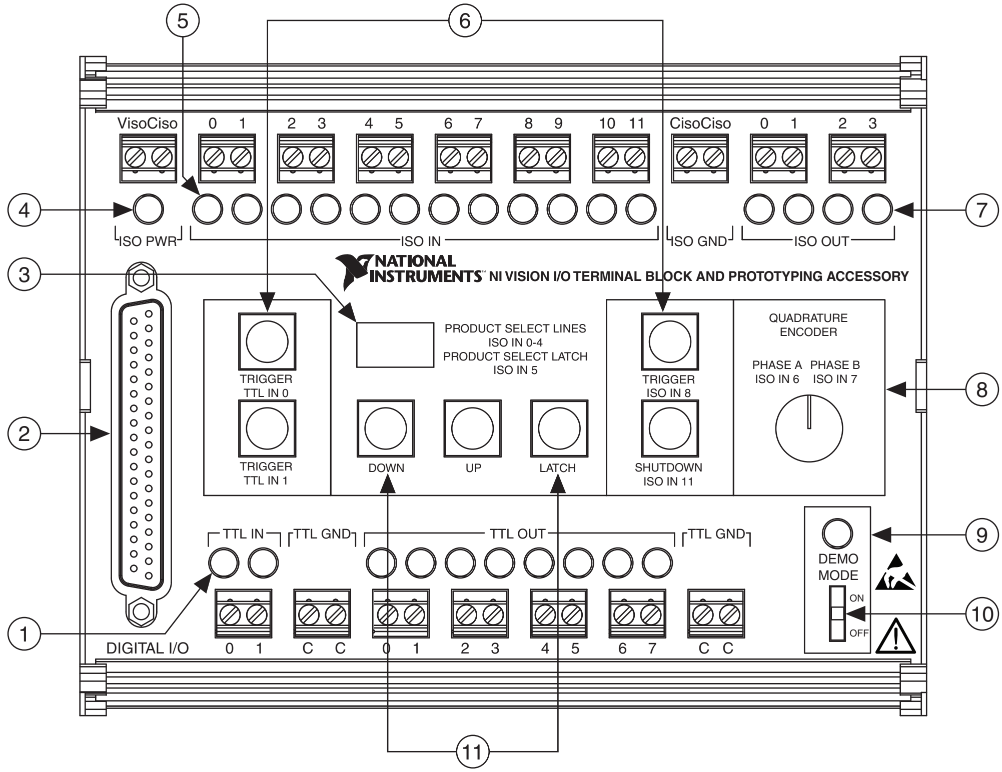
Connecting the Trigger Signal

The following instructions use the NI Vision I/O Terminal Block and Prototyping Accessory for easy connection to the I/O signals on the NI CVS-1450 device. You may also choose to connect trigger signals from the camera directly to the NI CVS-1450 device. Refer to the *NI Vision I/O Terminal Block and Prototyping Accessory User Guide* for more information about the NI Vision I/O Accessory.

Complete the following instructions to connect a trigger signal from the NI CVS-1450 device to the camera.

1. Connect the NI Vision I/O Accessory to the digital I/O connector on the NI CVS-1450 device using the I/O cable that came with the NI Vision I/O Accessory.
2. Refer to your camera documentation to determine which signal on the camera I/O connector to use for the trigger input signal. For the purpose of this lesson, this signal is called *Camera Trigger In*.
3. Refer to the *NI CVS-1450 Series User Manual* to determine which signal on the 44-pin connector to use to generate the trigger signal. For the purpose of this lesson, this signal is called *CVS Trigger Out*.
4. If necessary, connect the camera ground to the TTL GND connection on the NI Vision I/O Accessory.
5. Connect the *Camera Trigger In* signal from the camera to the terminal on the NI Vision I/O Accessory that corresponds to the *CVS Trigger Out* signal.

Figure 10-1 illustrates the front panel of the NI Vision I/O Accessory.



