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# Self-Teach Manual

# Bulletin 2803
# VIM™
# Vision Input Module
## (Cat. No. 2803-VIM1)

40062-038-01(A)

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# Chapter 1 Using This Manual

Read this chapter to familiarize yourself with the remainder of this manual. It tells you how to use this manual efficiently.

This manual describes step-by-step how to use an Allen-Bradley 2803 Vision Input Module (VIM) to perform simple non-contact inspection tasks.

We assume that you have access to a Vision Input Module and want to learn how to use it effectively. No previous knowledge of machine vision is necessary to use a VIM Module successfully. You do not need to know how to program Ladder Logic or be familiar with a Programmable Logic Controller (PLC) to read and use this manual.

Your VIM Module must be installed correctly in order to perform the applications contained in this document. For instructions and clarifications regarding the correct installations and setup of the module, consult the VIM Users Manual, Pub 2803-800 Chap. 5. Installation and integration.

---

This manual uses several terms in a way which may be new to you.

- BLOB - A contiguous string of ones or zeros along a given horizontal or vertical line in a thresholded image. This is described in Chapter 4.

- CONFIGURATION - The controlling parameters used by the VIM Module to inspect a workpiece. The configuration tells the VIM Module what to inspect and, optionally, how to judge it as acceptable.

- ICON - A pictorial representation of a command. The VIM user interface uses icons to inform you of the choices which are available at a given point in time. Touching an icon firmly with the tip of the light pen is termed "picking" an icon and causes the associated command to be executed. This is discussed in Chapter 2.

- IMAGE - The representation of a scene being viewed by a video camera as a two-dimensional array of numbers. A camera views a scene and transmits electronic signals to the Module. The Module turns those signals into an image. This is discussed in Chap. 5.

- LINE GAUGE - Analyzes a set of horizontally or vertically aligned pixels. You enable and specify the orientation, location, and size

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of the twenty-two (22) line gauges on an individual basis. This is discussed in Chapter 4.

- PIXEL - Literally, "PICture ELement. An elemental portion of an image represented by a single number. The VIM Module measures linear dimensions in terms of the number of pixels crossed in going from one location to the other. The VIM Module measures areas in terms of the number of pixels that are contained within the boundary of that area. This is discussed in Chapter 3 and Chapter 4.

- WINDOW - A user-defined region of the image in which white (or black) areas are to be measured. The area is measured in square pixel units and is commonly called the "pixel count". The number can be compared with a specified acceptance range as discussed in Chapter 3.

- WORKPIECE - The object to be inspected by the VIM Module.

Additional definitions of technical terms can be found in Chapter 1 of the VIM User's Manual (Publication 2803-800).

## Precautions

You will see two types of precautionary statements as you read this manual; IMPORTANT and CAUTION.

- IMPORTANT - Used to make you aware of circumstances which could cause the configuration you are currently establishing to be incorrect in the sense that it will REJECT all workpieces unconditionally.

- CAUTION - Used to make you aware of instances where damage to your equipment could occur.

## Related Products

You can install a VIM Module in any 1771 series I/O rack or any system that uses Allen-Bradley programmable controllers. There are more than 100 "universal I/O" products (see publication 1771-1.2).

## Compatible Chassis

- You can put your VIM Module in any module group of a 1771 Series I/O chassis.

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- You can put two or more VIM Modules in the same chassis as long as sufficient power is provided.

**Related Publications**

Consult the Vision Input Module User's Manual (Publication No. 2803-800) for reference information. That publication includes a detailed description of each icon, as well as other useful background information.

**What The VIM Self-Teach Manual Contains**

| CHAPTER | TITLE | WHAT'S COVERED |
|---|---|---|
| 1 | Using This Manual | Self-Teach Manual's purpose, audience, terminology, contents, and a list of related publications |
| 2 | Introduction to the Vision Input Module | Describes the functionality of the module, typical inspection tasks, general module set up procedures, gives an overview of Self-Teach sessions 1, 2, and 3. |
| 3 | Session 1: Using the Brightness Probe and Windows | Describes VIM module set-up. Explains contrast, confirming the presence of a hole, how to trigger the module. |
| 4 | Session 2: Using Line Gauges | Configuring the module to compensate for workpiece positioning. Adapting inspection procedures for surface feature measurement. |
| 5 | Session 3: Getting the Most Out Of Your VIM module | Describes Mode 1 lighting correction, verifying arbitrary shaped features, and areas of mixed contrast. Example of a blind hole, measuring the inspection cycle time. |

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Summary

You will produce successful applications of your Vision Input Module by following the techniques in this manual. We'll begin by giving you an overview of the VIM Module and what you can expect to do with it.

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# Chapter 2 Introduction

Chapter Objectives

This chapter answers some basic questions about industrial applications of the Vision Input Module.

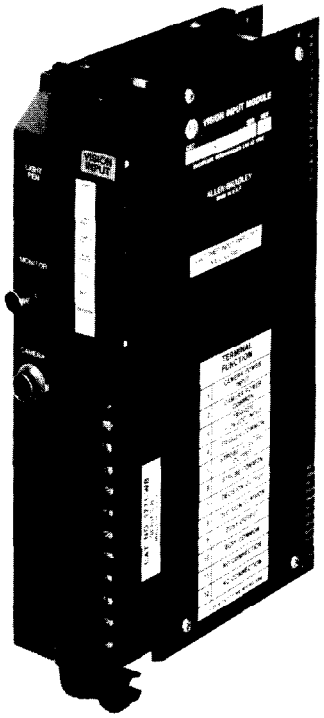
Introduction To The Vision Input Module

Welcome to the world of practical machine vision for your Allen-Bradley Programmable Logic Controller (PLC). The Vision Input Module (VIM) provides machine vision suitable for any environment where a 1771 I/O Chassis can be used. Moreover since you will be actively involved in configuring the VIM Module to perform inspections on your production line, you will be able to easily reconfigure should the requirements of your plant's production process change.

What is a VIM Module ?

First and foremost, the VIM Module is designed and built in the Allen-Bradley tradition of quality. This is a module which occupies a double slot in any 1771 series I/O chassis and is connected to a solid-state video camera and a monitor (see Figure 2-1). In production operation, the Module's "TRIGGER" can be a signal line which is set high by the Ladder Logic of the PLC. Having received a trigger, a second signal line is raised by the VIM Module indicating that it is "BUSY".

Fig. 2-1
Vision Input Module (VIM)



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This line goes low after the inspection has been completed. The outcome of the inspection is made available to the PLC on yet a third signal line: DECISION. Logic high on this line signifies a "REJECT" decision while logic low signifies an "ACCEPT" decision (i.e. this particular workpiece passed inspection). These same signals (i.e., "TRIGGER", "BUSY" and "DECISION") are also directly accessible via terminals on the swingarm, and allow the Module to be used in a "stand-alone" manner. When necessary, information on why a specific workpiece was rejected is available to the PLC via a block transfer operation. For more information on ladder logic, consult the appropriate PLC Manual.

## What Can The VIM Module Do?

The VIM Module can inspect workpieces placed in front of its video camera for the presence of critical items at known locations on the workpiece. The images it analyzes are painted with just two colors - black and white. Hence, the items whose presence is being verified need to have a certain amount of contrast with the surrounding areas of the workpiece. The Module can analyze as many as four different levels of contrast simultaneously. In those situations where the items being verified are always a fixed distance from the edges of the workpiece, the VIM module can be configured to automatically accommodate variations in the workpiece positioning in front of the camera.

Representative items which the four (4) windows and twenty-two (22) line gauges can readily verify are:

- the presence of pierced, drilled, or machined holes at known locations on a workpiece
- the presence of a light colored item on a dark workpiece or vice-versa
- that the outside dimensions of the workpiece fall within a user-specified range
- that the inside dimensions of an opening or cutout fall within specified ranges
- that the area of a contrasting region falls within a specified range
- that a contrasting object is located within a specified range from the edge of the workpiece in the X and Y directions
- that the correct number of certain items are present.

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**Can The VIM Module Keep Up With Your Production Lines?**

Industrial production lines run at rates which depend primarily upon the complexity of the operations being performed. Several seconds per workpiece is typical on automotive lines. Several workpieces per second is typical on electronic lines. On bottling lines, 1,200 or more workpieces per minute is common. Strictly speaking, the rate at which a VIM Module can inspect a workpiece depends upon how complex a task it is configured to do. However, for production line situations, a good working rule is;

> "If the advance of individual workpieces is controlled by a PLC, then a VIM Module can inspect what is in the camera's field-of-view at your production line's maximum rate."

**Can I Set Up A VIM Module?**

A light pen and monitor, attached to the VIM Module, support a simple menu of pictorial symbols called "icons". Most people quickly feel at ease with these icons for they depict the choices which are available as you configure a Module to meet the specific inspection needs of your production process. The Module also supports a "stand-alone" mode which allows you to work with sample workpieces away from the noise and distractions of the production line and then, when you feel ready, apply your ideas or your inspection procedure to workpieces on the actual production line.

**Is Machine Vision Difficult To Use?**

Since machine vision spans a broad range of disciplines, considerable attention to details is often required. The goal of this manual is to make machine vision an effective tool in your hands. Since most people learn more quickly by doing than reading, this manual is action-oriented. The three self-teach sessions in this manual will walk you through actual vision applications. Each succeeding session is intended to be roughly twice as long as the preceding one. You are encouraged to extend your experience with the VIM Module between each of these three sessions. Session 1 walks you through the use of "windows" to perform pass/fail verification of the presence of a hole in a workpiece. Many real-world inspection tasks can be done using simple variations of this application. A user who completes Session 1 will be able to successfully apply the VIM Module to some production line inspection tasks. Session 2 introduces you to line gauges and walks you through the key elements involved in pass/fail inspection. When you have completed Session 2, you will be able to use your VIM Module for most

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production line inspection tasks. Session 3 introduces you to the finer details of the Module's operation by walking you through examples of verifying the dimensions of a region of mixed contrast, and verifying the presence of "blind holes" in a workpiece. Completion of Session 3 will allow you to successfully use the full capability of the Module.

As you will see, the concepts involved in Allen-Bradley's Vision Input Module are rather simple to describe in words. However, the usefulness of the VIM Module in a factory is far-ranging. It is our hope that this Self-Teach Manual will serve as a gateway for you. Ultimately, your real teachers will be the camera images, the VIM Module itself, and your own, ongoing, experience in using it to improve production processes in your plant.

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# Chapter 3 Self-Teach Session I

Chapter Objectives

The objective of this session is to get you and your VIM working together. To this end we will:

- describe how to install and power up your VIM module.
- help you become familiar with the VIM module's capabilities by walking you through using it to inspect the sample workpiece supplied with this manual.

Along the way, we will acquaint you with some words which have technical meanings in the realm of machine vision.

The first example given - verifying the presence of a hole using backlighting - illustrates techniques which have a broad range of applicability. When you have completed this working session, and familiarized yourself with Chapter 1 of the VIM User's Manual, you will be able to successfully apply a VIM to some of the production line inspection applications in your plant.

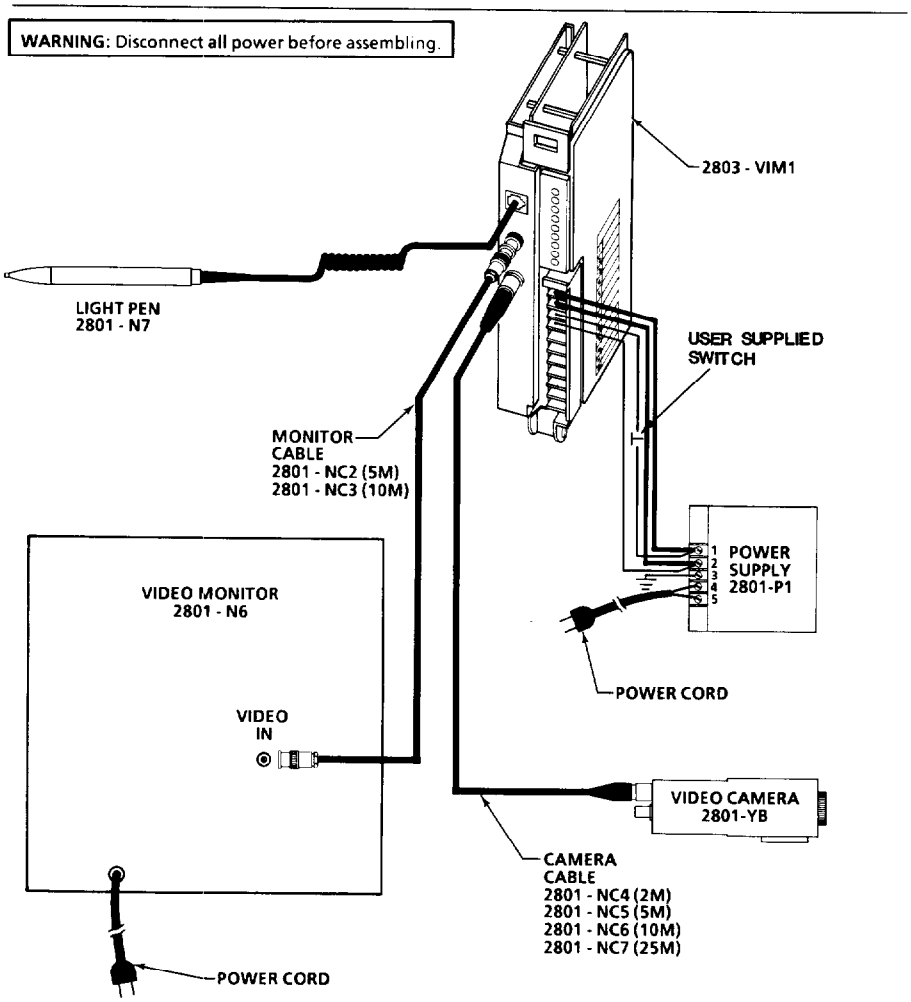
The things needed for Self-Teach Session I are:

- A 2803 Vision Input Module (Cat. # 2803-VIM1)
- A 1771 Series I/O Rack (such as Cat. # 1771-A2B or 1771-PSC)
- A Rack Power Supply such as (Cat. #1771-P3)
- A Camera (Cat. # 2801-YB)
- A Camera Cable (Cat. # 2801-NC5)
- A 25 mm C-Mount Lens (Cat. # 2801-NL1)
- A Video Monitor (Cat. # 2801-N6)
- A Video Monitor Cable (Cat. # 2801-NC2)
- A Light Pen (Cat. # 2801-N7)
- A VIM Power Supply (Cat. # 2801-P1)
- A Reliable Source of Light (such as Cat # 2801-N17 - Precision Ring Light)

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- o A VIM Self-Teach Manual (Publication No. 2803-819) Containing:
  - A Sample Workpiece (Metallic Drafting Shield)
  - Four (4) Different Sheets of Metallic Paper
- o A Camera Stand (Cat. # 2801-N3)
- o A Normally-Open Push Button Switch (Cat. # 800A-M2AG)
- o A Tape Measure (User-Supplied)
- o Sufficient Wire To Connect The Power Supply, VIM Module, Swingarm and Push Button

Fig. 3-1.
VIM Module Accessories And Connections




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## Installing and Powering Up A Vision Input Module

The mechanics of installing and powering up a VIM Module are straightforward. Simply power down the host chassis and insert the Module into any module group in the 1771 Series I/O Rack.

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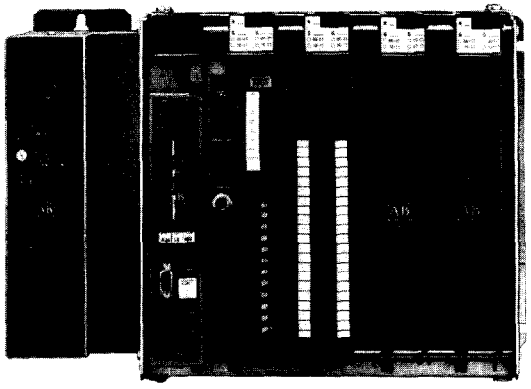
! CAUTION: Always turn off power to the system before inserting or removing modules. Failure to do so may damage the equipment.

---

Figure 3-2 shows a VIM Module installed in a 1771 I/O Rack with a PLC. Alternatively, the VIM Module can be installed in a standalone rack (without a PLC) as shown in Figure 3-3. Note, be sure the I/O chassis configuration plug is set properly (see Vim Users Manual). An improper setting will cause the CPU FAULT and CONFIG FAULT LEDs to light.

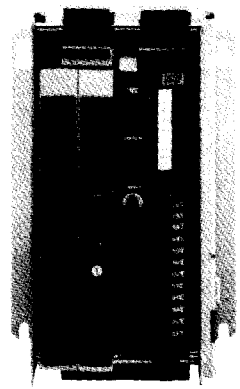
Fig. 3-2.
The VIM Module Installed In A 1771 I/O Rack

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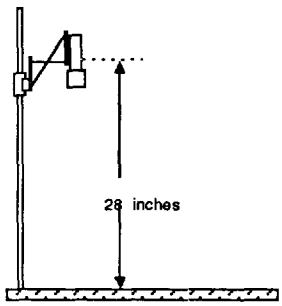
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Fig. 3-3.
The VIM Module Installed In A Standalone Rack Configuration



Then assemble the video camera, power supply, lens adapters, and 25 mm C-mount lens. Connect the camera to the front of the Module using the cable provided, plug the light pen into the front connector and connect up the video monitor. Next, connect the VIM power supply to the swingarm, and connect the normally-open push button switch as shown in Figure 3-1 (also see Figure 5-21, "Single Shot Pushbutton" in the User's Manual). Then power up the system.

Fig. 3-4.
Camera Mounted On Stand

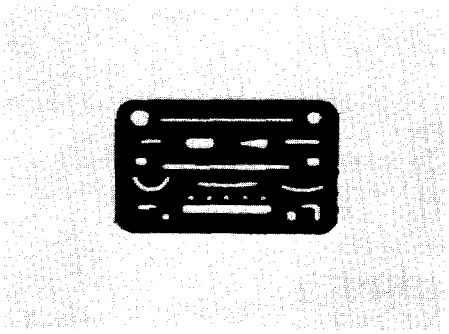



At this time, you should mount the camera on the stand so that its 1/4-20 mounting bolt is 28" ± 1/16" above the table as shown in Figure 3-4. Then locate the sample workpiece (drafting shield) which came in the brown envelope with this manual. Place it directly beneath the camera on the sheet of silver metallic paper also included with this manual. This will produce a silhouette. Now set the f-stop (upper moveable ring) on the camera lens to f-11, and the focus (lower moveable ring) on the camera to 0.7 meters.

As soon as power is applied to the 1771 Series I/O rack, the VIM Module will power up. This is signified by five of the seven LEDs on the front of the VIM Module being turned on in a test pattern. Four seconds later, they will all have gone out except for the uppermost LED labeled "PWR". At this point, a pure black and pure white, i.e., "Thresholded" image with a small bright square superimposed on its center will appear on the video monitor (see Figure 3-5).

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Fig. 3-5. Thresholded Image With Window No. 1 Shown As A Bright Square



The orientation of the workpiece on the video monitor should be as shown in Figure 3-5. If this isn't what you see the most likely cause is that something didn't get plugged in properly. If the LEDs do not come on, then either the I/O rack has no electrical power or the Module isn't properly seated. If the LEDs all lit up in sequence, then turned off leaving the "CONFIG. FAULT and BUSY"LEDs on don't worry, this situation will get corrected the first time we command the VIM Module to save a new "configuration". If the LEDs function as described but nothing appears on the video monitor, then either the video monitor is without electrical power, or the video monitor's cable isn't connected to the front of the Module or the brightness and contrast controls on the front of the video monitor simply need to be adjusted.

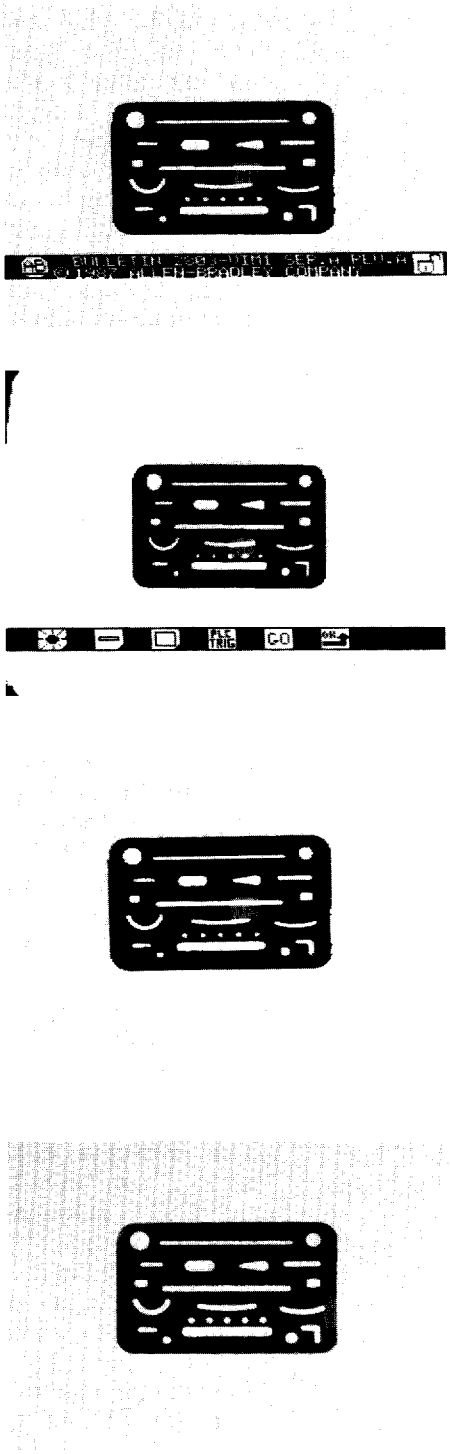
For the purposes of this manual all examples assume that you are operating in stand-alone mode. If you are using a PLC, power up in PROG. mode. You may have to "unlock" the VIM Module at this point, (see Figure 5-14, "PLC Bit Manipulation Menu Used to Force Control Bits" in Chapter 5 of the User's Manual).

