(2) Setup (Press 1)

Vision files for fiducial use are usually 0.

```
DATA IN            V-FILE NAME : FIDUCIAL
VISION

               1. SET UP
               2. CALIBRATION
               3. TEST
```

To access screen f7-2-1 from f7-1-1, press 0 (0. FIDUCIAL) → F6(NEXT).

```
DATA IN            V-FILE NAME : FIDUCIAL
VISION  SETUP                         GO

   MODE      : FID
   CAMERA    : 1
   OBJECT    : WHITE
   BINARY    : AUTO
   FILL      : 2
   CUT       : NO
   DISPLAY   : CROSS1
   WINDOW1   : ON+ (64,61)(191,174)
   WINDOW4   : OFF
   OPTION01: 78   "AREA
   OPTION02: 30   "AREA TOLERANCE

   F1      F2    F3    F4    F5    F6
  BINARY  FID   QUAD  SCP   OPT1  CONT.
```

Type 'G' to start calibration.

To access screen f7-2-2 from f7-2-1, press 1 (1.SET UP)

f7-2-2

```
DATA IN:          V-FILE NAME : FIDUCIAL
VISION  SET UP                      GO

WINDOW4   : OFF
OPTION01 : 78 "AREA
OPTION02 : 30 "AREA TOLERANCE
OPTION03 : 314"PERIMETER
OPTION04 : 20 "PERIMETER TOLERANCE
OPTION05 : 0
OPTION06 : 0
OPTION07 : 0
OPTION08 : 0
OPTION09 : 0
OPTION10 : 0

   F1       F2       F3       F4       F5       F6
  EDIT
```

f7-2-3

To access screen f7-2-3 from f7-2-2, press ROLL UP.

To access screen f7-4-1 from f7-2-1, press 3(3. TEST).

```
DATA IN      V-FILE NAME : FIDUCIAL
VISION  TEST               HISTOGRAM

STATUS     :--------------------------
EXE. TIME  :--------------------------
NUMBER     :--------------------------
FEATURE    :--------------------------

  F1      F2      F3      F4      F5      F6
  GO    RESET   OBJ(+)  OBJ(-)  FEA(+)  FEA(-)
  ↑
```

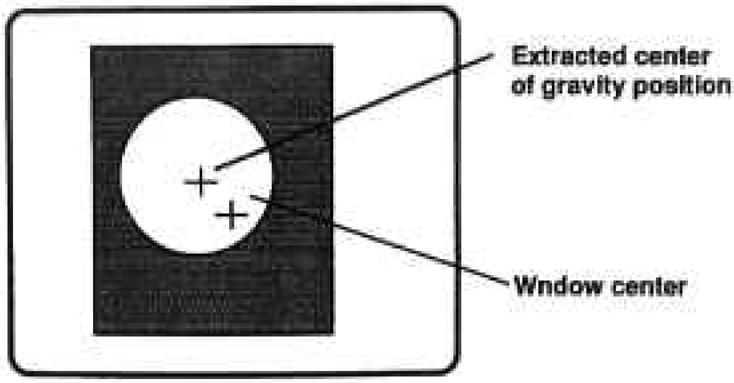
- STATUS: Post-test error notice
- EXE. TIME: Execution time
- NUMBER: Number of objects
- FEATURE: Refer to feature tables in section 7-3-6
- F1 (GO): Press F1 key and run the test.

f7-4-1

Remark:
After typing an 'H' you will get a variable density histogram on the vision monitor. This histogram can be used to check the threshold of the automatic binary encoding and the distribution of lightness and darkness in the image. See also chapter 3-7-3-5, testing.

(4) Test (Press 3)

Find the position of a fiducial mark within the camera's field of view, and run a test in the 'test mode' (see next page, figure f7-4-1). If the area and the centre of gravity (c.g.) coordinates are output as reproducible values, the test results are OK.



Follow the guidelines in the chart below to correct any defects that may occur during the image processing test.

NO.	Indications	Causes	Countermeasures
1	The binary image does not form a neat circle.	1) Threshold have not correct value	1) Set AREA
		2) Area/Perimeter of the mark is not entered properly in option 1/2.	2) Input the area/perimeter correctly or input the correct calibration
		3) Presence of bright (or lighted) objects other than the fiducial mark	3a) Adjust the size of the window so other objects do not enter the field of view. 3b) Correct the PCB pattern
		4) Poor lighting adjustment, burned out light	4) Adjust the amount of light, replace the light bulb
		5) Mark area is unevenly balanced	5a) Perform additional hole filling and/or small area cutting 5b) Improve the surface finish
2	Many holes and small objects appear in the binary image.	1) Hole filling or small area cutting were not done	1) Do hole filling, small area cutting

(3) Fiducial Calibration (Press 2).

At delivery time the CSM is equipped with a fiducial file (file 0). If new fiducial files are needed (e.g. different size of fiducial) it is only needed to copy the existing file to a new location (any file no between 0-29) and then change the specific parameters.

If however the CSM has no fiducial file then input the scale of the camera and the position of the camera relative to the teaching unit head (shift along the X and Y axes, and the amount of rotation).
Move the camera to the fiducial which is going to be calibrated. Then start the <CALIB> utility program (chapt. 3-2-6-5) part A - Initial calibration of the fiducial vision file.

CAUTION: **Re-calibration is also required AFTER the fiducial camera and/or lens is being moved or replaced.
If the calibration is not correct, it will be impossible to mount components accurately.**

NOTE : **When calibration adjustment of movable camera is done, head offset and feeder position data may be adjusted. Because the movable camera is defined as the machine teaching unit. (standard unit of robot arms).**

```
DATA IN      V-FILE NAME : FIDUCIAL
VISION CALIBRATION               0 O
-----------------------------------
HOLD      :MOVING
DIRECTION:DOWN
SCALE     :0.01844 0.01851
SHIFT     :-2.35 2.19 0.31

  F1     F2     F3     F4     F5     F6
 FIXED  MOVING
```

To access screen f7-3-1 from f7-2-1, press 2 (2.CALIBRATION).

f7-3-1

Label	Setting Value	Notes
HOLD	MOVING	To choose moving camera
DIRECTION	DOWN	Camera faces downward
SCALE	X: 0.01500 ~ 0.0200 Y: 0.01500 ~ 0.0200	Changes by diff. type of lenses or position of focus
SHIFT	X: -2.60 ~ -1.80 Y: 1.70 ~ 2.40 R: -2.00 ~ 2.00	Depends on SCALE

Parameters are set so the image processing of the fiducial marks on a PCB can be carried out accurately.

Label	Setting value	Notes
MODE	FID	
CAMERA	1	
OBJECT	Usually WHITE	Is WHITE when mark is brighter than board. Is BLACK when opposite
BINARY	AREA (30~50) or AUTO	When AREA the value of '( )' is square root of area of Fiducial Mark (Unit: pixel). After making binary, optimum value is to be given. When AUTO the values of '( )' is not used.
FILL	NO or 1-2	Changes according to the condidions of the binary image processing results. This number ineases when anything like a hole appears inside.
CUT	NO	Changes according to the condition of the image processing results.
WINDOW1	ON+	Defines the processing area. Changes according to the condition of the image processing results.
DISPLAY	CROSS1	Defines the output format on the vision monitor The size should be as small as possible, as long as the mark is inside.
OPTION01	Range 20-500 Fiducial mark surface area 1mm = 100	Unit: 0.01mm2 For round marks with diameter(d) of **1mm**, the area is:1/4 x d x d x pi = 0.25 x 1 x 1 x 3.14 = 0.78 mm2, so input: **78.** ø okrągłego markera
OPTION02	range: 1-100 **0 if no check is done.**	Tolerance of surface area of fiducial marks. Unit: %
OPTION03	Range: 80-2000 Peripheral length of fiducial mark.	Unit: 0.01mm. For round marks with diameter(d) of **1mm**, the length is: d x pi = 1 x 3.14 = 3.14 so input: **314.**
OPTION04	Normally 30 range: 1-100 **0 if no check is done.**	Tolerance in peripheral lengths of fiducial marks. Unit: %

NOTE: *Options 5 - 20 are not used for fiducials.*

(2) **Setup (components)**

Parameters are set for accurate detection of the center position of components.
For example, select the 1. QFP100.

```
DATA IN         V-FILE NAME : QFP100
VISION

            1. SET UP
            2. CALIBRATION
            3. TEST
```

To access screen f7-2-1 from f7-1-1, press 1 (1.QFP100P).

f7-2-1

```
DATA IN         V-FILE NAME : QFP100P
VISION  SETUP                      00

  MODE     : QFP1
  CAMERA   : 2
  OBJECT   : BLACK
  BINARY   : AUTO
  FILL     : 2
  CUT      : NO
  DISPLAY  : CROSS0
  WINDOW1  : ON+ (0,0)(255,239)
  WINDOW4  : OFF
  OPTION01: 30  "LEAD WIDTH
  OPTION02: 50  "LEAD WIDTH TOLERANCE

   F1      F2    F3    F4    F5    F6
 BINARY   FIX   QUAD   SOP  QFP1  CONT.
```

To access screen f7-2-2 from f7-2-1, Press 1.

f7-2-2

7-2-3-2
Component camera software set-up and calibration

(1) Component Vision file

Up to 30 types (in practice only 28) of components can be stored in the memory. Component names and pin numbers can be used as file names to make it easier to remember which file contains which data.
Changing the processing mode enables PLCC, SOP or QFP detection.

A sample vision file directory is shown below.

NO.	FILE NAME
0.	PCB 1
1.	QFP-100P
2.	QFP-54P
3.	QFP-80P1
4.	QFP-80P2
5.	QFP-80P3
6.	QFP-100P
7.	SOP-48P
8.	SOP-60P
9.	BADMARK

When creating a new component vision file, copy an existing vision file of a similar type component in the initial screen mode and correct any differences. This makes the operation easier.

3) **Brightness adjustment.**

Move the vision camera with a QFP100 above the component camera. Turn on the fluorescent light. After approx. three seconds the lamp lights and the QFP on the screen becomes indistinct because the light is to bright. Adjust the APERTURE ring so that the QFP appears in a clear and distinct way. (DO NOT ROTATE THE FOCUS RING!!). As a guide, a window is displayed outside of the field of view. When the window is clearly visible against the reflecting panel the brightness is set correctly. If the light is too bright, the leads of the QFP will be indistinct, making it impossible for the system to detect the centre position correctly. If the light is too weak the system will not be able to distinguish the QFP from the reflecting surface.

After the brightness adjustment, adjust the height of the fluorescent lamp assy. Take into account not to interfere with the chuck heads 1 and 2. See figure 3.
The clearance between the chuck-heads and the assy should be minimum 5 mm.
Make sure to work with clean hands when working on the camera's and never touch the CDD surface with your bare hands. Never leave the CDD surface exposed.