1 LEDs that show which TTL IN and TTL OUT lines are active
2 37-pin D-SUB connector to connect to the NI CVS-1450 Device
3 LED display that shows a digital representation of the product selection lines
4 LED that shows if ISO PWR is active
5 LEDs that shows which ISO IN lines are active
6 Push-button switches that allow you to generate a pulse on the TTL IN 0, TTL IN 1, ISO IN 8, and ISO IN 11
7 LEDs that shows which ISO OUT lines are active
8 Knob you can use to generate quadrature encoder signals to ISO IN 6 and ISO IN 7
9 LED that shows if the NI Vision I/O Accessory is in demo mode
10 DIP switch you can use to put the NI Vision I/O Accessory in either demo mode or user mode
11 Navigation buttons you can use to select a product selection line and a button that allows you to latch the selected product selection lines

Figure 10-1. NI Vision I/O Accessory Front Panel

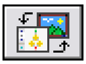
Creating a New Inspection

Complete the following instructions to launch Vision Builder AI and target the NI CVS-1450 device.

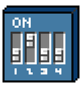
1. Launch Vision Builder AI.
2. On the Vision Builder AI Welcome screen, expand the **Execution Target** listbox, and select **Select Network Target**.
3. Select the NI CVS-1450 device you configured, and click **OK**.
4. On the Vision Builder AI Welcome screen, click **Configure Inspection** to launch the Configuration Interface.

Configuring the Trigger Signal

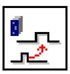
Complete the following instructions to configure an **Generate Pulse (NI-IMAQ I/O)** step to generate a signal from an NI CVS-1450 device to trigger the camera acquisition.



1. Click the **Toggle Main Window View** button on the toolbar to bring the inspection state diagram to the Main window.
2. Select **View»View Complete Inspection Setup** to display additional inspection setup options.



3. On the left side of the state diagram, click **Setup** to configure the Inspection Setup state.
4. In the Inspection Steps palette, select the **Communicate** tab.



5. Click the **Generate Pulse (NI-IMAQ I/O)** step. The property page for the step opens.
6. In the **Step Name** control, enter `Start Trigger Pulse`.
7. In the **Pulse Settings** table, select the *CVS Trigger Out* line on the NI CVS-1450 device to use to generate the trigger signal for the camera.
8. Set the **Action** for the I/O line to **Start Pulse Generation**.
9. Specify the **Polarity** of the generated pulse.
10. If necessary, modify the value of the **Delay** and **Width** controls to fit your application.
11. In the Continuous Pulse Settings controls, specify a **Triggered Pulse** that pulses every time *CVS Trigger In* detects a **Rising Edge**. *CVS Trigger In* is the I/O input line on the NI CVS-1450 device you want to use to detect when a trigger occurs.

The **Generate Pulse (NI-IMAQ I/O)** property page should resemble Figure 10-2.

