FANUC Robot series

R-30iB／R-30iB Mate／R-30iB Plus／R-30iB Mate Plus CONTROLLER

iRCalibration
OPERATOR'S MANUAL

B-83724EN/04

Thank you very much for purchasing FANUC Robot.

Before using the Robot, be sure to read the "FANUC Robot series SAFETY HANDBOOK (B-80687EN)" and understand the content.

SAFETY PRECAUTIONS

This chapter describes the precautions which must be followed to enable the safe use of the robot. Before using the robot, be sure to read this chapter thoroughly.

For detailed functions of the robot operation, read the relevant operator's manual to understand fully its specification.

For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral equipment installed in a work cell.
For safe use of FANUC robots, you must read and follow the instructions in "FANUC Robot series SAFETY HANDBOOK (**B-80687EN)**".

1   PERSONNEL

Personnel can be classified as follows.

Operator:
• Turns the robot controller power ON/OFF
• Starts the robot program from operator panel

Programmer or Teaching operator:
• Operates the robot
• Teaches the robot inside the safeguarded space

Maintenance technician:
• Operates the robot
• Teaches the robot inside the safeguarded space
• Performs maintenance (repair, adjustment, replacement)

- The operator is not allowed to work in the safeguarded space.
- The programmer or teaching operator and maintenance technician are allowed to work in the safeguarded space. Works carried out in the safeguarded space include transportation, installation, teaching, adjustment, and maintenance.
- To work inside the safeguarded space, the person must be trained on proper robot operation.

Table 1 (a) lists the work outside the safeguarded space. In this table, the symbol "O" means the work allowed to be carried out by the specified personnel.

Table 1 (a) List of work outside the Safeguarded Space

	Operator	Programmer or Teaching operator	Maintenance technician
Turn power ON/OFF to Robot controller	O	O	O
Select operating mode (AUTO/T1/T2)		O	O
Select remote/local mode		O	O
Select robot program with teach pendant		O	O
Select robot program with external device		O	O
Start robot program with operator's panel	O	O	O
Start robot program with teach pendant		O	O
Reset alarm with operator's panel		O	O
Reset alarm with teach pendant		O	O
Set data on teach pendant		O	O
Teaching with teach pendant		O	O
Emergency stop with operator's panel	O	O	O
Emergency stop with teach pendant	O	O	O
Operator's panel maintenance			O
Teach pendant maintenance			O

During robot operation, programming and maintenance, the operator, programmer, teaching operator and maintenance technician take care of their safety using at least the following safety protectors.

- Use clothes, uniform, overall adequate for the work
- Safety shoes
- Helmet

2 DEFINITION OF SAFETY NOTATIONS

To ensure the safety of users and prevent damage to the machine, this manual indicates each precaution on safety with "**WARNING**" or "**CAUTION**" according to its severity. Supplementary information is indicated by "**NOTE**". Read the contents of each **"WARNING"**, "**CAUTION**" and "**NOTE**" before using the robot.

Symbol	Definitions
⚠ **WARNING**	Used if hazard resulting in the death or serious injury of the user will be expected to occur if he or she fails to follow the approved procedure.
⚠ **CAUTION**	Used if a hazard resulting in the minor or moderate injury of the user, or equipment damage may be expected to occur if he or she fails to follow the approved procedure.
NOTE	Used if a supplementary explanation not related to any of WARNING and CAUTION is to be indicated.

TABLE OF CONTENTS

1   PREFACE

*i*RCalibration is a generic term for the functions supporting the startup of a robot system.   This manual describes the following *i*RCalibration functions:
- *i*RCalibration Vision Mastering
- *i*RCalibration Genkotsu Vision Mastering
- *i*RCalibration Vision Master Recovery
- *i*RCalibration Vision Axis Master
- *i*RCalibration All-Axis Vision Mastering
- *i*RCalibration Wrist-Axis Vision Mastering
- *i*RCalibration Vision TCP Set
- *i*RCalibration Vision Frame Set
- *i*RCalibration Vision Shift
- *i*RCalibration Vision Multi-Cal
- Grid Frame Set

1.1   ABOUT THIS MANUAL

About this manual

This manual describes how to operate *i*RCalibration Vision Mastering, Genkotsu Vision Mastering, Vision Master Recovery, Vision Axis Master, Wrist-Axis Vision Mastering, Vision TCP Set, Vision Frame Set, Vision Shift, Vision Multi-Cal, and All-Axis Vision Mastering for the R-30*i*B / R-30*i*B Mate / R-30*i*B Plus / R-30*i*B Mate Plus controller.

In this manual, only the operations of *i*RCalibration functions are explained, assuming that the installation of the robot is completed.   Refer to the "R-30*i*B / R-30*i*B Mate Operator's Manual(Basic Operation)" about other operations of FANUC robots.

> ⚠ **CAUTION**
> This manual is based on R-30*i*B / R-30*i*B Mate system software version 7DC3/02(8.30P/02).   Note that the functions and settings not described in this manual may be available, and some notation differences are present, depending on the software version.

Organization of this manual

This manual consists of the following chapters:

Chapter	Description
Chapter 2, "OVERVIEW"	Outline of the *i*RCalibration suite.
Chapter 3, "BASIC VISION FUNCTION OPERATION"	Describes the camera connection, image display, teaching of a model to be detected, and the parameter setting for detection.
Chapter 4, "VISION MASTERING"	Describes the setting and operation of Vision Mastering.
Chapter 5, "GENKOTSU VISION MASTERING"	Describes the setting and operation of Genkotsu Vision Mastering.
Chapter 6, "VISION MASTER RECOVERY"	Describes the setting and operation of Vision Master Recovery.
Chapter 7, "VISION AXIS MASTER"	Describes the setting and operation of Vision Axis Master.
Chapter 8, "ALL-AXIS VISION MASTERING"	Describes the setting and operation of All-Axis Vision Mastering.
Chapter 9, "Wrist-Axis Vision Mastering"	Describes the setting and operation of Wrist-Axis Vision Mastering.

Chapter	Description
Chapter 10, "VISION TCP SET"	Describes the setting and operation of Vision TCP Set.
Chapter 11, "VISION FRAME SET"	Describes the setting and operation of Vision Frame Set.
Chapter 12, "VISION SHIFT"	Describes the setting and operation of vision shift and the shift of a program.
Chapter 13, "VISION MULTI-CAL"	Describes the setting and operation of Vision Multi-Cal.
Chapter 14, "GRID FRAME SET"	Describes the setting and operation of Grid Frame Set.

Related manuals

OPERATOR'S MANUAL (Basic Operation) B-83284EN	Topics: Robot functions, operations, programming, interfaces Use: Applicable design, robot installation, teaching, adjustment
OPERATOR'S MANUAL (Alarm Code List) B-83284EN-1	Topics: alarms Use: Installation, start-up, connection, teaching, adjustment, maintenance
Optional Function OPERATOR'S MANUAL B83284EN-2	Topics: Description of the software optional functions. Use: Applicable design, robot installation, teaching, adjustment
R-30iB / R-30iB Mate iRVision OPERATOR'S MANUAL (Reference) B-83304EN	Topics: Outline of iRVision, basic operation, sensor calibration, description of each function, programming Use: Teaching, adjustment
R-30iB CONTROLLER MAINTENANCE MANUAL B-83195EN	Topics: Installation and set-up, connection to peripheral equipment, maintenance of the system Use: Installation, start-up, connection, maintenance
R-30iB Mate CONTROLLER MAINTENANCE MANUAL B-83525EN	Topics: Installation and set-up, connection to peripheral equipment, maintenance of the system Use: Installation, start-up, connection, maintenance
R-30iB Mate CONTROLLER Open Air MAINTENANCE MANUAL B-83555EN	Topics: Installation and set-up, connection to peripheral equipment, maintenance of the system Use: Installation, start-up, connection, maintenance
R-30iB Sensor Mechanical -Control unit OPERATOR'S MANUAL B-83434EN	Topics: Connection of the sensors, robot, and control devices, maintenance of the sensors Use: Connection and maintenance of the sensors

2   OVERVIEW

*i*RCalibration Vision Mastering, Genkotsu Vision Mastering, Vision Master Recovery, Vision Axis Master, Wrist-Axis Vision Mastering, Vision TCP Set, Vision Frame Set, Vision Shift, Vision Multi-Cal, and All-Axis Vision Mastering are options for supporting the startup and integration of a robot system by using a camera (vision system).

*i*RCalibration Vision Mastering

Vision Mastering applies high-precision mastering to the J2 through J5 axes of a robot using a camera. This function enhances robot position precision through TCP setting, offline programming, vision compensation, and so forth.

*i*RCalibration Genkotsu Vision Mastering (Standard function)

Genkotsu Vision Mastering enhances positional accuracy of Genkotsu-Robot by using a camera to measue a target that is attached to the tip of the robot tool by a camera to calculate the kinematic parameters of Genkotsu-Robot to compensate.

*i*RCalibration Vision Master Recovery (Standard function)

Vision Master Recovery recovers invalidated master data caused by the robot maintenance operation such as motor or reduction gear replacement.

*i*RCalibration Vision Axis Master

Vision Axis Master uses vision to recover mastering data of an axis of the robot. It is similar to the existing Single Axis Masering or Quick Mastering, but more accurate than those.

*i*RCalibration All-Axis Vision Mastering (Standard function)

All-Axis Vision Mastering can be used for the same purpose of Jig Mastering. It performs Mastering equivalent to factory default by automatic vision measurement.

*i*RCalibration Wrist-Axis Vision Mastering (Standard function)

The Wrist-Axis Vision Mastering calibrates wrist-axis mastering parameters (zero positions of J4, J5 and J6) with same accuracy as the Jig Mastering (Fixture Position Master) or All-Axis Vision Mastering with a simpler procedure. This is for a robot that requires wrist replacement.

*i*RCalibration Vision TCP Set

Vision TCP Set automatically sets the robot tool center point (TCP) by using a camera.
This function accurately defines a tool coordinate system to a user defined UTool.

*i*RCalibration Vision Frame Set

Vision Frame Set automatically sets the user frame by checking three reference marks (reference points) provided for a workpiece or the jig fixing the workpiece through the camera attached to the robot.

*i*RCalibration Vision Shift

Vision shift works by viewing reference marks or targets on a workpiece or fixture with a robot mounted camera. Vision shift measures the position of the workpiece or fixture based on the reference marks. The robot positions in a user-defined program are modified based on the measurements from vision shift.

If the position of a workpiece or fixture has changed because the robot system is moved or reinstalled, or a robot program created with the offline programming system is applied to a robot, vision shift can modify taught robot positions easily and efficiently.

*i*RCalibration Vision Multi-Cal

Vision Multi-Cal calibrates two robots or a system using a robot and a positioner controlled for coordinated motion.   With a camera attached to one robot and a reference mark attached to the other robot or the positioner, this function automatically measures the relative positions and postures of the two robots or the robot and the positioner to calibrate the coordinated pair with a high degree of accuracy.

Grid Frame Set

"Grid Frame Set" sets the frame of the robot using a camera. Compared to the method using touch-up, it has the following advantages:
- It can set accurately regardless of user's skill.
- Touch-up pins are unnecessary.
- TCP settings for touch-up pins are unnecessary.
- Because it is semiautomatic, the operation is simple.

Grid Frame Set measures the grid from several directions with a camera and sets the measured grid frame to robot's user frame area or tool frame area.

2.1   COMPONENTS

Overall configuration

The following components are mainly used:

- Camera
- Lens
- Camera cable

A camera is attached to the robot end of arm tooling (EOAT) or fix mounted, perhaps mounted to a commercially available tripod.
For details, see the chapter describing each function.

> **NOTE**
> The customer is to provide mounting hardware to attach a camera to the tool of the robot, or to mount the camera on the floor.

Camera

Use a following camera.

Specification	Quantity
SONY CCD camera XC-56	1
BASLER *i*Pendant USB camera acA640-20um	1
BASLER *i*Pendant USB camera acA640-750umFNC	1
KOWA monochrome camera SC130E B/W	1
KOWA monochrome camera SC130EF2 (R-30*i*B Plus controller)	1

> **NOTE**
> - Vision Axis Master uses a special camera unit instead of the camera listed above.
> - All-Axis Vision Mastering uses the special camera fixture.
>   See the chapter describing each function for details.