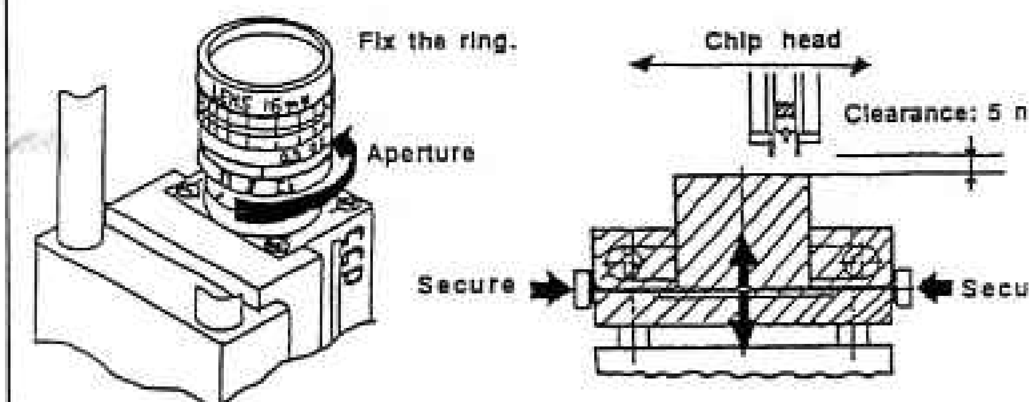


Figure 3

7-2-3-1 Component camera No.2 hardware set-up

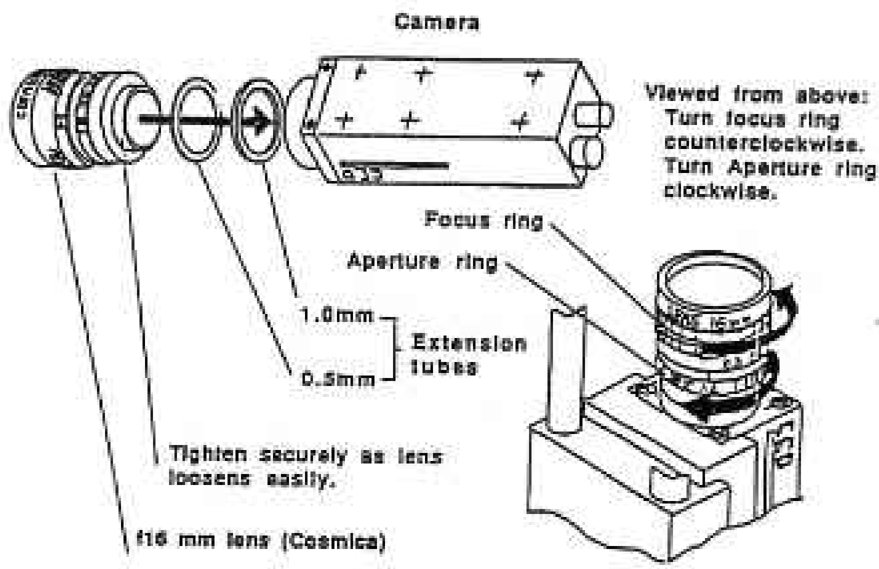
1) Magnification.

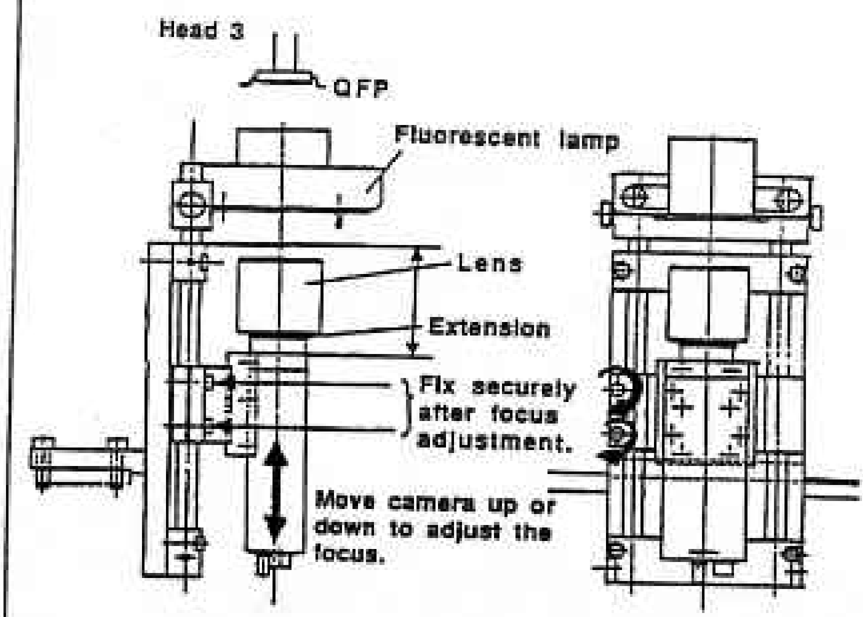
The component camera is equipped with two fixed extension tubes which determines the magnification of the lens system.See figure 1.

2) Focussing of the component camera.

Set initially the focus ring to 0.3m and open the aperture all the way. Move the vision head with a e.q. QFP100 above the camera No.2. While watching the screen display. Adjust the height of the camera so that an optimum focus is obtained. Secure the camera body after the adjustment is done. See figure 2.
REMARK: Do not used the focus ring on the lens because this turns too easily.

Set the fluorescent lamp brightness switch (HI/LO) to LO on front panel of H.F. power supply. Then, to ensure proper focus adjustment, set the main switch (ON/HOLD) to HOLD to turn off the lamp. After focus adjustment switch back to ON.





(3) Calibration

Camera scale and the relative positions (amount of shift in the X and Y axes and the amount of rotation) of the camera related to machine origin should be input. If the calibration is not carried out correctly, it is not possible to mount components accurately.

At the following occurrences, re-calibration is necessary:

a) when **QFP Head, the camera or the lens** is replaced or re-adjusted in height
b) when the total machine **is moved** (to a new location).

Use the **calibration utility program** <CALIB> to perform a **fine adjustment**. Each VFILE contains it's own calibration values e.g. scale and shift, depending on the thickness of the component.

When an existing VFILE is used for a new component (by copying the existing VFILE to a new -free- position with the name of that new component), camera calibration of the scale and shift (see 3-7-3-4) and the fine adjustment using <CALIB> is needed.

In chapter 3-7-2-5 (Component Calibration procedure) there is a description of how to calibrate a component vision file.

```
DATA IN        V-FILE NAME : QFP100P
VISION CALIBRATION              0 O

 HOLD      :FIXED
 DIRECTION:UP
 SCALE     :0.14500 0.14606
 SHIFT     :337.20 597.17 179.98

  F1     F2     F3     F4     F5     F6
FIXED  MOVING
```

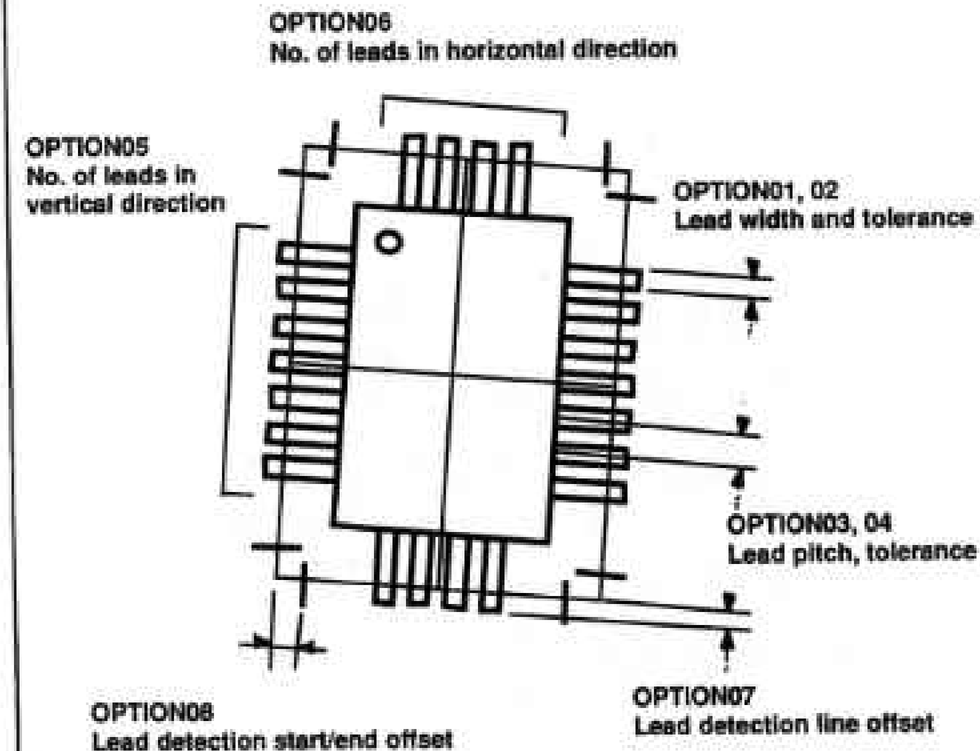
To access screen f7-3-1 from f7-1-1, press 2 (2.CALIBRATION).

f7-3-1

NOTE

<u>**In QUAD, OPTION01-08 are ignored.**</u>

The following diagram illustrates OPTION01-08.



Label	Setting value	Notes
MODE	QUAD, SOP, QFP1 CHIP	Changes according to part type QUAD: Rough position is decided by the shape only SOP: components with leads in 2 directions QFP1: components with leads in 4 directions Chip: ,, with no leads
CAMERA	2	
OBJECT	BLACK	
BINARY	AUTO	
FILL	2- 3	This is to stabilize rough positioning image processing. By this, gaps in the lead are filled.
CUT	NO	
WINDOW1	ON+	The size should be as small as possible, just large enough for the part to fit inside + pick-up tolarance
WINDOW4	OFF or ON+	When rough positioning is not required, turn ON. Set so that the window line intersects all part leads.
DISPLAY	CROSS0	Defines the output format on the vision monitor. Any parameter can be used (there is a difference in speed)
OPTION01	Limited to 20-50	Pin width (30 for 0.30mm)
OPTION02	0 or 10-30	Pin width tolerance (unit: %). No check when 0.
OPTION03	65, 80, 127	Pin pitch (65 for 0.65mm)
OPTION04	0 or 10-30	Pin pitch tolerance (unit: %). No check when 0.
OPTION05	0-100	No. of leads in the vertical direction. No check when 0.
OPTION06	0-100	No. of leads in the horizontal direction. No check when 0.
OPTION07	Normally 0 -5 to 5	Lead detection line offset (Unit : pixel)
OPTION08	Normally 0 10-15	Lead detection start/end offset (Unit : pixel)
OPTION09	0	Processing algorithm selection
OPTION10	0 or 1	Standard or Multi-stage regocnition type
OPTION11	Cal. eccentricity correction	If option10 is 0, than this correction is zero
OPTION12	Cal. eccentricity correction	If option10 is 90, than this correction is zero
OPTION13	Cal. eccentricity correction	If option10 is 180, than this correction is zero
OPTION14	Cal. eccentricity correction	If option10 is -90, than this correction is zero

Options 15 - 20 are not used.

```
DATA IN          V-FILE NAME : QFP100P
                               GO
VISION  SET UP
________________________________________________

WINDOW    : OFF
OPTION01 : 30 "LEAD WIDTH
OPTION02 : 50 "LEAD WIDTH TOLERANCE
OPTION03 : 65 "LEAD PITCH
OPTION04 : 50 "LEAD PITCH TOLERANCE
OPTION05 : 20 "V.LEAD NUMBER
OPTION06 : 30 "H.LEAD NUMBER
OPTION07 : 0  "DETECTION LINE OFFSET
OPTION08 : 0  "START/END OFFSET
OPTION09 : 0  "ALGORITHM SELECTION
OPTION10 : 0  "ROTATION ANGLE
OPTION11 : 0  "ECCENTRICITY 0-90
OPTION12 : 0  "ECCENTRICITY 90-180
OPTION13 : 0  "ECCENTRICITY 180-270(-90)
OPTION14 : 0  "ECCENTRICITY 270-0

   F1     F2     F3     F4     F5     F6
  EDIT
```

To access screen f7-2-2 from f7-2-1, press ROLL UP.

f7-2-2

NOTE

The options 11 through 14 are the calculated ECCENTRICITY corrections. These corrections compensates for eccentricity of the vision head shaft and will be calculated at calibration time. The unit of these values are 1/100 degree. So 10.3 means a correction of 0.103 degree.