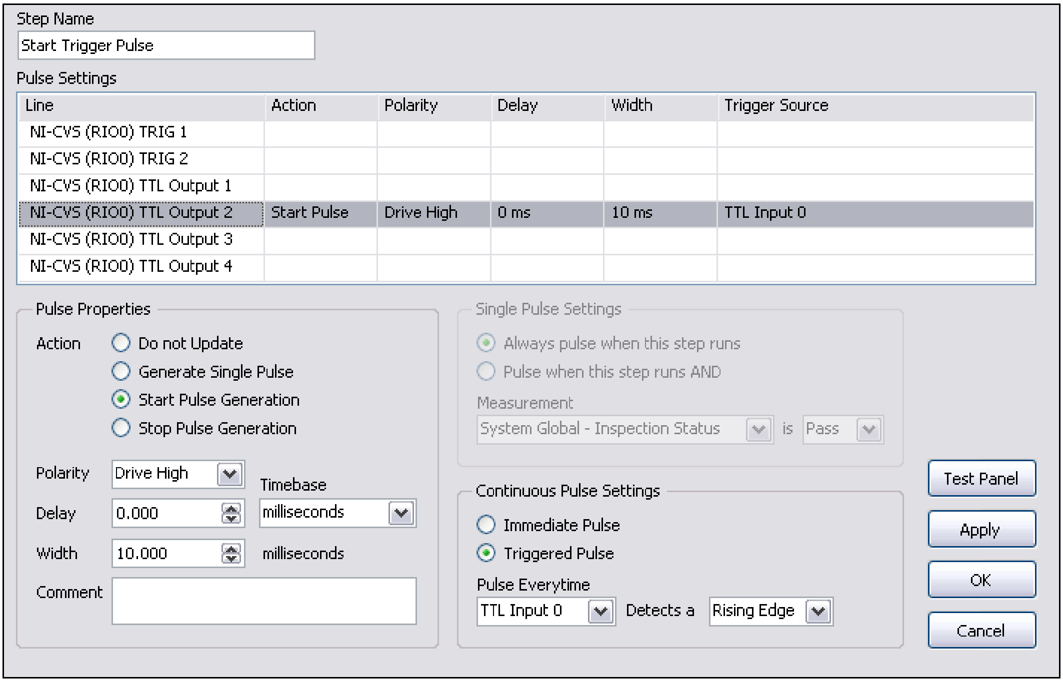


Figure 10-2. Configuring the Acquisition Trigger Signal

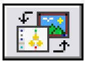
You can configure a single **Generate Pulse (NI-IMAQ I/O)** step to generate pulses on multiple output lines. For example, you can use a single input signal to trigger both a camera and a light source. To configure pulse generation on multiple output lines, simply select and configure each output line from the **Pulse Settings** table, shown in Figure 10-2.

12. Click **OK** to add the step to your inspection.

Resetting the I/O

Once you have configured the signal to trigger an acquisition, it is important to also stop the trigger signal and reset the I/O when the inspection is closed. This process is known as inspection cleanup. If you do not reset the I/O when you are finished with an inspection, the I/O settings will persist for future inspections until either the I/O settings are changed programmatically, or Vision Builder AI is closed.

Complete the following steps to stop the trigger signal once the inspection closes.



1. Click the **Toggle Main Window View** button on the toolbar to bring the inspection state diagram to the Main window.

2. On the left side of the state diagram, click **Cleanup** to configure the Inspection Cleanup state.
3. In the Inspection Steps palette, select the **Communicate** tab.
4. Click the **Generate Pulse (NI-IMAQ I/O)** step. The property page for the step opens.
5. In the **Step Name** control, enter `Stop Trigger Pulse`.
6. In the **Pulse Settings** table, select the *CVS Trigger Out* line used in the Setup state to generate the trigger signal for the camera.
7. Set the **Action** for the I/O line to **Stop Pulse Generation**.
8. Click **OK** to add the step to your inspection.

Acquiring Inspection Images

Complete the following instructions to configure an **Acquire Image (IEEE 1394)** step to acquire images when a trigger pulse is received from the NI CVS-1450 device.

1. Click the **Toggle Main Window View** button on the toolbar to bring the complete inspection setup to the Main window.
2. Click **State Diagram** to view the state diagram for the inspection in the Main window.
3. Double-click the **Inspect** state to launch the Edit State Name dialog box.
4. In the **State Name** control, enter `Acquire`, and click **OK**.
5. In the Inspection Steps palette, select the **Acquire Images** tab.

6. Click the **Acquire Image (IEEE 1394)** step. The property page for the step opens.
7. In the **Step Name** control, enter `Acquire Image`.
8. Select the camera to use for the acquisition from the **Devices** list.
9. On the **Trigger** tab, enable the **Triggered Acquisition** control.
10. In the **Trigger Timeout** control, specify the amount of time the camera waits to receive a trigger before the acquisition times out.

11. In the **Polarity** control, specify whether to begin the acquisition on the rising or falling edge of the trigger signal.

Note Not all IEEE 1394 cameras support the ability to set the trigger polarity. Check the camera documentation to determine which polarity options the camera supports.

12. Click **OK** to add the step to the inspection.

Saving the Inspection

Before you can run an inspection on the NI CVS-1450 device, you must save the inspection. Saving the inspection downloads the inspection from the host computer to the internal memory of the NI CVS-1450 device so the inspection can be run. Complete the following steps to save the inspection to the NI CVS-1450 device.

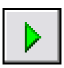
1. Select **File»Save** or click the **Save** button on the toolbar.
2. In the **Inspection Name** control, enter a name for the inspection.
3. Click **Save** to save the inspection.

Tip Select **File»Inspection Properties** to add a short description or comments about the inspection.

Testing the Acquisition

Complete the following steps to test the trigger configuration and make sure you can successfully acquire images.

1. On the NI Vision I/O Accessory, ensure that the **Demo Mode** switch in ON. The orange LED will be lit when the NI Vision I/O Accessory is in Demo mode.
2. In Vision Builder AI, select **File»Switch to Inspection Interface** to switch to the Vision Builder AI Inspection Interface.

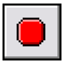


3. Click the **Start Inspection** button to run the inspection.
4. On the NI Vision I/O Accessory, press the push-button switch corresponding to the *CVS Trigger In* input signal you specified to detect when a trigger occurs.