## Displaying The Analog Image

Once the bright square appears on the video monitor, "pick" (i.e., firmly touch with the tip of the light pen) any bright area on the top half of the monitor four times. This selects the camera image directly to the video monitor. Your 1st pick will cause the VIM Module sign-on banner to appear across the lower portion of the image. On its far right, this banner has an icon representing an open padlock. Your 2nd pick will cause the main-user-interface menu to appear in place of the sign-on banner and the "BUSY" LED on the front of the VIM Module to light. Your 3rd pick will cause the strip of six icons or the main menu to vanish. Your 4th pick will cause the video signals from the camera to be routed directly to the monitor. This sequence of displays is shown in Figure 3-6. If the bright square appears in the center of the monitor, but there is no analog image, then either the camera cable isn't connected, the lens cap is still on the lens, the VIM power supply isn't on or the moveable ring on the lens nearest to the camera body ("f-stop") needs to be rotated to admit more light. The grey scale image which appears on the video monitor comes directly from the camera. This "analog" image as it is commonly called, shows exactly what the camera is viewing. This image is indeed "live". Wave your hand under the camera while watching the video monitor.

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Fig. 3-6.
Sequence of Displays Enroute To
Directing Live Camera Image to Video Monitor



If the image is too bright, turn the f-stop on the camera lens clockwise (i.e., toward larger numbers) to cut down the overall image brightness. Rotating the f-stop from one marking to another, say from f/8 to f/11 (the . between the "8" and "16" on the moveable ring) reduces the light level by exactly a factor of two. If the analog image is still blurred after the overall brightness has been set, then the focus on the camera lens needs to be adjusted.

**Focusing The Camera**

One way to accurately focus the camera on a workpiece is to open the f-stop on the lens as much as possible (for the 25 mm C-mount lens, this setting is f/1.4), turn the room lights down so that the analog image isn't too bright (i.e., "blooming"), then rotate the focus ring on the lens first one way and then the other until the largest hole in the erasure shield appears as small as possible. Then turn the lights back up and close the f-stop on the camera lens until the brightness of the image is pleasing to your eye.

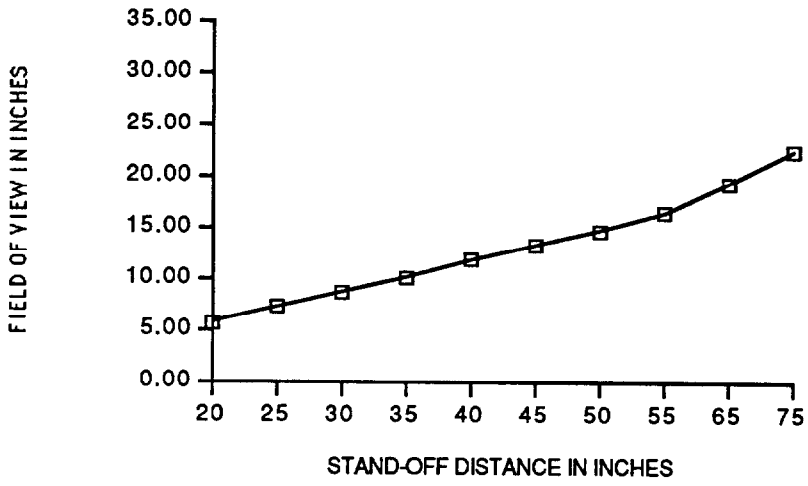
**Obtaining The Desired Camera Field-Of-View**

The size of the camera's field-of-view depends upon the distance between the camera and the workpiece ("stand-off" distance). The graph shown in Figure 3-7 gives the width of the field-of-view for the standard 25 mm focal length C-mount lens for different distances between the 1/4-20 camera mounting hole and the workpiece. As a general rule, doubling the distance between camera and workpiece doubles the camera's field-of-view. When doing your own inspection applications, you may wish to consult the VIM User's Manual, Chapter 4 for guidance on obtaining different fields-of-view at a given stand-off distance.

Important: This application is set-up using diffuse room lighting. A ring light around the camera lens will not provide a usable image.

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Fig. 3-7.
Camera to Workpiece Distance and Width of
The Camera's Field-Of-View



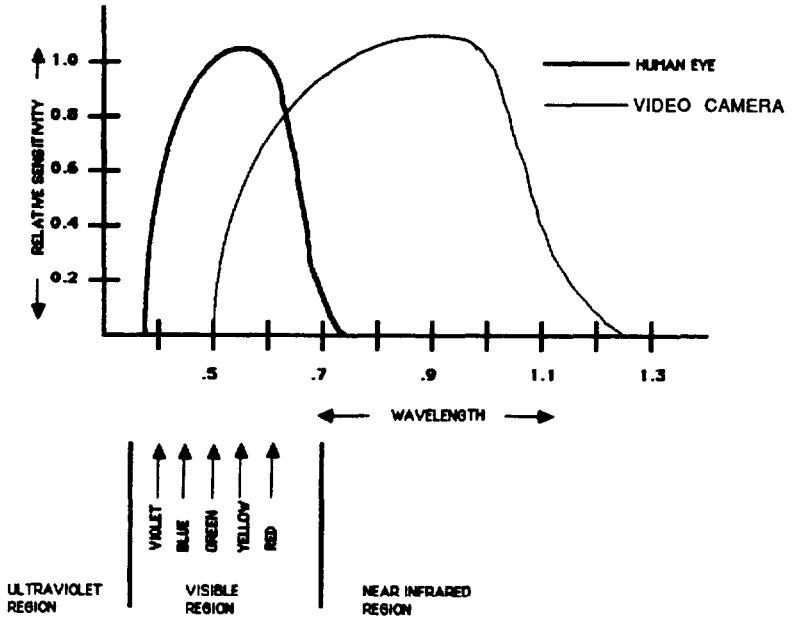

Viewing Through A Solid-State Camera

Figure 3-8 shows the spectral response of the human eye and the spectral response the video camera. The dominant wavelengths; blue, green, and red that our eyes see as colors are shown. Because solid-state video cameras have their peak sensitivity in the near infrared, the camera frequently does not see the same contrast as a human eye. This leads us to a rule-of-thumb for using the VIM Module.

"Before stating that a VIM Module can verify the presence of something, always place a sample workpiece under the camera and view the image on the Video Monitor. A significant difference between the region of interest and the surrounding areas as viewed on the Video Monitor is needed for reliability".

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Fig. 3-8.
Spectral Response of The Eye
And The Video Camera



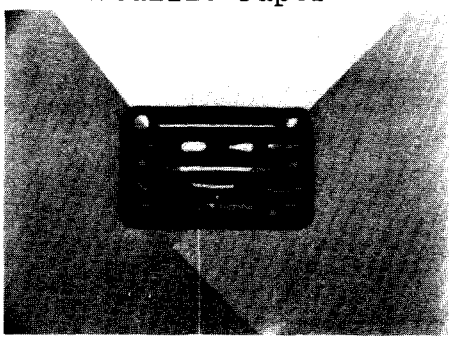

A metal drafting shield mentioned earlier will be used as the "sample workpiece" throughout these Self-Teach sessions. At the back of this manual are four (4) different sheets of metallic paper.

Remove a silver, a gold, and a copper colored sheet from the back of this manual and place them on the table in front of you. Now lay the sample workpiece on top of first one sheet, and then another, and then the third. At each step note the contrast your eyes see between the sample workpiece and each sheet of metallic paper.

Now, layer these three metallic sheets of paper together under the camera so that portions of all three can be viewed at once. Notice how the silver paper appears brightest to the camera, the copper paper appears darkest to the camera, and the brightness of the gold paper lies somewhere between the other two.

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Fig 3-9. Workpiece Viewed Against Three Sheets Of Metallic Paper



Then place the workpiece so that it lays across the junction of all three sheets as shown in Figure 3-9. Note the high contrast the camera sees between the workpiece and the silver paper, while it sees little or no contrast between the workpiece and the copper paper. In preparation for the first exercise, remove everything but the silver paper and place it so that it fills the camera's entire field-of-view. Then place the sample workpiece on that sheet so the large round hole is in the upper-left corner.

## Overview Of The VIM Module

The VIM Module accepts analog images from the video camera. As analog images enter the Module, a threshold is applied to produce a purely black and white image which the VIM Module then analyzes. The VIM Module contains four (4) separate windows. Each window has its own threshold parameter. Thus, the VIM Module can simultaneously handle four (4) different levels of contrast in the analog images it receives from the camera. The geometrical shape, size, and location of each window is selectable. The Module also measures average brightness and, at the users option, will scale ("float") any or all of the threshold levels up and down proportionally. The location of the brightness probe in the image is selectable.

The Module contains twenty-two (22) independent line gauges which can be set up to analyze the white (black) pixels in either a horizontal row or a vertical column of one of the thresholded images. The length and location of each line gauge is selectable. For a given line gauge the user can select any one of nine measurement pairs. For a workpiece to pass inspection, each of the selected window counts and line gauge readings must fall within the selected range.

The VIM Module also contians two (2) additional gauges - the X-gauge and the Y-gauge. When they are enabled, readings from these two dedicated gauges can be used to compensate, on an image by

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image basis, for variations in workpiece position. At the users option, any or all of the image analysis tools (i.e., windows and line gauges) can employ this dynamic repositioning.

Overview Of The User Interface

The user interface employed in the Vision Input Module is organized along the lines of the types of image processing operations supported by the VIM module. As shown in Figure 3-10 the user interface below the main menu is organized into three (3) primary branches.

The first of these branches - the "Brightness Branch" - allows you to specify the operation of the Brightness Probe and to set each of the four (4) thresholds. Figure 3-11 shows the structure of the Brightness Branch of the VIM User Interface. This branch has three (3) sub-menus; The Move Menu, The HiLo Range Menu and the Threshold Setting Menu. You will learn to use these later in this chapter.

The second branch - the "Line Branch" - allows you to enable any of the line gauges and specify which thresholded image it is to use. Your inputs are typically made with reference to a live image of the workpiece. The orientation, location, and length as well as the selection of the specific measurement that gauge should make and the acceptable range of those readings are all input by you. Figure 3-12 shows the structure of the Line Branch of the VIM User Interface. The Branch Menu has two (2) parts. Part 2 of the Line Branch Menu has three (3) Menus - The Move Menu, the Size Menu, and the HiLo Range Menu. You will learn to use these in Chapter 4 of this manual.

The third branch - the "Window Branch"allows you to enable any of the four (4) windows. Window 1 always works with images obtained using Threshold 1. Window 2 always works with images obtained using Threshold 2, etc. The Window Branch allows you to specify for each window whether the measurement of interest is the number of white pixels or the number of black pixels contained in that window. This branch also allows you to chose the geometrical shape of each window, its location in the image and its size as well as the acceptable range of the "readings".

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Fig. 3-10.
VIM User Interface Is Divided
Into Three (3) Primary Branches

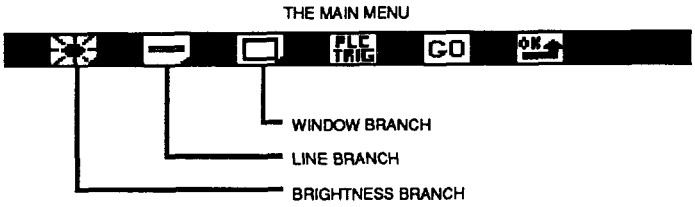
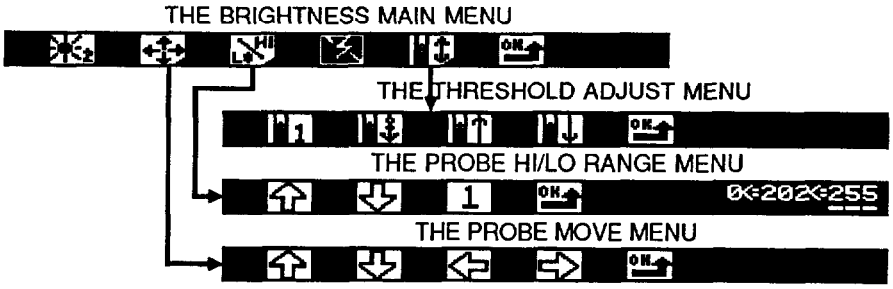



Fig. 3-11.
Structure Of Brightness Branch




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Figure 3-13 shows the structure of the Window Branch of the VIM User Interface. This Branch Menu also has two (2) parts. Part 2 of the Window Branch Menu has three (3) Menus - the Move Menu, the Size Menu, and the HiLo Range Menu. You will learn to use these later in this chapter.

The process of enabling and specifying the image processing operations you wish to have performed on the image of each workpiece is termed "configuring a VIM Module". When you have completed that process, the "configuration" is automatically stored into EEPROM. When stored in EEPROM, this information will be retained if the Module is powered down.

## Configuring A VIM Module to Verify The Presence Of A Workpiece On A Bright Background

The sample workpiece currently being viewed by the camera will be used to introduce you to the process of "configuring" a VIM Module. As you work through this example, you will learn to use the user-interface for tasks such as:

- Selecting swingarm triggering, freezing a window showing the image of the first workpiece that generates a REJECT decision.
- Adjusting the location of the brightness probe and selecting thresholds.
- Adjusting the windows by selecting their geometrical shape, location, and size, then setting the acceptable pixel count "range limits".
- Understanding what types of workpiece flaws will generate a REJECT decision.

Since this may be your first "hands-on" encounter with a vision system, this manual will walk you through each step and explain what is being accomplished by each action you take. When you have completed this example you will be able to configure your Vision Input Module to inspect workpieces that are accurately positioned in front of the camera.

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Fig. 3-12.
Structure of Line Branch

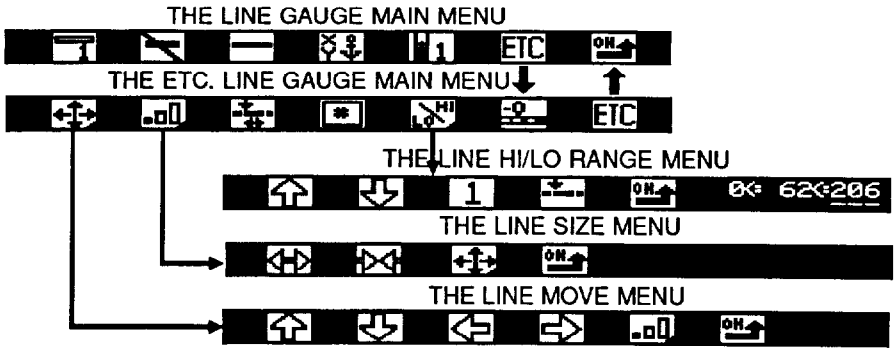
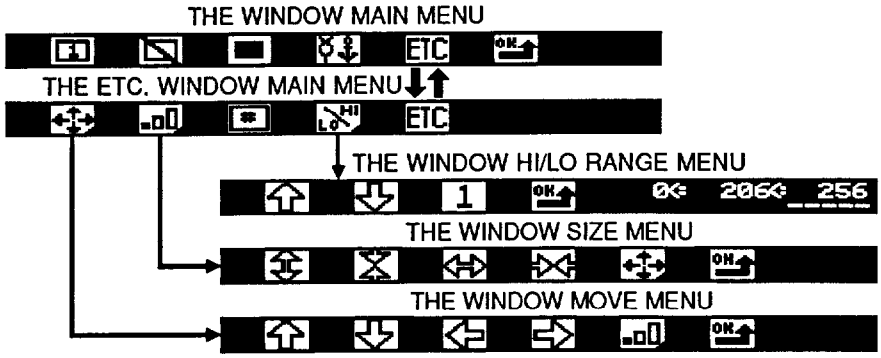



Fig. 3-13.
Structure Of Window Branch

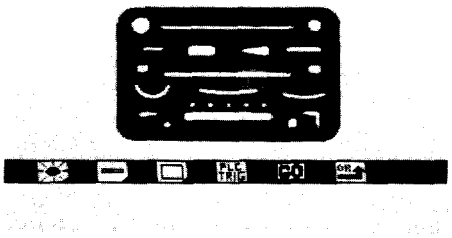



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### Selecting Swingarm Triggering And Freeze On Reject

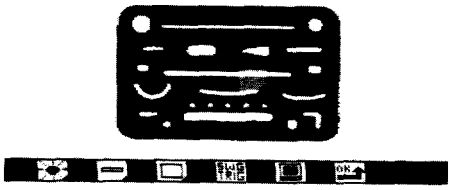
Begin by picking any bright region on the video monitor with the light pen. This action will cause the Main Menu to appear across the lower portion of the screen as shown in Figure 3-14.

Fig. 3-14. Display Showing Thresholded Image With Main Menu



- Now pick PLC TRIG (the fourth icon from the left) to select swingarm triggering ("SWG TRIG").
- Then pick GO (the fifth icon from the left) to select Freeze On Reject.

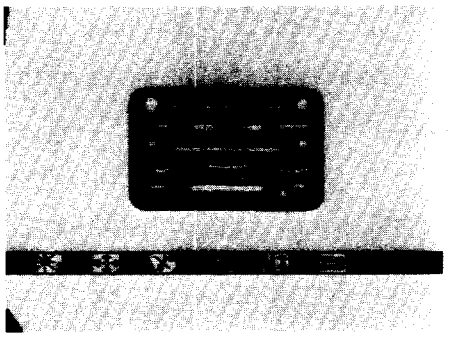
Fig. 3-15. Main Menu Showing Swingarm Triggering and Freeze On Reject



- When this has been successfully performed, the display on the Video Monitor should look like Figure 3-15.

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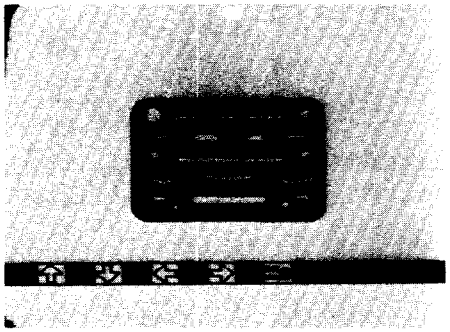
Fig. 3-16.
Brightness Main
Menu



o Now pick  to go to the Brightness Main Menu shown in Figure 3-16. This menu is the one you will use to specify the operation of the Brightness Probe and also to set the four (4) thresholds.

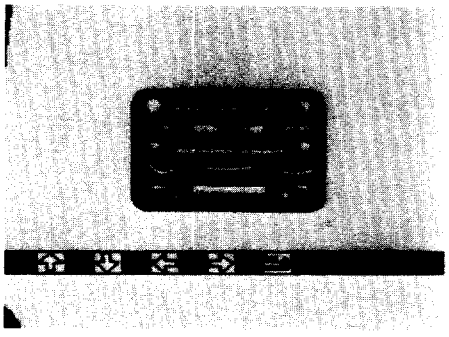
Notice that the lower right corners of the second, third, and fifth icons in this menu are cutoff. This signifies that these particular icons serve as an entry to a sub-menu.

Fig. 3-17.
Brightness Probe
Move Menu



o Pick  to go to the Brightness Probe Move Menu shown in Figure 3-17. You will use this menu to position the Brightness Probe where you would like it to be on the image.

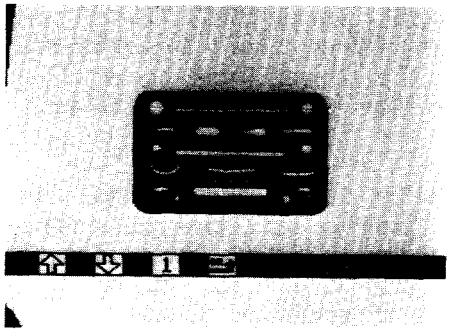
Fig. 3-18.
Brightness Probe
Moved To Upper-
Left Of Image



o Next use  and  icons to move the Brightness Probe (the bright square at the center of the screen) to the upper-left of the screen. When this is complete, the display on the Video Monitor should look like Figure 3-18. (Make sure that the switch on the front panel of the Video Monitor is set to UNDERSCAN. This allows you to see all the way to the edges of the picture.)

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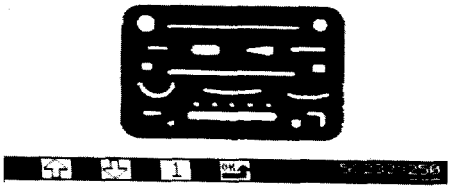
Fig. 3-19.
Brightness Probe
HiLo Range Menu



- Now pick  to return to the Brightness Menu which was already shown in Figure 3-16.