7-2-5 Component Calibration procedure

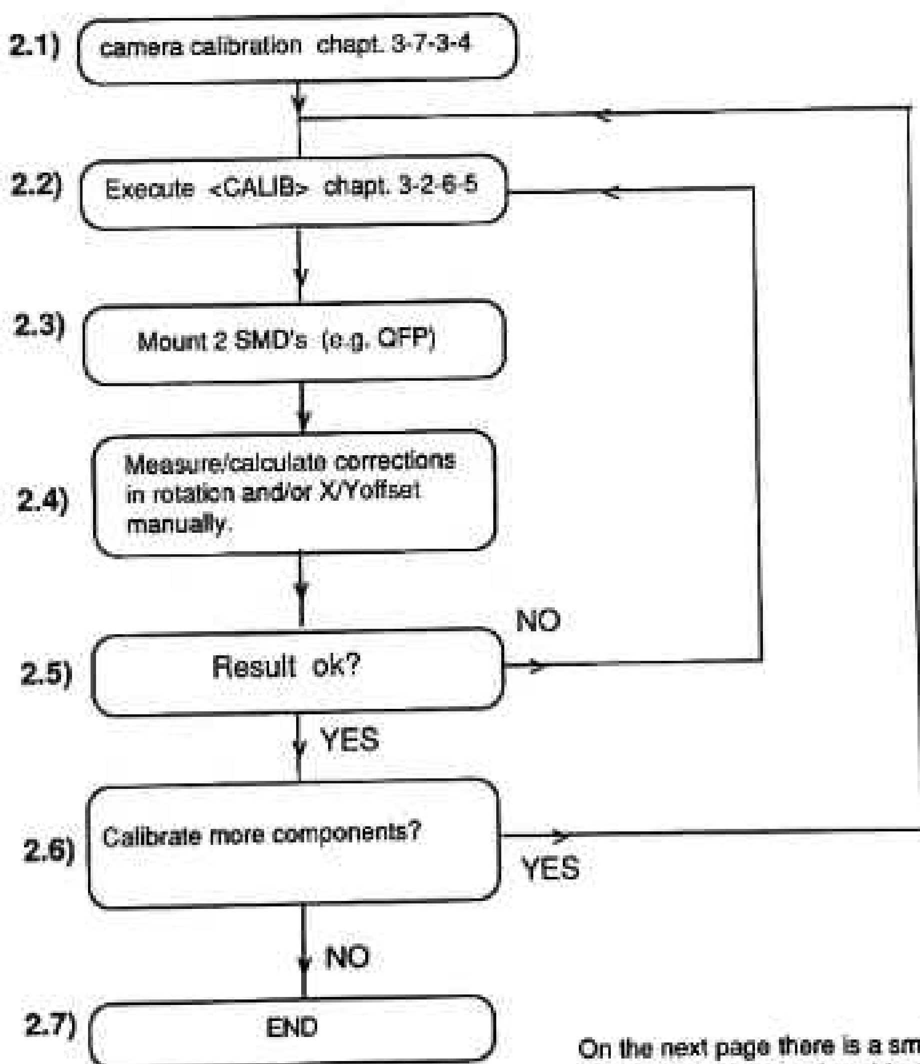
1) Introduction

This calibration session is build-up out of two parts;

a) **Coarse calibration** using the utility <CALIB> part B to determine the final scale and shift values of a component.

b) **Fine calibration** by mounting 2 components, one at 0 degree and one at 180 degree (or 90 and -90 degree). After mounting the components measure and calculate the offsets then use the utility <CALIB> part C to enter these corrections into the vision file. Repeat this procedure b) as long as the mount result is not within specification.

2) Calibration procedure block diagram



On the next page there is a small explanation of the various blocks.

7-2-4 Bad mark vision file settings

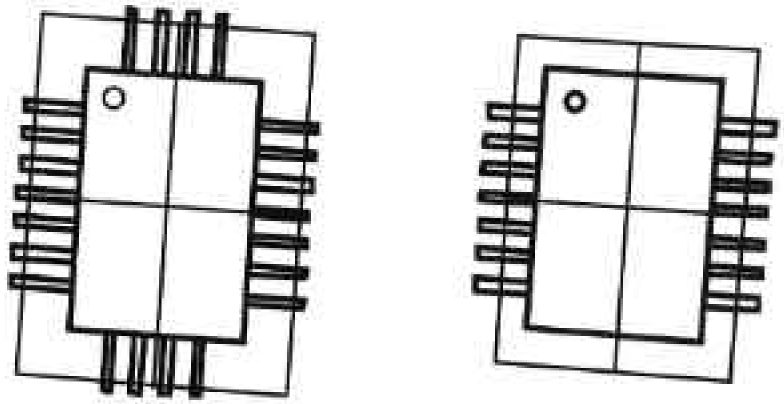
(1) Bad mark Vision file

The file name should be "BADMARK". Bad mark recognition takes place in response to the brightness of the image. No position data or other data is used. The only factor which can be adjusted by the user is the level of brightness. This function has no relation at all to calibration.

(2) Setup

The following parameters are used in bad mark recognition:

Label	Setting value	Notes
MODE	BINARY	
CAMERA	1	
OBJECT	WHITE	
BINARY	MANUAL (150)	Value in '()' is threshold for brightness. When inner window becomes white on Bad Mark and becomes black not on Bad Mark, that is O.K.. Usual
FILL	2	
CUT	NO	
WINDOW 1	ON+(112, 103)(143,134)	
DISPLAY	CROSS 1	Everyone is available (Only difference in calculation speed)



Counter measurements for image processing defects which occur during testing are listed below.

No.	Symptom	Cause	Remedy
1	The circumscribed quadrangle does not match the part position.	1) The angle of the part is not within the angle detection range. 2) The shape is too complex for the linear component sensor. 3) The light volume of the reflecting plate is inadequate or uneven.	1) Eliminate any tray rattling. Use the mechanical alignment (prior to use of the vision system) to determine the rough position. 2) Increase the FILL characters and stabilize the linear component sensor. 3a) Adjust the lens to obtain contrast between the reflecting plate (i.e. the background) and the component. 3b) Raise and lower the height of the light to make the brightness of the plate constant. 3c) Replace the fluorescent lamp.
2	Although the output circumscribed quadrangle is almost correct, lead pitch and number errors occur.	1a) The correct numerical value has not been input for the option. 1b) The vertical and horizontal numbers are reversed. 1c) The tolerance for both the lead width and the pitch is too small. 2) False recognition of the lead because of a dirty reflecting plate. 3) Light is striking the lead directly, causing it to shine and inhibiting lead recognition.	1) Choose the appropriate option setting. 2) Clean and replace the plate. 3) Adjust so the position of the image being received is in the center of the field of vision, then input again.

Label	Setting Value	Notes
HOLD	FIXED	Fixed camera
DIRECTION	UP	Up ward
SCALE	X : 0.10000~0.16000 Y : 0.10000~0.16000	changes by diff. types of lenses and position of focus
SHIFT	X : 300.00~600.00 Y : 300.00~500.00 R : 178.00~182.00	Vary by position of camera and distance from machine origin

SCALE definition: The size of one pixel in the fiducial image.

SHIFT definition: The distance between the vision origin and the centre of the field of view of the camera. (Is the number of pixels from the origin of the CCD multiplied by the scale).

(4) Test

Pick up the IC with head 3, and run the test in test mode. If the IC center coordinates are output as acceptable and repeatable, the results are OK.

```
DATA IN       V-FILE NAME : QFP100P
VISION  TEST                HISTOGRAM

STATUS     :
EXE. TIME  :
NUMBER     :
FEATURE    :

  F1      F2      F3      F4      F5      F6
```

To access screen f7-4-1 from f7-2-1, press 3(3. TEST).

Press F1 key and run the test.

f7-4-1

7-2-6 Comprehensive test

(1) **Mounting test**

* Mount a printed circuit board with components, including a chip. Confirm that the image of the PCB fiducial mark and QFP lead is processed repeatedly and accurately, and that the mounting has been done precisely.
* According to the selections made with regard to setup items such as the window size and the selected display screen, the processing speed is affected, so several trials should be attempted in order to find the optimal setup to work with.
* As for any problems which appear during the mounting test image processing, refer to the countermeasure charts listings described previously for tests done with the cameras. Also, for other problems, follow the suggested countermeasures listed in the chart below.

NO.	Indications	Causes	Countermeasures
1	Fiducial mark is not inside window.	1) Window is too small.	1a) Enlarge window size (but watch other parameters and patterns). 1b) Correct PCB origin point data or block shift point data so fiducial mark fits inside window.
2	Fiducial mark is processed properly, but "FIDUCIAL ERR" message appears when mounting program is run.	1) The correct area for the fiducial mark is not input in OPTION20 of the VFILE No. 0.	1) Input the correct surface area. For 1mm², input 100.
3	components cannot be recognized.		
4	Lead pitch errors occur frequently.	1) Lead width or pitch tolerance (OPTION02 or 04) is too small.	1) Enlarge the value of OPTION02 or 04, or input 0 to avoid a check.
5	Part is always offset in the same direction.	1a) Incorrect head offset amount. 1b) After adjustment, machine installation location was changed. 1c) Head and camera were adjusted and replaced. 2) Relative positions of PCB point data (fiducial mark) and mount data are not correct.	1) 2) Re-input the point data.
6	Mounting position varies.	1) Camera or lens rattles. 2) Arm rattles or belt is loose. 3) Calibration, in particular the scale and direction of rotation shift, is incorrect.	1) Securely position the camera and lens, then reset the calibration. 2) Adjust the arm or belt. 3) Readjust the calibration (Cx, Cy, Dr).

NOTE 1 When "VISION ERROR" message appears on the CRT, the cause should be checked in test mode of vision mode.

NOTE 2 If the object is not inside of window1 when image processing, the size of window1 should be enlarged or amount that the arm is moved should be shortened.

NOTE 3 When fixed camera adjustment is going to be done lead pitch error may happen. Because scale without adjustment can be deferent from actual scale and then lead width and lead pitch cannot be mesured correctly.
On that occasion execute <CALIB> program without checking them by entering 0 into both OPTION 02 and OPTION 04.

NOTE 4 If the video level (treshold) of the image is not sufficient enough to get a correct result it is possible to set with BINARY in manual mode different treshold values, so the system can calculate a better result.

3) Coarse calibration

To perform the coarse calibration we need the following tools:
- The <CALIB> utility program.
- A vision file which can be any file from 0 through 30 containing the vision data for a specific component (e.g. QFP100, PLCC48, etc.)
- A so called 'golden component' at a known component number.