NOTE
- SONY CCD camera XC-56 is available on R-30*i*B / R-30*i*B Mate controller, but is not available on R-30*i*B Plus controller.
- BASLER acA640-20um requires the system software version is 7DC3/02 (V8.30P/02) or later.
- BASLER acA640-20um requires *i*Pendant firmware version V8.3037 or later.   If the *i*Pendant firmware version is old, images can't be snapped and the alarm 'TP firmware version is too old' is posted when trying to snap image.
- BASLER acA640-750umFNC requires only V8.30P and V9.10P.
- The KOWA monochrome camera SC130E B/W can be used when the option for *i*RVision has been ordered. With the 7DC3/57 (V8.30P/57) or later software, it can be used if the *i*RCalibration digital camera (A05B-2600-S509) has been ordered, even if the option for *i*RVision has not been ordered. It is not available on the R-30*i*B Plus controller.
- The KOWA monochrome camera SC130EF2 is available on R-30*i*B Plus controller, but is not available on R-30*i*B / R-30*i*B Mate controller.   In addition, the KOWA monochrome camera SC130EF2 is not available for Genkotsu Vision Mastering.
- If the FROM size of the robot controller is 64MB or more, executing controlled start and cold start of the controller successively allows the *i*Pendant firmware to update automatically.   For details on controlled start and cold start of the controller, see "B.1. start mode" of "R-30*i*B/R-30*i*B Mate CONTROLLER OPERATOR'S MANUAL (Basic Operation)".
- If the FROM size of the robot controller is less than 64MB, contact FANUC service center to update the *i*Pendant firmware.

NOTE
If "Teach Pendant Disconnect Function" or "Teach Pendant Hot Swap Function" is available, do not disconnect *i*Pendant from the controller while snapping images with the USB camera as displaying the live images.

Lens
Use a C-mount lens for a 1/3-inch CCD camera.

Specification	Quantity
C-mount lens for a 1/3-inch CCD camera f=12mm	1

NOTE
- Vision Axis Master uses special camera unit instead of the camera and the lens listed above.
- All-Axis Vision Mastering uses the special camera fixture.
- In addition, Genkotsu Vision Mastering uses an extension ring.
See the chapter describing each function for details.

Camera cable
If SONY CCD camera XC-56 is used, connect it to the robot controller via the following camera cable. Select one of four types of cables: 7 m long, 14 m long, 20 m long, or 25m long.

Specification	Quantity
Camera Connection Cable for SONY CCD Camera XC-56 (7m)	1
Camera Connection Cable for SONY CCD Camera XC-56 (14m)	
Camera Connection Cable for SONY CCD Camera XC-56 (20m)	
Camera Connection Cable for SONY CCD Camera XC-56 (25m)	

If KOWA monochrome camera SC130E B/W is used, connect it with the following camera cable to the digital CCU which is connected to the robot controller. Select one of four types of cables: 7 m long, 14 m long, 20 m long, or 25m long.

Specification	Quantity
Camera Connection Cable for KOWA Monochrome Camera SC130E B/W (7 m)	1
Camera Connection Cable for KOWA Monochrome Camera SC130E B/W (14 m)	
Camera Connection Cable for KOWA Monochrome Camera SC130E B/W (20 m)	
Camera Connection Cable for KOWA Monochrome Camera SC130E B/W (25 m)	

If KOWA monochrome camera SC130EF2 is used, connect it to the robot controller via the following camera cable. Select one of four types of cables: 7 m long, 14 m long, 20 m long, or 25 m long.

Specification	Quantity
Camera Connection Cable for KOWA Monochrome Camera SC130EF2 (7m)	1
Camera Connection Cable for KOWA Monochrome Camera SC130EF2 (14m)	
Camera Connection Cable for KOWA Monochrome Camera SC130EF2 (20m)	
Camera Connection Cable for KOWA Monochrome Camera SC130EF2 (25m)	

> **NOTE**
> Each camera cable can't be connected to any other cameras than the specified camera.

If a BASLER *i*Pendant USB camera is used, prepare a USB cable (A05B-1405-K552) for connecting the camera to *i*Pendant.

> **NOTE**
> On R-30*i*B Plus controller, the KOWA color camera SC130EF2C and the 3D Vision Sensor are also available instead of the KOWA monochrome camera SC130EF2. The 3D Vision Sensor can be used when the option for *i*RVision 3D Vision Sensor (A05B-2670-J914) has been ordered.   The 3D Vision Sensor can be used for Vision TCP Set, Vision Frame Set, Vision Shift, Vision Multi-Cal, and Grid Frame Setting, but cannot be used for other functions such as Vision Mastering.

> **Tips**
> For details about the method of selecting a camera to use, refer to "3.5 USING *i*RVision CAMERA".

2.2   SOFTWARE

Vision Mastering, Vision Axis Master, Vision TCP Set, Vision Frame Set, Vision Shift, and Vision Multi-Cal are robot options.   To use these functions, the following software options are required respectively:

Function	Required option
Vision Mastering	*i*RCalibration Vision Mastering
Genkotsu Vision Mastering	None. This function is standard.
Vision Master Recovery	None. This function is standard.
Vision Axis Master	*i*RCalibration Vision Axis Master
All-Axis Vision Mastering	None. This function is standard.
Wrist-Axis Vision Mastering	None. This function is standard.
Vision TCP Set	*i*RCalibration Vision TCP Set
Vision Frame Set	*i*RCalibration Vision Frame Set
Vision Shift	*i*RCalibration Vision Shift
Vision Multi-Cal	*i*RCalibration Vision Multi-Cal
Grid Frame Set	*i*RCalibration Vision TCP Set
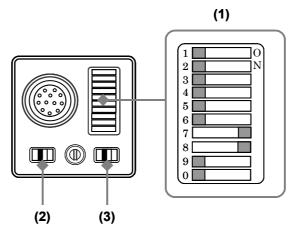
3   BASIC VISION FUNCTION OPERATION

This chapter describes the method of operating the vision function common to the *i*RCalibration.

3.1   CONNECTING A CAMERA

3.1.1   Setting SONY XC-56

Set the switches on the rear panel of a camera (SONY XC-56) as shown below. This setting is not necessary if an *i*Pendant USB camera is used.

No.	Switch	Setting for vision shift	Factory settings before shipment
(1)	DIP switch	Set 7 and 8 to ON (right side). Set the others to OFF (left side).	Set all switches to OFF (left side).
(2)	75Ω terminating switch	ON	←
(3)	HD/VD signal input switch	To the EXT side	←

Fig. 3.1.1 Setting a camera

Change the setting of switches 7 and 8 of the DIP switch (1) to ON (right side) from the factory settings of the camera.   Do not change the settings of the other switches from the factory settings.

3.1.2   Connecting the Camera to the Robot Controller or the *i*Pendant

When a SONY XC-56 camera is used and *i*RVision function is not used

Connect the camera to the JRL7 port on the main board.
Use a camera cable for connection.
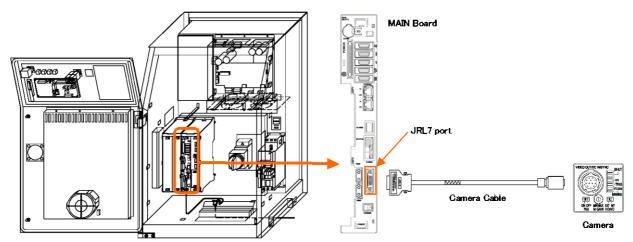
Fig. 3.1.2(a) Camera connection to the robot controller (SONY XC-56)

> ⚠ **CAUTION**
> Turn off the power to the controller, before you connect a camera or camera cable.

When SONY XC-56 is used, and another camera or multiplexer is connected to the JRL7 port (*i*RVision function is used)

If another camera or multiplexer is connected to the JRL7 port on the main board, temporarily detach the cable for the camera or multiplexer connected to the JRL7 port then connect the cable for the camera used for each *i*RCalibration function.
Alternatively, connect the camera to the JRL7A port (port 1) of the multiplexer.

After using each *i*RCalibration function, return the connection to the previous state.

> **Tips**
> On controllers with 7DC2/02(8.20P/02) or later software, cameras for *i*RVision are available for *i*RCalibration.
> Refer to "3.5 USING *i*RVision CAMERA" for more details.

When the *i*Pendant USB camera is used

Connect the camera and the *i*Pendant with an USB cable.
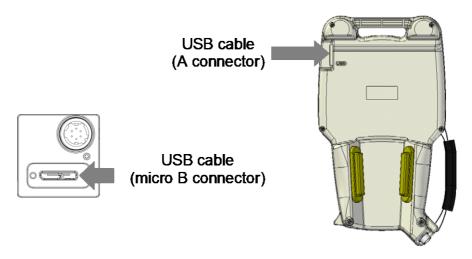
Fig. 3.1.2(b) USB port（an USB camera and an *i*Pendant）

> **NOTE**
> If "Teach Pendant Disconnect Function" or "Teach Pendant Hot Swap Function"
> is available, do not disconnect *i*Pendant from the controller while snapping
> images with the USB camera as displaying the live images.

When a KOWA SC130EF2 is used
Connect the camera to the CRJ3 port on the main board.
Use a camera cable described above for connection.

> ⚠ **CAUTION**
> Turn off the power to the controller, before you connect a camera or camera
> cable.
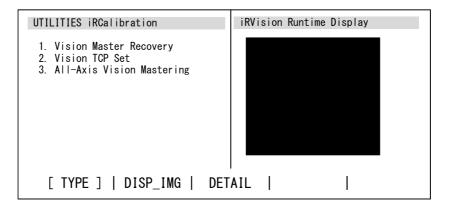
3.2   DISPLAYING THE RUNTIME MONITOR

A camera image can be displayed on the runtime monitor screen of the *i*Pendant.

Step
1   Press the MENU key, then select "UTILITIES" from the screen menu.
2   Press the F1 [TYPE] key, then select "*i*RCalibration" from the menu.
   The UTILITIES *i*RCalibration screen is displayed.   If a detail screen of an *i*RCalibration function is
   displayed here, press the PREV key multiple times until the list screen of *i*RCalibration functions is
   displayed.
3   Press the F2 (DISP_IMG) key.
   The *i*Pendant configuration displays "Double" pane mode, and the runtime monitor screen
   (hereinafter referred to as the runtime monitor) is displayed on the right-hand screen.

```
UTILITIES iRCalibration          iRVision Runtime Display

  1. Vision Master Recovery      ┌──────────────────┐
  2. Vision TCP Set              │                  │
  3. All-Axis Vision Mastering   │                  │
                                 │                  │
                                 │                  │
                                 │                  │
                                 │                  │
                                 └──────────────────┘

   [ TYPE ] | DISP_IMG |  DETAIL  |         |
```

3.3   ADJUSTING THE LENS

The lens should be adjusted for focus and brightness.
Step
1   Twist the lens into the camera body.
2   If the camera does not have proper focus and exposure setting, following the steps listed below:
   i.   Open the aperture and adjust the exposure time for proper brightness.
   ii   Adjust the focus to bring the target into focus.
   iii   Adjust the aperture and exposure time again. Refer to "3.4.4.1 Adjusting the Exposure Time"
       for more details.
Repeat step ii and iii as needed.

NOTE
1 Some lenses have locking screws. Loosen them before adjusting the aperture
   and the focus.   Tighten the locking screws after the adjustment.
2 You need to secure the aperture ring, the focus ring, and the lens and camera
   body after the adjustment.   You can use locking screws, hot glue, tape, and so
   on, to secure the camera and the lens.
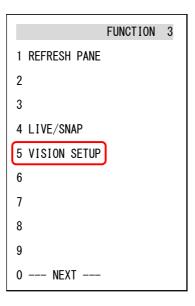
3.4   VISION DATA SETUP SCREEN

The Vision Data Setup Screen is for setting vision parameters and training the target for vision detection.
This operation is only required for Vision TCP Set, Vision Frame Set, Vision Shift and Vision Multi-Cal.
For Vision Mastering, Vision Master Recovery, Genkotsu Vision Mastering, Vision Axis Master,
All-Axis Vision Mastering, or Wrist-Axis Vision Mastering, the detection parameters are set in their own
menu screen.
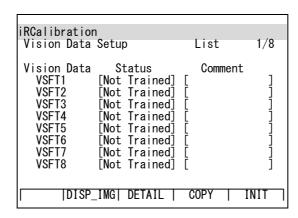
Procedure 3-1   Displaying the Vision Data Setup Screen

Step
1   Press the FCTN key to display the FCTN menu.
2   Select "0 – NEXT –" twice, then select "VISION SETUP".

```
                         FUNCTION   3

        1 REFRESH PANE

        2

        3

        4 LIVE/SNAP

        5 VISION SETUP

        6

        7

        8

        9

        0 --- NEXT ---
```

3   The Vision Data Setup Screen is displayed.

```
iRCalibration
 Vision Data Setup              List      1/8

 Vision Data    Status         Comment
   VSFT1     [Not Trained] [              ]
   VSFT2     [Not Trained] [              ]
   VSFT3     [Not Trained] [              ]
   VSFT4     [Not Trained] [              ]
   VSFT5     [Not Trained] [              ]
   VSFT6     [Not Trained] [              ]
   VSFT7     [Not Trained] [              ]
   VSFT8     [Not Trained] [              ]


 [     |DISP_IMG| DETAIL |  COPY  |  INIT  |
```

Ending the Vision Data Setup Screen

Press the PREV key to close the Vision Data Setup Screen, and display the previously displayed menu.