   For example, if the trigger signal in the Inspection Setup state is set to generate every time TTL Input 0 on the NI CVS-1450 device detects a rising edge, then press the **Trigger TTL In 0** switch on the NI Vision I/O Accessory.

The acquired image is displayed on the external monitor connected to the NI CVS-1450 device. To view the image for within the Vision Builder AI Inspection Interface, select one of the options from the **View** menu.

5. Press the switch repeatedly to acquire multiple images. Vary the speed that you press the switch and notice that an image is acquired only when you press the switch.



6. Click the **Stop Inspection** button to stop the inspection.

Preventing an Acquisition Timeout

While testing the acquisition, you may have noticed that sometimes the **Acquire Image (IEEE 1394)** step status changes from Pass to Fail between presses of the NI Vision I/O Accessory trigger switch. This behavior occurs when the acquisition step does not receive a trigger from the NI CVS-1450 device within the **Trigger Timeout** period specified on the property page of the acquisition step. If a timeout occurs, any processing steps in the inspection that occur after the acquisition step will also fail because there is no image available to process.

Ideally you would set the acquisition step **Trigger Timeout** to an infinite value to ensure that a timeout never occurs. However, since Vision Builder AI allows only finite values for the timeout period, you must use another method to achieve the desired behavior. Instead of setting an infinite timeout, you can use the inspection state diagram to configure Vision Builder AI to only run the image processing steps in an inspection when an image has been acquired.

Creating the Inspection State Diagram

Complete the following instructions to implement the behavior of an infinite timeout in Vision Builder AI.

1. Select **File»Switch to Configuration Interface** to switch to the Vision Builder AI Configuration Interface.
2. Click the **Toggle Main Window View** button on the toolbar to bring the inspection state diagram to the Main window.

3. Right-click an open area on the state diagram and select **Create New State** to add a new state to the inspection, as shown in Figure 10-3. The Edit State Name dialog box opens.

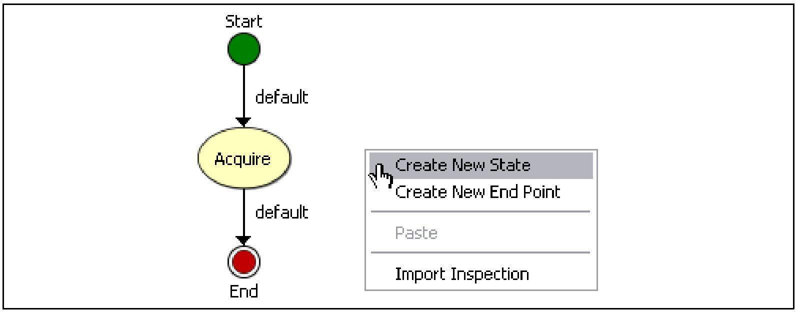


Figure 10-3. Creating a New Inspection State

4. In the **State Name** control, enter `Inspect`.

Next, you will define transitions between the inspection states. Notice that every state has a default transition. You can also create additional transitions between states based on measurement results or variable values.

Note The default transition occurs when the transition requirements for other possible transitions are not met.

5. Click the Acquire state **default** transition and drag it so that the transition loops back to the Acquire state.
6. Click the Inspect state **default** transition and drag it to the End point.

The state diagram should now resemble the state diagram shown in Figure 10-4.