Make sure that the camera is calibrated (see chapter 3-7-3-4) before continuing with following steps:

(a) Change temporary the tolerance parameter of the pin-pitch and pin-width to 0 (options 2 and 4) of the vision file which is going to be calibrated. In this way there is no check on these parameters.

(b) Start the utility job <CALIB>part B (chapter 3-2-6-5), and proceed as is indicated on the screen. Make sure that the component which is going to be calibrated is at the inputted component number and that the vision file number of this component is the same as the one you want to calibrate.

(c) After the <CALIB> is successfully finished, change the options 2 and 4 of the vision file again to standard values (e.g. between 10 and 30). Run a vision check again by moving the component above the fixed (component) camera and execute the vision test (see chap. 3-7-3-5).

4) Fine calibration

For the fine calibration we need the same tools as with the coarse calibration plus an additional mount program which is capable to mount at least 2 components, one at 0 and one at 180 degree (or at 90 and -90 degree).
Take care that:
- the mount-data of the components is correct and accurate (e.g. from a CAD system)
- the correct vision file is used.
- the correct component number is used which contains the correct vision number.

To perform a fine calibration we need to execute the steps 2.2 - 2.3 - 2-4 and 2.5 of the block-diagram several times:

(a) Mount 2 components with the mount program e.g. MNTQFP (block 2.3)

(b) Measure and calculate rotation by means of the X/Yoffset. (block 2.4) The rotation correction can be calculated by measuring 3 positions so we can draw a triangle. By knowing the two sides of this triangle we can calculate the arctg of the correction angle and thus also the correction angle itself.

(c) Is the result ok? If not then **first correct for ROTATION** by going back to block 2.2 which is the <CALIB> utility. In this <CALIB> utility goto part C (Fine calibration of a component vision file by means of mounting results) and proceed as indicated on the screen. (be careful to use the correct sign when inputting the corrections).

(d) After the correction values are inputted with the CALIB program, continue with (a) until the rotation in the mount result is within specification.

(e) Repeat the above described loop (a, b, c and d) but now measuring and inputting the X/Yoffset.

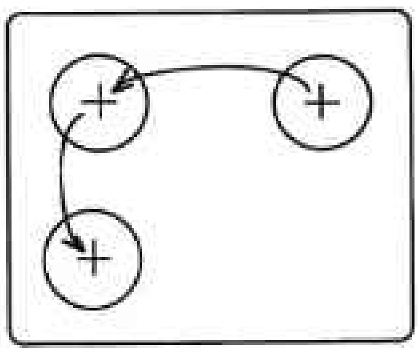
Remark: **Offset X/Y and Rotation is the amount of <u>movement of the board</u> to improve the placement result.**

2.1 Camera calibration

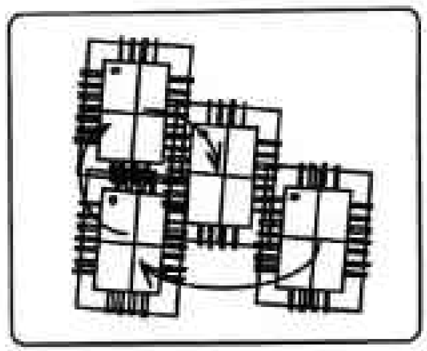
This calibration takes care of the camera's scale and shift corrections. To perform this calibration goto chapter 3-7-3-4 of this manual. This calibration has to be done each time the camera has been **changed, moved or readjusted.**

2.2 CALIB utility program (see chapt. 3.2.6.5)

With the CALIB utility program (part B) the **final SCALE and SHIFT** values will be calculated for **each individual component** e.g. QFP100, QFP160, PLCCxx. Make sure that the parameters are set correctly for the component in question. Also the measured and/or calculated corrections (X/Y shift and Rotation) is inputted here. See 2.4



Movable camera



Fixed camera

2.3 Mount 2 SMD's

Use for this mounting two components with perfect sizes (so called GOLDEN components). Prepare a mount program for 2 components using e.g. a small part of the Acceptance board and name it MNTQFP. The program must contain at least 2 mount lines on for 0 and one for 180 degree, or 90 and -90 degree.

2.4 Measurement results.

If the mounting results of the two components are ok, then the calibration is finished. If not then measure manually (by means of the fiducial camera) the offset in X/Y and calculate the rotation. First correct for rotation, if any, and then for X/Y offset. Input the corrections into the <CALIB> program (use part C of this utility). After the CALIB is finished run again the mount program. Repeat the above described procedure until the mount result is within specification.

2.6 More vision components.

If there are more components which are have to be calibrated repeat the procedure as described above.

7-3-3
Setup

(1) Setup screen

Press 1 to select SETUP from the menu screen. This is used to set the windows, conditions and the process to be used in carrying out image processing.

```
DATA IN       V-FILE NAME:FIDUCIAL
VISION  SETUP                 GO

MODE       : FID
CAMERA     : 1
OBJECT     : WHITE
BINARY     : AUTO
FILL       : 2
CUT        : NO
DISPLAY    : CROSS1
WINDOW1    : ON+ ( 64, 61)(191,174)
WINDOW4    : OFF
OPTION01 : 78 "AREA
OPTION02 : 30 "AREA TOLERANCE

  F1      F2     F3     F4     F5    F6
BINARY   FID    SOP    OPT1   OPT2  CONT
```

To access screen f7-2-2 from f7-2-1, press 1 (1.SET UP).

f7-2-2

(a) Use the ↑ and ↓ keys to select a setup item. The content of the function keys changes according to the selected item.

(b) Use the ROLL UP and ROLL DOWN keys to scroll through the screen display.

(c) Change the settings using the F1, F2, F3, F4, and F5 keys. The content of the function keys changes according to the selected item. When entering numerical values, press the F1 or EDIT key followed by Æ to display the cursor and the 0-9 keys to input the value. Then press the ⮕ key to enter the value.

(d) Use the F6 key to scroll through the functions.

(e) Press the G key to run an image processing test. The results of the processing will be displayed on the vision side of the CRT, but no changes are reflected on the robot side. Settings can be changed to see how the image will be processed in this simple test.

(f) Pressing the EXIT key ends the setup operation and returns to the menu screen.

(2) **Menu Screen**

After a file has been selected from the initial screen in the vision mode, when pressing the ◈ key the contents of that file can be shown and changed. In this sample initial screen, selecting file no. 0 will cause the following type of screen to appear.

```
DATA IN        V-FILE NAME : FIDUCIAL  --------- File name
VISION                            G0

                                          ----- Menu
  1. SET UP          ---
  2. CALIBRATION        |------------------
  3. TEST            ---
```

To access screen f7-2-1 from f7-1-1, press 0 (0.FIDUCIAL)→ F6

f7-2-1

Selecting one of the three items allows the contents of the file to be changed and a test to be run.

"1" key: Setup
: Image processing procedures, conditions, windows and other parameters are set.

"2" key: Calibration
: In order to match the mechanical system of coordinates with that of the vision system, both the scale of the vision coordinate X and Y axes and the shift volume of the X, Y, and R axes are set.

"3" key: Test
: An image processing test is done to confirm the parameters established during setup and calibration. In addition, a variable density histogram is plotted to check the brightness.

EXIT key: Exit
: Pressing this key concludes editing of the file contents and returns operation to the initial screen.

7-3 Vision Mode

7-3-1 Introduction

It is necessary to preset the VFILE setting to use the vision system for the purpose specified. VFILE is used to select cameras and functions, condition settings, the scale, and amount of shift in the coordinates. VFILE is set in a newly implemented vision mode.

Please read the following for information about key operations or for details about the parameters or image processing. Because this description of the vision mode is not limited to procedures done with a mounter, it is not essential for normal mounting operations.

7-3-2 Initial screen and menu screen

(1) Initial screen

When vision mode is selected (MAIN --> Data input --> Vision), the screen shown below will appear. The VFILE has the capacity to register 31 different files. A file is selected by writing a file name in a file number between 0 and 30. The file selected can then be registered. The contents can then be renewed and converted and VFILE No. can be selected in the robot language 'VFILE' statement.

```
DATA IN
VISION

 0.  FIDUCIAL
 1.  QFP100P
 2.  QFP160P
 3.  QFP44P
 4.
 5.
 6.
 7.
 8.
 9.

F1    F2    F3    F4    F5    F6
```

To access screen f7-1-1 from MAIN MENU, press MAIN MENU →3→3.

f7-1-1

(a) Select one file number between 0 and 30 with the ↑ and ↓ keys. After being selected, the original image picked up by the camera assigned in the file is displayed. (This is equivalent to the execution of the robot language 'VFILE' statement.)

(b) A new file name can be registered (or an old file can be renamed) by pressing the → key, a combination of alphanumeric keys (max. 8 letters) and ⇨ key

(c) Pressing C , a number key (i.e. 0-9) and ⇨ key will select a file number to which the data file can be copied. The file name and the contents of the entire file are then copied. (It is possible to repeat a file name, but it is easier to distinguish between files if a different name is used.)

(d) A file is deleted by pressing the DEL key and confirming (i.e. 1). (In other words, the register is erased.)

(2) Other points to note

1) Do not handle any of the cameras, especially the movable camera, carelessly. This can cause offset in the calibration, making precise mounting impossible.

2) The aperture and focus of the fixed camera lens can be changed. Adjustment has been made with the focus turned all the way to 0.3m or less, so please do not move it.

   Adjust the aperture so that the silhouette of the part can be clearly seen without the background brightness reaching the saturation level.

   (saturation being the point where the lines of the window cannot be seen anymore).
   Movable cameras do not have apertures, so the brightness must be adjusted using the appropriate knob.

3) Replace the fluorescent lamp when a noticeable deterioration of the brightness occurs. The lamp should last about 1500 hours.

Optional Parameters Table (1/2)

[FIDUCIALS]

Item	Label	Meaning
Option 1	OPTION01	Fiducial area [1/100mm²]
Option 2	OPTION02	Fiducial area error [%] 0: No area check 1-99: Specified value
Option 3	OPTION03	Fiducial peripheral length [1/100mm]
Option 4	OPTION04	Fiducial peripheral length error 0: No peripheral length check 1-99: Specified value

NOTE If both OPTIONS 02 and 04 are set to 0, the object with the largest area will be set as the fiducial.