- Then pick  to obtain the Brightness Probe HiLo Range Menu shown in Figure 3-19. You use this menu to specify the upper and lower limits of acceptable illumination. The initial low limit is "0" (no light), while the initial high limit is 255. (A "255" is the value the brightness probe will read when the image is very bright.) The number between the inequality signs (a "233" in our case) is the present reading of the Brightness Probe. Note, your readings may vary slightly from this number. The underline appearing beneath the left-most number (a zero in this case) signifies that picking the  and  icons will change the low range limit. The number "1" which appears in the third icon signifies that each pick of the light pen will increment or decrement that limit by 1.

Fig. 3-20.
Display After
Brightness Probe
Limits Are Set



- Now pick  five (5) times to raise the low range limit from 0 to a value of 5. Then pick a bright place on the number ("255") appearing on the extreme right to switch to controlling the high range limit. Now pick  the icon five (5) times to decrease the high range limit from 255 to 250. After the range limits have been correctly set, the display should look like Figure 3-20. Should the camera lose power or fail, the low limit of 5 on the Brightness Probe "reading" will cause the ACQ ERROR LED to be lighted. Similarly, if too much light reaches the camera and causes it to bloom, the high limit of 250 will also light the ACQ ERROR LED. In the future, you may find it helpful to return to this menu and use the Brightness Probe to numerically examine the effects of different lighting or the relative contrast between different regions on a workpiece. As you exit this menu, the reading of the Brightness Probe is "latched" as the "nominal brightness value" for use as a reference.

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IMPORTANT: When using lighting compensation, make sure your illumination is normal before leaving. If you intend to use "Floating Thresholds", do not exit from the Brightness Probe HiLo Menu. This is necessary to enable the proper compensation for lighting changes.

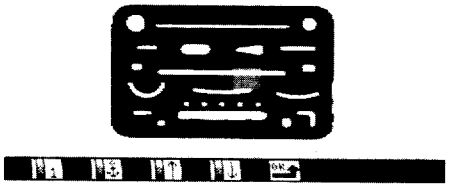
As you exit from the HiLo Range Menu, the last "reading" is "latched" to serve as the reference value or "nominal" brightness of the image. Compensations will be made whenever the probe reads brighter or darker than this reference level.

o Now pick  to return to the Brightness Branch menu which was shown previously in Figure 3-16.

Setting Thresholds

As mentioned earlier, the module contains four (4) independent thresholds so that as many as four different levels of contrast in the camera image can be analyzed simultaneously. In the current example, you will only employ the first two (2) thresholds.

Fig. 3-21. Threshold Setting Menu

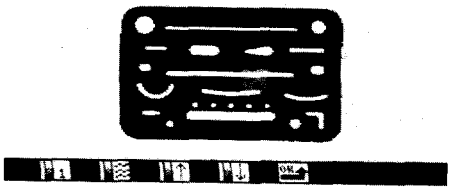


o Pick  icon to obtain the Threshold Setting menu shown in Figure 3-21. You will use this menu whenever you specify a threshold. The numeral 1 appearing in the left-most icon signifies that any selections you make at this time will be only for Threshold 1.

o Picking (and holding the light pen against)  will cause the amount of white in the image to begin increasing (i.e., it lowers this threshold), while picking (and holding)  will cause the amount of black in the image to begin increasing. When the threshold reaches a very low value, the image will appear totally white. Similarly, when the threshold reaches a very high value, the image will appear totally black. If the threshold value is already at its lower (upper) limit and you try to decrease (increase) it, the icon will simply flash in and out of reverse video signifying that no further change is available in that direction. The operation of selecting a threshold is one that will become very familiar to you. It is at this point that quantitative meaning is given to the phrase

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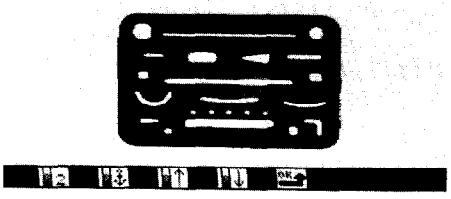
Fig. 3-22. Threshold Setting Menu After Floating Threshold 1



"significant contrast between the region of interest and the surrounding areas of the workpiece". The silver paper provides a high contrast to the sample workpiece. Manipulate these two icons until you are satisfied that the left edge of the workpiece, as well as the round hole in the upper-left of the sample workpiece, is clearly defined.

o Now pick  to specify that this threshold is to be adjusted ("floated") in the same proportion that the readings from the brightness probe increase or decrease from the nominal value. Figure 3-22 shows the Threshold Setting Menu after Threshold 1 has been correctly set and floated.

Fig. 3-23. Threshold Setting Menu For Threshold 2

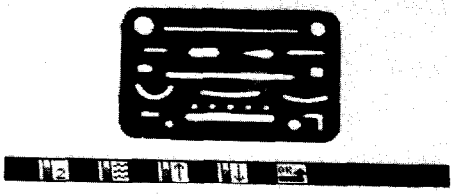


o Now pick  (left-most icon) to obtain the Threshold Setting Menu for Threshold 2 as shown in Figure 3-23. The numeral "2" now appearing in the left-most icon signifies that any selections you make at this time will be only for Threshold 2.

o Again manipulate the  and  icons until you are satisfied that the round hole in the upper-left of the sample workpiece, as well as the left edge of the workpiece, are clearly defined.

o Now pick  to specify that this threshold is to be "floated". Figure 3-24 shows how the Threshold Setting Menu will appear after Threshhold 2 has been correctly set and floated.

Fig. 3-24. Threshold Setting Menu After Floating Threshold 2



o Now pick  to return to the Brightness Main Menu which was shown previously in Figure 3-16.

o Having completed the setting of Threshold 1 and Threshold 2, you now pick  to return to the Main Menu as it was shown previously in Figure 3-10.

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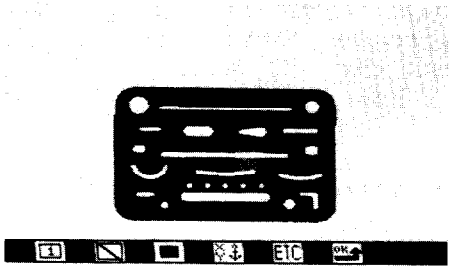
## Adjusting The Windows

The VIM Module has four (4) windows. Since Window 1 uses the image obtained by Threshold 1, while Window 2 uses the image obtained by Threshold 2, each window works independently. In our example, we will only employ the first two (2) windows.

## Enabling And Selecting Window 1

o Pick  (third icon from the left on the Main Menu) to obtain the Window Main Menu shown in Figure 3-25. The numeral "2" which appears in the left-most icon signifies that any selections you make at this time will be just for Window 2. The large slash across the second icon indicates that this window is disabled. The other icons on this menu will not respond to the light pen until the window is enabled. Pick the window number icon until window 1 appears.

Fig. 3-25.
Window Main Menu



## Selecting Window Shape

o Pick  to enable Window 1 (note that the slash mark is now gone).

Several geometrical shapes are available for the windows. The bright rectangle in the center represents the present shape, location and size of Window 1. This pictorial representation will always match exactly what the window is analyzing. The rectangle which presently appears in the third icon from the left indicates that Window 1 currently has a rectangular shape.

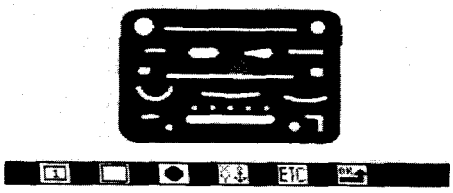
o Pick  to change Window 1 from a rectangle to a right triangle. Notice how the bright region on the screen also becomes triangular in shape.

o Now pick  to change the orientation of the triangle.

o Then pick  to change the orientation of the triangle again.

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Fig. 3-26.
Window 1 Is Now
Circular



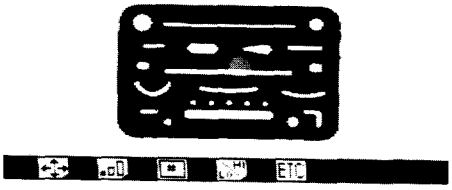

o Then pick  to change the triangle shape to the last triangular orientation.

o Now pick  to change Window 1 from a right triangle into a circular shape. This is signified both by the dark circle appearing in the icon and by the fact that the bright region on the screen which represents the window is circular. Figure 3-26 shows the Window Main Menu after a circular shape has been selected for Window 1.

Positioning
Window 1

The Window Main Menu actually has two parts. The second icon from the right (the "ETC" icon) is used to toggle back and forth between the two parts of this menu.

Fig. 3-27.
Part 2 of Window
Main Menu



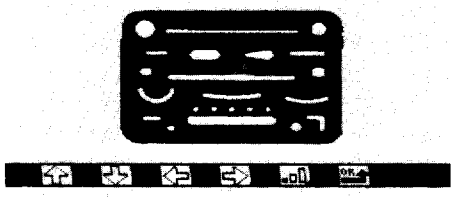

o Now pick  to obtain Part 2 of the Window Main Menu as shown in Figure 3-27.

The # symbol that appears against a white background in the third icon signifies that white areas are to be counted in Window 1. Picking that icon will cause the count to toggle to reading the black area in this window (in which case the # symbol in this icon will appear against a black background). Since the hole we wish to detect is white, you want to measure the white areas in Window 1. The first icon serves as an entry to the Window Move Menu.

o Pick  to obtain the Window Move Menu shown in Figure 3-28.

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Fig. 3-28.
Window Move Menu



Now use the four "arrow" icons,



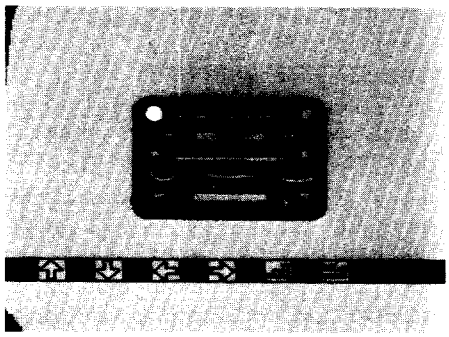
to move the bright shape representing Window 1 so it is centered on the round hole at the upper-left of the workpiece. Note: Picking an "arrow" once moves the window exactly one pixel, holding the light pen down on an arrow icon will rapidly move the window. Figure 3-29 shows how the Window Move Menu should look after Window 1 has been correctly positioned.

o Pick  to return to Part 2 of the Window Branch Menu which was shown previously in Figure 3-27.

Size Window
Window No. 1

The second icon serves as an entry to the Window Size Menu.

Fig. 3-29.
Window 1 Has
Been Correctly
Positioned



o Pick  to obtain the Window Size Menu shown in Figure 3-30. The first and second icons are used to change the height of the window. The third and fourth icons are used to change the width of the window. Since the height of a circle is the same as its width, in this particular case both sets of icons behave the same.

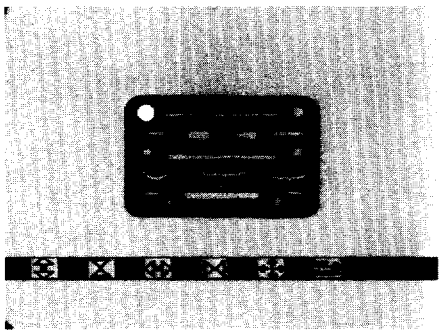
o Pick  three (3) times to decrease the radius of Window 1 so that it is the largest circular shape which fits inside the hole on the upper-left of the workpiece.

Note, you may find it necessary to slightly adjust the location of Window 1. If so, that can be done as follows:

(a) Pick  to transfer directly to the Window Move Menu that was shown in Figure 3-28.

(b) Then use the "arrow" icons on that menu to adjust the position of the window.

Fig. 3-30.
Window Size Menu



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Note that this window has been set up to detect holes too small or not punched correctly. It will not detect oversized holes. The next window will demonstrate how to verify both "too large and to small" holes.

Fig. 3-31.
Window 1 Has
Been Positioned
And Sized

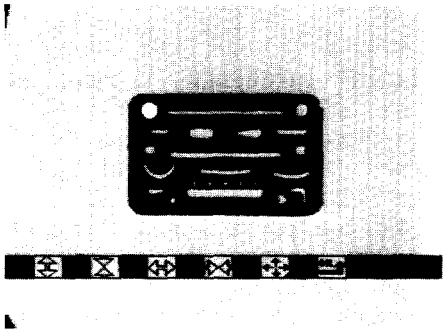


Figure 3-31 shows how the Window Size Menu will appear after Window 1 has been correctly positioned and sized.

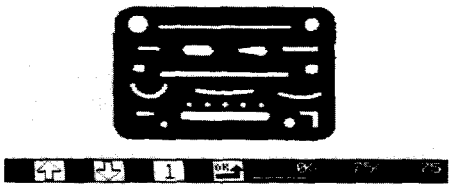
o Pick 

to return to Part 2 of the Window Main Menu as shown in Figure 3-27.

Setting HiLo
Range Limits
For Window 1

Having selected a circular shape for Window 1 and correctly positioned and sized it, we must now set the corresponding low and high range limits. The fourth icon serves as an entry to the HiLo Range Menu.

Fig. 3-32.
HiLo Range Menu



o Pick 

to obtain the HiLo Range Menu shown in Figure 3-32. The number appearing on the extreme right (in our case "75") is the high range limit. Note, if your high range number is different than "75", you must return to the Window Size Menu and make it the proper size. The Module constrains the high range limit so that it can't be larger than the total area of the window or smaller than the low range limit. The number appearing between the inequality signs is the reading for Window 1. In our case, this should be the same as the high range limit. The number appearing on the left is the low range limit. An underline appearing beneath a range limit signifies that it is this limit which can be changed. Picking the third icon will change from increments of "1" to increments of "10".

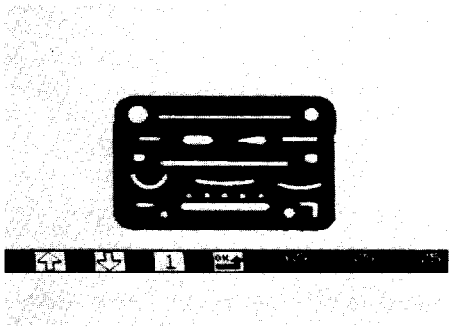
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o Pick [1] to obtain increments of "10".

o Now pick [↑] several times to change the low range limit to the value "60".

o Next pick [10] several times to obtain increments of 1 again.

Fig. 3-33. Window 1 HiLo Range Limits Have Been Set



o Now pick the [↑] icon several times to change the low range limit from the value "60" to the value "65". Figure 3-33 shows the HiLo Range Menu when the range limits for Window 1 have been correctly set. We expect this window to contain only white pixels. However, we chose a low range limit that is ten below the high range limit so that normal variations in the image or slight mispositioning of the workpiece, will not result in a REJECT decision.

o Now pick [OK] to return to Part 2 of the Window Main Menu as was shown in Figure 3-27.

o Then pick the "ETC" icon to obtain the Window Main Menu as shown previously in Figure 3-26.

Window 2 will now be adjusted in a similar manner. However, the size of Window 2 will be chosen so that both the interior of the hole in the sample workpiece and some of the surrounding workpiece is included.

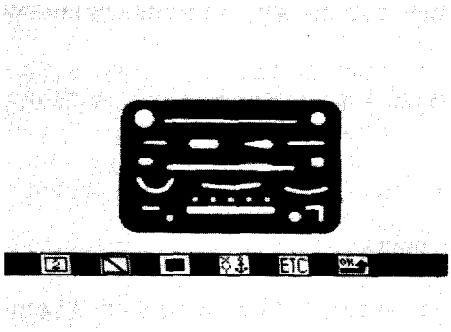
The HiLo limits will be used to verify that both the hole and the surrounding workpiece are present.

Enabling and Selecting Window 2

o Pick [1] to change from adjusting Window 1 to adjusting Window 2. The Window Main Menu will now appear as shown in Figure 3-34. The numeral "2" appearing in the first icon signifies that any selections you make at this time will apply only to Window 2.

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Fig. 3-34.
Window Main Menu,
Window 2 Is Being
Adjusted



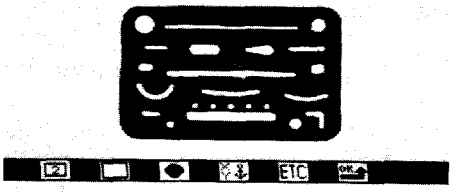
- Pick  to enable Window 2

  (note that the slash mark has now vanished.)

- To change the geometrical shape of Window 2 from rectangular to circular shaped pick the third icon from the left until you see a darkened circular shape. Note that the bright region on the screen which represents the window is now circular also. Figure 3-35 shows the Window Main Menu after Window 2 has been enabled and a circular shape has been selected.

- Pick the "ETC" icon to obtain Part 2 of Window Main Menu as shown in Figure 3-36.

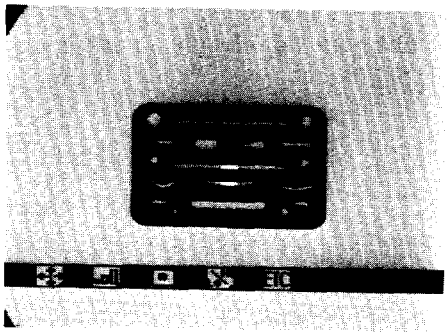
Fig. 3-35.
Window 2 Has Been
Enabled And A
Circular Shape
Selected



- Pick  to obtain the Window Move Menu, and use the "arrow" icons to center the bright shape representing Window 2 over the round hole in the upper-left corner of the sample workpiece. After Window 2 has been correctly positioned, the Window Move Menu should look like Figure 3-37.

- Pick  to return to Part 2 of the Window Main Menu as shown previously in Figure 3-36.

Fig. 3-36.
Part 2 of Window
Main Menu



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Size Window 2

Fig. 3-37.
Window 2 Has
Been Positioned

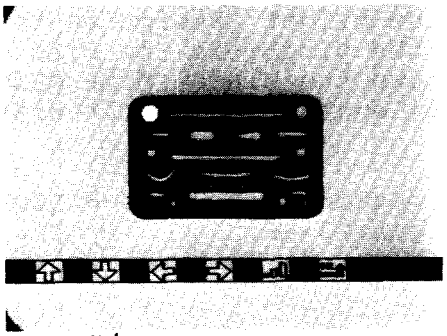


Fig. 3-38.
Window 2 Has
Been Correctly
Sized

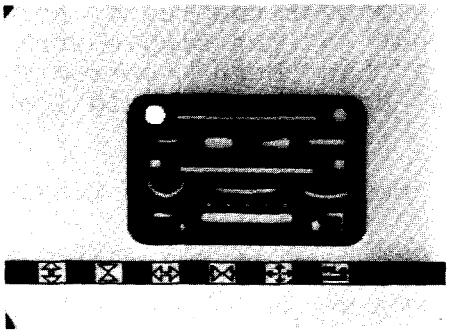
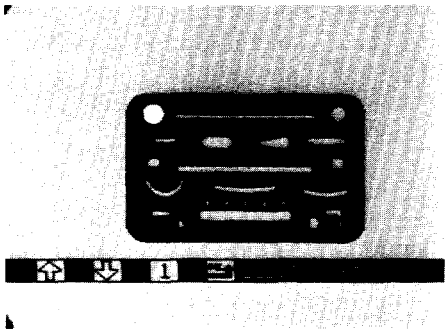


Fig. 3-39.
HiLo Range Menu
With Initial
Limits



o Now pick  to obtain the Window Size Menu. If necessary, pick either the  or the  icon so that the circular shaped window is slightly larger than the hole in the workpiece. Figure 3-38 shows the Window Size Menu after Window 2 has been correctly sized.

o Pick  to return to Part 2 of the Window Main Menu as in Figure 3-36.

Having selected a circular shape for Window 2 and correctly positioned and sized it, we must now set the low and high range limits.

o Pick  to obtain the HiLo Range Menu as shown in Figure 3-39. Note that since the size of Window 2 was chosen to be larger than the hole in the workpiece, the actual number of white pixels ("114") contained in this window is somewhat less than the maximum possible (in our case "165").

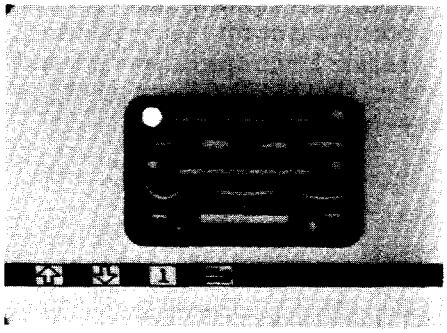
o Pick  to change to increments of 10. Then pick the  icon several times to obtain a low range limit of 100. Now pick the number appearing on the far right of the menu (in our case "165") to move the underline beneath it so the high range limit can be adjusted. Then pick the  icon several times to obtain high range limit of "125".

o Pick  several times to change back to increments of 1.

o Now pick the  to obtain a high range limit of "124" pixels.

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Fig. 3-40.
Range Limits For
Window 2 Have
Been Correctly Set



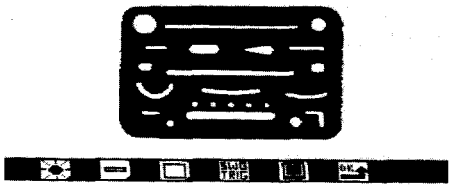
- Next pick the number "100" to move the underline beneath the low range limit. Now pick the  icon several times to obtain a low range limit of "104" pixels. After the range limits for Window 2 have been correctly set, the HiLo Range Menu will appear as shown in Figure 3-40.