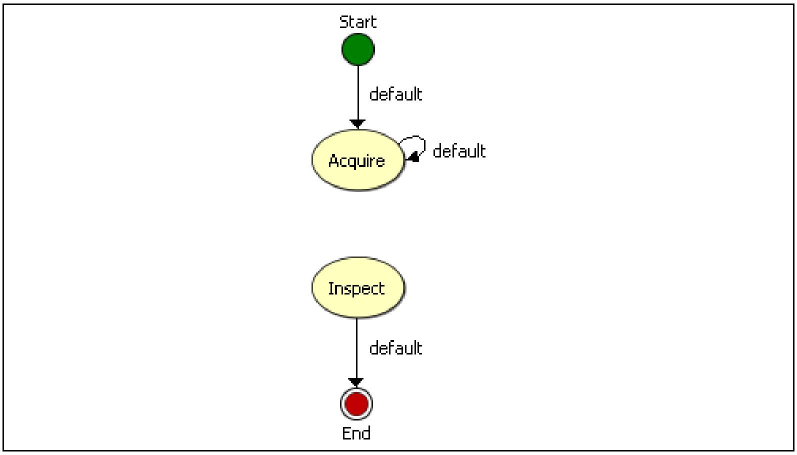


Figure 10-4. Configuring the Default Transitions

7. Right-click the **Acquire** state and select **Create New Transition**.
8. Click the **Inspect** state to create a transition between the Acquire state and the Inspect state.
9. Double-click the transition to launch the Edit Transition dialog box.
10. In the **Transition Name** control, enter `Image Acquired`.
11. In the **Measurement** control, configure the transition to occur when **Acquire Image - Timeout** is **False**.
12. Click **OK** to close the dialog box.

The state diagram should now resemble the state diagram shown in Figure 10-5.

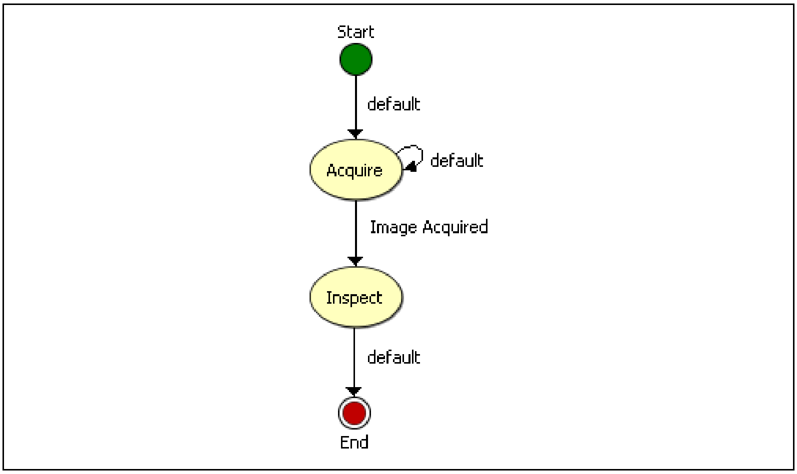


Figure 10-5. Completed State Diagram for the Inspection

13. Add and configure additional steps in the Inspect state to complete your application.
14. Save the Inspection.
15. Switch to the Inspection Interface and run the inspection.

When you run the inspection, notice that when a timeout occurs, the inspection simply loops back to the Acquire state and resumes waiting for a trigger. A timeout no longer affects the rest of the steps in the inspection.

Tip Set the **Acquire Image (IEEE 1394)** step **Acquisition Mode** to **Immediate** to prevent the inspection from missing triggers that may occur when the inspection transitions between states.

11

Inspection Selection

This chapter introduces the inspection selection feature in Vision Builder AI. Inspection selection allows you to automatically select which inspection you want to run based on the value of an I/O line or the result of a communication step. Follow the instructions in this chapter to create an inspection that reads a string sent by a host computer, using TCP/IP communication, to determine which inspection to run on a remote target.

Connect to a Remote Target

Complete the following instructions to launch Vision Builder AI and connect to a remote target.

1. Launch Vision Builder AI.
2. On the Vision Builder AI Welcome screen, expand the **Execution Target** listbox, and select **Select Network Target**.
3. Select the remote target you want to use, and click **OK**.

Tip Record the IP address of the remote target you selected. You will need the IP address later in this lesson to send TCP/IP commands to the target.

4. On the Welcome screen, click **Configure Inspection** to launch the Configuration Interface.

Installing Examples on the Remote Target

Complete the following instructions to verify that the correct example inspections are installed on the remote target before proceeding to the next section.

1. Select **Target»Add/Retrieve Inspections** to launch the Inspection Manager.
2. In the Remote Device section of the Inspection Manager, verify that `Tutorial - 1 Coordinate System.vbai` and `Tutorial - 6 State Diagram Looping.vbai` are listed.

If either of these inspections are missing, complete the following instructions to copy the inspections from the development computer to the remote target.

a. In the This Computer section of the Inspection Manager, navigate to the `<Vision Builder AI>/Examples` directory, where `<Vision Builder AI>` is the location where Vision Builder AI is installed.

b. Select **Tutorial - 1 Coordinate System.vbai**, and click **Copy**.

c. Select **Tutorial - 6 State Diagram Looping.vbai**, and click **Copy**.

The Inspection Manager dialog box should resemble Figure 11-1.