[CHIP]

Item	Label	Meaning
Option 1	OPTION01	Vertical length of target object [1/100mm] 0: Automatic calculation -1: No reference to vertical length
Option 2	OPTION02	Horizontal length of target object [1/100mm] 0: Automatic calculation - 1: No reference to vertical length
Option 3	OPTION03	Length indexing on each side [%] 0: Default value (60%)
Option 10	OPTION10	Component regocnition: 0: Standard 1: Multi-stage recognition

Remark: for the options 11 - 14 see next page. (only for CHIP)

Setup Table (3/3)

Item	Label	Function	Meaning
Display screen	DISPLAY	INPUT0	Input image
		INPUT1	Binary image (for binary trace)
		EDGE0	Trace results + input image
		EDGE1	Trace results + binary image
		CROSS0	Center of gravity or intersection + input image
		CROSS1	Center of gravity or intersection + binary image
		ALL0	Trace results + center of gravity or intersection + input image
		ALL1	Trace results + center of gravity or intersection
		TEST0	Center of gravity or intersection + input image + numeric value
		TEST1	Center of gravity or intersection + binary image + numeric value

Setup Table (2/3)

Item	Label	Function	Meaning
Binary threshold value	BINARY	AUTO	Automatic binary
		MANUAL	Fixed level binary
		AREA	Fixed object binary, P-tile method
		+	Level change (+ side)
		-	Level change (- side)
		+10	Level change (10-unit + side)
		-10	Level change (10-unit - side)
Hole filling/small area cuttin	FILL CUT	NO	Hole filling • Small area cut
		1	Hole filling/small area cutting (1 time)
		2	Hole filling/small area cutting (2 times)
		:	:
		9	Hole filling/small area cutting (9 times)
Window 1,4	WINDOW1 WINDOW4	1-LEFT	Move corner 1 left
		1-RIGHT	Move corner 1 right
		2-LEFT	Move corner 2 left
		2-RIGHT	Move corner 2 right
		1-UP	Move corner 1 up
		1-DOWN	Move corner 1 down
		2-UP	Move corner 2 up
		2-DOWN	Move corner 2 down
		ON+	Window valid, scan on + side
		ON-	Window valid, scan on - side
		OFF	Window invalid

(2) Setup table

The chart below shows the items and functions available during the setup operation. The functions corresponding to the labels are displayed on the function keys, so set the appropriate function from among the labels. The meaning of optional parameters changes depending on the processing method.

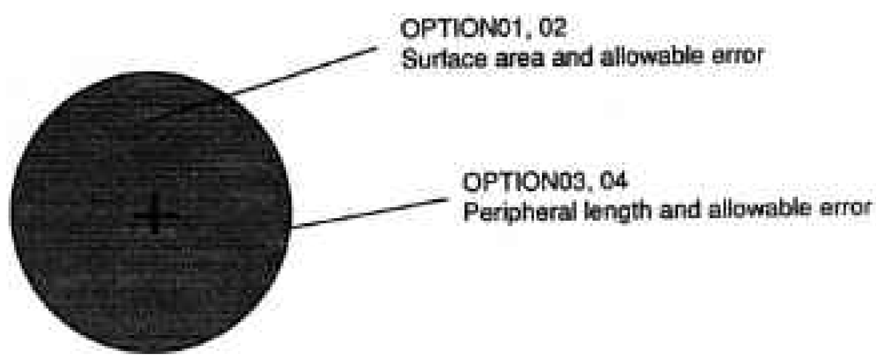
Setup Table (1/3)

Item	Label	Function	Meaning
Image processing mode	MODE	BINARY	Binary trace
		FID	Fiducial mark recognition
		QUAD	Detects center and inclination of chip or PLCC
		SOP	Detects center and inclination of SOP
		QFP1	Detects center and inclination of QFP
		CHIP	Detects center and inclination of chip or PLCC
		QFP2	Detects corner of QFP-
		DISP	Needed when using the High Speed Dispense system
Camera selection	CAMERA	1	Selects Camera 1
		2	Selects Camera 2
		3	Selects Camera 3
		4	Selects Camera 4
Object identification	OBJECT	WHITE	Object: White
		BLACK	Object: Black

Fiducial mark recognition (FID)

The basic internal processing is the same as that for the binary trace, explained previously.
For this process, entering data pertaining to the surface area and the peripheral length enables objects satisfying the conditions in the vision system to be identified as fiducial marks. An error is assumed if there are two or more objects fulfilling the conditions, or if no object fulfilling the conditions is found.
[WINDOW1:] is used to define the range of the area to be processed.
There are several optional parameters which can be used in processing.

For OPTION01 and OPTION02, input the surface area of each of the fiducial marks, and the allowable margin of error. For example, if the surface area of the mark is 3.00m² and the dispersion is within 20%, enter 300 for OPTION01 and 20 for OPTION02. If 0 is entered for OPTION02, judgment is not done based on surface area.
In the same way, OPTION03 and OPTION04 are used for the peripheral length of the fiducial mark and the allowable margin of error. For example, if the peripheral length of the mark is 6.50mm and the dispersion is within 30%, enter 650 for OPTION03 and 30 for OPTION04. If 0 is entered for OPTION04, judgment is not done based on peripheral length.
If both OPTION02 and OPTION04 are 0, the object with the largest surface area is taken as the fiducial mark.



(3) **Setup details**

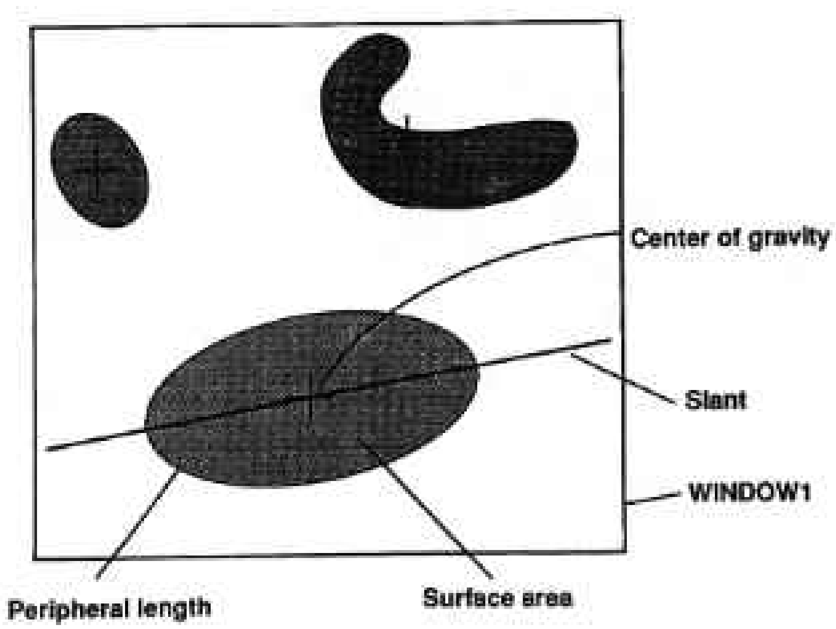
Each of the setup items is described below in detail. Since each option is related to other image processing methods, explanations of those will be added as necessary.

(4) **Image processing mode [MODE:]**

This determines the type of processing mode. The feature amount extracted differs depending on the mode. Image processing modes are divided into two general classes: those provided in the vision system ROM, and vision programs developed by the user and stored in the vision system RAM. Select (USER) to select a vision program.
The feature amount that can be extracted depends on the image processing method. For details on feature amounts, please see Section 3-6, "Table of Feature Amounts".

Binary Trace (BINARY)
This converts a density-variable image of a 256-level density to a 2-level density binary image. In other words, pixels with a density value of less than the threshold value are converted to a density value of 0, while those above the threshold value are converted to 1. The edge of the target object can then be traced and the contour of the object extracted. However, when a binary image is displayed, pixels with a density value of 1 are converted to a density value of 255 and displayed. The binary threshold value is set under a separate item [BINARY:].

For each of the recognized objects, the X and Y coordinates of the center of gravity, the slant of the inertial axis, the surface area, and the peripheral length can be output.W INDOW1:] is used in specifying the area to be processed. No options are used.

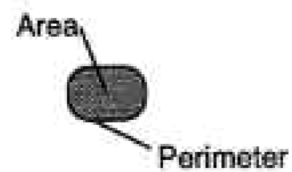


Disp - mode

Item	Label	Meaning
Option 1	OPTION01	Maximum area of collective dots. unit:1/100 mm2. Zero (0) means no check.
Option 2	OPTION02	Minimum area of collective dots. unit:1/100mm2. Zero (0) means no check.
Option 3	OPTION03	Shape code. (unit:1/100) is approximately 355 (=2Vpi), see remark -1.
Option 4	OPTION04	Shape tolerance, unit:%. Zero (0) means no check. See remark -2.
Option 5	OPTION05	Standard area for head 1. (see remark-3)
Option 6	OPTION06	Standard area for head 2.
Option 7	OPTION07	Standard area for head 3.
Option 8	OPTION08	Dispense timer head 1.
Option 9	OPTION09	Dispense timer head 2.
Option 10	OPTION10	Dispense timer head 3.
Option 11	OPTION11	Maximum object number.
Option 12	OPTION12	Algoritm selection. (NOT USED)

Remark-1:

After checking the area by option 1,2, the shape of the glue is checked. The vision software compares the value @ = shape-code x Varea (mm) and measured perimeter. If the difference is within the tolerance as given in option 4, than we treat this area as collect.



Remark-2:

If ((Perimeter < @ x (100 + tolerance)/100) or
(Perimeter > @ x (100 - tolerance)/100)) then ok.

After the checking is completed the common program reads in the area-numbers of only the good shaped dots.

Remark-3:

The options 5-11 are set-up by the <CALIB> utility program and used by the common program automatically.

Option Parameters Table (2/2)

[QUAD, SOP, QFP1]

Item	Label	Meaning
Option 1	OPTION01	Lead width [1/100mm]
Option 2	OPTION02	Lead width error [%] 0: No lead width check 1-99: Specified value
Option 3	OPTION03	Lead pitch [1/100mm]
Option 4	OPTION04	Lead pitch error [%] 0: No pitch check 1-99: Specified value
Option 5	OPTION05	No. of vertical leads 0: No check 1-99: Specified value
Option 6	OPTION06	No. of horizontal leads 0: No check 1-99: Specified value
Option 7	OPTION07	Lead detection line offset 0: Default (2) 1-255: Specified value
Option 8	OPTION08	Lead detection start/end offset for recognition of QFP with bumper 0-255; normally 0
Option 9	OPTION09	Processing algorithm selection 0: Use method least square 1: Use half-conversion of 0.5° unit 2: Use half-conversion of 1° unit
Option 10	OPTION10	Component regognition: 0: Standard 1: Multi-stage
Option 11	OPTION11	Cal. eccentricity, is 0 when opt.10 is 0 degree. unit is 1/100 degree
Option 12	OPTION12	Cal. eccentricity, is 0 when opt.10 is 90 degree. unit is 1/100 degree
Option 13	OPTION13	Cal. eccentricity, is 0 when opt.10 is 180 degree. unit is 1/100 degree
Option 14	OPTION14	Cal. eccentricity, is 0 when opt.10 is 270 degree. unit is 1/100 degree

NOTE: With QUAD, OPTION01-08 are ignored.

As the parameters for these types of processing, several of the optional parameters from <Setup> are used.

The lead width and allowable error are input for OPTION01 and OPTION02, while the lead pitch and allowable error are input for OPTION03 and OPTION04. For example, for a QFP with a lead width of 0.3mm and a lead pitch of 0.65mm, 30 and 65 are input for OPTION01 and OPTION02. If the allowable error is, for example, 30%, then 30 is input for OPTION02 and OPTION04. Inputting 0 for these parameters causes a check of the lead width and lead pitch to be skipped. Since the lead width and lead pitch are not closely tied to the measured length, input the optimum allowable error for the conditions at hand. Normally 0 is input for OPTION02 and 30 for **OPTION04**.

For **OPTION05 and OPTION06**, input the number of leads in the vertical and horizontal directions. For example, for a QFP with 30 vertical leads and 20 horizontal leads, input 30 for OPTION05 and 20 for OPTION06. Inputting 0 causes the check of the number of leads to be skipped. For SOP, the leads in the direction for which a value is input will be detected, but if values have been input for both OPTION05 and OPTION06, OPTION05 is given priority.