- Pick  to return to Part 2 of the Window Main Menu as shown in Figure 3-36.

- Now pick the "ETC" icon to return to the Window Main Menu as shown in Figure 3-35.

- Finally, pick the  icon to return to the Main Menu as shown in Figure 3-41.

Fig. 3-41.
Main Menu After
Configuring The
VIM Module

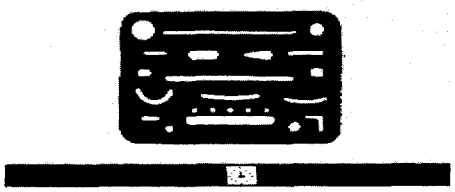


Having selected swingarm triggering, adjusted the Brightness Probe, set Thresholds 1 and 2, and adjusted Window 1 and Window 2, we would like the Module to retain this information in the event it is powered down.

- Pick  on the Main Menu to command the VIM Module to store its present "configuration" in EEPROM. Note that a "clock" icon (see Figure 3-42) is displayed while the configuration is being stored. This storing operation takes about four (4) seconds.

After the configuration has been stored, the menu strip will vanish from the Video Monitor (see Figure 3-43) and the "BUSY" LED will go off. The Module is now ready to go to work.

Fig. 3-42.
Clock Icon
Displayed While
Storing "Con-
figuration"

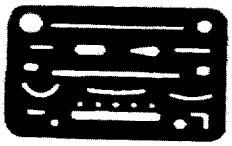


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Inspecting The Sample Workpiece

To command the Module to inspect the sample workpiece, press the push button switch connected to the swingarm. Pressing this button causes both the "TRIG" LED and the "BUSY" LED to turn on. Both of these LEDs will go off as soon as the push button is released. Each time the push button is pressed, a single picture from the camera is processed and the corresponding ACCEPT or REJECT decision is made. This is called an "Inspection Cycle".

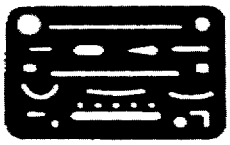
Fig. 3-43. Display After Storing Of Configuration Is Complete



Freeze On Reject Operation

Place your hand carefully in front of the camera above the sample workpiece so that it shadows the hole in the upper-left corner without interfering with the Brightness Probe. Now press the push button switch. The "TRIG" and "BUSY" LEDs will behave exactly as before. However, when the button is released, the "DECISION" LED will light; i.e., based upon what the camera saw, this particular workpiece should be rejected.

Fig. 3-44. Rejected Image Frozed On Video Monitor



Removing your hand and then pressing the push button again will result in the "DECISION" LED being turned off; i.e., this time the inspection decision is to ACCEPT the workpiece. The Module will inspect the workpiece afresh each time the push button is pressed. However, because we selected the Freeze On Reject Mode, when a REJECT decision gets generated, the display on the Video Monitor is frozen (see Figure 3-44).

Manual intervention is required to restore the video monitor to a live image. Pick the screen anywhere to return to "live".

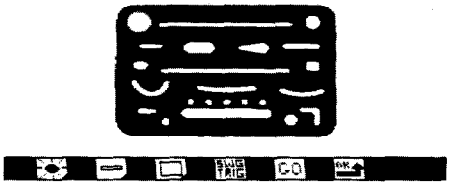
- Then pick the screen twice to go to the Main Menu. (Note that the "BUSY" LED is now on since the VIM module is not able to respond to TRIGGER commands.) If we wanted to continue in the Freeze On Reject mode, we would pick the "OK" icon which would resave the configuration and turn out the "BUSY" LED.

Go On Reject Operation

At this point; however, it is best to change to Go On Reject mode.

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Fig. 3-45.
"Go On Reject"
Has Been Selected



o Pick  and then pick the  icon.

Figure 3-45 shows the Main Menu after selecting the "Go On Reject" Mode.

o Now pick  to save the new configuration.

The clock icon reappears indicating that the configuration is being stored. When this operation is completed, the clock icon vanishes and the "BUSY" LED goes off.

Now press the push button to inspect the workpiece. The "TRIG" and "BUSY" LEDs will behave exactly as they did in the previous mode. Again, place your hand between the camera and the sample workpiece and press the button. The "DECISION" LED will come on; i.e., based upon this image, a REJECT decision was generated. This state of the "DECISION" signal from each inspection is retained until the Module completes another inspection. Removing your hand from the camera's view and pressing the button will generate an ACCEPT decision and cause the "DECISION" LED to go off.

Workpiece Flaws Which Will Cause A "Reject" Decision

A small piece of white paper placed on top of the sample workpiece can be used to simulate various types of flaws. Placing white paper over the upper-left corner of the sample workpiece will make it appear that the corner of the workpiece is missing (see Figure 3-46). Pressing the button while the paper is in place will result in the "DECISION" LED being lit (i.e., a REJECT decision). After the paper is removed, pressing the button will result in the "DECISION" LED going off (i.e., an ACCEPT decision).

Fig. 3-46.
Workpiece With Missing Upper-Left Corner



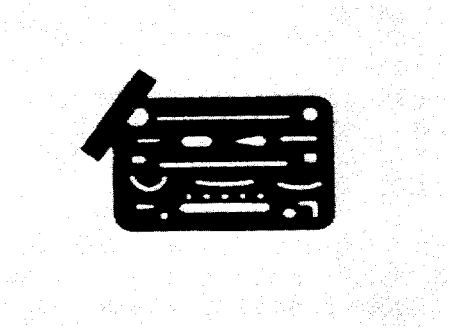
Placing a thin strip of black paper over the upper-left corner of the sample workpiece will make it appear that the hole in the sample workpiece was improperly punched (see Figure 3-47). Images like this will also cause a REJECT decision.

Placing a round-shaped piece of white paper that is slightly larger than the hole directly over the hole will make it appear that the hole was punched oversize (see Figure 3-48). Images like this will also cause a REJECT decision.

Removing the round-shaped piece of white paper and blackening all but a center region then placing the paper directly over the hole will make it appear that the hole was punched undersized (see Figure 3-49). Images like this will also cause a REJECT decision.

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Fig. 3-47.
Workpiece With
Improperly
Punched Hole



Now remove the white paper so that an ACCEPT decision is generated when the push button is pressed.

## Controlling The VIM Module From A PLC

Up to this point, you have always commanded the VIM Module from the light pen or from the swingarm pushbutton. To the PLC, the VIM Module is simply a module to which the PLC's Ladder Logic can command any of eight (8) discrete bits, or from which the Ladder Logic can read any of eight (8) discrete bits.

Fig. 3-48.
Workpeice with
Oversized Hole

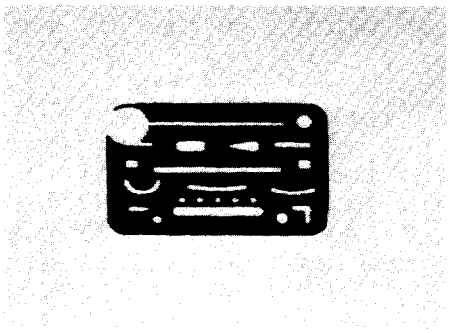


Figure 3-50 shows the functions of the discete bits output from the PLC to a VIM Module. In this session two of these discrete output bits are of interest to us; UNLOCK (discrete bit 10) and TRIGGER (discrete bit 15).

---

IMPORTANT: To allow configuration of a VIM module when a PLC is in the 1771 I/O Rack, the UNLOCK bit must be set to 1. Failure to set the UNLOCK bit will prevent you from using the light pen to configure the Module.

---

Fig. 3-49.
Workpiece With
Undersized Hole

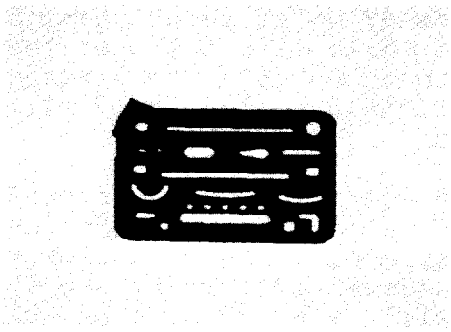


Figure 3-51 shows the functions of the discrete bits to the PLC from a VIM Module. Input Bit Address 12 will be a 1 when the VIM Module is busy. This will occur when either the VIM Module is being configured or the VIM Module is still processing an image in response to TRIGGER command. After the PLC outputs a TRIGGER command to the VIM Module, BUSY should be examined for a 0. When BUSY becomes 0, the inspection decision is available.

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Fig. 3-50.
Command Bits Output From PLC To VIM Module

| OUTPUT BIT ADDRESS | FUNCTION |
|---|---|
| 10 | Unlock (0 = Lock the Module/Disable Progrmg., 1 = Unlock/Enable Progrmg.) |
| 11 | Reserved for Future Expansion |
| 12 | Reserved for Future Expansion |
| 13 | Reserved for Future Expansion |
| 14 | Reserved for Future Expansion |
| 15 | Trigger (0 = Stand By, 1 = Initiate an Inspection Cycle) |
| 16 | Binary/BCD results (0 = Standard Binary Number Format , 1 = BCD Format) |
| 17 | Save configuration data (0 = Temporary Storage (Fast Mode), 1 = Configure Permanently) |

Fig. 3-51.
Status Bits Input From VIM Module to PLC

| INPUT BIT ADDRESS | FUNCTION |
|---|---|
| 10 | Module Fault (0 = Running OK, 1 = Fault) |
| 11 | Configuration fault (0 = Configuration OK, 1 = EEPROM/CONFIG. invalid) |
| 12 | Module Busy (0 = Ready, 1 = Busy) |
| 13 | Master range alarm (0 = Accept, 1 = Decision Reject) |
| 14 | Probe Error (0 = OK, Normal Operation, 1 = Error, Probe Out of Range) |
| 15 | X/Y float Error (0 = OK, Normal Operation, 1 = Error, Out of Range) |
| 16 | Reserved for Future Expansion |
| 17 | Reserved for Future Expansion |

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The sequence of operations used to place the Module under the control of the PLC are:

(a) Unlock VIM (set Command Bit 10)

(b) Configure VIM (using the light pen)

(c) Select PLC Triggering

(d) Save the configuration in EEPROM

(e) Lock the VIM (reset Command Bit 10)

(f) Proceed with Normal Production Operation.

Summary

In Self-Teach Session 1, you have installed and powered up your VIM Module. You then used the VIM Module to direct analog images from the camera directly to the Video Monitor. After reading an overview of the image processing operations performed by the Module, and an overview of the User Interface, you "configured" your Module to use Windows 1 and 2 to detect the presence of a hole in a sample workpiece. Finally, you used "TRIGGER" signals from a push button to explore the types of flaws this configuration will REJECT.

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# Chapter 4 Self-Teach Session II

**Chapter Objectives**

In this chapter you will learn how to use the X-gauge, Y-gauge and the twenty-two (22) line gauges. After you have completed Self-Teach Session 2, you will be able to configure a VIM Module to successfully perform many of the vision applications which are encountered on production lines.

**Introduction To Self-Teach Session 2**

The inspection of workpieces on a production line should be tolerant of minor mispositioning and modest changes in lighting. Also, given the large numbers of workpieces which pass by during a shift, it is important that the inspection process continue to work well in the face of"insignificant" variations in workpiece appearance and dimensions. The Module allows you to readily generalize the inspection it performs to these needs of your production line.

In this Self-Teach Session you will:

- configure your VIM Module so that it compensates for mispositioning of the workpiece in X and Y directions

- be told how to use representative sample workpieces to select the low and high range limits for a particular "reading"

-learn about "configuration blocks"

**Configuring A VIM Module To Compensate For Workpiece Position**

In Session 1 we walked through the Brightness Branch and the Window Branch of the VIM User Interface. The remaining branch - the Line Branch gives you access to the tools designed to automatically compensate for mispositioning of a workpiece. The X-gauge and the Y-gauge are dedicated to providing "readings" which can, at your option, be used to adjust the location in the image where any or all of the other image processing tools are applied. Building upon the example used in Self-Teach Session 1, we will walk through configuring for position compensation. You will then explore how well position compensation works.

You should begin this working session with your Module configured exactly as you left it at the close of Self-Teach Session 1. Namely,

**Beginning Configuration**

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Main Menu showing:

- Swingarm Triggering ("SWG TRIG")
- Go On Reject as in Figure 3-45.

Brightness Branch showing:

- Brightness probe in the upper-left corner of the image as in Figure 3-18.

- A Low Range Limit of 5 and a High Range Limit of 250 as in Figure 3-20.

Window Branch Showing:

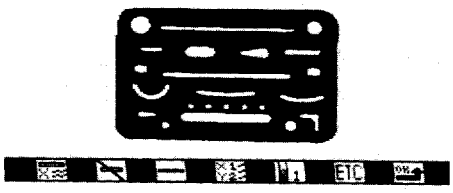
- Window 1 as a circular shape that is centered on and slightly smaller than the round hole in the upper-left of the workpiece.

- A Low Range Limit of "65" and a High Range Limit of "75" as shown in Figure 3-33.

- Window 2 as a circular shape that is centered on and slightly larger than the round hole in the upper-left of the workpiece.

- A Low Range Limit of "104" and a High Range Limit of "124" as shown in Figure 3-40.

Fig. 4-1. Line Main Menu When Adjusting X-Gauge



The sample workpiece should generate an "ACCEPT" decision when the button is pressed.

## Adjusting The X-Gauge And Y-Gauge

Bring up the Main Menu. (Note: If you were using a branch menu or sub-menu, pick the "OK" icon as many times as needed to return to the Main Menu. If you were currently inspecting the sample workpiece, just pick any bright region once to obtain the sign-on banner and then pick again to obtain the Main Menu.)

o Pick  (second icon from the left) to obtain the Line Main Menu as shown in Figure 4-1. The short bright horizontal line in the middle of the screen represents the X-gauge. The fifth icon from the left contains the numeral "1". This indicates that the X-gauge is working with the image obtained using Threshold 1. Until the X-gauge is "enabled", none of the other icons on this menu will respond.

## Enabling The X-Gauge

o Pick  to enable the X-gauge.

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Fig. 4-2.
X-Gauge Enabled

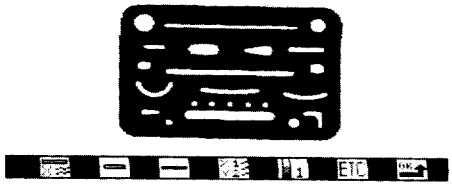


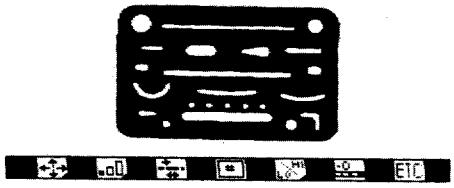
Figure 4-2 shows the Line Main Menu after the X-gauge has been enabled.

Like the Window Main Menu, the Line Main Menu has two (2) parts. When you are in either part of this menu, picking the "ETC" icon will obtain the other part.

o Pick  to obtain part 2 of the Line Main Menu as shown in Figure 4-3.

Selecting X-Gauge Measurement

Fig. 4-3.
Line Main Menu,
Part 2



The X-gauge can work with either white pixels or black pixels. The fourth icon indicates that X-Gauge will analyze white blobs. Since our sample workpiece appears as a black silhouette on a white background, you want the X-gauge to analyze black blobs.

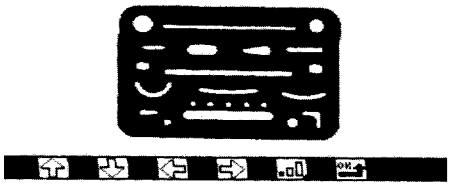
o Pick  so that the X-gauge will toggle to analyzing black blobs. Note how the background of this icon switched from white to black.

o Now pick  to obtain the Line Move Menu as shown in Figure 4-4.

o Then use the four (4) "arrow" icons to move the X-gauge up and to the left so that its right end touches the edge of the sample workpiece as shown in Figure 4-5.

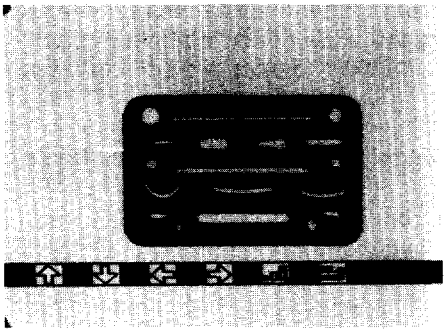
o Pick  to go to the Line Size Menu as shown in Figure 4-6.

Fig. 4-4.
Line Move Menu



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Fig. 4-5.
X-Gauge Has Been Positioned

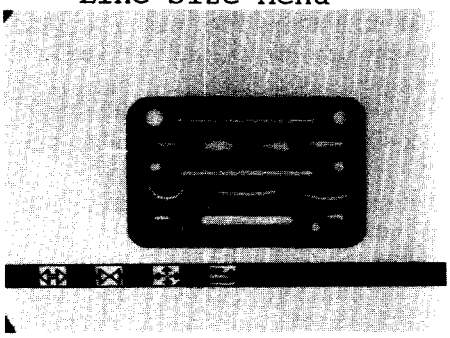


- Pick the  icon and hold it until the X-Gauge extends approximately as far into the workpiece as it extends beyond the workpiece on the left. Note, as you make a horizontal gauge longer or shorter, its left end remains fixed. Figure 4-7 shows the Line Move Menu after the X-gauge has been correctly sized.

- Pick  to return to part 2 of the Line Main Menu.

The size of the X-gauge determines the amount of position variation along the X-axis which can be accommodated. So long as the left edge of the sample workpiece falls somewhere along the X-line gauge, the X-gauge will be able to perform the compensation.

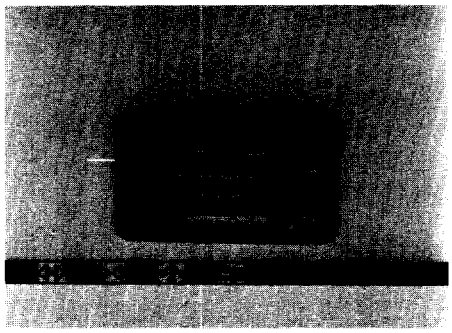
Fig. 4-6.
Line Size Menu



Having positioned the X-gauge on the left edge of the sample workpiece and sized the X-gauge, we now need to set its high and low range limits.

- Pick  to get to the HiLo Range Menu as shown in Figure 4-8. (Look to be sure that the fourth icon in this menu appears as shown in this figure. If it isn't, return to part 2 of the Line Main Menu and make it look like Figure 4-3.) Note that the low range limit and the high range limit are identical. In our case, to find out what the allowable extremes are, you must decrease the low range limit to its minimum value.

Fig. 4-7.
X-Gauge Has Been Sized



- Place the tip of the light pen firmly against  and hold it until that icon begins to blink. The number displayed is the minimum value. Increase it by one to verify that the blob edge is truly detected.

- Pick the number that appears at the extreme right of the screen (in our case an "85") so that the underline moves beneath it signifying that the "arrow" icons now control the high range limit.

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Fig. 4-8.
HiLo Range Menu

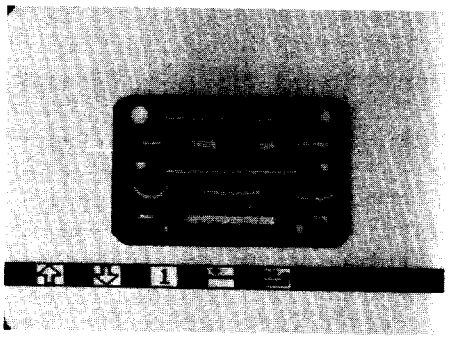


Fig. 4-9.
X-Gauge Range

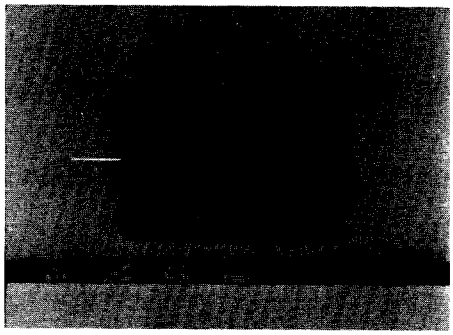
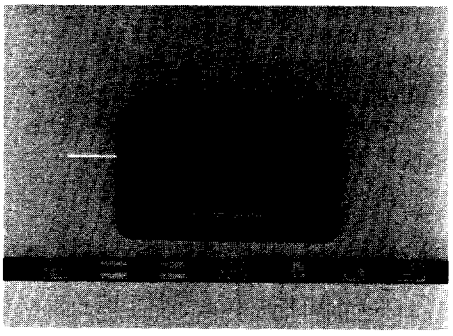


Fig. 4-10.
X-Gauge Has
Been Adjusted



o Now place and hold the tip of the light pen against the  until that icon begins to blink. Then pick the left-most number to move the underline beneath it. Figure 4-9 shows the HiLo Range Menu after the X-gauge range limits have been correctly set. The number which appears between the inequality signs is the "reading" of the X-gauge. As we have set things up, this value is simply the location of the left edge of the workpiece. In our case, the left edge of the workpiece is "63" on a horizontal scale which is "0" at the left border of the image and "255" at the right border.

As you exit from the HiLo Range Menu, the most recent "reading" is "latched" to serve as the reference value or "nominal X-position" of the workpiece. Compensation will be made whenever the readings are to the left or right of this reference position.