3.4.1   Menu Structure of Vision Data Setup Screen


```
Press [FCTN].
Select "VISION SETUP"
```

```
iRCalibration
Vision Data Setup          List     1/8

Vision Data    Status        Comment
 VSFT1      [Not Trained] [           ]
 VSFT2      [Not Trained] [           ]
 VSFT3      [Not Trained] [           ]
 VSFT4      [Not Trained] [           ]
 VSFT5      [Not Trained] [           ]
 VSFT6      [Not Trained] [           ]
 VSFT7      [Not Trained] [           ]
 VSFT8      [Not Trained] [           ]

|    |DISP_IMG| DETAIL |  COPY  |  INIT  |
```

Vision Data Setup Screen – List Screen

F3 (DETAIL)

Vision Data Setup Screen – Detail Screen

```
iRCalibration
Vision Data Setup          Detail   1/4

Vision Data :              VSFT1
Status :                   Not Trained
1 Comment :                [        ]
2 Camera Type :            SONY XC-56

3 Model :                  <Detail>
4 Param :                  <Detail>


|    |DISP_IMG|  LIVE  |        |        |
```

Move cursor to desired item
with ↑ or ↓ key.

Select Item 1.

Vision Data Setup Screen –Detail Screen
- Specify Comment

Select Item 2.

Vision Data Setup Screen –Detail Screen
- Choose camera type.

PREV key or
F4 [CHOICE]

Select Item 3 (ENTER key). → Model Training Screen

- Set train window.

- Train/display/test model.

PREV key

```
iRCalibration
Vision Data Setup          Model    1/5

Vision Data :              VSFT1
  Status :                 Not Trained
  Camera Type :            SONY XC-56

1 Exposure Time:           33.33  ms
2 Multi Exposures:             3
3 Train Window Radius:       64   pix
4         Pos.(Up Down):    240   pix
5         Pos.(Left Right): 320   pix


 STD.  |DISP_IMG| LIVE  |   +   |   -   |>
```

Select Item 4 (ENTER key). → Parameter Setting Screen

- Set parameters for detection

PREV key

Vision Data Setup Screen -
Detail Screen

PREV key

```
iRCalibration
Vision Data Setup        Parameter   1/7

Vision Data :              VSFT1
  Status :                 Not Trained
  Camera Type :            SONY XC-56

1 Exposure Time:           33.33  ms
2 Multi Exposures:             3
3 Distance Range: (+/-)    25.0   %
4 Rotation Angle: (+/-)    46.0   deg
5 Tilt Angle:              35.0   deg
6 Score:                   70.0
7 Contrast:                15.0
 STD.  |DISP_IMG| LIVE  |   +   |   -   |>
```

Vision Data Setup Screen -
List Screen

PREV key

Finish

Fig. 3.4.1 Menu structure of the vision setup screen

3.4.2   List Screen

Press the FCTN key on the teach pendant, then select "VISION SETUP" from the menu.   The Vision
Data Setup List Screen is displayed as shown below.

```
iRCalibration
Vision Data Setup              List    1/8

Vision Data    Status         Comment
  VSFT1      [Not Trained] [            ]
  VSFT2      [Not Trained] [            ]
  VSFT3      [Not Trained] [            ]
  VSFT4      [Not Trained] [            ]
  VSFT5      [Not Trained] [            ]
  VSFT6      [Not Trained] [            ]
  VSFT7      [Not Trained] [            ]
  VSFT8      [Not Trained] [            ]


|      |DISP_IMG| DETAIL |  COPY  |  INIT  |
```

In the Vision Data Setup List Screen, users can check the status and comment for each vision data item. However, the "Status" and "Comment" cannot be changed in this screen.   You can modify the "Comment" in the Detail Screen of the Vision Data Setup Screen.   For details, refer to "3.4.3 Detail Screen".   The "Status" shows whether or not a model is trained for the vision data.   The "Status" has the following value:

• Not Trained
  The model of a vision data is not trained.
• Trained
  The model of a vision data is trained.
• Reserved
  The data is already in use and *i*RCalibration should not use it.   If "Status" is "Reserved", the Detail Screen cannot be opened.   In addition, you cannot copy or initialize this vision data.

Functions of the function keys
F2 (DISP_IMG)   :   The *i*Pendant configuration displays   "Double" pane mode.
                          Displays the runtime monitor screen on the right-hand screen.
F3 (DETAIL)   :   Displays the Detail Screen of the selected vision data.
F4 (COPY)   :   Copies the selected vision data.
F5 (INIT)   :   Initializes the selected vision data.
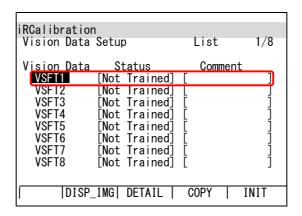
The procedure is detailed below.

Procedure 3-2   Display the Detail Screen of the Vision Data Setup Screen

Step
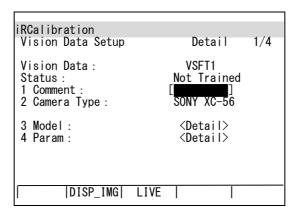
1   Move the cursor by using the $\uparrow$ key or the $\downarrow$ key to select a vision data from any one of the vision data from VSFT1 to VSFT8.

```
iRCalibration
Vision Data Setup              List    1/8

Vision Data    Status         Comment
  VSFT1      [Not Trained] [            ]
  VSFT2      [Not Trained] [            ]
  VSFT3      [Not Trained] [            ]
  VSFT4      [Not Trained] [            ]
  VSFT5      [Not Trained] [            ]
  VSFT6      [Not Trained] [            ]
  VSFT7      [Not Trained] [            ]
  VSFT8      [Not Trained] [            ]


|      |DISP_IMG| DETAIL |  COPY  |  INIT  |
```

2   Press the F3 (DETAIL)   key.
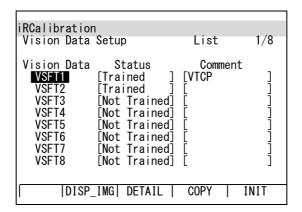
3   The Detail Screen of the selected vision data is displayed.

```
iRCalibration
Vision Data Setup            Detail    1/4

Vision Data :                VSFT1
Status :                     Not Trained
1 Comment :                  [████████]
2 Camera Type :              SONY XC-56

3 Model :                    <Detail>
4 Param :                    <Detail>


|       |DISP_IMG| LIVE  |       |
```
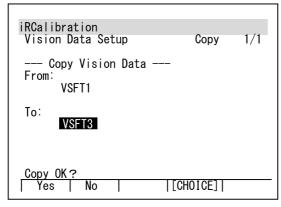
Procedure 3-3   Copy vision data
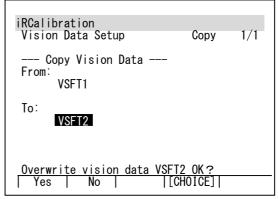
Step

1   Using the $\boxed{\uparrow}$ key or the $\boxed{\downarrow}$ key to move cursor to the source vision data.

```
iRCalibration
Vision Data Setup            List      1/8

Vision Data    Status         Comment
 VSFT1        [Trained   ] [VTCP        ]
 VSFT2        [Trained   ] [            ]
 VSFT3        [Not Trained] [            ]
 VSFT4        [Not Trained] [            ]
 VSFT5        [Not Trained] [            ]
 VSFT6        [Not Trained] [            ]
 VSFT7        [Not Trained] [            ]
 VSFT8        [Not Trained] [            ]

|      |DISP_IMG| DETAIL |  COPY  | INIT
```

2   Press the $\boxed{\text{F4 (COPY)}}$ key.
3   The Copy Screen of the Vision Data Setup Screen is displayed.

```
iRCalibration
Vision Data Setup        Copy    1/1

 --- Copy Vision Data ---
From:
     VSFT1

To:
    VSFT3



Copy OK?
| Yes  |  No   |      |[CHOICE]|
```

```
iRCalibration
Vision Data Setup        Copy    1/1

 --- Copy Vision Data ---
From:
     VSFT1

To:
    VSFT2



Overwrite vision data VSFT2 OK?
| Yes  |  No   |      |[CHOICE]|
```
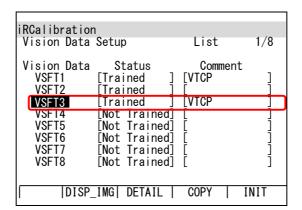
untrained vision data   **trained vision data**

4   Press the $\boxed{\text{F4 [CHOICE]}}$ key, and choose the destination vision data from VSFT1~VSFT8.
5   Press the $\boxed{\text{F1 (YES)}}$ key to copy vision data from the source to the destination.   However, if the source and destination has the same name, no copy is made.
     Press the $\boxed{\text{F2 (NO)}}$ key to return to the previous screen without copying the vision data.
6   The following is an example of copying vision data from VSFT1 to VSFT3.
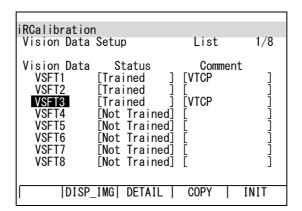
- 15 -

```
iRCalibration
 Vision Data Setup        List    1/8

 Vision Data    Status        Comment
   VSFT1     [Trained   ] [VTCP        ]
   VSFT2     [Trained   ] [            ]
   VSFT3     [Trained   ] [VTCP        ]
   VSFT4     [Not Trained] [           ]
   VSFT5     [Not Trained] [           ]
   VSFT6     [Not Trained] [           ]
   VSFT7     [Not Trained] [           ]
   VSFT8     [Not Trained] [           ]

 |      |DISP_IMG| DETAIL |  COPY  |  INIT
```
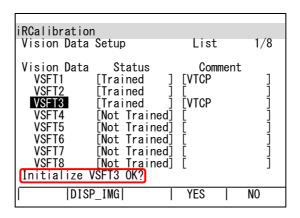
Procedure 3-4   Initialize vision data

Step

1   Using the ↑ key or ↓ key to move the cursor to the vision data you want to initialize.

```
iRCalibration
 Vision Data Setup        List    1/8

 Vision Data    Status        Comment
   VSFT1     [Trained   ] [VTCP        ]
   VSFT2     [Trained   ] [            ]
   VSFT3     [Trained   ] [VTCP        ]
   VSFT4     [Not Trained] [           ]
   VSFT5     [Not Trained] [           ]
   VSFT6     [Not Trained] [           ]
   VSFT7     [Not Trained] [           ]
   VSFT8     [Not Trained] [           ]

 |      |DISP_IMG| DETAIL |  COPY  |  INIT
```
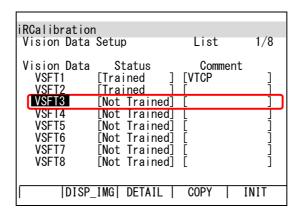
2   Press the F5 (INIT)   key.
3   A message is displayed on the List Screen for confirmation.

```
iRCalibration
 Vision Data Setup        List    1/8

 Vision Data    Status        Comment
   VSFT1     [Trained   ] [VTCP        ]
   VSFT2     [Trained   ] [            ]
   VSFT3     [Trained   ] [VTCP        ]
   VSFT4     [Not Trained] [           ]
   VSFT5     [Not Trained] [           ]
   VSFT6     [Not Trained] [           ]
   VSFT7     [Not Trained] [           ]
   VSFT8     [Not Trained] [           ]
 Initialize VSFT3 OK?
 |      |DISP_IMG|        |  YES   |  NO
```

4   Press the   F4 (YES) key to
     • Set vision data to its default value.
     • Clear the comment.
     • Delete the trained model.
     Press the   F5 (NO) key to cancel the initialization.
The following is the example in the case of the vision data VSFT3 is initialized.
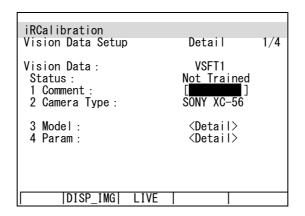
```
iRCalibration
Vision Data Setup              List      1/8

Vision Data    Status          Comment
  VSFT1     [Trained   ] [VTCP           ]
  VSFT2     [Trained   ] [               ]
  VSFT3     [Not Trained] [              ]
  VSFT4     [Not Trained] [              ]
  VSFT5     [Not Trained] [              ]
  VSFT6     [Not Trained] [              ]
  VSFT7     [Not Trained] [              ]
  VSFT8     [Not Trained] [              ]

|      |DISP_IMG| DETAIL |  COPY  |  INIT
```

3.4.3   Detail Screen

Press the F3 (DETAIL) key on the Vision Data Setup List Screen to display the detail Screen shown below.   You can change the comment and select the camera type in this screen.

```
iRCalibration
Vision Data Setup           Detail     1/4

Vision Data :              VSFT1
 Status :                  Not Trained
 1 Comment :               [███████ ]
 2 Camera Type :           SONY XC-56

 3 Model :                 <Detail>
 4 Param :                 <Detail>




|      |DISP_IMG|  LIVE  |        |
```
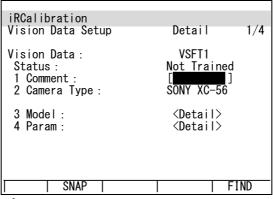
There are two function keys
F2 (DISP_IMG) :   Turns the Teach Pendant in "Double" panes mode, and the runtime monitor
                        screen is displayed on the right pane.
F3 (LIVE) :   Displays a live image.