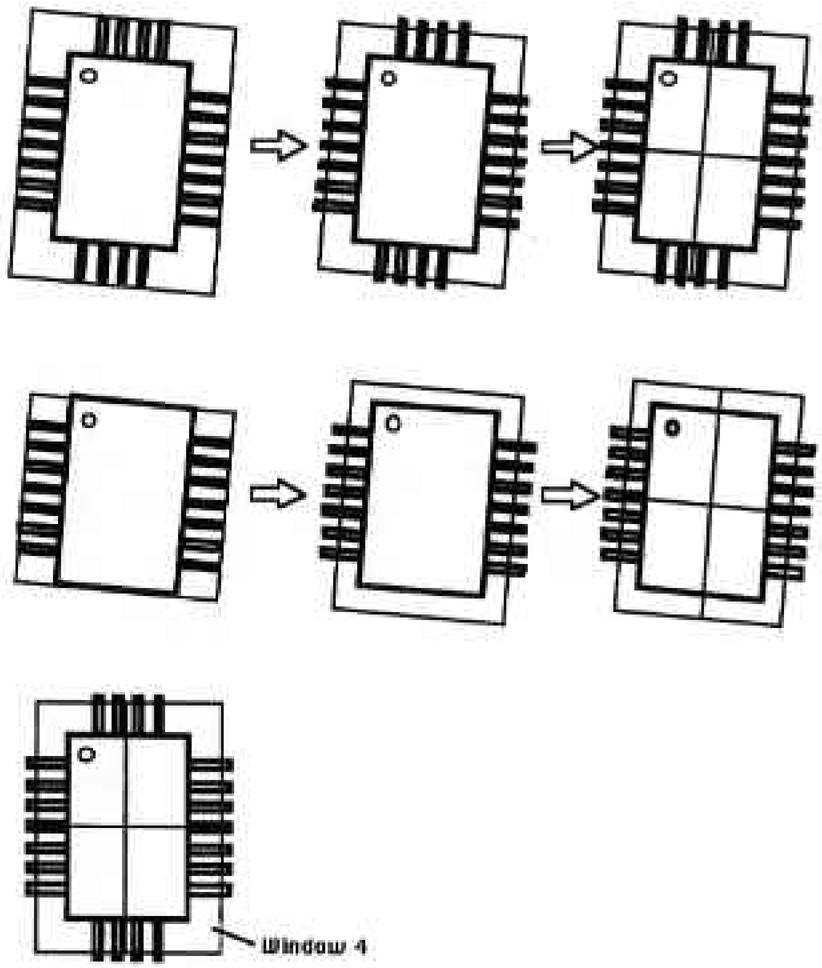
OPTION07 is the offset amount when setting the lead detection line from the quadrangle circumscribing a previously detected part. Normally this can be 0, but 5 can be input, for example, to detect a lead 5 pixels inside of the quadrangle.

OPTION08 is used after setting the detection line of the lead, to specify the offset amount setting the position where lead detection is to start and stop. The unit of measurement is pixels. Normally this can be 0, but, for example with a QFP that has bumpers in the four corners, OPTION08 must be set to the appropriate setting to make sure the bumpers will not be detected. In a case like this, the setting value is usually set to about 10.

OPTION09 is used to select the processing algorithm for quadrangle detection. This will not be explained at this point.

For **OPTION10** is used for component recognition. There are two types of component recognition: normal recognition and multi-stage recognition. With normal recognition, the component is recognized once, correction is applied and the component is mounted. This method also enhances the overall system performance.With multi-stage recognition, the component is recognized two or three times, with correction being applied, so that components can be mounted with higher precision.

Below is a simple diagram of the processing operation. It shows SOP and QFP1 when [WINDOW4:] is not used, and when it is used.



IC center detection and general recognition (QUAD, SOP, QFP1)
This mode allows for precise position adjustment of QFP-type electrical components. It is used by the surface mounter.

This can be divided into two main types of processes. In the first step of the process, the circumscribed quadrangle on the IC is sought, while in the second step, once the IC lead is identified, the correct position center is calculated. The first stage uses binary data; the second one employs multi-value data. At this time, only QUAD makes exclusive use of the first step of the process. With rectangular parts such as PLCCs, QUAD is used to determined the center and slant of the part.

When using lead detection in recognizing precise positioning, SOP and QFP1 are used to specify whether lead detection is done on two or four sides.

With QFP1 the positions of all leads intersecting the sides of the circumscribed quadrangle determined in the first stage are averaged and the average set as the midpoint of the side. The midpoint of the opposite side is found in the same way , and the intersection connecting the two opposing midpoints is set as the center of the QFP, with the slant of the intersecting line being the slant of the QFP.

SOP is used to determine the midpoint of sides with no leads, from the circumscribed quadrangle.

Start

1 Image input

↓

← 2 Enable window 4?

↓

3 Determine quadrangle circumscribing workpiece

↓

← 4 Detect lead?

↓

→ 5 Lead detection is done on two sides (SOP) or 4 sides (QFP1) and the center position of the workpiece determined.

↓

→ 6 Data output/image output

↓

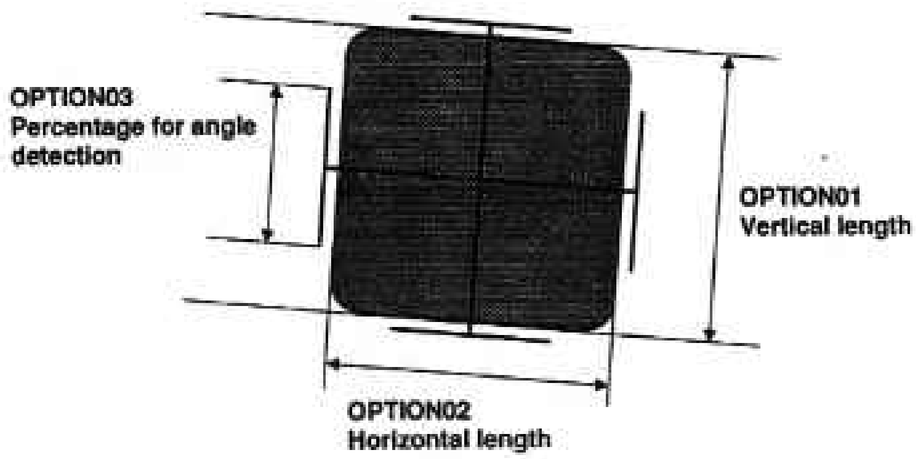
End

[WINDOW1:] specifies the processing area, while [WINDOW4:] is used as the detection line of the IC lead.
Setting [WINDOW4:] on for SOP and QFP1 causes the first stage to be omitted and the lead intersecting [WINDOW4:] to be recognized. When there is little or no offset in the position of the IC, window 4 is enabled, and the process that adjusts the size of all leads so they can cross window 4 stably is done at high speed. [WINDOW4:] is normally off.

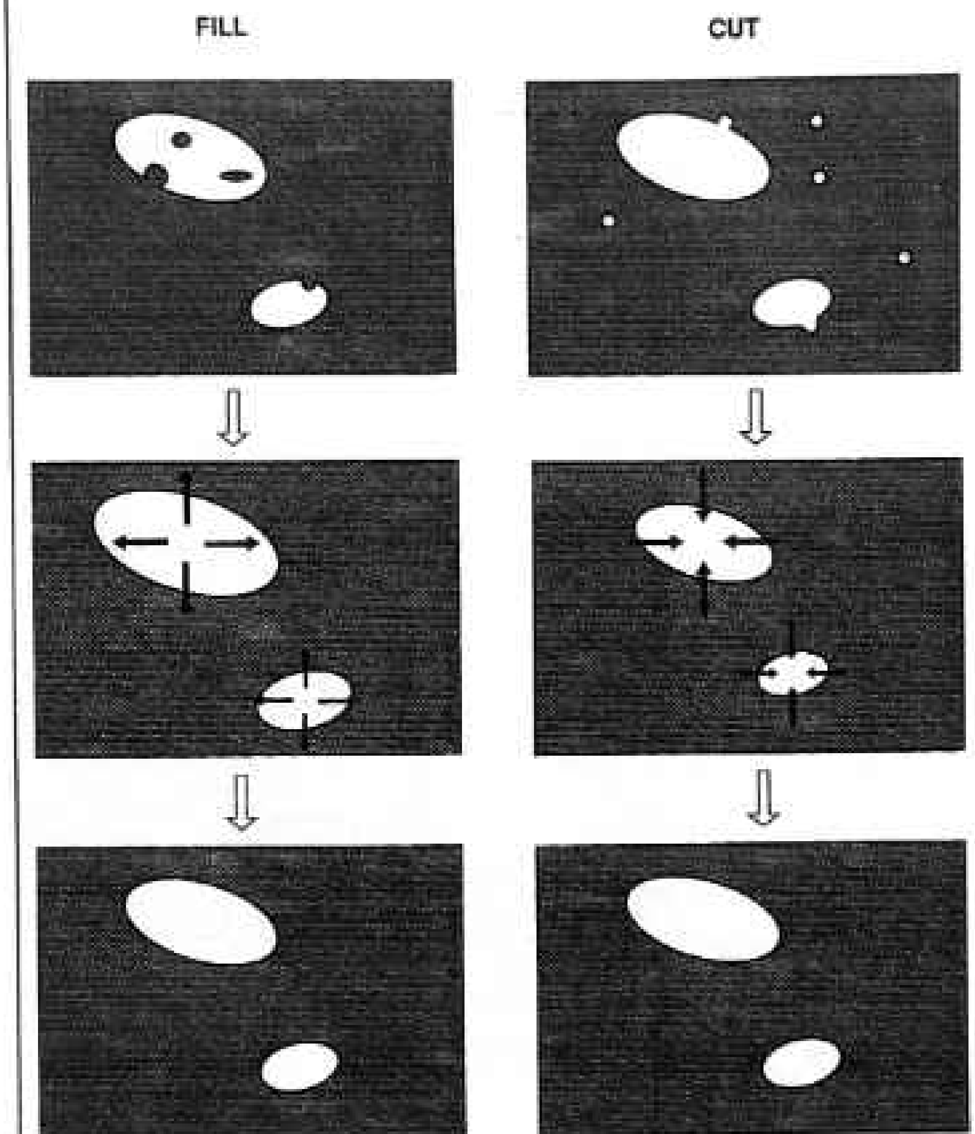
Detection of center position of chip (CHIP)

The basic internal processing is the same as that for the binary trace, described above.
With this process, the object with the largest surface area is taken as the chip, and the center of gravity is set as the center of the part. The slant of the part is determined from the linear components of the 4 sides: upper, lower, left and right. [WINDOW1:] is used to define the range of the area to be processed.

OPTION01 and OPTION02 are the vertical and horizontal lengths of each of the parts. For example, to recognize a rectangular part with a vertical length of 5mm and a horizontal length of 10mm, input 500 for OPTION01 and 1000 for OPTION02. entering 0 here causes the length in that direction to be determined automatically. For a nearly rectangular part, 0 is sufficient. If -1 is input, the data in that direction is not used in calculating the slant of the part. If -1 is entered for both OPTION01 and OPTION02, an error is issued.
OPTION03 is a percentage used to calculate the slant of the detected sides. For example, input 80 if 80% can be used. If 0 is entered, 60% is automatically used for calculation.
Normally, 0 is entered for OPTION01-03.