---

IMPORTANT: When using X-Y Position Compensation, make sure that the workpiece is in its "normal" position before exiting the HiLo Range Menu. This is necessary to enable the proper compensation for positional variances.

---

Note that you may also set the HI/LO range limits for the blob width measurement. Even when one of the measurements is not used both are always performed.

o Pick 

to return to part 2 of the Line Main Menu. Then pick the "ETC" icon to return to the Line Main Menu. Figure 4-10 shows the Line Main Menu after the X-gauge has been correctly adjusted.

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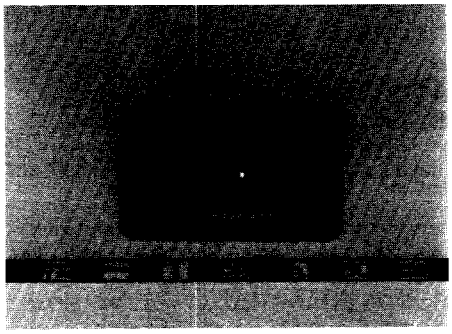
## Adjusting The Y-Gauge

Having enabled, moved, sized, and established the nominal value for the X-gauge so that its "readings" correspond to the left edge of the sample workpiece, we wish to adjust the Y-gauge so that it will behave similarly.

- o Pick  (the leftmost icon) to obtain the Line Main Menu for the Y-Gauge. The short bright vertical line appearing at the center of the screen is the Y-gauge. The numeral "1" which appears in the fourth icon from the left, signifies that the Y-gauge will be working with the image obtained using Threshold 1. (Note, if we wanted this gauge to work with Threshold 2, we would simply pick that icon and the numeral "2" would replace this "1").

- o Pick  to enable the Y-gauge as shown in Figure 4-11.

Fig. 4-11. Line Main Menu When Adjusting The Y-Gauge



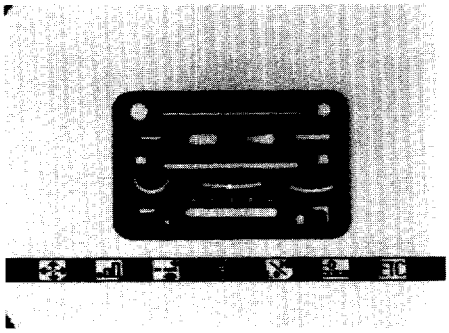
None of the other icons on the menu will respond until the gauge is enabled.

- o Pick ETC to obtain part 2 of the Line Main Menu.

- o Pick the  icon to toggle the Y-gauge from analyzing white blobs to black blobs.

- o Now pick the third icon from the left (this icon initially appears as ) several times. Each time you pick this location, the icon will change such that the small arrowhead in the upper-half will appear in a new location. As you pick this icon repeatedly, seven (7) different patterns are displayed. Figure 4-12 shows how Part 2 of the Line Main Menu will appear after the "trailing edge of the lowest black blob" has been selected as the Upper Measurement.

Fig. 4-12. Line Main Menu, When Measuring "Trailing Edge Of Lowest Black Blob"



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Fig. 4-13.
Y-Gauge Has Been Positioned

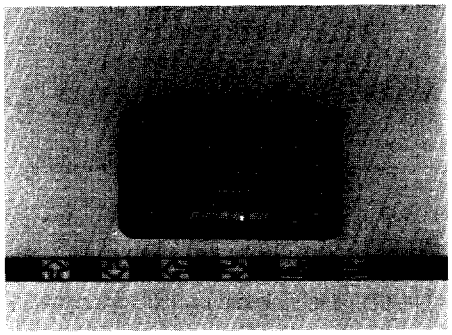
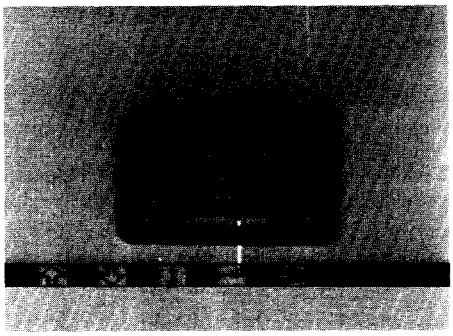


Fig. 4-14.
Y-Gauge HiLo Limits Have Been Set



o Now pick  to obtain the Line Move Menu. Use the four (4) "arrow" icons to move the Y-gauge down so that its bottom end just touches the lower edge of the workpiece as in Figure 4-13.

o Now pick  to transfer directly to the Line Size Menu.

o Pick and hold  until the Y-Gauge extends approximately as far below the sample workpieces as it extends into it. Note, as you make a vertical line gauge longer or shorter its upper end remains fixed.

o Pick the "OK" icon to return to Part 2 of the Line Main Menu as was previously shown in Figure 4-12.

Having positioned the Y-gauge on the lower edge of the sample workpiece and sized the Y-gauge so that it extends equally on and off the workpiece, you now need to set its working range limits.

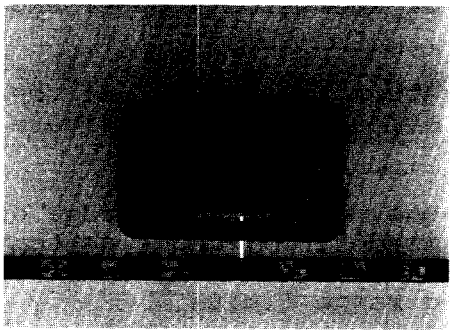
o Pick the  icon to get the HiLo Range Menu. To insure that both the high and low range limits are at their extreme values, pick and hold the  icon until it starts blinking. Now pick the upper range limit to move the underline beneath it. Then pick and hold the  icon until it starts blinking and then decrease it by one. The number between the inequality signs is the "reading" of the Y-gauge. As we have set things up, this value is simply the location of the lower edge (trailing edge of the lowest black blob) of the workpiece. In our case, that edge is at "178" on a vertical scale which is "0" at the top border of the image and "252" at the bottom border of the image. Figure 4-14 shows the HiLo Range Menu after the Y-gauge range limits have been correctly set. The values you get may be slightly different.

As you exit from the HiLo Range Menu, the most recent reading is "latched" to serve as the "nominal Y-position" of the workpiece.

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INFORMATION: When using X-Y position compensation, make sure that the workpiece is in "normal" position before exiting the Y-gauge HiLo Range Menu. This is necessary to latch the proper reference value and enable position compensation.

Fig. 4-15. Line Main Menu Part 2, After Y-Gauge Has Been Adjusted



o Pick OK to return to Part 2 of the Line Main Menu. Figure 4-15 shows Line Main Menu part 2 after the Y-gauge has been correctly adjusted.

o Now pick ETC to return to the Line Main Menu.

o Now pick the "OK" icon to return to the Main Menu.

### Floating The Windows In X and Y

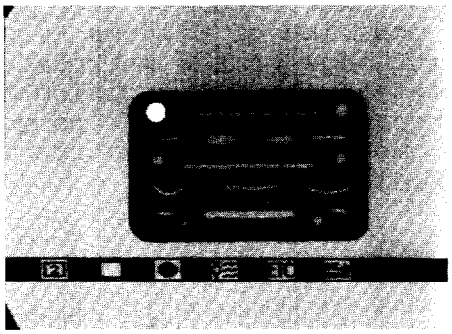
Now that you have enabled the X-gauge and Y-gauge and adjusted them to determine the horizontal and vertical location of the workpiece, you can "float" the locations of Windows 1 and 2. When this is done, the VIM Module will compute the "reading" of the X-gauge and Y-gauge on eachimage, then translate any tools that you have "floated" so that the workpiece appears in its "nominal position". The choice of whether something "floats" or is "anchored" is made by you. Any or all of the windows and any or all of the twenty-two line gauges can be "floated". However, for a given configuration, everything that is floated is based upon the same X-gauge, Y-gauge or X and Y gauge "readings". The Brightness Probe is always anchored; i.e., it does not float in the X and Y directions.

### Floating The Windows

Pick the icon to obtain the Window Branch Menu. Note that a numeral appears inside the first icon. This signifies what window we are controlling. Pick this icon to select window 2. The anchor symbol which currently appears in the right side of the fourth icon signifies that this window is "anchored".

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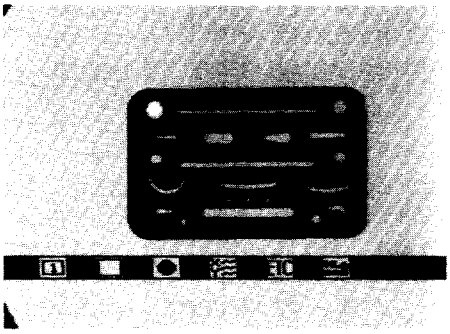
Fig. 4-16. Window 2 Has Been Floated In X and Y



- Pick the  icon to "float" Window 2. Figure 4-16 shows how the Window Main Menu will appear when Window 2 has been floated in X and Y.

Floating Window 1

Fig. 4-17. Window 1 Has Been Floated



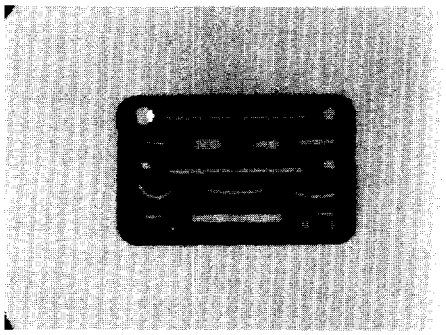
- Pick the first icon several times to obtain a Window Main Menu which has the numeral "1" appearing inside the first icon.
- Then pick  to float Window 1. Figure 4-17 shows how the Window Main Menu should look now.
- Pick the "OK" icon to return to the Main Menu. You have now finished enabling the X-gauge and Y-gauge and "floated" Window 1 and 2.
- Pick the "OK" icon to store the configuration. As soon as the "clock" vanishes, you are ready to test position compensation.

Testing The Position Compensation Setup

Press the button to inspect the workpiece. An ACCEPT decision will be generated. Now draw a faint pencil line along either the top or bottom edge of the sample workpiece to aid you in retaining the workpiece's vertical position. Now carefully slide the workpiece about half the width of the hole towards the left on the screen. Figure 4-18 shows how the video monitor will appear when this has been done.

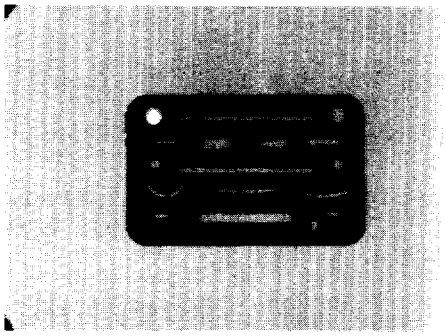
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Fig. 4-18. Workpiece Slid Toward Left On Screen



Press and hold the push button down. Note how the displayed representation of Window 1 shifts to the left on the screen so the sample workpiece appears in its nominal position as shown in Figure 4-19. This shifting is based upon the "reading" from the X-gauge. In effect, the X-position of Windows 1 and 2 have been tied to the left edge of the workpiece. Releasing the button causes an ACCEPT decision to be generated. Also, the representation of Window 1 displayed on the video monitor then reverts to normal as shown in Figure 4-18.

Fig. 4-19. Window 1 As Shifted By Module



Return the sample workpiece to its original location. (Use the pencil line as a guide in the vertical direction and slide the workpiece horizontally until Window 1 is centered in the hole.

For the sake of illustration, slide the sample workpiece about half the width of the hole towards the top of the screen as shown in Figure 4-20. When the button is now pushed, variations in the workpiece position along the Y-axis are compensated for based upon the Y-gauge and variations along the X-axis are compensated for based upon the X-gauge.

Now move the workpiece close to the top of the image as shown in Figure 4-21. Since the lower edge of the sample workpiece no longer falls along the Y-gauge, the workpiece position along the Y-axis will cause an "ACQ ERROR" to be generated as well as a "REJECT" decision. Both LEDs will come on. Now return the workpiece to its original position again.

Fig. 4-20. Workpiece Slid Up On Screen

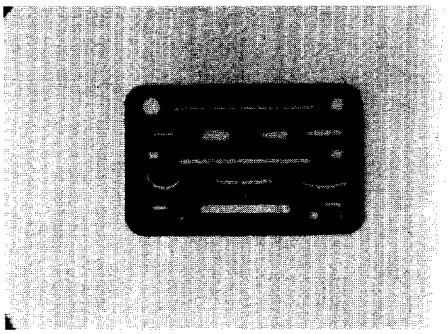


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Chosing Range Limits Based Upon An Ensemble Of Workpieces

Given the large numbers of workpieces which pass through a production line on a daily basis, it is important that the inspection done perform well across "insignificant" variations in workpiece appearance and dimensions. The choice of low an high range limits may, ultimately, have to be made with reference to a representative ensemble of production samples.

Fig. 4-21. Workpiece Slid Off The Y-Gauge



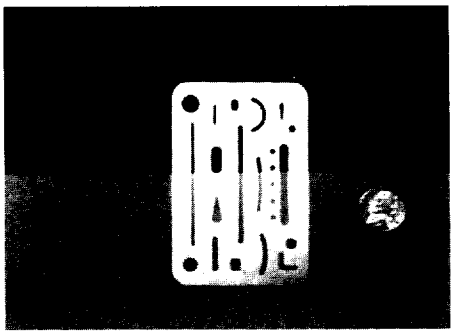
Before configuring a Module to perform a vision application for your own production line, gather several workpieces which you consider to be representative examples of acceptable workpieces; i.e., "known good" and also several more workpieces which provide representative examples of flaws which you want the Module to REJECT (i.e., "known bad").

It is all right to configure your Module using a single "ideal" workpiece, provided that after you have done so, you test using the ensemble of "known good" and "known bad" workpieces. The procedure is as follows. Use the VIM Module to inspect all the "known good" workpieces. Where necessary, go back and slightly loosen (widen) the HiLo Range Limits on Windows and line gauges until all of the workpieces generate ACCEPT decisions. Now inspect all the "known bad" workpieces. Where necessary, tighten (narrow) the Range Limits on Windows and line gauges until all of these workpieces generate REJECT decisions. The Range Limits which will perform best lie somewhere between these two extremes.

Adapting To Frontlighting

You may encounter production line vision applications where it is not feasible to install backlighting or a light background. The same techniques which we applied to a backlighted workpiece can be adapted to situations where the lighting is on the same side as the camera.

Fig. 4-22. Camera Image Obtained Using Front Lighting



Pick a bright area on the top half of the screen four (4) times to select the camera image to the Video Monitor.

Now relocate the workpiece so that the region containing the round hole we have been verifying extends beyond the edge of your worktable. Then open up the f-stop on the lens to f/8 and move the stand until the workpiece is within the camera's field-of-view as shown in Figure 4-22. Note how an object, (in this case a coin) which has approximately the same reflectance as the workpiece has been placed at the same stand-off distance. The sample workpiece now appears bright compared to its background. This will usually be the case whenever the workpiece is in sharp focus while the back-

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ground is further enough away to be out of focus. In some situations, however, you may still need to build a light shield beneath or behind the workpiece to eliminate stray light.

The changes required to adapt the techniques used previously to the situation where the background is dark are largely due to the fact that the workpiece is now bright. Since you just finished working through one example, this section will describe what you want the Module to do. Illustrations of the Video Monitor will be given. A new concept - spatial filtering - will also be covered.

### Adaptations Made Using The Brightness Branch

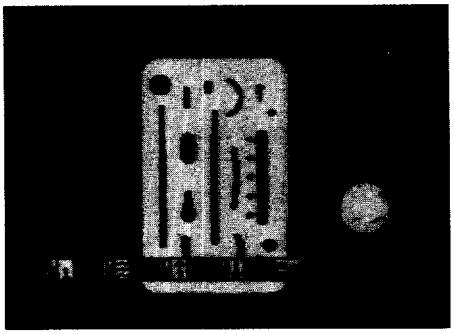
Since the level of contrast between the region of interest and the surrounding background has been changed, we begin our adaptation with the Brightness Branch.

### Setting Thresholds

o Go to the Brightness Main Menu.

- Select the Threshold Setting Menu and adjust Threshold 1 to produce a sharply defined "white" silhouette of the workpiece as shown in Figure 4-23.*

Fig. 4-23. Threshold 1 Has Been Set



- In order to have an easy way to re-establish the previous example, leave Threshold 2 unchanged. (In a moment, we will be disabling Window 2).

- Select and float Threshold 3 then adjust Threshhold 3 to produce a sharply defined silhouette of the sample workpiece as shown in Figure 4-24.

### Adjusting The Brightness Probe

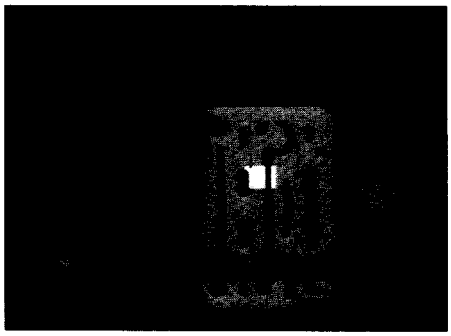
Now return to the Brightness Main Menu.

- Move the brightness probe so that it is located on a bright region which is illuminated by the same light as the workpiece (in our case the coin).

*For the sake of clarity, the photographs used in this section were produced using a black paper backdrop. You may wish to do the same.

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Fig. 4-24.
Threshold 3 Has
Been Set



- Enter the HiLo Range Menu to "latch" the nominal or "reference" brightness value. Figure 4-25 shows how the HiLo Range Menu should apear.

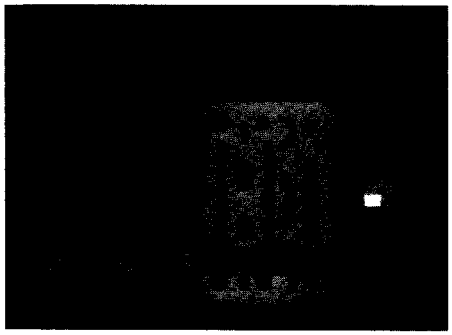
- Then return to the Main Menu.

Adaptations Made
Using The Window
Branch

Having selected new values for Threshold 1 and 3, we will now use the Window Branch to adjust the corresponding Windows.

Obtain the Window Main Menu. Since Threshold 3 was one we most recently adjusted, the Window Main Menu comes up with Window 3 displayed.

Fig. 4-25
Brightness Probe
Position And
Reference Value



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Adjusting Window 3

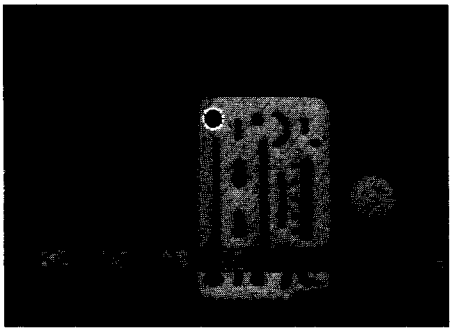
o Use the Window Branch Menu to:

- Enable Window 3.
- Float Window 3 in the X and Y directions.
- Select a circular window.

o Use Part 2 of the Window Branch Menu to:

- Specify that Window 3 measure black areas.
- Move Window 3 so that it is centered over the round hole at the upper left of the workpiece.
- Size Window 3 so that it is only slightly larger than the round hole in the workpiece.
- Enter the HiLo Range Menu and adjust the low and high range limits as shown in Figure 4-26.
- Now return to the Window Main Menu.

Fig. 4-26. Window 3 Has Been Adjusted



Adjusting Window 1

In the previous example, Window 1 was sized to fit completely within the round hole in the sample workpiece. Since the camera stand-off distance hasn't changed, there should be no need to change the size of Window 1.

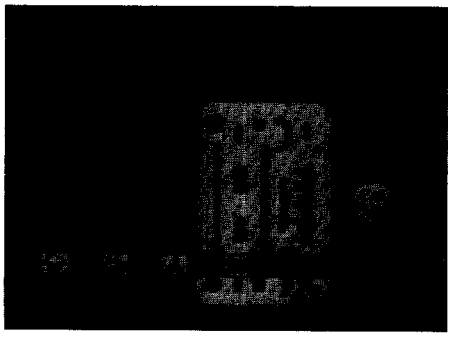
o Obtain the Window Branch Menu in a form that controls Window 1.

o Use Part 2 of the Window Branch to:

- Specify that Window 1 count black pixels
- Move Window 1 so that it is centered in the round hole in the workpiece.

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Fig. 4-27. Window 1 Has Been Adjusted



- Enter the HiLo Range Menu and adjust the low and high range limits as shown in Figure 4-27.

o Now Return to the Window Branch Menu.

Disabling Window

o Select Window 2.

- Disable Window 2. (Notice that the X Y float icon reverts to "anchored" whenever a window is disabled.)

- Now return to the Main Menu.

Adaptations Made Using The Line Branch

In addition to relocating the X-gauge and Y-gauge and specifying that they analyze white "blobs" you must also select the spatial filtering to be employed and the appropriate "measurement pair".

Spatial Filtering Of Line Gauges

When you work with thresholded images, some of the pixels along the edges of the workpiece may flicker from white to black and back again from image to image. The X-gauge and Y-gauge support spatial filtering to compensate for this effect. Filter selection is done using the sixth icon in Line Main Menu Part 2. As shown in Figure 4-28, three filtering options are available. These same spatial filters are also available on the twenty-two line gauges.