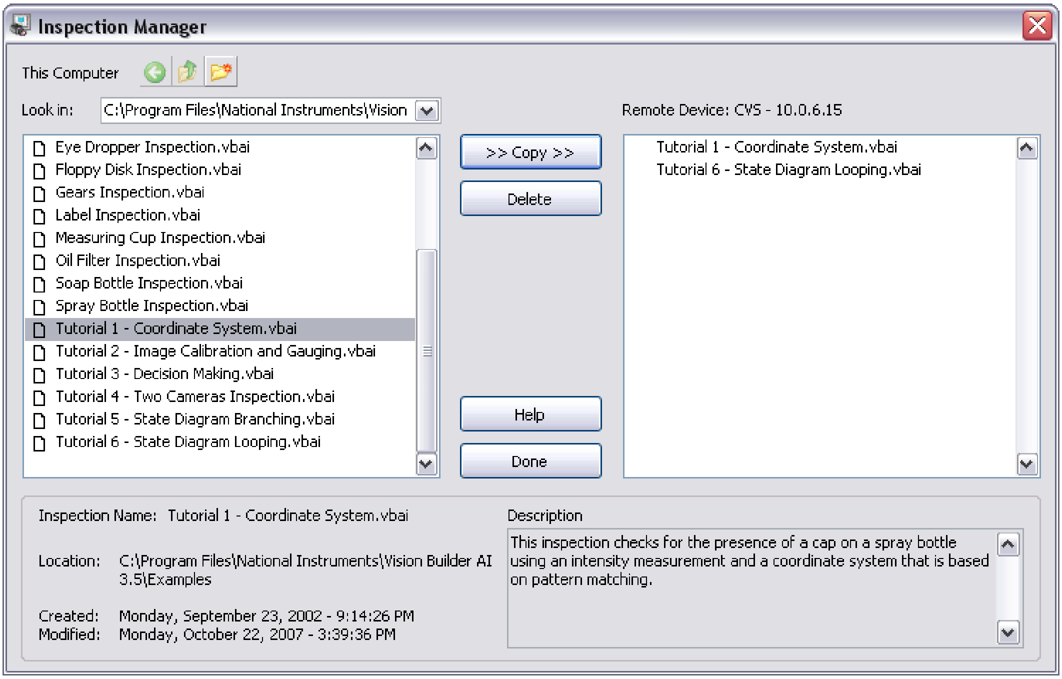


Figure 11-1. Copying Inspections to a Remote Target

3. Click **Done** to close the Inspection Manager dialog box.

Opening an Inspection

Complete the following steps to open an inspection on the remote target.

1. Select **File»Open**, or click the **Open** button on the toolbar.
2. Select **Tutorial 1 - Coordinate System.vbai**.
3. Click **OK** to open the inspection.

Adding a Communication Device

Complete the following instructions to define a TCP/IP communication device and add the device to Vision Builder AI.

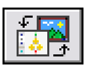
1. Select **Tools»Communication Device Manager** from the Vision Builder AI toolbar to launch the Communication Device Manager.
2. Click **New Device** to launch the New Communication Device dialog box.
3. In the **Device Name** control, enter `Desktop PC`.
4. In the **Protocol** control, select **TCP/IP**.
5. In the **Port** control, enter the communication port you want to use to listen for communication.

Tip Record the port number you selected. You will need the port number later in this lesson to send TCP/IP commands to the remote target.

6. Click **OK** to add the device to Vision Builder AI.
7. In the Communication Device Manager dialog box, click the TCP/IP Server **Start Server** button.
8. Click **OK** to close the dialog box.

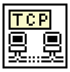
Configuring TCP/IP Communication

Complete the following instructions to configure a **TCP I/O** step to receive information from a TCP device.



1. Click the **Toggle Main Window View** button on the toolbar to bring the inspection state diagram to the Main window.
2. Select **View»View Complete Inspection Setup** to display additional inspection configuration options.

3. On the left side of the state diagram, click **Select Inspection** to configure the Select Inspection state.
4. In the Inspection Steps palette, select the **Communicate** tab.