Press the NEXT key ([>]) on the TP to see function keys in the next page, as it is shown below.   Press the NEXT key ([>]) again to return to previous page.

```
iRCalibration
Vision Data Setup           Detail     1/4

Vision Data :              VSFT1
 Status :                  Not Trained
 1 Comment :               [███████ ]
 2 Camera Type :           SONY XC-56

 3 Model :                 <Detail>
 4 Param :                 <Detail>




|      |  SNAP  |        |        |  FIND
```

There are two function keys in the next page:
F2 (SNAP) : Snaps an image.
F5 (FIND) : Finds the target mark according to the currently displayed parameters.
             (A model needs to be trained beforehand.)

In this screen, the following items can be changed.
- Comment
- Camera Type

Vision Data
The name of the vision data.

Status
The vision data status. The status can be either "Trained" if the model has been trained, or "Not Trained" if the model has not been trained before.

Comment
The vision data can have up to 10 characters as its comment.

Camera Type
The camera types that are used when the vision data is selected. The camera type can be selected from the following list.

SONY XC-56
> The default camera type.   Choose this when using "SONY XC-56" camera that connects to JRL7 port on the main board or JRL7A port on the multiplexer.

BASLER acA640-20um
> Choose this when BASLER *i*Pendant USB camera ac640-20um is used.

KOWA SC36MF
> Choose this when KOWA *i*Pendant USB camera SC36MF is used.

*i*RVision Camera
> Choose this camera type when using a camera that has been set up by the *i*RVision setup screen.
> For details, refer to "3.5 USING *i*RVision CAMERA".

Model
Move the cursor to this item and press the ENTER key to display the Model Training Screen.

Param
Move the cursor to this item and press the ENTER key to display the Parameter Setting Screen.
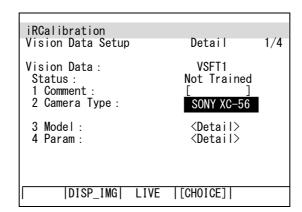
Procedure 3-5   Choosing a camera type

To change the camera type, move the cursor to the Camera Type item and press the F4 [CHOICE] key. Then choose a camera type from the pop-up menu.
The procedure is detailed below.
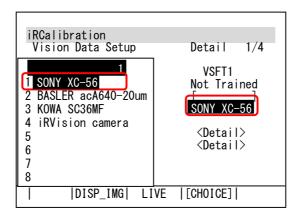
Step
1   Move the cursor to "2 Camera Type" by using the ↑ key or ↓ key.

```
┌─────────────────────────────────────────┐
│ iRCalibration                             │
│ Vision Data Setup        Detail    1/4    │
│                                           │
│ Vision Data :            VSFT1            │
│  Status :                Not Trained      │
│  1 Comment :             [         ]      │
│  2 Camera Type :         ▐SONY XC-56▌     │
│                                           │
│  3 Model :               <Detail>         │
│  4 Param :               <Detail>         │
│                                           │
│                                           │
│                                           │
│ |    |DISP_IMG| LIVE  |[CHOICE]|          │
└─────────────────────────────────────────┘
```
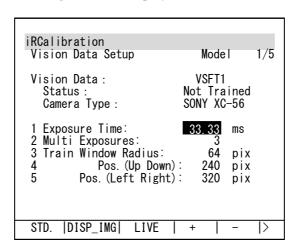
2   Press the F4 [CHOICE] key to display the pop-up menu of the camera type.

```
┌─────────────────────────────────────────┐
│ iRCalibration                             │
│  Vision Data Setup       Detail   1/4     │
│ ┌───────────────────────┐                 │
│ │▐                  1▌   │  VSFT1          │
│ │1 SONY XC-56       │    │  Not Trained    │
│ │2 BASLER acA640-20um│   │                 │
│ │3 KOWA SC36MF       │   │  SONY XC-56     │
│ │4 iRVision camera   │   │                 │
│ │5                   │   │  <Detail>       │
│ │6                   │   │  <Detail>       │
│ │7                   │   │                 │
│ │8                   │   │                 │
│ └───────────────────────┘                 │
│ |    |DISP_IMG| LIVE  |[CHOICE]|          │
└─────────────────────────────────────────┘
```

3   Select the desired camera type from the displayed pop-up menu.

3.4.4   Model Training Screen

Select "3 Model" on the Detail Screen of the Vision Data Setup Screen by moving the cursor with the ↑ key or ↓ key.   The Model Training Screen is displayed as shown below.

```
┌─────────────────────────────────────────┐
│ iRCalibration                             │
│  Vision Data Setup       Model    1/5     │
│                                           │
│  Vision Data :           VSFT1            │
│   Status :               Not Trained      │
│   Camera Type :          SONY XC-56       │
│                                           │
│  1 Exposure Time:        ▐33.33▌  ms      │
│  2 Multi Exposures:           3           │
│  3 Train Window Radius:      64   pix     │
│  4        Pos. (Up Down):   240   pix     │
│  5     Pos. (Left Right):   320   pix     │
│                                           │
│                                           │
│ STD. |DISP_IMG| LIVE  |  +  |  -  |  >    │
└─────────────────────────────────────────┘
```

Vision Data
The item indicates the name of the vision data for model training.

Status

The item indicates the status of the vision data for parameter setting.   In the case of the model of the target mark is trained, "Trained" is displayed.   In the case of the model of the target mark is not trained, "Not Trained" is displayed.

Camera Type

The item indicates the camera type of the vision data.   The type of the camera which is used when this vision data is selected.

Other items

The Model Training Screen enables the items below to be set.
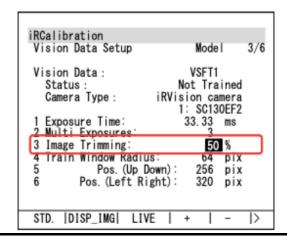
(1)   Exposure Time:
      Camera exposure time [msec].
(2)   Multi Exposures:
      The multi-exposure function snaps multiple images by changing exposure time and combines them to generate an image with a wide dynamic range.   Specify the number of images to be snapped.
      As this number is larger, a wider dynamic range results, but a longer time is required for image snapping.
(3)   Train Window: Radius:
      Size of the teach window (radius) [pix].
(4)   Train Window: Pos (Up Down):
      Center position of the training window (Vt) [pix].
(5)   Train Window: Pos (Left Right):
      Center position of the training window (Hz) [pix].

NOTE

On R-30*i*B Plus controller, 'Image Trimming' is added as an item to be set.
When using a KOWA monochrome camera SC130EF2, the time to process an image may be longer than that of usual and/or it may become easier to detect false at the end of the image because the number of pixels of this camera is larger than existing cameras. In order to deal with such a problem, the number of pixels of cameras can be reduced by setting the value of 'Image Trimming' in a range from 0% to 75%.

```
iRCalibration
Vision Data Setup            Model    3/6

Vision Data :                VSFT1
  Status :                   Not Trained
  Camera Type :              iRVision camera
                             1: SC130EF2
1 Exposure Time:             33.33   ms
2 Multi Exposures:           3
3 Image Trimming:            [50] %
4 Train Window Radius:       64    pix
5           Pos. (Up Down):  256   pix
6           Pos. (Left Right): 320  pix


STD. |DISP_IMG| LIVE |  +  |  -  | |>
```

3.4.4.1   Adjusting the exposure time
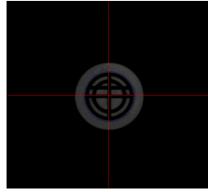
This subsection describes the procedure to adjust the exposure time.   Some image samples with different exposure times are shown below.
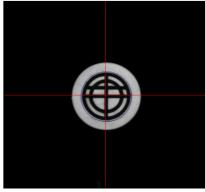
Adjust the exposure time so that the image is not pure white but rather gray in the area around the target mark.   Then, adjust the exposure time so the white background and black mark can be clearly distinguished.

Target mark image with too short exposure time	Target mark image with appropriate exposure time	Target mark image with too long exposure time

---
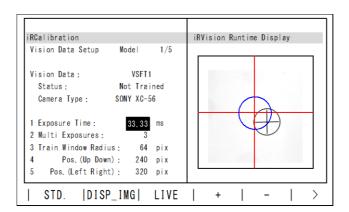
NOTE

Before modifying exposure time, the focus and the aperture of lens should be adjusted as followings.

Step 1: Press the F2 (DISP_IMG) key to display the Model Training Screen of the Vision Data Setup Screen and the runtime monitor on the *i*Pendant side by side in dual panes mode.

Step 2: Press the F1 (STD.) key to set the Exposure Time to the default value.
Step 3: Press the F3 (LIVE) key to display the live camera image on the runtime monitor.
Step 4: Adjust aperture ring on the lens to display the live camera image with proper brightness.
Step 5: Open the aperture by aperture ring and adjust the Exposure Time to display the live camera image with proper brightness.
Step 6: Adjust the focus ring so the target is clearly displayed in the live image. .
Step 7: Move aperture handle to the position adjusted by Step 4 and press the F1 (STD.) key to reset the Exposure Time to the default value.
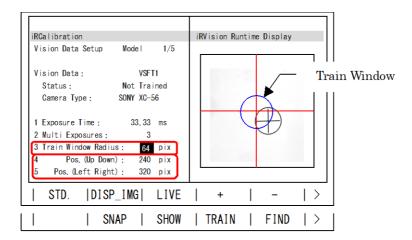
3.4.4.2   Operating the model training screen

Overview of model training

You can use function keys to specify the size and position of the training window, and display and train the model.   The runtime monitor screen displays a circular training window.

Specify the size and position of the circular training window with the function keys then enclose the target and train the model.
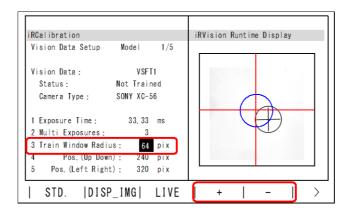
Adjust the Exposure Time so the edges of the target can be detected.   Next, adjust the radius and position of the training window to enclose the target, and then press the function key to train the model ([TRAIN]).   The target in the window is trained as a reference model for vision detection.

Adjusting the size and position of the training window

Use the function keys to adjust the size and position of the training window.

Adjusting the training window size

Select "3 Train Window: Radius" on the Model Training Screen by moving the cursor with the $\uparrow$ key or $\downarrow$ key.   The definition of these function keys is listed below.

F1 (STD.)   :   Resets the size of the window to the default.
F2 (DISP_IMG)   :   Changes the *i*Pendant display to "Double" pane mode.
                        The runtime monitor screen is displayed in the right pane.
F3 (LIVE)   :   Displays a live image.
F4 (+)   :   Enlarges the training window.
F5 (-)   :   Reduces the training window.
        (Pressing the F4 or the F5 while holding down the SHIFT key makes a greater value change.)
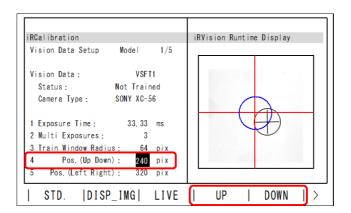
Adjusting the training window position

Select "4 : POS.(Up Down)" on the Model Training Screen by moving the cursor with the ↑ key or ↓ key.   The definition of these function keys is listed below.

```
iRCalibration                              iRVision Runtime Display
Vision Data Setup      Model      1/5

Vision Data :             VSFT1
  Status :             Not Trained
  Camera Type :        SONY XC-56

1 Exposure Time :         33.33  ms
2 Multi Exposures :          3
3 Train Window Radius :     64  pix
4      Pos.(Up Down) :     240  pix
5      Pos.(Left Right) :   320  pix

|   STD.   |DISP_IMG|   LIVE  |    UP    |   DOWN   | >
```

Use the function keys to move the window position, perform LIVE/SNAP operation, display, train, and detect a model.