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Fig. 4-28.
Filter Selections

| ICON | THE SPATIAL FILTER EMPLOYED |
|---|---|
|  | No filtering |
|  | Single pixel blobs are ignored |
|  | Single and two pixel blobs are ignored |

The level of spatial filtering needed depends primarily upon the quality of the images with which you are working. As a general principle, you should use as little filtering as possible while still obtaining reliable results. In these examples no filtering is necessary on the X-gauge and the Y-gauge because of the high contrast. Images with low contrast may need line filtering, so we will use it in the next example.

Adjusting The Y-Gauge

o Obtain the Line Main Menu.

o Obtain Part 2 of the Line Branch Menu and use it to:

- specify that the Y-gauge is to analyze white blobs

- select filter selection 1 (single pixel blobs are to be ignored.)

Line Gauge Measurements

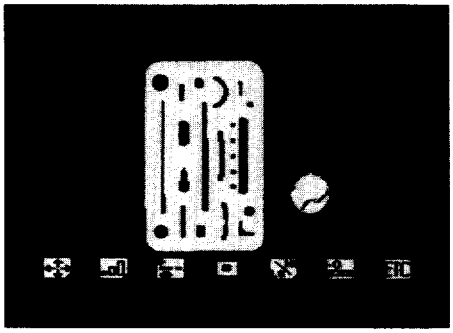
The third icon in Part 2 of the Line Main Menu selects the "measurement pair" for this line gauge. The selection available is shown in Figure 4-29. Each pair is comprised of an upper and lower measurement. Both measurements in this pair are made on every inspection cycle.

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Fig. 4-29.
Measurement Pairs Available With
X-Gauge and Y-Gauge

| ICON | SELECTED FEATURE SET |
|---|---|
|  | (a) Leading edge of largest blob<br>(b) Width of the largest blob |
|  | (a) Trailing edge of the largest blob<br>(b) Width of the largest blob |
|  | (a) Center of the largest blob<br>(b) Width of the largest blob |
|  | (a) Leading edge of the leading blob<br>(b) Width of the leading blob |
|  | (a) Center of the leading blob<br>(b) Width of the leading blob |
|  | (a) Trailing edge of the trailing blob<br>(b) Width of the trailing blob |
|  | (a) Center of the trailing blob<br>(b) Width of the trailing blob |

Fig. 4-30.
Selected Measurement Pair Is Leading Edge and Width Of The First White Blob



- Select as the measurement pair the leading edge and width of the leading blob for the Y-gauge. Figure 4-30 shows Part 2 of the Line Main Menu after this has been done.

- Move the Y-gauge such that half is above the top edge and half of it is on the workpiece.

- Now enter the HiLo Range Menu to set the high and low limits of the Y-gauge. Figure 4-31 shows the HiLo Range Menu after this has been done properly.

o Pick "OK" to return to the Line Main Menu. (This latches the reference position for the Y-gauge.)

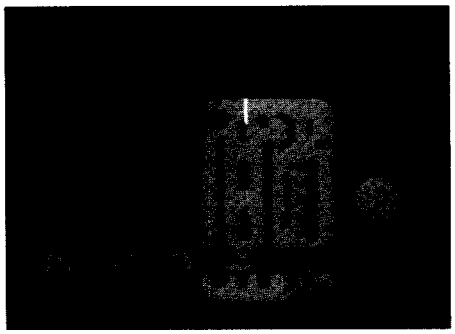
We wish to use the X-gauge to measure the location of the left edge of the workpiece. To return to the X-gauge, you must first cycle through the twenty-two line gauges.

o Pick and firmly hold the first icon until the X-gauge icon appears again.

o Go to Part 2 of the Line Main Menu and use it to:

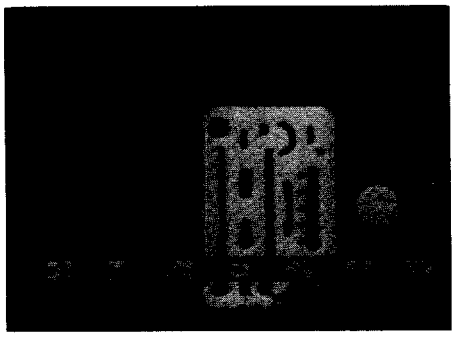
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Fig. 4-31. Y-Gauge Measures Leading Edge Of First White Blob



- specify that the X-gauge analyze white pixels
- select Filter Selection 1 (single pixel blobs are ignored).
- select the measurement pair comprised of the leading edge and width of the first blob. Figure 4-32 shows Part 2 of the Line Main Menu after this has been done.
- move the Y-gauge such that half is off the left edge and half of it is on the wokrpiece.
- now enter the HiLo Range Menu to set the high and low limits of the X-gauge. Figure 4-33 shows the HiLo Range Menu after this has been done properly.
- o Pick "OK" to return to the Main Menu. (This latches the reference position of the X-gauge).
- Save the configuration.

Fig. 4-32. Measurement Pair Includes Leading Edge Of First White Blob



You have now completed configuring your Module to inspect the sample workpiece with front lighting on a dark background.

## Testing

Any and all of the tests which were performed on the previous example can now be performed provided you use black paper in place of white and vice-versa to simulate the flaws.

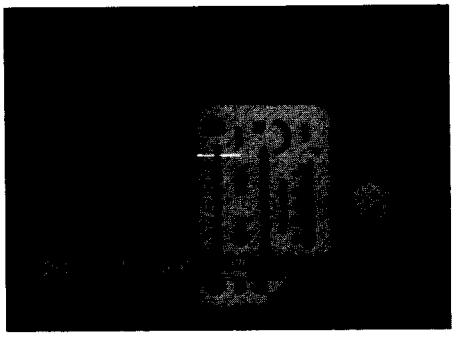
We will now turn our attention to the twenty-two line gauges.

## Controlling The Twenty-Two Line Gauges

All of the Line Gauges are set up using the Line Main Menu. However, at a given time, only a single line gauge can be viewed by this menu. In the previous example, you began by enabling and setting up the X-gauge, then indexed forward to enable and set

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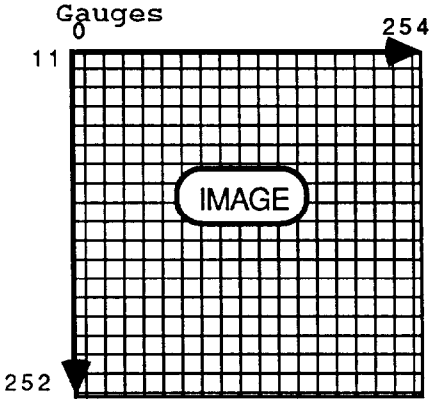
Fig. 4-33.
X-Gauge Measures
Leading Edge Of
First White Blob



up the Y-gauge. Control of the twenty-two (22) Line Gauges is obtained by using the first icon in the Line Branch to index beyond the Y-gauge. These Line Gauges are referred to by number (i.e., Line Gauge 1, Line Gauge 2, ... Line Gauge 22.) Each of them is completely independent in the sense that they are individually enabled. Just as with the X-gauge and Y-gauge, you can select whether a given line gauge is to analyze the image produced by Threshold 1, 2, 3 or 4 and control their location, size and HiLo Range Limits. In a similar manner, all of the measurement pairs shown above for the X-gauge and Y-gauge are available to the twenty-two line gauges.

When measuring the width of a blob, a line gauge's readings are always the number of pixels crossed in going from the start of the blob to the end of the blob.

Fig. 4-34.
Coordinate System
Used By Line
Gauges




When used to measure the position of the edge of a blob, a horizontal line gauge's "reading" is the "column number" i.e., the number of pixels crossed in going from the left border of the image to the "edge" on the workpiece. Similarly, a vertical line gauge's "reading" is the "row number" i.e., the number of pixels crossed in going from the top border of the image to the "edge" on the workpiece. Figure 4-34 illustrates this coordinate system.

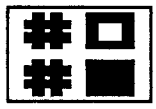
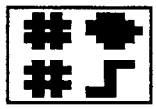
Differences Between X-Gauge, Y-Gauge And The Numbered Line Gauges

For each of the twenty-two line gauges, you can select whether or not you wish them to "float" in X and Y. Each of the twenty-two line gauges is completely general in the sense that you can specify either a horizontal or a vertical line. The twenty-two line gauges also support two (2) additional measurement pairs.

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Figure 4-35 shows the additional measurement pairs available with the numbered line gauges.

Fig. 4-35.
Additional Measurement Pairs Available
With The Numbered Line Gauges

| ICON | SELECTED MEASUREMENT PAIR |
|---|---|
|  | Count the number of white pixels ( upper )<br>Count the number of black pixels ( lower ) |
|  | Count the number of blobs (upper )<br>Count the number of edges (lower ) |

**Counting Blobs With A Line Gauge**

o Use the first icon on the Line Main Menu to index to Line Gauge 1.

- After enabling Line Gauge 1, use the third icon to toggle from a horizontal line to a vertical line. (Note, how the third icon changes appropriately.)

- Use the fifth icon (which currently has the numeral "1" appearing inside it) to select the image obtained using Threshold 3 for analysis by this line gauge. Figure 4-36 shows the Line Main Menu after this has been done.

Fig. 4-36.
Line Gauge No. 1
Is Vertical And
Uses Image 3



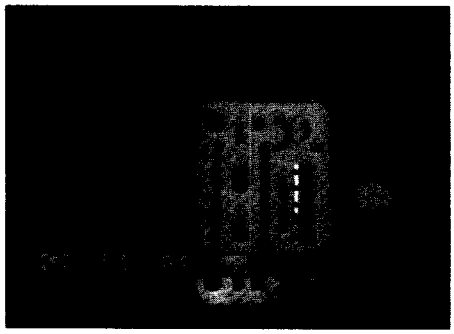
o Obtain Part 2 of the Line Main Menu.

- Use the Line Move Menu in conjunction with the Line Size Menu to adjust Line Gauge 1 so that it cuts across three (3) of the small holes in the sample workpiece.

- Use the fourth icon to select the analysis of black blobs.

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Fig. 4-37.
Selected Measurement
Pair For Line Gauge 1

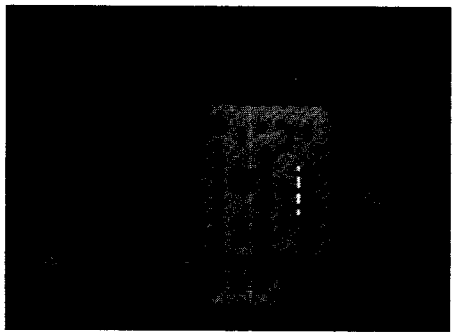


- Now use the third icon to select the measurement pair comprised of count the number of blobs, and count the number of edges. Figure 4-37 shows part 2 of the Line Main Menu after this has been done correctly.

- Obtain the HiLo Range Menu as shown in Figure 4-38. The "upper" measurement (count number of blobs) is being displayed. The reading of "3" is just the number of black blobs on the Line gauge.

- Use the fourth icon in the menu to toggle to the "lower" measurement (count number of edges) as shown in Figure 4-39. The reading of "10" is the number of transitions on the Line gauge.

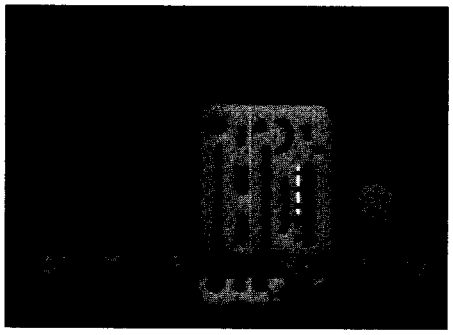
Fig. 4-38.
Line Gauge 1
Counts Black
Blobs



Return to part 2 of the Line Main Menu and set up a Line gauge 1 to count the number of white pixels along its length or to count the number of black pixels along its length.

All of these measurement pairs behave like the Line gauge functions which you tested earlier. The exploration of these functions is left for the interested reader.

Fig. 4-39.
Line Gauge No. 1
Counts Edges



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Block Transfer Of The VIM Module Configuration To A PLC

The information set up in the VIM Module during the process of configuring it is stored in EEPROM within the module. This information can be copied via block transfers, into the PLC for archiving. Then, at a later date, it may be transferred back to the Module.

The VIM Module uses three (3) "blocks" of different lengths to hold its configuration. Configuration Block 1 is thirty (30) words long and contains all the Main Menu inputs and the four (4) Windows. Configuration Block 2 is sixty-two (62) words long and contains the X-gauge, Y-gauge and Line Gauge 1 through Line Gauge 10. Configuration Block 3 is Sixty-three (63) words long and contains Line Gauges 11 through Line Gauge 22. Since each configuration block has a unique length, the requested length of a block transfer is used to identify which of the three configuration blocks is involved. Note, it is recommended that you transfer all three (3) configuration blocks as a matched set.

The User's Manual for your PLC describes how to perform Block Transfers on your PLC. Specific details concerning VIM Module data formats can be found in the VIM User's Manual, Chapter 6.

Summary

In this session you have learned how to use the VIM Module X-gauge and Y-gauge to compensate for variations in workpiece positioning. You have also adapted the techniques employed in the previous session to the situation where the sample workpiece is viewed against a dark background. You have learned why spatial filtering is needed and have configured the X-gauge and Y-gauge to use it. We have also described the transfer of configuration blocks from the Module to a PLC. At this point in time you should be able to apply the techniques you have been shown to successfully apply the VIM Module to most of the inspection applications encountered on an industrial environment.

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# Chapter 5 Self-Teach Session III

Chapter Objectives

In this chapter you will explore each of the VIM Module image analysis tools in a more detailed manner than was done in previous sessions.

When you have completed this session, you will understand how to use all of the capabilities of the VIM Module.

Chapter Contents

In the two previous Self-Teach Sessions you became familiar with the image analysis tools provided by the VIM Module by using them for simple vision tasks. In this session you will extend your ability to employ the brightness probe, the four (4) windows, the X-gauge, the Y-gauge, and the twenty-two line gauges by applying them to more difficult vision tasks. You will:

- o set-up the brightness probe to respond immediately to variations in illumination
- o verify the presence of arbitrarily shaped regions using line gauges.
- o verify the presence of arbitrarily shaped regions using windows
- o verify the presence of a region of interest with mixed contrast.
- o detect and verify the diameter of a "blind hole" in a workpiece.
- o learn the inspection cycle time of the VIM Module for specific configurations.
- o be told about PLC block transfers to access detailed VIM Module "results".

While the focus in each section of this chapter is on using the VIM Module effectively under particular circumstances, along the way you will have the opportunity to explore each of the VIM Module's image analysis "tools" in more depth than was done in previous sessions.

It is assumed that you have worked completely through Session 1 and Session 2. It would be helpful if you already have had an opportunity to try to configure the VIM Module to inspect workpieces. You should feel free to concentrate on the topics which are relevant to the specific vision application you are interested in doing.

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**Brightness Probe**

As mentioned in Session 1, you can specify that any or all of the four (4) thresholds be "floated" (i.e., automatically raise and lower in the same ratio as the "readings" from the Brightness Probe.)

The "mode" of the Brightness Probe is controlled by the first icon in the Brightness Branch Menu. Up to this point, that icon has always had the numeral "2" showing in it. This "2" appears when the VIM Module is using "Mode 2", Lighting Compensation.

**Mode 2 Lighting Compensation**

In "Mode 2", this ratio is determined by using the Brightness Probe "reading" obtained from the preceding camera image. Mode 2 - Lighting Compensation is of broad applicability. It compensates for lighting changes, such as the aging of lamps, which occur gradually over time. In Mode 2 there are no restrictions on the location of either the Brightness Probe or the Windows or Line Gauges.

**Mode 1 Lighting Compensation**

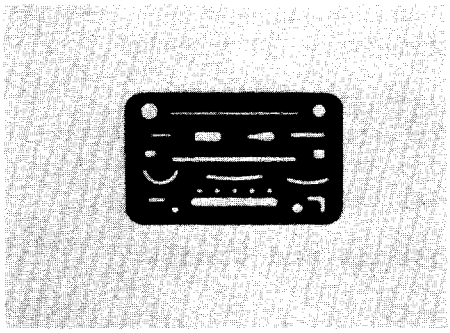
There are situations, such as when a strobe light is employed, where substantial variations in illumination can occur from image to image. "Mode 1" of the Brightness Probe was designed to compensate for this type of variation. In Mode 1 you can specify that any or all of the thresholds be "floated" using the ratio between the Brightness Probe "reading" in the image that is being processed and the nominal value of the Brightness Probe. When Mode 1 is selected, the Brightness Probe must be located on or above image scan line forty (40). Since the Brightness Probe always moves in increments of 8 pixels, this corresponds to the probe being in the first, second or third vertical location available. Mode 1 also requires that no part of the windows, or the X-gauge, or the Y-gauge, or any of the twenty-two line gauges extend above scan line forty-eight (48). Note: Disabling a Window or a Line gauge which extends above scan line forty-eight (48) is not sufficient to permit Mode 1 to be selected. All portions of all of the windows and line gauges (enabled or disabled) must be below image scan line fourty-eight (48). Failure to do so will result in the first icon simply blinking when you try to enter Mode 1.

**Starting Configuration For This Session**

At this time you need to once again place the silver metallic paper in the camera's field-of-view and re-establish the configuration similar to the way it was when you initially enabled the X-gauge and Y-gauge in Session 2. (An easy way to reposition the workpiece is to return the f-stop

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Fig. 5-1. Approximate Position Of Sample Workpiece



of the lens to f/11, direct the camera image to the Video Monitor, and place the workpiece on silver paper beneath the camera so that they appear as shown in Figure 5-1. Then select and enable Window 2. Finally, move the camera left/right or toward you/away until Window 2 is centered on the large round hole in the sample workpiece as shown in Figure 5-2.)

The starting configuration is:

o Main Menu

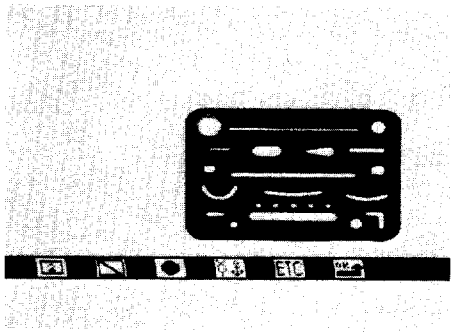
- Swingarm Triggering (SWG TRIG)
- Go On Reject (GO)

o Brightness Branch

- Brightness Probe
  Mode 2 Lighting Compensation
  Located at the center-left of the image
  Low range limit of 20
  High range limit of 250

- Thresholds
  Threshold 1
  Floated (Lighting Compensation Enabled)
  Adjusted to give good definition of the sample workpiece.
  Threshold 2
  Floated (Lighting Compensation Enabled)
  Adjusted to give good definition of the sample workpiece.

Fig. 5-2. Sample Workpiece With Window 2



o Line Branch

- X-Gauge
  Enabled
  Measures black blobs
  Leading edge of largest "blob" selected as the upper measurement.
  Filter selection 0
  Sized so that it is approximately 32 pixels in length (one-eighth the screen).
  Located such that it is centered over the left edge of the workpiece.
  Low range limit set to maximum attainable +1.
  High Range limit set to maximum attainable.
  Note, when the object has holes in it the leading edge of the first blob is a more reliable measurement than the leading edge of the largest blob.

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- Y-Gauge
  Enabled
  Measures black blobs.
  Trailing edge of the bottom black blob selected as the upper measurement.
  Filter selection 0.
  Sized so that it is approximately 32 pixels in length.
  Located such that it is half off the bottom edge and half on the workpiece.
  Low range limit set to minimum attainable.
  High range limit set to maximum attainable -1.

- All of the twenty-two line gauges and Window 3 and 4 disabled.

o Window Branch

- Window 1
  Circular shaped
  Centered on the large round hole in the workpiece
  Sized so that it is just contained with the image of the hole.
  Analyzes white areas.
  High range limit set to maximum attainable.
  Low range limit set to 5 less than the high range limit.
  Floated in X and Y directions.

- Window 2
  Circular shaped
  Centered on the large round hole in the workpiece.
  Sized so that it is slightly larger than the image of that hole.
  Analyzes white areas.
  High range limit set to actual + "10".
  Low range limit set to actual - "10".
  Floated in X and Y directions.

- Window 3 and 4 disabled.

After you have reestablished and saved this configuration in EEPROM, use the push button trigger to verify that inspection of the workpiece will generate an ACCEPT decision.

### Entering Mode 1 Lighting Compensation

o Go to the Brightness Main Menu and pick the first icon. This icon will blink, indicating that the conditions required to enter Mode 1 are not met. (This is because the Brightness Probe is too low in the image.)

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o Now move the Brightness Probe to the upper-left corner of the image.

  Now return to the Brightness Branch and pick the first icon. The numeral "2" appearing in it should change to the numeral "1". If so, you have now selected Mode 1 of the Brightness Probe.

  - Enter Mode 1.

o Move the Brightness Probe toward the bottom of the screen. Note how the arrow icon will blink when you try to move the probe below scan line fourty (40).

o Move the Y-gauge to the top of the screen. Note how the arrow icon will blink in reverse video when you try to move this gauge above scan line fourty-eight (48).

The reason behind these restrictions is that the VIM Module must receive the Brightness Probe reading adjust the thresholds, and use them on the incoming image in Real Time.

o Now return the Y-gauge centered on the bottom edge of the workpiece. Because this line gauge was moved you must re-establish the HI/LO range limits.