5. Click the **TCP I/O Step**. The property page for the step opens in the Main window.
6. In the **Step Name** control, enter `Receive TCP Data`.
7. Click the **Wait for String** command button.
8. In the Wait for String dialog box, set the **Fixed Number of Bytes** option for the **Wait For** control to `1`.
9. In the **Timeout** control, enter `0`. For this lesson, inspection selection values are retrieved from a buffer to determine the current inspection, so no timeout is necessary. If your inspections require additional time to receive the inspection selection data, specify a larger **Timeout** value.
10. Click **OK** to save the command settings and close the dialog box.
11. Click **OK** to add the step to the Select Inspection state

Mapping I/O Values to Inspections

After you configure the step to receive signals from an external TCP device, you must map each possible value for the signal to a Vision Builder AI inspection. Complete the following instructions to configure a **Select Inspection** step and map the I/O signal values to Vision Builder AI inspections.

1. In the Inspection Steps palette, select the **Use Additional Tools** tab.

2. Click the **Select Inspection** step. The property page for the step opens in the Main window.
3. In the **Select Inspection Source** control, verify that **Receive TCP Data - String # 0** is selected.
4. Click **Add** to add an I/O signal value to the Inspections table.
5. In the **Value** control, enter `1`.
6. In the **Inspection** control, select **Tutorial 1 - Coordinate System.vbai**.
7. Click **Add** to add another value to the Inspections table.
8. In the **Value** control, enter `2`.

9. In the **Inspection** control, select **Tutorial 6 - State Diagram Looping.vbai**.
10. Select the **Enable Inspection Selection** checkbox. The property page should now resemble the property page shown in Figure 11-2.
11. Click **OK** to add the step to the Select Inspection state.

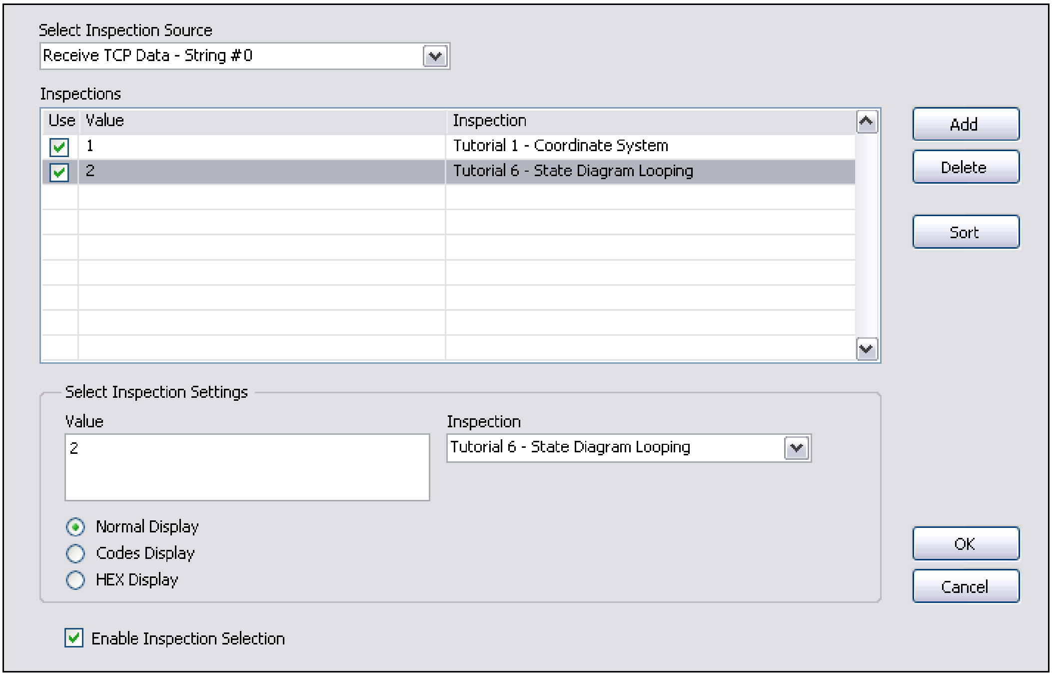
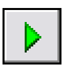


Figure 11-2. Configuring the Select Inspection Step

Running the Inspection

Complete the following instructions to switch Vision Builder AI from Configuration mode to Inspection mode and begin running an inspection.

1. Select **File»Switch to Inspection Interface**. Notice that the **Inspection Selection** button is now available on the toolbar.



2. Click the **Start Inspection** button to begin running the inspection.

Note If inspection images are not displayed when the inspection is running, select **View» Display All Images** to view the inspection images.

Generating TCP Commands and Testing the Inspection

Complete the following instructions to send TCP commands to Vision Builder AI and change the active inspection.