F1 (STD.)   :   Resets the vertical position of the window to the default value.
F2 (DISP_IMG)   :   Changes the *i*Pendant display to "Double" pane mode.
                            The runtime monitor screen is displayed in the right pane.
F3 (LIVE)   :   Displays a live image.
F4 (UP)   :   Moves the position of the training window in the upward direction
                            (minus direction of Vt).
F5 (DOWN)   :   Moves the position of the training window in the downward direction
                            (plus direction of Vt).
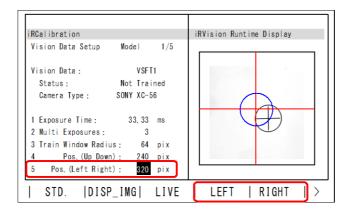
Select "5 : POS.(Left Right)" on the Model Training Screen by moving the cursor with the ↑ key or the ↓ key.   The definition of the function keys is listed below.

```
iRCalibration                              iRVision Runtime Display
Vision Data Setup      Model      1/5

Vision Data :             VSFT1
  Status :             Not Trained
  Camera Type :        SONY XC-56

1 Exposure Time :         33.33  ms
2 Multi Exposures :          3
3 Train Window Radius :     64  pix
4      Pos.(Up Down) :     240  pix
5      Pos.(Left Right) :   320  pix

|   STD.   |DISP_IMG|   LIVE  |   LEFT   |  RIGHT   | >
```

F1 (STD.)   :   Resets the horizontal position of the window to the default value.
F2 (DISP_IMG)   :   Changes *i*Pendant configuration to "Double" pane mode.
                            Displays the runtime monitor screen on the right-hand screen.
F3 (LIVE)   :   Displays a live image.
F4 (LEFT)   :   Moves the position of the training window in the left direction
                            (minus direction of Hz).
F5 (RIGHT)   :   Moves the position of the training window in the right direction
                            (plus direction of Hz).
(Pressing F4 or F5 and [SHIFT] key at the same time makes position movement greater.)
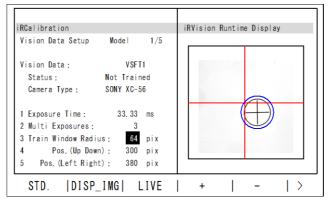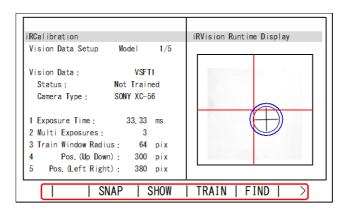
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While selecting "3 Train Window Radius", "4 Pos. (Up Down)" and "5 Pos. (Left Right)", use the function keys to enclose the target diagram in the image for the model training with the train window, as shown below.

```
iRCalibration                          iRVision Runtime Display
Vision Data Setup      Model    1/5
                                       ┌──────────────────────┐
Vision Data :          VSFT1           │         │            │
  Status :             Not Trained     │         │            │
  Camera Type :        SONY XC-56      │         │            │
                                       │─────────┼──⊕────────│
1 Exposure Time :        33.33  ms     │         │            │
2 Multi Exposures :          3         │         │            │
3 Train Window Radius :    64  pix     └──────────────────────┘
4       Pos.(Up Down) :   300  pix
5     Pos.(Left Right) :   380  pix

   STD.  |DISP_IMG|  LIVE  |   +   |   −   | >
```

Training a model

Press the NEXT key ([>]) on the TP to access the next page of function keys.

```
iRCalibration                          iRVision Runtime Display
Vision Data Setup      Model    1/5
                                       ┌──────────────────────┐
Vision Data :          VSFT1           │         │            │
  Status :             Not Trained     │         │            │
  Camera Type :        SONY XC-56      │         │            │
                                       │─────────┼──⊕────────│
1 Exposure Time :        33.33  ms     │         │            │
2 Multi Exposures :          3         │         │            │
3 Train Window Radius :    64  pix     └──────────────────────┘
4       Pos.(Up Down) :   300  pix
5     Pos.(Left Right) :   380  pix

    |      | SNAP  | SHOW  | TRAIN | FIND  |    >
```

F2 (SNAP) : Snaps an image.
F3 (SHOW) : Displays the currently trained model.
F4 (TRAIN) : Trains a model.
F5 (FIND) : Finds the target mark using the currently displayed parameters.

Press F4 (TRAIN) to train the target within the training window as the model.

NOTE
Follow the steps listed below to return to the screen before the vision data setup screen was displayed.
1, Press the PREV key to return to the Detail Screen.
2, Press the PREV key to return to the List Screen.
3, Press the PREV key to exit the Vision Data Setup Screen and return to the prior screen.

Example of a target mark

The following pictures depict recommended vision targets

Fig. 3.4.4.2 (a) Example 1 of a target   **Fig. 3.4.4.2 (b) Example 2 of a target**

- 24 -
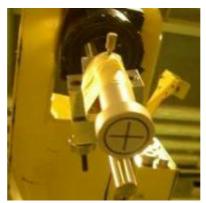
Fig. 3.4.4.2 (c) Example of setting a target mark

The target should have the following features:
- A flat detection surface.
- A contour that makes it easy to recognize the size of the target. (The circle in the above examples.)
- A contour that makes it easy to recognize rotation within a 45 degree range. (The cross in the above examples.)
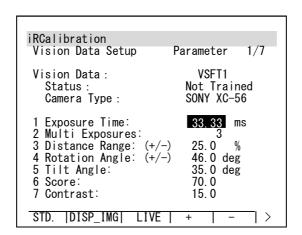
Also, train the model with the surface of the target flat and lined up square to the camera.

> **Tips**
> The surface of the target should be flat and lined up square to the camera.
> Visual accuracy is sufficient to line up the target flat to the camera.

3.4.5   Parameter Setting Screen

The following items can be set in the Parameter Setting Screen.

```
iRCalibration
Vision Data Setup        Parameter   1/7

Vision Data :                VSFT1
  Status :                   Not Trained
  Camera Type :              SONY XC-56

1 Exposure Time:             33.33  ms
2 Multi Exposures:               3
3 Distance Range: (+/-)     25.0   %
4 Rotation Angle: (+/-)     46.0 deg
5 Tilt Angle:               35.0 deg
6 Score:                    70.0
7 Contrast:                 15.0

STD. |DISP_IMG| LIVE |  +   |  -  | >
```

Vision Data
This item indicates the name of the vision data for parameter setting.

Status
This item indicates the vision data status. The status can be either "Trained" if the model has been trained, or "Not Trained", if the model has not been trained before.
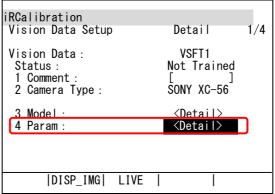
Camera Type

This item indicates the camera type used for the vision data.
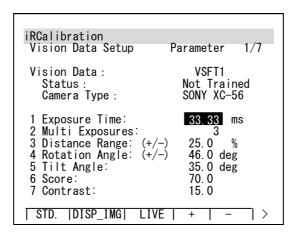
Procedure 3-6   Displaying the Parameter Setting Screen

Step

1   Move the cursor to "4 Param" by using the $\boxed{\uparrow}$ key or $\boxed{\downarrow}$ key.

```
┌─────────────────────────────────────┐
│iRCalibration                         │
│ Vision Data Setup      Detail    1/4 │
│                                      │
│ Vision Data :            VSFT1       │
│  Status :                Not Trained │
│  1 Comment :             [         ] │
│  2 Camera Type :         SONY XC-56  │
│                                      │
│  3 Model :               <Detail>    │
│  4 Param :               <Detail>    │
│                                      │
│                                      │
│       |DISP_IMG|  LIVE  |        |   │
└─────────────────────────────────────┘
```

2   Press the $\boxed{\text{ENTER}}$ key.   The Parameter Setting Screen is displayed.

```
┌─────────────────────────────────────┐
│ iRCalibration                        │
│ Vision Data Setup     Parameter  1/7 │
│                                      │
│  Vision Data :           VSFT1       │
│   Status :               Not Trained │
│   Camera Type :          SONY XC-56  │
│                                      │
│  1 Exposure Time:        33.33  ms   │
│  2 Multi Exposures:          3       │
│  3 Distance Range: (+/-)  25.0   %   │
│  4 Rotation Angle: (+/-)  46.0 deg   │
│  5 Tilt Angle:            35.0 deg   │
│  6 Score:                 70.0       │
│  7 Contrast:              15.0       │
│ | STD. |DISP_IMG|  LIVE | + | - | >  │
└─────────────────────────────────────┘
```

3.4.5.1   Detection parameters

You can set the following items in the Parameter Setting Screen.

(1)   Exposure Time:
       This item indicates the exposure time of the camera in msec.
(2)   Multi Exposures:
       The multi-exposure function snaps multiple images by changing exposure time and combines them
       to generate an image with a wide dynamic range.   With a large number in Multi Exposures, you get
       an image with a wider dynamic range but it takes a longer time to snap the image.
(3)   Distance Limit:
       This item indicates the allowable percentage of change in distance, with respect to the distance
       between the camera and target at model training time [%].
(4)   Rotation Angle:
       This item indicates the allowable angle of rotation of the target, with respect to the rotation of the
       trained target in degrees.
(5)   Tilt Angle:
       This item indicates the allowable variation in inclination angle, relative to the angle between the
       optical axis of the camera to the normal of the target plane at model training time [deg].

(6)   Score:
      This item indicates the score threshold for evaluating the degree of geometrical feature matching between the detected target and the trained model.
(7)   Contrast:
      This item indicates the image contrast threshold.
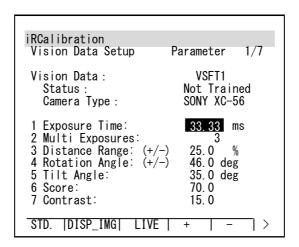
3.4.5.2   Adjusting detection parameters

Move the cursor to an item you want to modify and use function keys to change the value of the item.

```
iRCalibration
Vision Data Setup      Parameter   1/7

Vision Data :          VSFT1
  Status :             Not Trained
  Camera Type :        SONY XC-56

1 Exposure Time:       33.33  ms
2 Multi Exposures:        3
3 Distance Range:  (+/-)   25.0   %
4 Rotation Angle:  (+/-)   46.0 deg
5 Tilt Angle:          35.0 deg
6 Score:               70.0
7 Contrast:            15.0

 STD.  |DISP_IMG| LIVE |  +  |  -  | >
```

Functions of the function keys

F1 (STD.) :	Resets the value to the default value.
F2(DISP_IMG) :	Changes the *i*Pendant display to "Double" pane mode.
	The runtime monitor screen is displayed in the right pane.
F3 (LIVE) :	Displays a live image.
F4 (+) :	Increases the value.
F5 (-) :	Decreases the value.
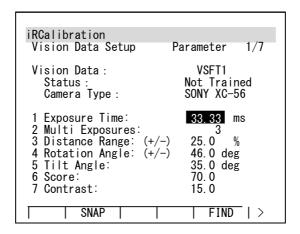
```
┌─────────────────────────────────────────────────────────┐
│  NOTE                                                     │
│     Pressing the F4 or the F5 key while holding down the  │
│     SHIFT key changes the value at a faster rate.         │
└─────────────────────────────────────────────────────────┘
```

Pressing the NEXT key ([>]) on the TP shows the function keys in the next page, as shown below. Pressing the NEXT key ([>]) again returns the function keys to the current page.

```
iRCalibration
Vision Data Setup      Parameter   1/7

Vision Data :          VSFT1
  Status :             Not Trained
  Camera Type :        SONY XC-56

1 Exposure Time:       33.33  ms
2 Multi Exposures:        3
3 Distance Range:  (+/-)   25.0   %
4 Rotation Angle:  (+/-)   46.0 deg
5 Tilt Angle:          35.0 deg
6 Score:               70.0
7 Contrast:            15.0

 |      | SNAP |     |     | FIND | >
```

Functions of the function keys

F2(SNAP) :   Snaps an image.
F5 (FIND) :   Finds the target using the currently vision parameters.
                (A model needs to be trained beforehand.)

NOTE
Follow the steps listed below to return to the screen before the vision data setup screen was displayed.
1, Press the PREV key to return to the Detail Screen.
2, Press the PREV key to return to the List Screen.
3, Press the PREV key to exit the Vision Data Setup Screen and return to the prior screen.

3.5   USING *i*RVision CAMERA

Cameras to be used for *i*RVision can be used for *i*RCalibration. How to select the cameras is different in R-30*i*B / R-30*i*B Mate controller and R-30*i*B Plus controller.