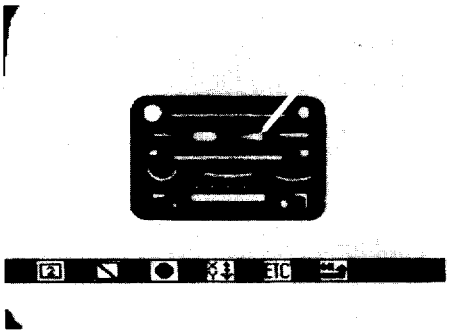
## Verifying Arbitrarily Shaped Regions Using Line Gauges

In most of the simplest machine vision applications, there is rarely any "right" approach to accomplish the inspection of a workpiece. There are often several approaches or "configurations" which will yield approximately the same ACCEPT or REJECT decisions. Each approach will differ from the others in certain respects such as adaptability to the natural variation among workpieces, inspection cycle time or susceptability to noise. As when trying to assess the contrast between a region of interest and the background, you will find it helpful to use the Module to explore and confirm your own judgement as to which approach suits your needs best.

The shape of the region to be detected is known. Since that may be any shape; rectangular, triangular, or round, this section will show you how to use the line gauges to verify any shape. In a following section you will learn how to use Windows to accomplish this same task.

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Fig. 5-3. Teardrop Shaped Opening Used In This Example



The drafting shield provides a wide variety of shapes. In this section you will work with the teardrop shaped opening shown in Figure 5-3. This teardrop can be characterized by its width, maximum height and the angle of its top and bottom edges. Thus, you can verify the presence of an opening of the right size at the proper location by any combination of line gauges that confirm these.

You should generally allow some tolerance on line gauge "readings" to avoid generating false REJECT decisions. This is necessary because of the finite sampling of the digital image.

Starting Configuration For This Example

Begin with the sample workpiece on silver paper and the VIM Module configuration as it was at the end of the previous section.

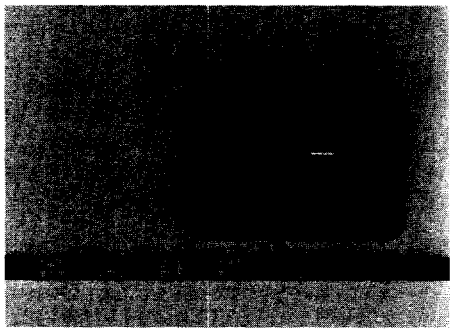
o Now use the Window Branch to disable all windows.

o Then use the Line Branch to:

Measuring Width Of The Teardrop

- Enable Line Gauge 1
  Make it horizontal.
  Floating in X and Y directions
  Analyze the image obtained with Threshold 1.
  Analyze white blobs.
  Select a measurement pair which includes width of the largest blob
  Filter selection 0.
  Locate Line Gauge 1 so that it passes through the middle of the teardrop shaped hole and is sized as shown in Figure 5-4.
  Use the HiLo Range Menu to
  (1) Set the high and low limits for the upper measurement as wide as possible (this measurement is not used here.)
  (2) Toggle to the lower measurement and specify width of the largest blob with the low range limit set to 2 less than the reading and the high range limit set to 2 more than the reading.

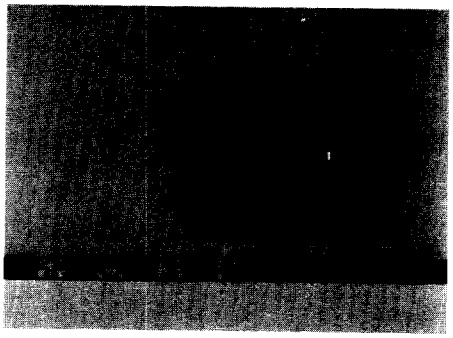
Fig. 5-4. Line Gauge 1 Is Used To Verify Width



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Measuring The Height Of The Teardrop

Fig. 5-5. Line Gauge 2 Is Used To Verify Height

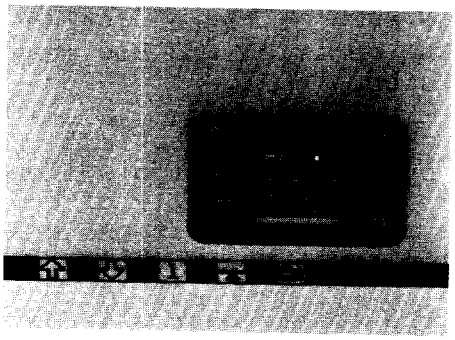


- Enable Line Gauge 2
  Make it vertical.
  Floating in X and Y directions.
  Analyze the image obtained using Threshold 1.
  Analyze white blobs.
  Select a measurement pair which includes width of the largest blob.
  Filter selection 0.
  Position Line Gauge 2 so that it passes through the teardrop shaped hole at its greatest height and is sized as shown in Figure 5-5.

Use the HiLo Range Menu to
(1) set the high and low limits for the upper measurement as wide as possible,
(2) Toggle to the lower measurement and specify width of the largest blob, with the low range limit set to 2 less than the reading and the high range limit set to 2 more than the reading.

Measuring Angle Of Top/Bottom Edges

Fig. 5-6. Line Gauge 3 Is Used To Verify Taper Of The Teardrop



- Enable Line Gauge 3
  Make it vertical.
  Float Line Gauge 3 in X and Y directions.
  Analyze the image obtained with Threshold 1.
  Analyze white blobs.
  Select a measurement pair which includes width of the largest blob.
  Locate Line Gauge 3 so that it passes through the teardrop shaped hole as shown in Figure 5-6.
  Use the HiLo Range Menu to specify width of the largest blob with the low range limit set to 2 less than the reading and the high range limit set to 2 more than the reading.

o Pick "OK" on the Main Menu to save this configuration.

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Selecting Range Limits On Line Gauges

Without moving the sample workpiece, press the push button several times to verify that an ACCEPT decision is always generated.

Now, slide the sample workpiece to the left and press the push button switch again several times to verify that an ACCEPT decision is always generated.

Repeat this test again while the workpiece has been slid to the right on the screen, then again while it has been slid down on the screen.

Your results should show that an ACCEPT decision is generated in all cases.

Now return the workpiece to its nominal location. (Note, when the sample workpiece is in this location, the window displayed on the screen will not shift when the push button is pressed).

- Use the Line Branch to change the low range limits on Line Gauges 1, 2 and 3 from 2 less than their reading to only 1 less than their readings and to also change their range limits to 1 more than their readings.

- Pick "OK" on the Main Menu to save the configuration.

  Without moving the workpiece, press the push button twenty-five (25) times in succession keeping a tally of how many of these inspections generate an ACCEPT decision and how many generate a REJECT decision.

  Now slide the sample workpiece to the left on the screen and press the pushbutton switch twenty-five (25) times keeping a tally of how many ACCEPT and how many REJECT decisions are generated. Repeat this test again while the workpiece has been slid to the right on the screen, then again while it has been slid up, and yet again while it has been slid down on the screen.

- Now return the workpiece to its nominal location.

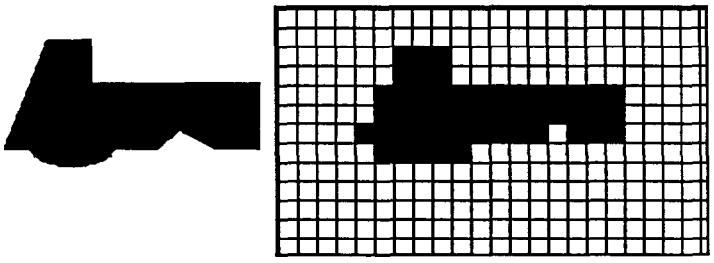
Your results will be similar to those shown in Figure 5-7. This variable ACCEPT/REJECT pattern is due to image-to-image variability.

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Fig. 5-7.
Typical Decision Results When Range Limits Are Set Too Tight

| Workpiece Location on Screen | No. of Accept decisions | No. of Reject decisions |
|---|---|---|
| Nominal Position | 24 | 1 |
| Shifted to the Left | 23 | 2 |
| Shifted to the Right | 25 | 0 |
| Shifted Up | 24 | 1 |
| Shifted Down | 22 | 3 |

Fig. 5-8
Formation Of A Digital Image



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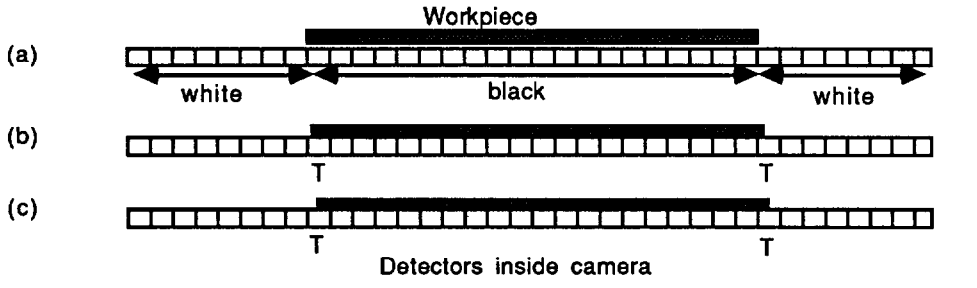
## Image-To-Image Variability

Every digital image can be thought of as simply a mosaic of numbers where each number (i.e., "pixel") represents the average brightness of the scene over a small rectangle. Figure 5-8 illustrates how this comes about.

Each pixel value in the camera image represents the area of a small rectangle which is receiving light. If the entire rectangle is struck by light, that pixel appears bright. If none of its area is being struck by light, that pixel appears dark. If 20% of its area is being struck by light, that pixel appears dark-grey. Whereas if 80% of its area is being struck by light, that pixel appears light-grey. When a camera image is thresholded, all pixels whose values are larger than the threshold are turned into white while all pixels whose values are smaller than the threshold are turned into black. Pixels which represent the boundary of a workpiece will be white (black) as the small rectangular area they represent is (or is not) more than 50% covered by the workpiece.

The effect of this is that the width of a blob (or its location relative to an edge of the sample workpiece) can vary by 1 to 2 pixels depending upon how the edges of the workpiece line up with the sampled grid used to digitize the image. This effect is illustrated in Figure 5-9 for three slightly different locations of the workpiece. In location (a) the ends of the workpiece closely match the detector grid elements. In locations (b) and (c) the grid elements marked "T" are partially covered by the workpiece. When thresholded, the elements marked "T" can turn out white or black depending upon whether their brightness happens to fall above or below the threshold selected.

Fig. 5-9.
Variations In Length Measurements
Due To Finite Spatial Sampling




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## Verifying Arbitrarily Shaped Regions Using Windows

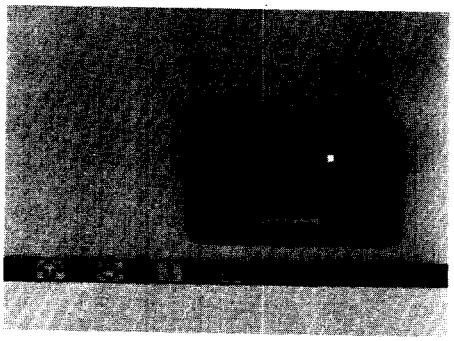
Any or all of the four Windows can be selected to be rectangular, triangular or circular. You also specify their location and size. Verifying regions of interest with any of those shapes is straightforward. An excellent way to verify the presence of a region of interest which has a more complex shape is to represent that region as a combination of rectangles, triangles and circles. The teardrop shaped opening in the sample workpiece will again be used as an example.

## Verifying Presence Of A Teardrop

o Disable Line gauges 1, 2 and 3.

o Use the Brightness Branch to adjust Threshhold s 2, 3, and 4 to produce an image like that obtained using Threshhold 1. (Note, you will only be using Windows 2, 3 and 4 in this example.

Fig. 5-10. Window 2 Is Inside The Right Side Of Teardrop

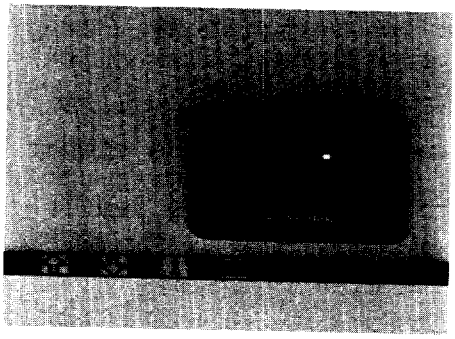


o Use the Window Branch to:

- Enable Window 2
  Select a circular shape.
  Float Window 2 in X and Y directions.
  Analyze white areas.
  Locate and size Window 2 and set its low range limit to the reading -5 as shown in Figure 5-10.

- Enable Window 3
  Select a circular shape.
  Float Window 3 in X and Y directions.
  Analyze white areas.
  Locate and size Window 3 and set its low range limit to the reading -4 as shown in Figure 5-11.

Fig. 5-11. Window 3 Is Inside The Left Side Of Teardrop



- Enable Window 4
  Select a rectangular shape
  Float Window 4 in X and Y directions.
  Analyze white areas.
  Locate and size Window 4 and set its low range limits to the reading -22 as shown in Figure 5-12.

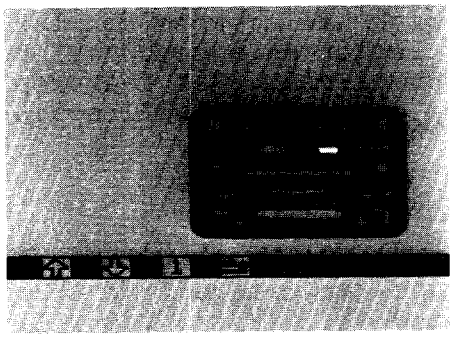
o Pick "OK" on the Main Menu to save this configuration.

o Select the live camera image on the Video Monitor.

Now take the light pen in your left hand with your thumb resting on its tip. Depressing the tip once with your thumb will display Window 1. Press the tip again to display Window 2 then again and again.

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Fig. 5-12. Window 4 Is Inside The Body Of The Teardrop

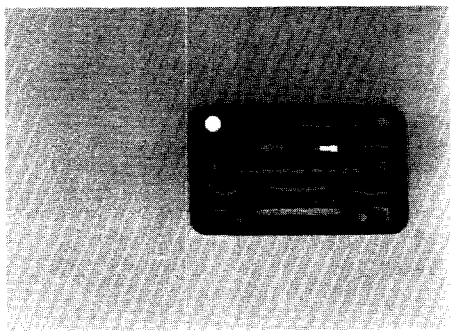


Note how the windows cycle by in order, then all four of them are displayed simultaneously. As shown in Figure 5-13, the interior of the teardrop shaped region is well represented by the combination of Windows 2, 3, and 4.

Verifying Presence Of An L-Shape

Using multiple windows, the L-shaped hole which appears on the screen in the lower-left of the workpiece can be verified by the combination of two rectangular shapes - one located inside its horizontal arm and the other located inside its vertical arm.

Fig. 5-13. Teardrop Shaped Region Represented By Windows



Verifying Presence Of A Long Slot

In a similar manner, the long slot near the bottom of the drafting shield can be verified by a long rectangular window with additional disk shaped windows located at each end.

The advantage of using windows which are either rectangular, or triangular, or circular (or a combination thereof) is that these shapes are available for all windows and, in the event of power down, can be reconstructed.

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**Using "Through-The-Lens'Windows**

The VIM also supports a process based upon a direct comparison of the image with a reference image. This approach, referred to as "through-the-lens", is useful in situations where the shape of the region of interest is either very complex or comprised of several disjoint areas. The through-the-lens windows can only be employed when using Window 1, Window 2 or Window 3. The shape of the "through-the-lens" window is defined at the instant you pick the third icon in the Window Branch Menu. (i.e., whatever is white in the image at the instant this third icon is "picked" becomes the "through-the-lens" window.) For subsequent images the "reading" is the number of pixels that lie beneath white areas of the mask. A "through-the-lens" window can also be floated in X and Y.

**Physical Setup For This Example**

At this point darken the background by extending the workpiece over the edge of the table on which you are working, changing the f-stop on the lens to f/8, and moving the camera stand so that the sample workpiece appears in the camera's field-of-view. If necessary, place a backdrop on the floor beneath the workpiece to eliminate any spurious bright spots.

**Configuring For A "Through-The-Lens Window**

o Use the Brightness Branch to:

- Select Mode 2 lighting compensation.
- Adjust Threshold 3 to obtain a white silhouette of the sample workpiece.
- Adjust Threshold 4 to also obtain a white silhouette of the sample workpiece.
- Enter the HiLo Range Menu to latch the nominal brightness value (Low Limit = 20, High Limit = 250)

o Use the Line Branch to:

- Adjust the X-gauge
  Analyze the image obtained using Threshold 3.
  Measure white blobs.
  Select a measurement pair containing the leading edge of the first blob.
  Filter selection 1.
  Locate the X-gauge half off and half on the left edge of the workpiece.
  Enter the HiLo Range Menu to latch the nominal X-gauge value.

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Fig. 5-14.
Window 3 Is
"Through-The-Lens"

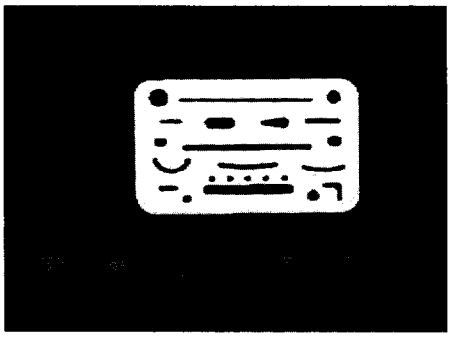


Fig. 5-15.
Workpiece With
Additional White

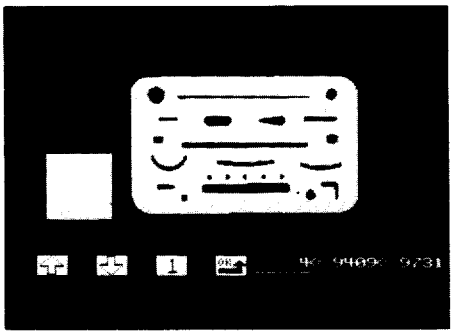
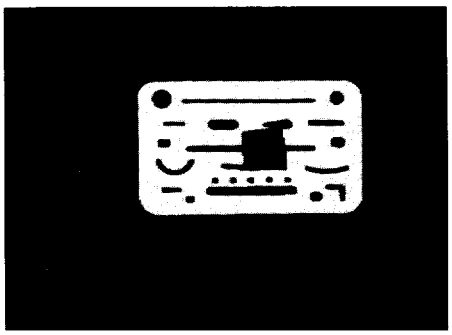


Fig. 5-16.
Workpiece With
Additional Black



- Adjust the Y-gauge
  Analyze the image obtained using Threshold 3.
  Measure white blobs.
  Select a measurement pair containing the leading edge of the first blob.
  Filter selection 1.
  Locate the Y-gauge half off and half on the top of the workpiece.
  Enter the HiLo Range Menu to latch the nominal Y-gauge value.

o Use the Window Branch to:

- Disable Window 2 and Window 3.
- Enable Window 4.
  Now "pick" the third icon with the light pen several times.Note how this icon goes through the rectangle shape, the four orientations of a right triangle, and the disk shape then starts that cycle all over again. This is because "through-the-lens" is not available on Window 4.
  Now disable Window 4.

- Enable Window 3.
  Pick the third icon. Note how this icon changes to resemble a random shape.

You have just captured a "through-the-lens" window for Window 3. Figure 5-14 shows how the display on the Video Monitor should appear now.

- Float Window 3 in X and Y directions.

o Go to Part 2 of the Window Main Menu and enter the HiLo Range Menu. The high range limit represents the total number of white pixels in the "through-the-lens" window. The reading is the number of white pixels in the image which fall within this mask.

o Now place a small strip of white paper on the table near the workpiece as shown in Figure 5-15. Note how the reading remains essentially unchanged. Then place a small strip of blackened paper on the workpiece as shown in Figure 5-16. Note how the reading has now decreased.

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Set the low range value to the reading: about 450.

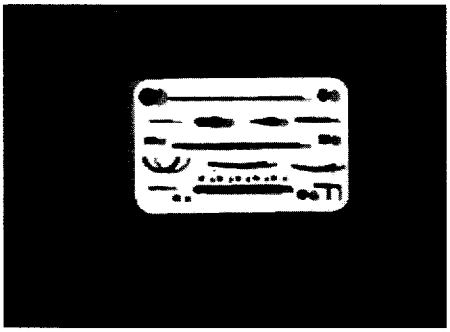
- Pick "OK" on the Main Menu to save this configuration.

Testing A "Through-The-Lens" Window

- Now use the push button switch to inspect the workpiece several times. (Note, an ACCEPT decision should be generated by each inspection.)

- Place the small slip of white paper on the table near the workpiece. Now use the push button to inspect the workpiece several times. Note that ACCEPT decisions are still generated.

Fig. 5-17. Workpiece Slid Toward Left Of Screen



Slide the workpiece to the left on the screen as shown in Figure 5-17. Then use the push button to inspect the workpiece several times. (Here again, an ACCEPT decision should be generated by each inspection.)

Now place the strip of black paper on the workpiece. Again, press the push button switch. Note that this time, a REJECT decision is generated.

- Remove the black strip of paper and press the push button. The decision generated should once again be ACCEPT.