Hole Fill and Small Area Cut



(5) **Camera selection [CAMERA:]**
This selects which of the four cameras is to be used. The instant a selection is made, the CRT screen changes to show the original image. The initial value is (1).

(6) **Object-based recognition [OBJECT:]**
This selects whether an object to be recognized with binary processing is black or white. Select WHITE if the background is dark and the object is white, and BLACK for the reverse conditions. Setting this in reverse makes the background taken as the image. The initial value is WHITE.

(7) **Binary level [BINARY:]**
This selects the method by which the binary threshold value will be decided. In a processing mode using binary images, this must be set to the appropriate selection. There are 3 methods and numeric data that is used with each one.

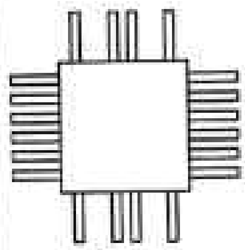
Automatic binary processing by variable density distribution (AUTO)
Based on the density distribution of the image, the most appropriate threshold value is determined through a judgment analysis method, and binary processing carried out. This enables stable binary processing even when the illumination changes, but calculation of the threshold value requires some time, and the results may be influenced somewhat by the shadow of the object.

Automatic binary processing method derived from the surface area of the object (AREA):
First, a histogram is created for each density of the variable-density image, and then the accumulation frequency distribution is obtained. The threshold value is determined from this accumulation frequency distribution and the size of the input object, and binary processing is carried out.
This is the most effective method in terms of time and is much faster than AUTO as long as the size of the object and the number of objects do not change. The size of the object is changed between 0 and 255, using the (+1), (-1), (+10), and (-10) keys to set the value in parentheses next to the function, and the optimum value is determined while actually running the binary processing. This numerical value indicates the square root of the surface area of the object in pixel units. For example, if "100" is input, the surface area is set as 100 x 100 = 10000 pixels.

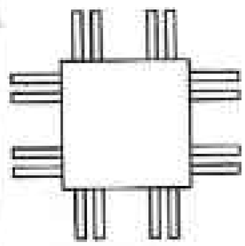
Fixed binary (MANUAL)
This is a binary process in which the variable density threshold value is fixed ahead of time. Binary processing can be carried out at maximum speed, but illumination and other factors must be stabilized. The numerical data in parentheses indicates the variable density just as it is. The threshold value is set between 0 and 255, using the (+1), (-1), (+10), and (-10) keys, and the optimum value is determined while actually running the binary processing.

(8) **Hole fill and area cut [FILL:, CUT:]**
After the image undergoes binary processing with the BINARY function, it may, depending on the conditions, have shadowy characteristics or holes where binary processing could not be carried out cleanly. The FILL and CUT functions are used to remove these.
With FILL, the object specified by the OBJECT parameter for the binary image (if WHITE, the white portions) is expanded a specified number of times and then contracted so that holes, projections and indentations can be eliminated. CUT is the opposite of FILL, in that the image is reduced a specified number of times and then expanded so that small debris-like areas and projections can be removed.
In either case, increasing the number of times processing is done reduces the speed and distorts the shape of the object.

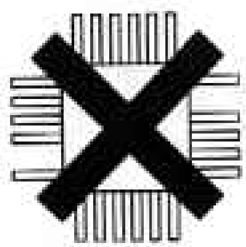
With SOPs and QFP1s, if the leads of the sides are not basically symmetrical at the top, bottom, left and right, the center position and slant cannot be detected. The following restrictions apply:



(1) With parts that have different vertical and horizontal lead pitches, a lead pitch check is impossible. Therefore, 0 must be input for OPTION04. In the same way, if the widths are different a width check cannot be carried out, so 0 must be entered for OPTION02.

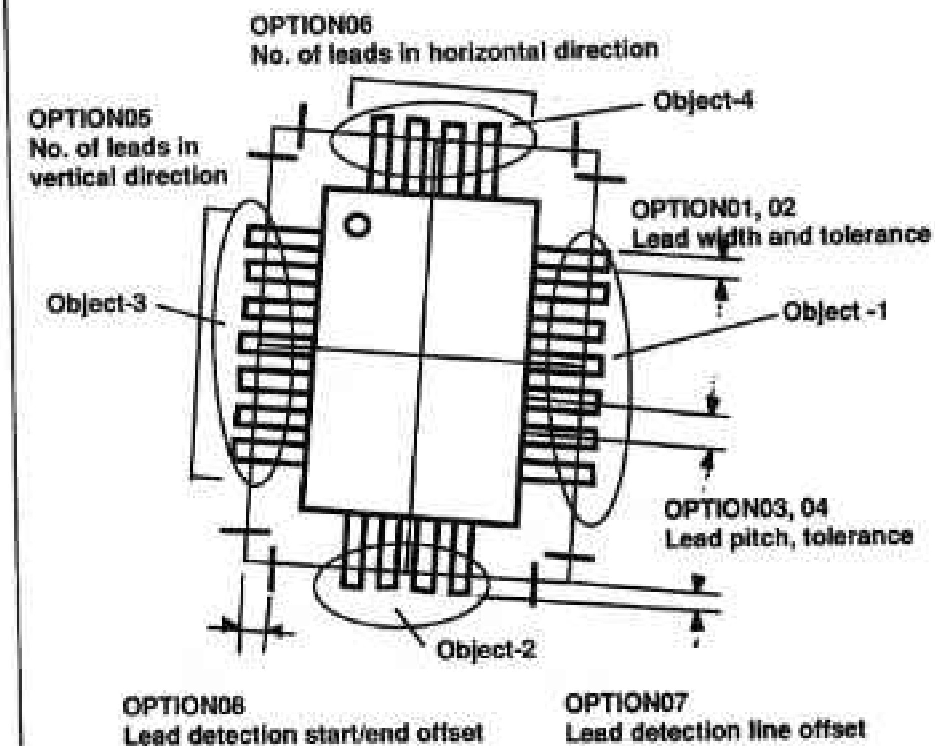


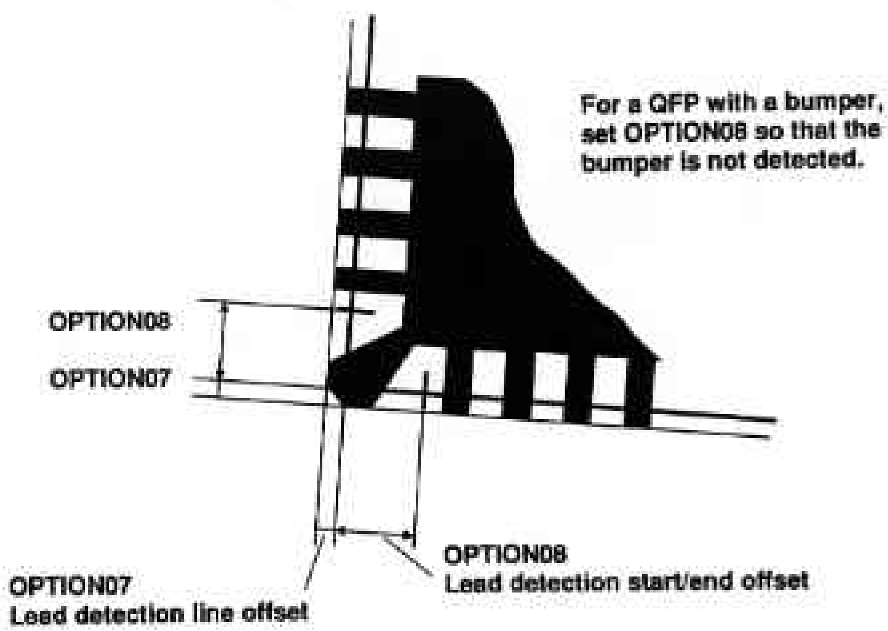
(2) If the part has missing leads, a lead pitch check is impossible. Therefore, 0 must be input for OPTION04.



(3) Parts cannot be recognized unless the top/bottom and left/right sides are symmetrical.

OPTION01-08 are ignored with QUAD.
The diagram below illustrates OPTION01-08.



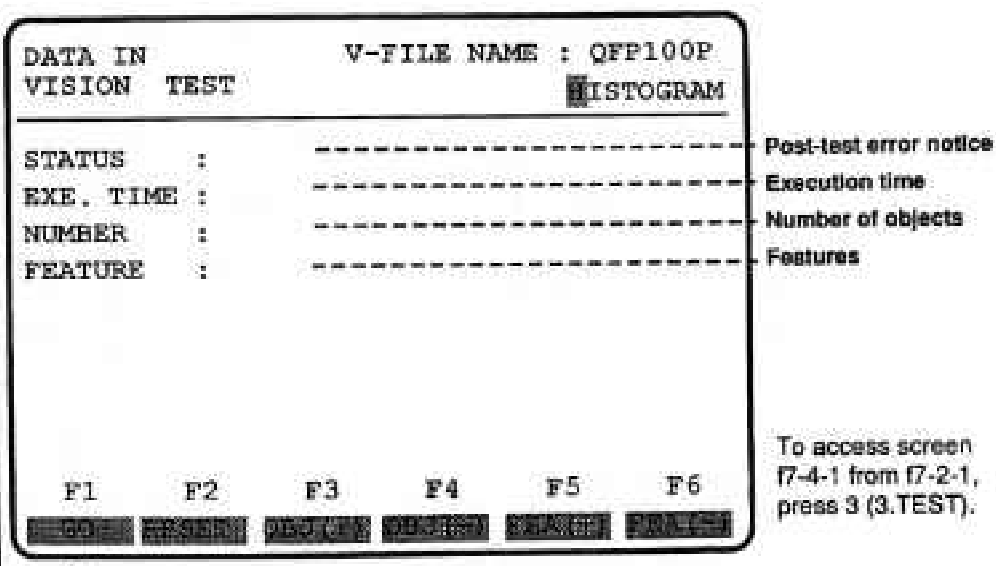


7-3-5 Test

Press "3" on the menu screen to select "TEST" and run an image processing test. In this function, an image is actually read and processed in accordance with the currently specified setup and calibration settings. (This corresponds to the VGET instruction in the robot language.) If the image processing proceeds normally, "OK" will appear on the screen. If it does not, an error message will be displayed under STATUS.

When "OK" is displayed, the time required to execute the image processing will be shown under EXE.TIME, the total number of objects (and/or intersecting points) will be displayed under NUMBER, and "FEATURE: (x, y)" will show the feature volume corresponding to feature y of object x. If "OK" does not appear or if the feature volume is different from what was expected, the setup and calibration settings are not the optimum settings, and should be revised.

The feature volume which can be extracted changes depending on the image processing mode.



To access screen f7-4-1 from f7-2-1, press 3 (3.TEST).

f7-4-1

(a) Pressing F1 starts the image processing. When the processing is completed, the status, execution time, total number of objects, and feature volume are displayed. When "OK" appears, the feature volume may be extracted. If an error has occurred, take corrective action in response to the error status displayed on the screen.
If the processing was normal, the following display will occur. Execution time is measured in milliseconds.

(2) Calibration items chart

The chart below shows the items and functions involved in calibration. Just as with setup, the functions correspond to the labels on the function keys, so set up by selecting the functions which meet the demands of the desired operation.