3.5.1   Using *i*RVision Camera on R-30*i*B / R-30*i*B Mate Controller

On the R-30*i*B／R-30*i*B Mate controller with 7DC2/02(8.20P/02) or later software, Vision Mastering, Vision Master Recovery, Vision TCP Set, Vision Frame Set, Vision Shift and Vision Multi-Cal can share the camera data created by the *i*RVision setup screen.
To share *i*RVision camera data with *i*RCalibration options, one of the following software option is required.
- *i*RVision 2DV
- *i*RVision 3DL
- *i*RVision Bin Picking
- *i*RVision ImgToPnts
- *i*RPickTool / *i*RVision
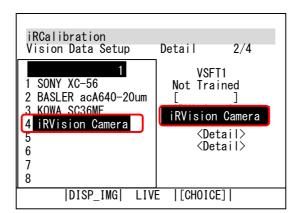
*i*RVision should create the camera data before sharing it with *i*RCalibration options.   To create *i*RVision camera data , refer to "R-30*i*B / R-30*i*B Mate *i*RVision OPERATOR'S MANUAL (Reference) B-83304EN".
The *i*RVision camera data can be used *i*n the measurement program generation screen of the Vision Mastering and the Vision Master Recovery, and the Detail Screen of the Vision Data Setup Screen.
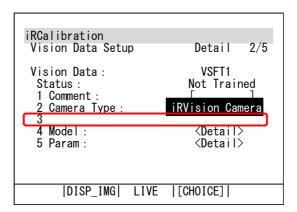
The following is an example of using *i*RVision camera data in the Detail Screen of the Vision Data Setup menu.

1,   In the Detail Screen of the Vision Data Setup menu, move the cursor to the item 2 "Camera Type", and press the F4 [CHOICE].
    Choose "*i*RVision Camera" in the popup menu.

```
 iRCalibration
 Vision Data Setup      Detail    2/4
 ┌──────────────────┐
 │                 1│        VSFT1
 │                  │     Not Trained
 │ 1 SONY XC-56     │     [         ]
 │ 2 BASLER acA640-20um│
 │ 3 KOWA SC36MF    │   ┌──────────────┐
 │ 4 iRVision Camera│   │ iRVision Camera│
 │ 5                │   └──────────────┘
 │ 6                │       <Detail>
 │ 7                │       <Detail>
 │ 8                │
 └──────────────────┘
        |DISP_IMG| LIVE  |[CHOICE]|
```

2,   After chosen "*i*RVision Camera" for item 2, the camera data of *i*RVision can be selected by moving the cursor done to next item:

```
 iRCalibration
 Vision Data Setup      Detail    2/5

 Vision Data :          VSFT1
  Status :             Not Trained
  1 Comment :          [         ]
  2 Camera Type :     ┌──────────────┐
  3                   │ iRVision Camera│
                      └──────────────┘
  4 Model :            <Detail>
  5 Param :            <Detail>



        |DISP_IMG| LIVE  |[CHOICE]|
```
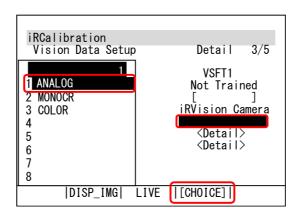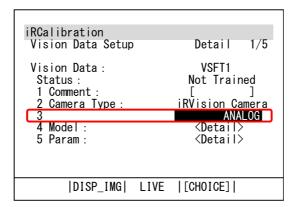
3,   Press the F4 [CHOICE] and a popup menu of *i*RVision camera data is displayed. (The vision data "ANALOG", "MONOCR", and "COLOR" were created in the setup screen of *i*RVision)

```
 iRCalibration
 Vision Data Setup      Detail    3/5
 ┌──────────────────┐
 │                 1│        VSFT1
 │ 1 ANALOG         │     Not Trained
 │ 2 MONOCR         │     [         ]
 │ 3 COLOR          │     iRVision Camera
 │ 4                │     ┌──────────┐
 │ 5                │     └──────────┘
 │ 6                │       <Detail>
 │ 7                │       <Detail>
 │ 8                │
 └──────────────────┘
        |DISP_IMG| LIVE  |[CHOICE]|
```

4,   Select the camera data. Now *i*RCalibration can do target training and target detection using the *i*RVision camera data chosen in the item 3.

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```
iRCalibration
Vision Data Setup        Detail    1/5

Vision Data :              VSFT1
 Status :                  Not Trained
 1 Comment :               [         ]
 2 Camera Type :           iRVision Camera
 3                              ANALOG
 4 Model :                 <Detail>
 5 Param :                 <Detail>


        |DISP_IMG|  LIVE  |[CHOICE]|
```

3.5.2 Using *i*RVision Camera on R-30*i*B Plus Controller
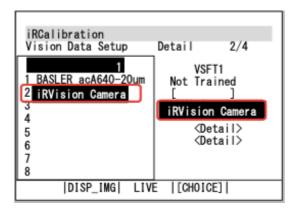
On R-30*i*B Plus controller, Vision Mastering, Vision Master Recovery, Vision TCP Set, Vision Frame Set, Vision Shift, and Vision Multi-Cal can be operated with cameras used for *i*RVision.
Unlike R-30*i*B / R-30*i*B Mate controller, installation of *i*RVision option and/or creation of camera data are/is not necessary.
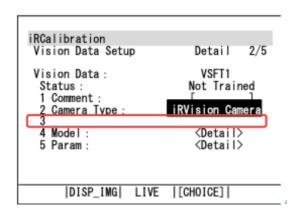
The following is an example of using *i*RVision camera in the Detail Screen of the Vision Data Setup menu.

1   In the Detail Screen of the Vision Data Setup menu, move the cursor to the item 2 "Camera Type", and press the F4 [CHOICE].
     Choose "*i*RVision Camera" in the popup menu.

```
iRCalibration
Vision Data Setup     Detail    2/4
        1                VSFT1
 1 BASLER acA640-20um  Not Trained
 2 iRVision Camera     [         ]
 3
 4                     iRVision Camera
 5
 6                        <Detail>
 7                        <Detail>
 8
     |DISP_IMG|  LIVE  |[CHOICE]|
```

2   After chosen "*i*RVision Camera" for item 2, the camera data of *i*RVision can be selected by moving the cursor done to next item:

```
iRCalibration
Vision Data Setup        Detail    2/5

Vision Data :              VSFT1
 Status :                  Not Trained
 1 Comment :               [         ]
 2 Camera Type :           iRVision Camera
 3
 4 Model :                 <Detail>
 5 Param :                 <Detail>


        |DISP_IMG|  LIVE  |[CHOICE]|
```
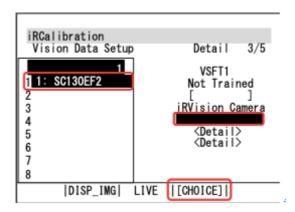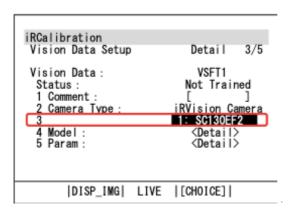
3   Press the F4 [CHOICE] and a popup menu of *i*RVision camera is displayed. (The camera KOWA SC130EF2 is connected to the controller in this case)

```
iRCalibration
Vision Data Setup          Detail   3/5

          1_                    VSFT1
  1: SC130EF2               Not Trained
2                              [       ]
3                           iRVision Camera
4
5                            <Detail>
6                            <Detail>
7
8
          |DISP_IMG|  LIVE  |[CHOICE]|
```

4   Select the camera. Now *i*RCalibration can do target training and target detection using the *i*RVision camera chosen in the item 3.

```
iRCalibration
Vision Data Setup          Detail   3/5

Vision Data :              VSFT1
  Status :                 Not Trained
  1 Comment :              [       ]
  2 Camera Type :          iRVision Camera
  3                        1: SC130EF2
  4 Model :                <Detail>
  5 Param :                <Detail>


      |DISP_IMG|   LIVE  |[CHOICE]|
```

3.6   SAVING AND READING VISION DATA

The *i*RCalibration vision data (VSFT1.VD to VSFT8.VD) can be stored as a file in the file I/O devices such as memory card or USB drive.
You can select the file I/O devices in the file menu.   For details of selecting the file I/O devices, refer to "R-30*i*B / R-30*i*B Mate OPERATOR'S MANUAL (Basic Operation)B-83284EN".

Saving data

By executing an All files backup on the file menu, the *i*RCalibration vision data is saved to the file I/O devices together with the programs and other data files.

Reading data

The saved *i*RCalibration vision data VSFT1.VD to VSFT8.VD, and so on can be read back to the controller using the File menu. Therefore, other controllers can share the *i*RCalibration's vision data trained by one controller.

⚠ CAUTION
1. The R-30iB/R-30iB Mate controller's vision data is incompatible with the vision data of R-30iA/R-30iA Mate controller.
   Do not load R-30iA/R-30iA Mate vision data to an R-30iB/R-30iB Mate controller, and vice versa. Similarly, R-30iB Plus controller's data is incompatible with the vision data of R-30iA/R-30iA Mate controller and R-30iB/R-30iB Mate controller.
2. For R-30iB/R-30iB Mate controllers with later system software (7DC2/02(8.20P/02) or later), reading vision data that was created by earlier R-30iB controller (the series 7DC1(8.10P), 7DD0(8.13P) or 7DC2/01(8.20P/01)), you need to do the following.
   After reading the vision data, open the Detail Screen in the Vision Data Setup menu, and change the "Camera Type" to the camera type that is to be used.

---

4   VISION MASTERING

4.1   VISION MASTERING

What is Vision Mastering?

Vision Mastering automatically measures a fixed target by using a camera attached to the tool tip of a robot while changing the posture of the robot, and adjusts J2 through J5 axis mastering data and J2 through J6 axis spring constants.   The spring constants can be adjusted only when the Gravity Compensation Function (used as an optional function) is enabled.   This function can enhance robot position precision through TCP setting, vision shifting in offline programming, general vision compensation, and so forth.

> **NOTE**
> With 7DC3/23 (V8.30P/23) or later software, Vision Mastering supports a Top Loader robot. And, if it is a Top Loader robot, J3 through J5 axis mastering data are adjusted and adjustment of the spring constants is not supported.

Features of Vision Mastering

Enhanced precision by mastering parameters:
Mastering parameters are optimized according to the load on and the operation area of a robot in an actual production line so that the robot can be placed in its absolute position more precisely.

Automated operations:
Operations other than camera installation are performed automatically.   Manual operations are therefore simplified, and the operation results do not depend on the skill of the operator.

TP programs used for Vision Mastering

Vision Mastering uses robot operation programs (hereinafter referred to as TP programs) to perform a sequence of operations.
When Vision Mastering is performed, these TP programs are generated automatically.   TP programs can also be created beforehand with offline programming.   This can further reduce work time on the factory floor and accomplish work efficiently in a shorter time.
For details of TP programs, please refer to "4.7.1 TP PROGRAM" in this manual.

4.2   SYSTEM CONFIGURATION

4.2.1   Overall Configuration

The Vision Mastering system consists of a robot controller, an *i*Pendant, a camera, lens, and a target.
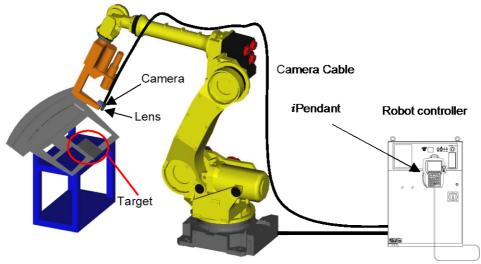
Fig. 4.2.1 System configuration of Vision Mastering
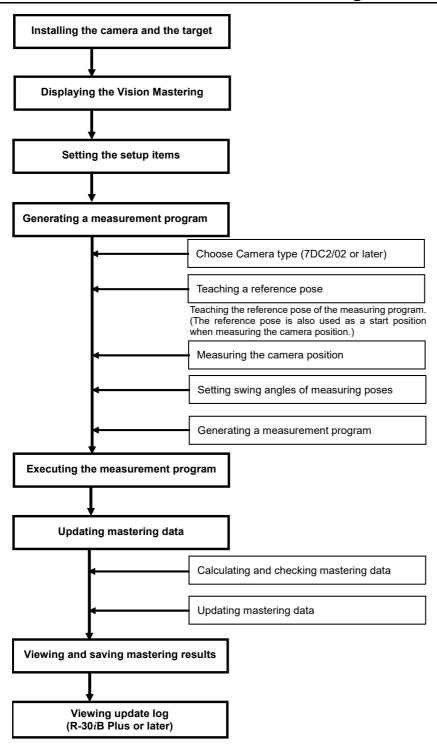
NOTE
  The customer is to prepare hardware such as a camera with lens, a target, a jig for holding the camera, and a jig for holding the target.

Tips
  For controllers with 7DC2/02(8.20P/02) or later software, cameras not described in "2.1 COMPONENTS" can be used. For more details, please refer to "3.5 USING *i*RVision CAMERA".

4.2.2   Outline of the Vision Mastering Procedure