Now turn off the electrical power to the system. After a few moments, turn it back on again and press the push button. The red "CONFIG ERR" light will come on becuase your "through-the-lens" window was lost when the Module was powered down. You can correct this CONFIG ERR by capturing the "through-the-lens" window and saving the configuration.

- Go To the Main Menu pick the "OK" icon to save the configuration.

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Through this example you have learned that a "through-the-lens" window is well-suited for detecting missing portions of a complex region of interest.

**Working With Mixed Contrast**

You may encounter situations where the region of interest is neither the brightest thing in the scene nor the darkest. In this section, you will use the X-gauge and Y-gauge together with Line gauges to verify the presence and width of a strip of material which is bounded on one side by something which is bright and on the other side by something which is dark.

**Physical Setup For This Example**

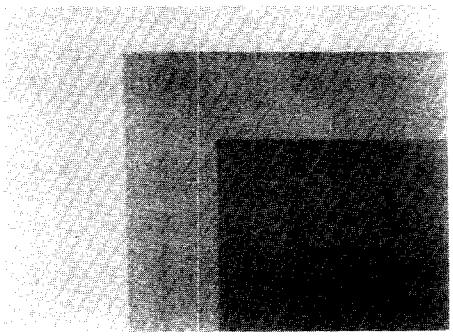
This example uses three different sheets of paper to simulate a region of mixed contrast. Begin by layering the silver sheet, the gold sheet and the blue sheet as shown in Figure 5-18. Direct the camera image to the Video Monitor and adjust the f-stop of the lens to produce the best contrast possible between the middle sheet and the top sheet.

**Configuring VIM Module For Mixed Contrast**

Use the Window Branch to disable all windows.

o Use the Line Branch to disable the X-gauge and Y-gauge as well as all Line gauges. You may need to "anchor" all enabled tools first.

Fig. 5-18. Arrangemnt of Metallic Sheets



Silver Gold Blue

o Using the Brightness Branch:

- Move the Brightness Probe so that it is located completely on an exposed portion of the silver (bottom) sheet. Then enter the HiLo Range Menu and note the reading from this region.

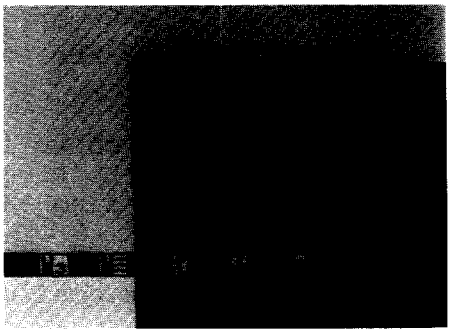
- Next, move the Brightness Probe so that it is located completely on the exposed portion of the gold sheet. This is the region of interest in this example. Enter the HiLo Range Menu and again note the reading from this region.

- Then move the Brightness Probe so that it is located completely on the blue (top) sheet. Enter the HiLo Range Menu and again note the reading. Note that all three readings are different.

- Move the Brightness Probe to the upper-left of the screen and select Lighting Correction Mode 1.

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Fig. 5-19.
Threshold 3 Separates Silver Sheet From Gold



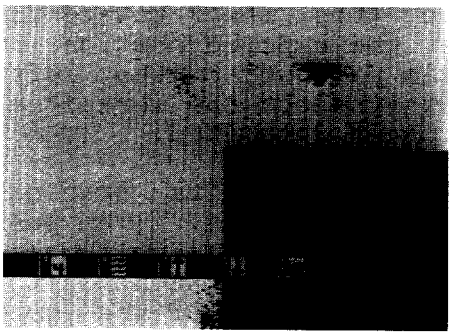
In this example the gold sheet can not be isolated by simply thresholding, for any threshold which will discriminate the bottom sheet from the middle sheet also blends the middle and top sheets together. A different threshold is required for each boundary.

- Float Threshold 3 and adjust it to give the best possible definition of the silver (bottom) sheet as shown in Figure 5-19.

- Float Threshold 4 and adjust it to give a clear definition of the left and top edges of the blue (top) sheet as shown in Figure 5-20.

o Use the Line Branch to:

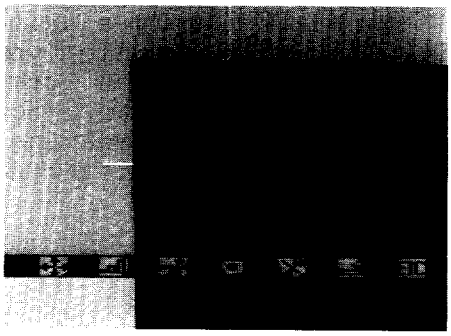
Fig. 5-20.
Threshold Separates Gold Sheet From Blue



- Enable X-gauge
  Analyze the image obtained using Threshold 3.
  Measure white blobs.
  Select a measurement pair containing the trailing edge of the largest blob.
  Filter selection 2
  Size and locate the X-gauge as shown in Figure 5-21 and then enter the HiLo Range Menu to latch it nominal value.

- Enable the Y-gauge
  Analyze the image obtained using Threshold 3.
  Measure white blobs.
  Select a measurement pair containing the trailing edge of the largest blob.
  Filter Selection 2.
  Size and locate the Y-gauge as shown in Figure 5-22 and then enter the HiLo Range Menu to latch its nominal value.

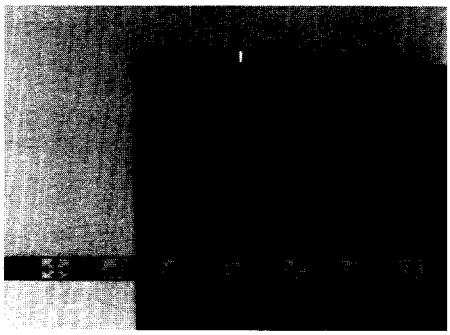
Fig. 5-21.
X-Gauge Has Been Adjusted



- Enable Line gauge 1
  Float Line gauge 1 in X and Y.
  Analyze the image obtained using Threshold 4.
  Analyze black blobs.
  Select a measurement pair containing the leading blob.
  Filter Selection 1.
  Size and locate Line gauge 1 as shown in Figure 5-23. Enter the HiLo Range Menu to set the low limit to reading -4, and its high limit to reading +4.

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Fig. 5-22.
Y-Gauge Has Been Adjusted



- Enable Line gauge 2.
  Float Line gauge 2 in X and Y.
  Analyze the image obtained using Threshold 4.
  Measure black blobs.
  Select a measurement pair containing the Leading Edge of the Leading Blob.
  Filter Selection 1.
  Size and locate Line gauge 2 as shown in Figure 5-24 and then enter the HiLo Range Menu to set its Low Limit to reading -4, and it high limit to reading +4.

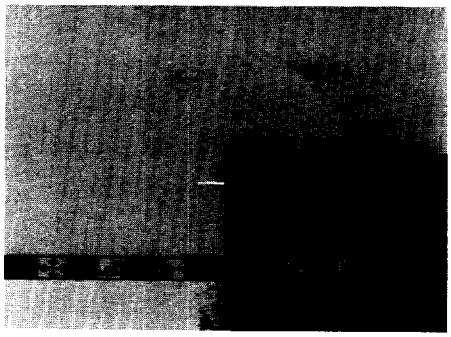
o Pick "OK" on the Main Menu to save this configuration.

Testing Your Mixed Contrast Configuration

Press the push button several times. (An ACCEPT decision should be generated every time.)

Carefully move the blue (top) sheet toward the left on the screen so that the exposed portion of the gold (middle) sheet is narrower on the left. Now use the push button to inspect the workpiece. Note that a REJECT decision is generated.

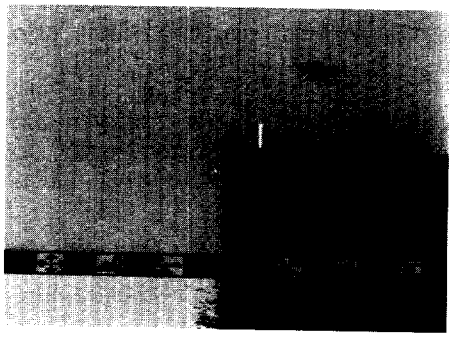
Fig. 5-23.
Line Gauge 1 Has Been Adjusted



Now move the copper sheet back to its original position in the left-right direction. (The push button will once again produce ACCEPT decisions.) Then move the gold sheet toward the bottom of the screen so that the exposed portion of the gold sheet is wider at the top (as shown in Figure 5-30) than originally. Again use the push button to inspect the workpiece. Note that a REJECT decision is generated.

Verifying the width (or height) of a region of interest which has mixed contrast involves using two different thresholds. In this example, you used the X-gauge and Y-gauge to relate the locations of the line gauges to edges in an image obtained using one threshold while their readings were based upon edges obtained using a different threshold.

Fig. 5-24.
Line Gauge 2 Has Been Adjusted



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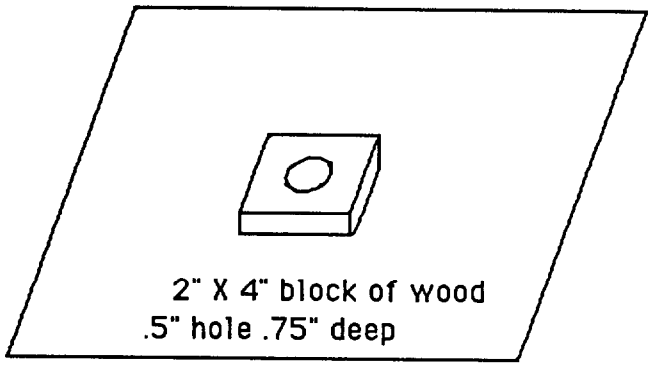
## Verifying The Presence Of A Blind Hole

The high contrast obtainable when a hole goes all the way through a workpiece makes viewing and measuring the hole easy. In this section you will learn how to verify the presence of a "blind" hole (i.e., the hole does not extend all the way through the workpiece). The way the Module is used to verify blind holes is similar in many respects to what you have already done. The major difference is in the lighting and contrast between the blind hole and its surroundings.

## Lighting

We have used a short length of 2" x 4" wood with a 1/2" diameter hole drilled 3/4" deep in the top as depicted in Figure 5-25. The 2 x 4 was viewed against a wooden table top to obtain a background with the same brightness as the region of interest. You may use a three dimensional object of any type provided it (a) has sufficient thickness, and (b) has a hole in it which is at least as deep as its diameter.

Fig. 5-25.
Physical Setup For Blind Hole Measurement

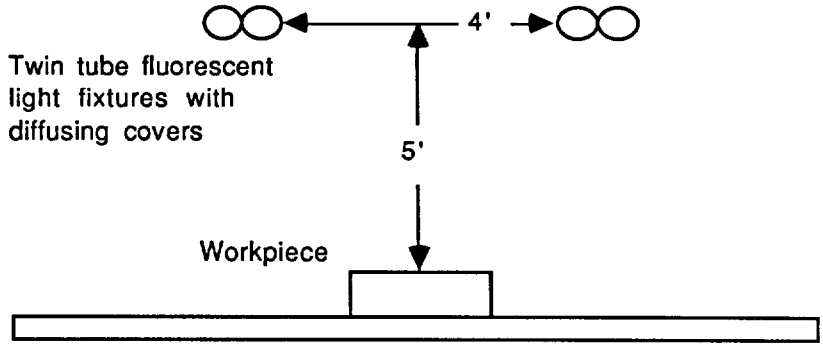



As shown in Figure 5-26, the lighting employed for this example was overhead fluorescent lighting of the type typically found in an office building or laboratory.

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Fig. 5-26.

Diffuse Lighting Used For Blind Hole Measurement




For this work a fluorescent ring light located just beneath the camera lens will work quite well. The important thing is to have diffuse light impinging on the workpiece from all directions similar to the way the ground is illuminated when a uniform layer of clouds diffuses the sun's light.

Fig. 5-27.
Camera Image For
Illustrative
Example

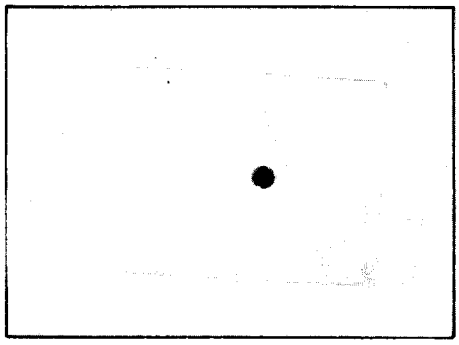
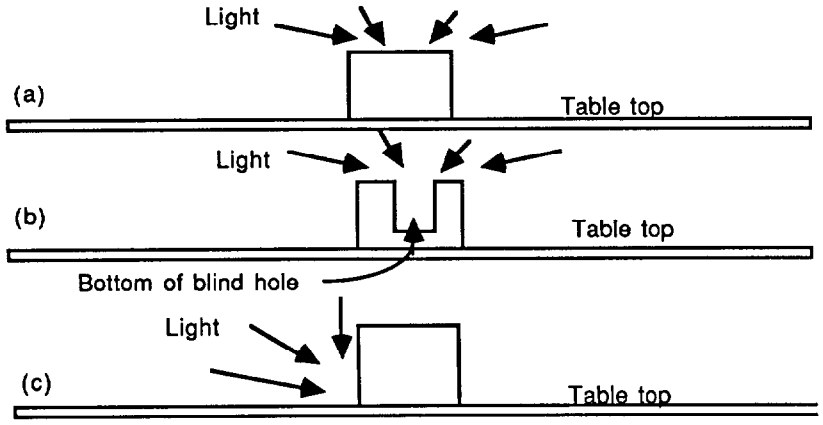


Figure 5-27 shows the camera image. Note how the top of the workpiece and the top of the wooden table appear equally bright. This is because the wooden workpiece reflects the same amount of light as the wooden table. The blind hole in the workpiece and the regions around the immediate edges of the workpiece appear slightly darker due to shadowing. As shown in part (a) of Figure 5-28, the top of the workpiece and the wooden table top receive incoming light from many angles. As shown in part (b) of Figure 5-28, the bottom of the blind hole only receives light from directly above. The walls of the hole block some of the light and make it slightly darker at the bottom of the hole. The sides of the workpiece also block some light, as shown in Figure 5-28 (c).

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Fig. 5-28.
Phenomenology Exploited By Illustrative Example




Configuring The VIM Module To Verify The Presence Of A Blind Hole

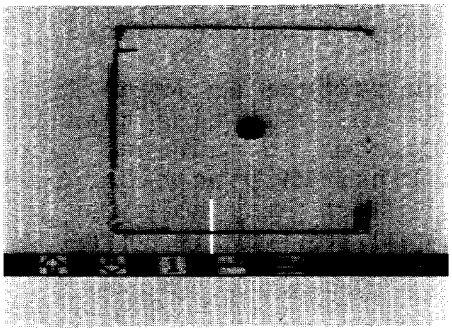
The following steps were performed to configure the VIM Module for this example.

o Use the Window Branch to:
  - Disable all windows.

o Use the Line Branch to:
  - Disable all windows.

o Use the Brightness Branch to:
  - Select Mode 1 of the Brightness Probe.
  - Adjust Threshold 3 to give a clear definition of the left and bottom edge of the workpiece.
  - Adjust Threshold 4 to give a clear definition of the blind hole whose presence in the workpiece is to be verified.

Fig. 5-29.
Y-Gauge Has Been Adjusted



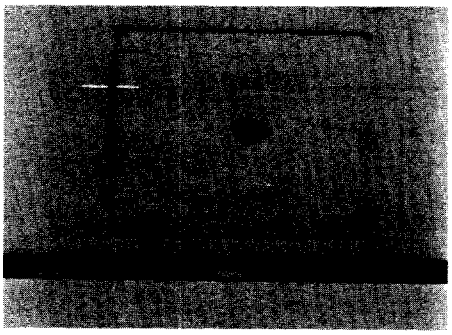
Note, in this particular example, a single threshhold will suffice to bring out both the workpiece edges and the blind hole. However, since the general case requires two different thresholds, we will use two here.

o Using the Line Branch
  - Enable the Y-gauge
    "Pick" the fourth icon to select y-position compensation followed by x-position compensation.
    Analyze the image obtained with Threshold 3.
    Measure white blobs..
    Select a measurement pair containing the trailing edge of the largest blob.
    Filter Selection 2.

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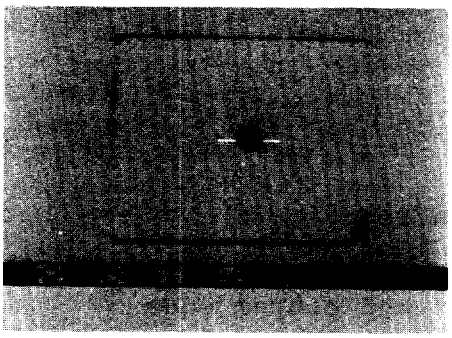
Locate and size the Y-gauge and enter the HiLo Menu to latch the nominal value of the Y-gauge as shown in Figure 5-29.

Fig. 5-30.
X-Gauge Has Been Adjusted



- Enable the X-gauge
  Analyze the image obtained with Threshold 3.
  Measure white blobs.
  Select a measurement pair containing the leading edge of the largest blob.
  Filter Selection 2.
  Locate and size the X-gauge and enter the Range Setting Sub-Menu to latch the nominal value of the X-gauge as shown in Figure 5-30.

Fig. 5-31.
Line Gauge 1
Has Been Adjusted



- Enable Line gauge 1
  Float Line gauge 1 in X and Y.
  Analyze the image obtained using Threshold 4.
  Measure black blobs.
  Select a measurement pair which contains the width of the largest blob.
  Locate and size Line gauge 1 as shown in Figure 5-31.
  Enter the HiLo Range Menu and select width of the largest blob, adjust the low range limit to reading -6, and adjust the high range limit to reading +6.

o Pick "OK" on the Main Menu to save this configuration.

## Inspection Cycle Time

"Inspection Cycle Time" is the term used for the elapsed time from the trigger until the inspection is complete. The inspection cycle time depends upon the configuration.

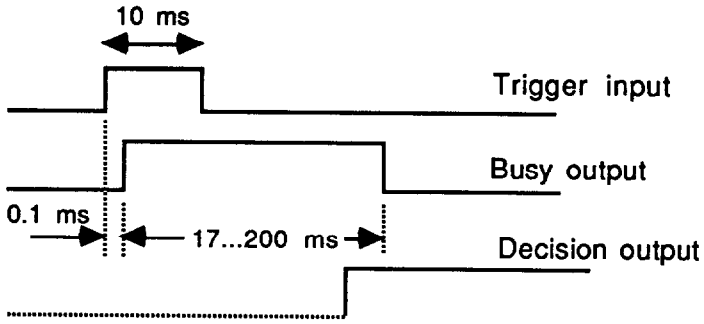
At a minimum, it takes 1/60th of a second to receive and process a new image from the camera.

The VIM Module typically can capture an image from the camera and analyze it in less time than it takes for the next workpiece to advance into position on the production line. This section provides timing information which may help you in situations where the inspection cycle time is critical.

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Figure 5-32 shows a timing diagram for the key control signals input and output by the VIM Module. A cycle begins when the TRIGGER line rises. The BUSY line goes high about 0.1 milliseconds later. When the Module has completed the image analysis, the DECISION line is set high or low in accordance with the inspection results. At this time, the BUSY line is also set low signifying that the Module is ready for the next trigger. Note that BUSY will be held high as long as TRIGGER is held high. The DECISION should be sampled after the BUSY line drops.

Fig. 5-32.
VIM Module Signal Timing-Short Trigger




The fastest VIM Module cycle time attainable occurs using TRIGGER and DECISION signals via the swingarm. With all four (4) windows enabled (but not floated in X and Y) and all Line Gauges disabled, the VIM Module cycle time is 1/60th of a second.

Enabling the X-gauge and Y-gauge and floating the four (4) windows in X and Y will result in a cycle time of approximately 1/15th of a second. Employing filtering to eliminate transitions of length 1 pixel for both the X-gauge and Y-gauge will not change this number appreciably unless there are many white to black and black to white transitions along these gauges.

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Inspection cycle times will increase as more Line gauges are enabled, or as the length used for each Line gauge is increased.

Having all the windows disabled, the X-gauge and Y-gauge enabled, and two (2) 64 pixel long Line gauges enabled and floated in X and Y, and using Filter Selection 1 will result in a cycle time of 1/30th of a second.

Increasing the number of enabled, floated and filtered Line gauges from two (2) to eight(8) will result in a cycle time of approximately 1/15th of a second.

Enabling, floating and filtering all twenty-two line gauges will result in a cycle time around 1/8th of a second.

In the absolute worst case, enabling and floating all four (4) windows, enabling all twenty-two (22) line gauges as 128 pixels in length, floated in X and Y and using Filter Selection 2 will result in a cycle time on the order of 1/6th-1/4th second.

When you must know precisely what the VIM Module cycle time is with your particular configuration, the best way to obtain that information is to measure it directly. This may be done by connecting an oscilloscope to the "TRIGGER" and "BUSY" terminals on the VIM's swingarm. Trigger the scope scan with the rising edge of the TRIGGER signal. Make sure that the trigger is a staccato pulse, about 10 ms in duration. Measure the time until the BUSY signal drops. This is the VIM Module Inspection Cycle Time. Make sure to measure it under a variety of image condition - this can have an impact on the inspection cycle time.

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