Item	Label	Function	Meaning
Camera "hold"	HOLD	FIXED	Fixed camera
		MOVING	Camera moves on the X/Y axes
Direction of camera's field of vision	DIRECTION	UP	Faces up
		DOWN	Faces down
Scaling of X and Y axes	SCALE	EDIT	System coordinates scaled relative to those of the robot
Shift volume of X, Y, and R axes	SHIFT	EDIT	System coordinates shift volume relative to those of the robot (Units for X and Y: mm. For R: degrees)

(3) Details about calibration

When the camera is facing upward (UP) relative to the robot, and fixed separately from the robot, if the scale of the robot coordinates (relative to the system coordinates) is set to (CX, CY), the amount of shift from the origin set as (DX, DY), and the rotation of the shift as DR, the following formula can be used to convert a pair of optional vision system coordinates (x, y) to a robot coordinate point (X, Y).

$$\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} COS \cdot Dr & -SIN \cdot Dr \\ SIN \cdot Dr & COS \cdot Dr \end{bmatrix} \times \begin{bmatrix} x \cdot Cx \\ y \cdot Cy \end{bmatrix} + \begin{bmatrix} Dx \\ Dy \end{bmatrix}$$

CX, CY, DX, DY, and DZ represent the calibration SCALE and SHIFT. Conversely, when the camera is facing downward relative to the robot, the vision system coordinates are inverted relative to the coordinates of the robot. In this situation, the system coordinates (x, y) are changed to (x, -y) and then converted to the robot coordinates (X, Y).

In addition, depending on the camera hold procedure used, the feature amount output by the calibration (DX, DY) and the vision system may take on different meanings.

(a) With a fixed camera (FIXED)
- DX, DY --- Amount by which the origin point of the robot coordinates is off from the origin point of the vision coordinates.
- Feature volume output by coordinate value (center of gravity position, etc.) --- Becomes absolute position on robot coordinates.

(b) With a movable camera (MOVING)
- DX, DY --- Amount by which vision coordinate origin point is offset in relation to robot coordinate origin point.
- Feature volume output by coordinate value --- Relative position of robot coordinate from current position of the robot used to carry out the image processing.

7-3-4 Camera Calibration

(1) Calibration screen

"Calibration" is selected by pressing "2" when the vision screen is displayed. In the vision system, the definition of the direction of the coordinates (front or rear) and the feature amount are changed in accordance with the direction and method of attachment of the camera's mechanical (robot unit) section. Once the robot and camera are set up in the workplace, they must be attached, and then their respective directions must be set correctly. After this, in order to make sure the coordinates of the mechanical system match those of the vision system, the scale for the vision system X, Y and R axes is set, as well as the amount of shift along the X, Y and R axes.
There are two methods of setting the scale and amount of shift: one is by inputting the numerical values directly, and the other is calculation of the set values by teaching three arbitrarily selected points to the vision system and computing the values.

```
DATA IN        V-FILE NAME :QFP100
VISION  CALIBRATION          00
-------------------------------------
HOLD        : FIXED
DIRECTION: UP
SCALE      : 0.14500   0.14606
SHIFT      : 337.20 597.17 179.98







 F1     F2     F3     F4     F5     F6
FIXED  MOVING
```

To access screen f7-3-1 from f7-2-1, press 2 (2.CALIBRATION).

f7-3-1

(a) Use the ↑ and ↓ keys to select the desired setup item. The operations assigned to the function keys will change according to the item selected.

(b) Use the F1 and F2 keys to change the setting. When numerical data is to be input, press F1 (EDIT), and then use the 0-9 keys to enter the value. Input the value by pressing the ⏎ key.

(c) Press the G key to run a test of the image processing. The results are displayed on the vision side CRT, but no changes are made on the robot side CRT. It is easy to change the settings and run a test to see the image processing results. Among the setup items, set [DISPLAY:] to either (TEST0) or (TEST1). If numerical data is displayed on the vision side CRT, the image processing is being carried out correctly.

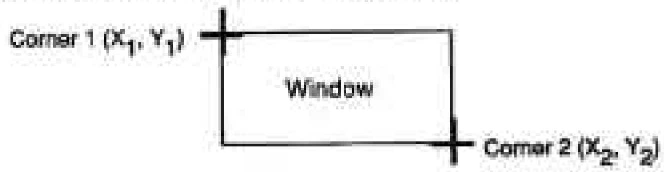
(d) Use the EXIT key to terminate the calibration procedure and return to the menu screen.

(9) Window [WINDOW1:, WINDOW4:]

This sets the relevant range for image processing. The meaning differs depending on the processing mode, but in processing modes that are already set up in advance, only [WINDOW1:] and [WINDOW4:] can be used.

Using the 1-LEFT, 1-RIGHT, and other function keys, the corners of the window can be moved up, down, left and right to change the size of the window. The corners move one pixel at a time in the up/down directions, but in the left and right directions, movement is possible only in units of 16 pixels at a time, except for Window 4. The four numerical values shown in two groups each are the X and Y coordinates of the corner. ($0 \leq X \leq 255$, $0 \leq Y \leq 239$)

ON+, ON- and OFF select whether or not the window is effective. ON+ and ON- indicate the directionality of the window, and either value may be set. Setting OFF causes the window display to disappear. For the initial value, [WINDOW1:] is ON+ (0, 0) (255, 239), and other windows are OFF.



(10) Display screen [DISPLAY:]

After image processing is run, the image to be output on the CRT is selected. This does not affect the processing content in any way, but if the display is particular complex, that segment is run as the total, slowing down the processing speed. Thinking in terms of speed alone, INPUT0 is the fastest for displaying the input image only. The 5 items shown below are displayed, some of them overlapping in different processing modes.

	Original image	Binary image	Detect ed edge	Center position	Numerical data
INPUT 0	4				
INPUT 1		4			
EDGE 0	4		4		
EDGE 1		(4)	4		
CROSS 0	4			4	
CROSS 1		4		4	
ALL 0	4		4	4	
ALL 1		(4)	4	4	
TEST 0				4	4
TEST 1		(4)		4	4

* Items in parentheses (4)
When the detected edge is displayed, it may disappear if it overlaps a binary image. In this case, only the edge is displayed.

7-3-7 Error status chart

When a test is done in vision mode, or if it is executed via a robot language VGET statement, the status changes to the image processing completed status (i.e. error status). (This corresponds to feature volume: VFEA (0, 0).) If an error has occurred, either change the contents of the VFILE or eliminate the error according to the program.

Status No.	Message at Time of Test	Contents (Term in parentheses indicates processing mode)
0 or more	OK	Ended normally
-400 -401 -402 -403	Setup error Object overflow	There is an error in the vision file setup.
-301	Lead detection error	(BINARY) Total number of detected objects is too large.
-320 -331	Lead number error	(SOP, QFP1) IC lead could not be detected.
-332	Lead pitch error	(SOP, QFP1) Number of IC leads does not match.
-321	NG	(SOP, QFP1) IC lead width or pitch exceeds allowable range.
-330	Object detect error	No values are given for scale or shift

(3) CHIP (Position detection of chip parts through general recognition)

Feature Vol. No. Y	Object No. x = 0	Object No. x $1 \le x \le 4$
0	Image processing completed	Total no. of objects
1	X coordinate of center of work piece [mm]	X coordinate of center of gravity for object x [mm]
2	Y coordinate of center of work piece [mm]	Y coordinate of center of gravity for object x [mm]
3	Slant of workpiece [°]	Slant of object x [°]
4	Surface area of work piece [mm²]	Surface area of object x [mm²]
5	Peripheral length of work piece [mm]	Peripheral length of object x [mm]

(4) QUAD, SOP, QFP1 (Position detection of ICs through general recognition)

Feature Vol. No. Y	Object No. x = 0	Object No. x $1 \le x \le 4$
0	Image processing completed	Fixed value: 4
1	X coordinate of center of work piece [mm]	X coordinate of midpoint of side x [mm]
2	Y coordinate of center of work piece [mm]	Y coordinate of midpoint of side x [mm]
3	Slant of work piece [°]	No. of leads detected on side x

(5) QFP2 (Midpoint detection of ICs through division recognition)

Feature Vol. No. Y	Object No. x = 0	Object No. x > 0
0	Image processing completed	Total no. of lead intersections
1	------------	X coordinate intersection x [mm]
2	------------	Y coordinate of intersection x [mm]

7-3-6 Feature volume chart

The processing mode established in [MODE:] determines the definitions of the various feature volumes in the image processing procedure, so check carefully before proceeding. The table below shows the feature volumes corresponding to each image processing mode. When a vision program is run, the output varies depending on the program.

(1) BINARY (Binary trace)

Feature Vol. No. Y	Object No. x = 0	Object No. x > 0
0	Image processing completed	Total no. of objects
1	X coordinate of center of gravity for largest object [mm]	X coordinate of center of gravity for object x [mm]
2	Y coordinate of center of gravity for largest object [mm]	Y coordinate of center of gravity for object x [mm]
3	Slant of largest object [°]	Slant of object x [°]
4	Surface area of center of gravity for largest object [mm²]	Surface area of object x [mm²]
5	Peripheral length of center of gravity for largest object [mm]	Peripheral length of object x [mm]

(2) FID (Recognition of PCB fiducial mark)

Feature Vol. No. Y	Object No. x = 0	Object No. x > 0
0	Image processing completed	Total no. of objects
1	X coordinate of center of gravity for fiducial mark [mm]	X coordinate of center of gravity for object x [mm]
2	Y coordinate of center of gravity for fiducial mark [mm]	Y coordinate of center of gravity for object x [mm]
3	-------------------- [°]	Slant of object x [°]
4	Surface area of fiducial mark [mm²]	Surface area of object x [mm²]
5	Peripheral length of fiducial mark [mm]	Peripheral length of object x [mm]

```
DATA IN      V-FILE NAME : QFP100P
VISION  TEST                    HISTOGRAM
──────────────────────────────────────────
STATUS     : OK
EXE. TIME  : 120[MSEC]
NUMBER     : 10
FEATURE    : (1,1)=1.23456E3



  F1      F2      F3      F4      F5      F6
  GO    RESET   OBJ(+)  OBJ(-)  FEA(+)  FEA(-)
```

To access screen f7-4-2 from f-7-4-1, press F1 (F1.GO).

f7-4-2

(b) When the STATUS shows "OK", use F3 and F4 to select the object number, and F5 and F6 for the feature volume number. After each selection has been made, the specified feature volume is displayed, to be checked by the user. The feature volume is displayed as an exponential value.

In the example above, the data for the feature volume number 1 of object number 1 is:

$1.23456 \times 10^3 = 1234.56$

The definitions of the object and feature volume numbers change depending on the processing mode established during setup. Features indicating position and length are shown in mm, the surface area is measured in mm^2, and the angle in degrees.

(c) F2 is used to reset the vision monitor, and display the original image. Alternately pressing F2 and F1 will repeat the test as many times as desired.

(d) Pressing H will cause the image read from Window 1 to be displayed as a variable density histogram. This is used to check the threshold of the automatic binary encoding and the distribution of lightness and darkness in the image. The robot screen display will not change at all.

(e) Image processing can be interrupted by pressing the STOP key. This is effective if image processing enters an endless loop because of a programming problem or if some other program-based problem occurs.

(f) Pressing EXIT ends the test and returns to the menu screen.