```
┌─────────────────────────────────────┐
│  Installing the camera and the target │
└─────────────────────────────────────┘
                 │
┌─────────────────────────────────────┐
│     Displaying the Vision Mastering   │
└─────────────────────────────────────┘
                 │
┌─────────────────────────────────────┐
│          Setting the setup items      │
└─────────────────────────────────────┘
                 │
┌─────────────────────────────────────┐
│    Generating a measurement program   │
└─────────────────────────────────────┘
       │        ┌──────────────────────────────────────────┐
       │◄───────│ Choose Camera type (7DC2/02 or later)      │
       │        └──────────────────────────────────────────┘
       │        ┌──────────────────────────────────────────┐
       │◄───────│ Teaching a reference pose                  │
       │        └──────────────────────────────────────────┘
       │   Teaching the reference pose of the measuring program.
       │   (The reference pose is also used as a start position
       │   when measuring the camera position.)
       │        ┌──────────────────────────────────────────┐
       │◄───────│ Measuring the camera position              │
       │        └──────────────────────────────────────────┘
       │        ┌──────────────────────────────────────────┐
       │◄───────│ Setting swing angles of measuring poses    │
       │        └──────────────────────────────────────────┘
       │        ┌──────────────────────────────────────────┐
       │◄───────│ Generating a measurement program           │
       │        └──────────────────────────────────────────┘
┌─────────────────────────────────────┐
│     Executing the measurement program │
└─────────────────────────────────────┘
                 │
┌─────────────────────────────────────┐
│          Updating mastering data      │
└─────────────────────────────────────┘
       │        ┌──────────────────────────────────────────┐
       │◄───────│ Calculating and checking mastering data    │
       │        └──────────────────────────────────────────┘
       │        ┌──────────────────────────────────────────┐
       │◄───────│ Updating mastering data                    │
       │        └──────────────────────────────────────────┘
┌─────────────────────────────────────┐
│   Viewing and saving mastering results│
└─────────────────────────────────────┘
                 │
┌─────────────────────────────────────┐
│         Viewing update log            │
│         (R-30iB Plus or later)        │
└─────────────────────────────────────┘
```

4.2.3   Features of the Vision Mastering Function, Including Adjustment of Gravity Compensation Parameters

The Gravity Compensation function calculates the amount of deflection caused by the weight on the arm. This may include the weight of a device attached to the arm (such as a tool or workpiece attached to the hand of the robot) or the arm's own weight.   It compensates the motor position for the weight, thereby improving the absolute position accuracy.

Gravity Compensation parameters in addition to the zero position of robot axes can be adjusted by using Vision Mastering.   By adjusting the Gravity Compensation parameters, the robot can provide higher absolute position accuracy when it uses a heavy tool or workpiece.

> ⚠ **CAUTION**
> The Gravity Compensation function is an option. You have to set the mass and center of gravity of the payload accurately for this option to work. You can use another option, the Payload Identification option, to identify the mass and center of the gravity of the payload. For details on the Gravity Compensation and Payload Identification functions, please refer to "R-30*i*B/R-30*i*B Mate CONTROLLER Optional Function OPERATOR'S MANUALB-83284EN".

> **NOTE**
> Top Loader robots don't support adjusting the Gravity Compensation parameters. The procedure without Gravity Compensation Function is always used.

4.3   MEASURING POSES FOR VISION MASTERING

4.3.1   Outline of Measuring Poses
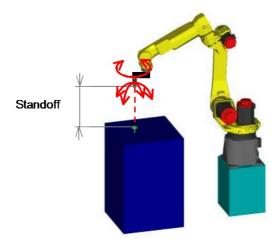
Fig. 4.3.1 Measuring Poses

Vision Mastering uses 27 measuring poses.   These measuring poses are automatically generated based on a reference pose (initial value).

The measuring poses are generated as detailed below:

- The number of measuring poses is 27. But with 7DF1/04 (V9.10P/04) or later software, 27 or 8 can be selected as the number of measuring poses.
- When the number of measuring poses is 27, a total of 27 measuring poses are generated by combining three different swing angles, (a positive maximum swing angle, negative maximum

swing angle, and 0), about each axis of orientation (W, P, R) of the reference pose. (Thus 3 times 3 times 3 = 27)

- When the number of measuring poses is 8, a total of 8 measuring poses are generated by combining two different swing angles, (a positive maximum swing angle and negative maximum swing angle), about each axis of orientation (W, P, R) of the reference pose. (Thus 2 times 2 times 2 = 8)
- Each robot measuring pose is adjusted so that the standoff (the distance between the camera and target) remains constant.

NOTE

With 7DF1/04 (V9.10P/04) or later software, It is recommended to select 8 poses to shorten the measurement time.

4.3.2   Determining the Reference Pose

Use the central, actual work pose of the robot (which is required for accuracy) as the reference pose.
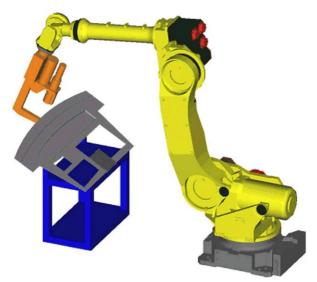
Fig. 4.3.2(a) Central, actual work pose of the robot

As the robot is used to cover a wide work area, in general, it may be difficult to determine the central pose of the robot.   In such cases, focus on an area which requires the highest position accuracy.
If the robot used in its actual pose can interfere with the surroundings, try the following measures:

1   Change only the value of the J1 axis with respect to the reference pose of the robot, move the robot hand section to a place where it can move more easily, then determine the current pose as the new reference pose.
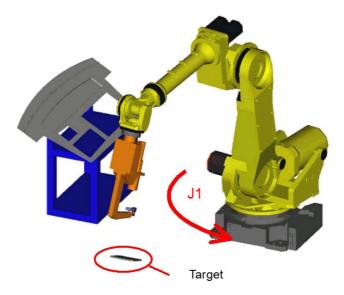
Fig. 4.3.2(b) Adjusting the reference pose by rotation of the J1 axis

2   Move the robot hand section to a place where it can move more easily without changing its pose with respect to the reference pose of the robot, then determine the current pose as the new reference pose.
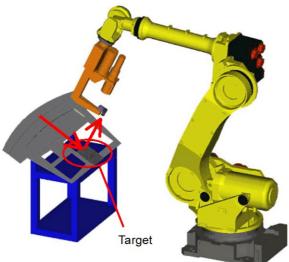
Fig. 4.3.2(c) Adjusting the reference pose without changing the wrist pose

> ⚠ **CAUTION**
> When the wrist flange surface of the robot faces laterally, generated multiple measuring poses may cross singularity in some reference poses.   In that case, adjust the robot pose so that the reference pose does not approach singularity.

4.3.3　　Examples of Reference Pose

Reference pose example in which the robot can operate relatively easily

Setting the reference pose as shown below results in a large maximum swing angle for the measuring pose.
1　　The J2-axis and J4-axis angles are around 0 degree.
2　　The J3-axis angle is negative.
3　　The wrist flange surface of the robot faces down.
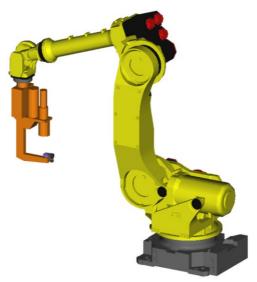
Fig. 4.3.3(a) Reference pose in which the robot can operate relatively easily

Reference pose example advantageous to adjust Gravity Compensation parameters

Setting the reference pose as shown below results in calculation of Gravity Compensation parameters at relatively high accuracy.
1　　The wrist flange surface of the robot faces horizontally.
2　　The J2-axis angle is about 30 degrees or more.
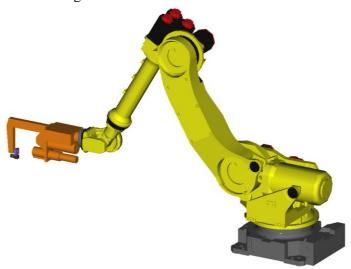
Fig. 4.3.3(b) Reference pose advantageous to adjust Gravity Compensation parameters

4.4   INSTALLATION OF THE CAMERA AND TARGET

4.4.1   Installing the Camera

Secure the camera to the tool tip of the robot.

> **NOTE**
> Although there are no installation precision requirements imposed on the camera and target, please try to fix them securely so that they do not move during measurement.

Mount the camera such that the camera lens center line is offset at least 100 mm from the center line of axis six. The recommended offset is at least 100 mm and the recommended standoff (distance between the camera and target) is 400 mm.
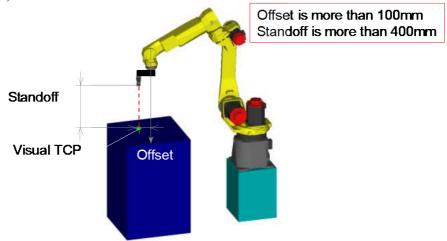
Fig. 4.4.1 (a) Installing the camera

Keep the camera and the tool away from the base section of the robot and tilt the J3 arm downward as shown below, so that the wrist section hardly causes interference.
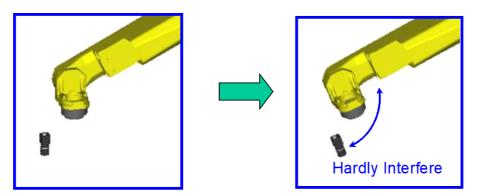
Fig. 4.4.1 (b) Wrist pose in which the camera hardly interferes with the robot

If the camera or tool is close to the base section of the robot or if the J3 arm is tilted upward in contrast, the wrist section is liable to cause interference.   In that case, the swing angle of measuring pose must be reduced, involving a risk of degrading mastering results.
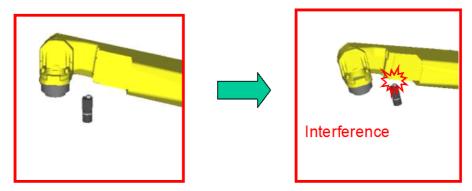
Fig. 4.4.1 (c) Wrist pose in which the camera is liable to interfere with the robot

Check these examples for reference to appropriately install the camera and select the reference pose of the robot.

Tips
    The reference pose in which the camera is close to the base section of the robot, as shown in Fig.4.4.1(d), can improve the quality of the set of measuring poses which are generated by using the reference pose.
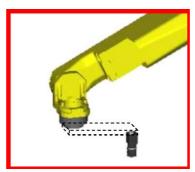
    Fig. 4.4.1 (d) Wrist pose in which the camera is close to the base section

4.4.2   Installing the Target

Place the target at a position where it can be installed in a stable condition.
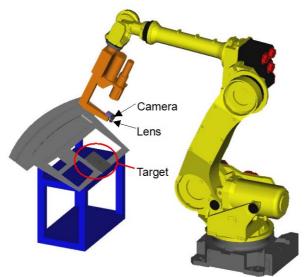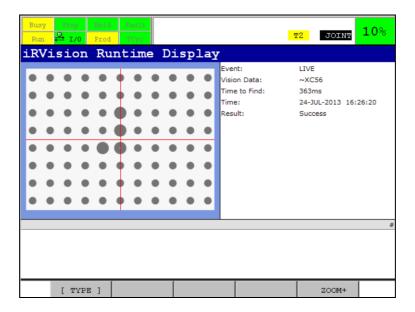
Fig. 4.4.2 Installation of target

Installing the calibration grid

Install the target such that the X-axis direction (three large circle of the backwards "L") of the calibration grid (See Subsection 4.9.1, "Calibration Grid") points upward in the camera image.   (For displaying the image, please refer to "3.2 DISPLAYING THE RUNTIME MONITOR".)

Install the calibration grid with its face approximately perpendicular to the optical axis of the camera.
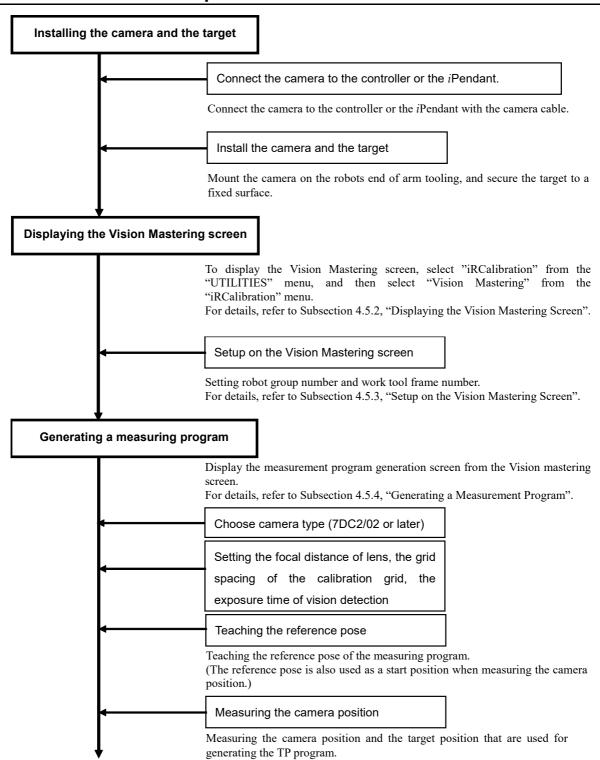
> Tips
>   The calibration grid should be placed near the center of the field of view.
>   Roughly placing the calibration in the center of the field of view is sufficient, its placement doesn't require a high level of precision.
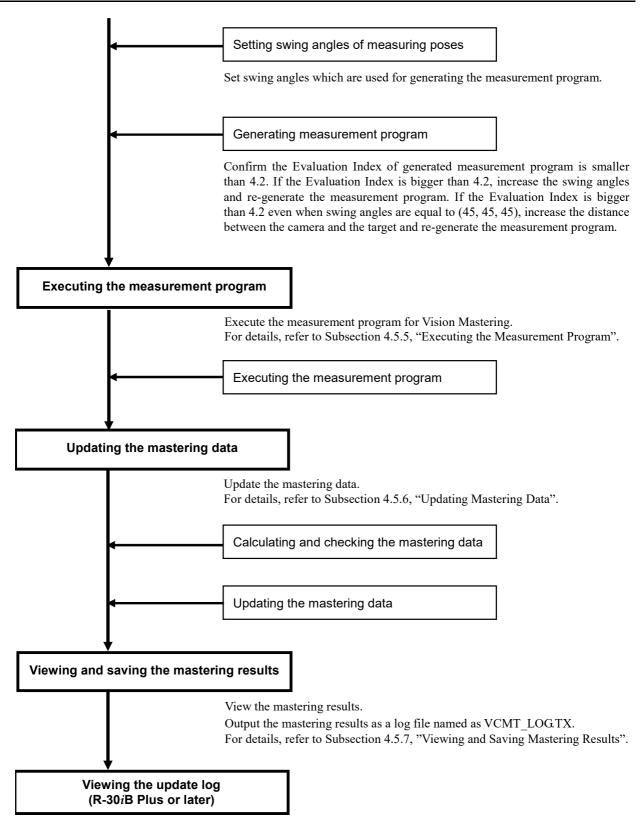
4.5 OPERATION OF VISION MASTERING WITH THE GRAVITY COMPENSATION FUNCTION UNAVAILABLE

This section describes the procedure for Vision Mastering when the Gravity Compensation Function is unavailable.

4.5.1 Outline of the Operation Procedure

Installing the camera and the target

→ Connect the camera to the controller or the *i*Pendant.

Connect the camera to the controller or the *i*Pendant with the camera cable.

→ Install the camera and the target

Mount the camera on the robots end of arm tooling, and secure the target to a fixed surface.

Displaying the Vision Mastering screen

To display the Vision Mastering screen, select "iRCalibration" from the "UTILITIES" menu, and then select "Vision Mastering" from the "iRCalibration" menu.
For details, refer to Subsection 4.5.2, "Displaying the Vision Mastering Screen".

→ Setup on the Vision Mastering screen

Setting robot group number and work tool frame number.
For details, refer to Subsection 4.5.3, "Setup on the Vision Mastering Screen".

Generating a measuring program

Display the measurement program generation screen from the Vision mastering screen.
For details, refer to Subsection 4.5.4, "Generating a Measurement Program".

→ Choose camera type (7DC2/02 or later)

→ Setting the focal distance of lens, the grid spacing of the calibration grid, the exposure time of vision detection

→ Teaching the reference pose

Teaching the reference pose of the measuring program.
(The reference pose is also used as a start position when measuring the camera position.)

→ Measuring the camera position

Measuring the camera position and the target position that are used for generating the TP program.

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```
┌─────────────────────────────────────────────┐
│  Setting swing angles of measuring poses      │
└─────────────────────────────────────────────┘
```