1. Navigate to the `<Vision Builder AI>` directory on the development computer, and double-click `Vision Builder Ethernet Terminal.exe` to launch the Vision Builder Ethernet terminal.
2. In the Connect To dialog box, enter the **IP address** and **Port Number** of the remote target you used to configure the inspection selection.
3. Click **OK**.
4. In the Vision Builder Ethernet Terminal, enter `2`. Notice how the active inspection in the Vision Builder AI Inspection Interface changes from `Tutorial - 1 Coordinate System.vbai` to `Tutorial - 6 State Diagram Looping.vbai`.
5. In the Vision Builder Ethernet Terminal, enter `1`. Notice how the active inspection changes back to `Tutorial - 1 Coordinate System.vbai`.

To disable inspection selection while an inspection is running, click the **Inspection Selection** button on the toolbar.

A

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Visit the following sections of the award-winning National Instruments Web site at `ni.com` for technical support and professional services:

- **Support**—Technical support at `ni.com/support` includes the following resources:
  - **Self-Help Technical Resources**—For answers and solutions, visit `ni.com/support` for software drivers and updates, a searchable KnowledgeBase, product manuals, step-by-step troubleshooting wizards, thousands of example programs, tutorials, application notes, instrument drivers, and so on. Registered users also receive access to the NI Discussion Forums at `ni.com/forums`. NI Applications Engineers make sure every question submitted online receives an answer.
  - **Standard Service Program Membership**—This program entitles members to direct access to NI Applications Engineers via phone and email for one-to-one technical support as well as exclusive access to on demand training modules via the Services Resource Center. NI offers complementary membership for a full year after purchase, after which you may renew to continue your benefits.

    For information about other technical support options in your area, visit `ni.com/services`, or contact your local office at `ni.com/contact`.
- **Training and Certification**—Visit `ni.com/training` for self-paced training, eLearning virtual classrooms, interactive CDs, and Certification program information. You also can register for instructor-led, hands-on courses at locations around the world.
- **System Integration**—If you have time constraints, limited in-house technical resources, or other project challenges, National Instruments Alliance Partner members can help. To learn more, call your local NI office or visit `ni.com/alliance`.

If you searched ni.com and could not find the answers you need, contact your local office or NI corporate headquarters. Phone numbers for our worldwide offices are listed at the front of this manual. You also can visit the Worldwide Offices section of ni.com/niglobal to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

Glossary

C

coordinate system	A reference location (origin) and angle in an image that ROIs can relate to when positional and angular adjustments of the ROI are necessary. A coordinate system is depicted by two lines representing the orientation and direction of its two axes.

D

data type	A format for information. Acceptable data types for most functions are numeric, array, and string.

F

field of view	The area of inspection that the camera can acquire as an image.
focal point	The pixel location in a pattern matching template whose coordinates are returned as the location of a match in the inspection image.

I

inspection	A vision inspection application created in and run from Vision Builder AI that can perform inline or offline visual inspections.
intensity	The gray-level value of a pixel in a grayscale image.

M

match score	A number ranging from 0 to 1,000 that indicates how closely an area of an acquired image matches the template image. A match score of 1,000 indicates a perfect match. A match score of 0 indicates no match.

O

object	A connected region or grouping of pixels in an image in which all pixels have intensity levels in the same range.

P

pattern matching	The technique used to quickly locate a grayscale template within a grayscale image.
pixel	Picture element—The smallest division that makes up a digital image. For measurement tasks, optimum pixel dimensions are square (aspect ratio of 1:1, or the width equal to the height).

R

resolution	The number of rows and columns of pixels. An image composed of m rows and n columns has a resolution of $m \times n$.
ROI	Region of Interest—An area of the image that is graphically selected from a window displaying the image. This area can be used to focus further processing.

S

spatial calibration	Assigning physical dimensions to the area of a pixel in an image.
state	A particular set of steps that execute under certain conditions during an inspection.
state diagram	A graphical representation of a finite state machine.
step	A component of a Vision Builder AI inspection that performs a specific visual inspection task or supporting tasks, such as decision making and serial communication.

T

template	Pattern that you are trying to match in an image using the Match Pattern, Match Color Pattern, Geometric Matching, or Detect Defects steps. A template can be a region selected from an image or it can be an entire image.
transition	Event that causes the inspection to move from one state to another.