Set swing angles which are used for generating the measurement program.

```
┌─────────────────────────────────────────────┐
│  Generating measurement program               │
└─────────────────────────────────────────────┘
```

Confirm the Evaluation Index of generated measurement program is smaller than 4.2. If the Evaluation Index is bigger than 4.2, increase the swing angles and re-generate the measurement program. If the Evaluation Index is bigger than 4.2 even when swing angles are equal to (45, 45, 45), increase the distance between the camera and the target and re-generate the measurement program.

```
┌─────────────────────────────────────────────┐
│  Executing the measurement program            │
└─────────────────────────────────────────────┘
```

Execute the measurement program for Vision Mastering.
For details, refer to Subsection 4.5.5, "Executing the Measurement Program".

```
┌─────────────────────────────────────────────┐
│  Executing the measurement program            │
└─────────────────────────────────────────────┘
```

```
┌─────────────────────────────────────────────┐
│  Updating the mastering data                   │
└─────────────────────────────────────────────┘
```

Update the mastering data.
For details, refer to Subsection 4.5.6, "Updating Mastering Data".

```
┌─────────────────────────────────────────────┐
│  Calculating and checking the mastering data   │
└─────────────────────────────────────────────┘
```

```
┌─────────────────────────────────────────────┐
│  Updating the mastering data                   │
└─────────────────────────────────────────────┘
```

```
┌─────────────────────────────────────────────┐
│  Viewing and saving the mastering results      │
└─────────────────────────────────────────────┘
```

View the mastering results.
Output the mastering results as a log file named as VCMT_LOG.TX.
For details, refer to Subsection 4.5.7, "Viewing and Saving Mastering Results".

```
┌─────────────────────────────────────────────┐
│  Viewing the update log                        │
│  (R-30iB Plus or later)                        │
└─────────────────────────────────────────────┘
```

View the update log of the mastering data.
For details, refer to Subsection 4.5.8, "Viewing Update Log".

4.5.2   Displaying the Vision Mastering Screen

Procedure 4-1   Displaying the Vision Mastering screen

Step
1   Press the MENU key.
2   Select "UTILITIES".
3   Press the F1 [TYPE].
4   Select "*i*RCalibration".

The following screen appears on the teach pendant.
The available item list of *i*RCalibration functions is displayed in this screen.   The items to be displayed are different depend on the states of options.

```
UTILITIES iRCalibration
                                    1/2
 1 Vision Mastering
 2 Vision Master Recovery




[ TYPE ]DISP_IMG DETAIL
```

5   Move the cursor to "Vision Mastering", then press the F3 (DETAIL) or the ENTER key.
The following "Vision Mastering" screen appears on teach pendant.

```
UTILITIES iRCalibration
Vision Mastering                    1/6
 1 Robot Group:            1
 2 Work Tool Frame Number: 9
 3 Create Program          (Not Done)
 4 Run:    VMAST11          (Not Done)
 5 Update Master CT         (Not Done)
 6 View Result



[ TYPE ]DISP_IMG
```

Select and execute each item on the screen sequentially from the top so that the mastering parameters can be adjusted.

4.5.3   Setup on Vision Mastering Screen

There are two setup items on Vision Mastering screen
- Robot Group Number
- Work Tool Frame Number
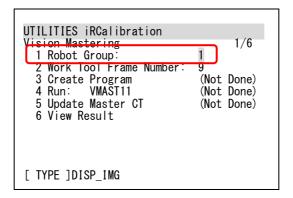
> **NOTE**
> With 7DF1/04 (V9.10P/04) or later software, 27 or 8 can be selected as the number of measuring poses. It is recommended to select 8 poses to shorten the measurement time.

Set Robot Group Number

Move the cursor to "Robot Group" on the Vision Mastering screen, then enter the group number of the robot to be calibrated.

```
UTILITIES iRCalibration
Vision Mastering                    1/6
 1 Robot Group:            1
 2 Work Tool Frame Number: 9
 3 Create Program          (Not Done)
 4 Run:   VMAST11          (Not Done)
 5 Update Master CT        (Not Done)
 6 View Result



[ TYPE ]DISP_IMG
```

Set Work Tool Frame Number

Move the cursor to "Work Tool Frame Number" on the Vision Mastering screen, and then enter the tool frame number to be used for vision measurement.

```
UTILITIES iRCalibration
Vision Mastering                    2/6
 1 Robot Group:            1
 2 Work Tool Frame Number: 9
 3 Create Program          (Not Done)
 4 Run:   VMAST11          (Not Done)
 5 Update Master CT        (Not Done)
 6 View Result



[ TYPE ]DISP_IMG
```
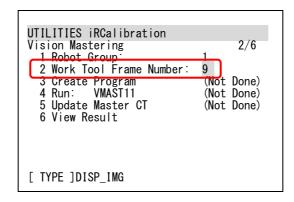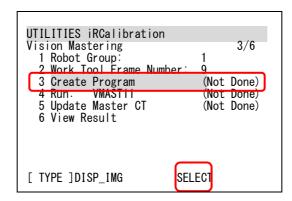
4.5.4   Generating a Measurement Program
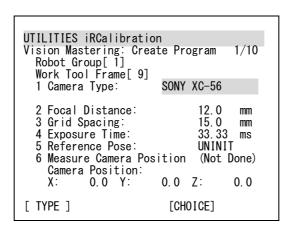
Procedure 4-2   Generating a measurement program

Step

Move the cursor to "Create Program" on the Vision Mastering screen, then press the F4 (SELECT)   or
the ENTER key.

```
UTILITIES iRCalibration
Vision Mastering                    3/6
  1 Robot Group:            1
  2 Work Tool Frame Number: 9
  3 Create Program          (Not Done)
  4 Run.    VMAST11         (Not Done)
  5 Update Master CT        (Not Done)
  6 View Result




[ TYPE ]DISP_IMG           SELECT
```

The teach pendant displays a measurement program generation screen as shown below.

```
UTILITIES iRCalibration
Vision Mastering: Create Program   1/10
  Robot Group[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:            SONY XC-56

  2 Focal Distance:            12.0   mm
  3 Grid Spacing:              15.0   mm
  4 Exposure Time:             33.33  ms
  5 Reference Pose:            UNINIT
  6 Measure Camera Position   (Not Done)
   Camera Position:
   X:    0.0  Y:    0.0  Z:    0.0

[ TYPE ]                   [CHOICE]
```

2   Set the camera type. (7DC2/02 or later)
     Below items can be selected as camera type.

SONY XC-56
    Choose this when using "SONY XC-56" camera that connects to JRL7 port on the main board
    or JRL7A port on the multiplexer. This camera type can be selected on only R-30*i*B / R-30*i*B
    Mate controller.

BASLER acA640-20um
    Choose this when BASLER *i*Pendant USB camera ac640-20um is used.

KOWA SC36MF
    Choose this when KOWA *i*Pendant USB camera SC36MF is used. This camera type can be
    selected on only R-30*i*B / R-30*i*B Mate controller.

*i*RVision Camera
    Choose this camera type when using KOWA monochrome camera SC130EF2 (only R-30*i*B
    Plus controller) or a camera for *i*RVision.

For details, please refer to "3.5 USING *i*RVision CAMERA".

```
UTILITIES iRCalibration
Vision Mastering: Create Program    1/10
  Robot Group[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:          SONY XC-56

  2 Focal Distance:             12.0    mm
  3 Grid Spacing:               15.0    mm
  4 Exposure Time:              33.33   ms
  5 Reference Pose:             UNINIT
  6 Measure Camera Position   (Not Done)
    Camera Position:
    X:    0.0  Y:     0.0  Z:     0.0

[ TYPE ]                   [CHOICE]
```

3   Set the focal distance (mm) of the camera lens.

```
UTILITIES iRCalibration
Vision Mastering: Create Program    2/10
  Robot Group[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:          SONY XC-56

  2 Focal Distance:             12.0    mm
  3 Grid Spacing:               15.0    mm
  4 Exposure Time:              33.33   ms
  5 Reference Pose:             UNINIT
  6 Measure Camera Position   (Not Done)
    Camera Position:
    X:    0.0  Y:     0.0  Z:     0.0

[ TYPE ]DISP_IMG
```

4   Set the grid spacing (mm) of the calibration grid

```
UTILITIES iRCalibration
Vision Mastering: Create Program    3/10
  Robot Group[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:          SONY XC-56

  2 Focal Distance:             12.0    mm
  3 Grid Spacing:               15.0    mm
  4 Exposure Time:              33.33   ms
  5 Reference Pose:             UNINIT
  6 Measure Camera Position   (Not Done)
    Camera Position:
    X:    0.0  Y:     0.0  Z:     0.0

[ TYPE ]DISP_IMG
```

5   Set the exposure time (ms) for vision measurement.

```
UTILITIES iRCalibration
Vision Mastering: Create Program    4/10
  Robot Group[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:         SONY XC-56

  2 Focal Distance:        12.0   mm
  3 Grid Spacing:          15.0   mm
  4 Exposure Time:         33.33_ ms
  5 Reference Pose:        UNINIT
  6 Measure Camera Position  (Not Done)
    Camera Position:
    X:     0.0 Y:     0.0 Z:    0.0

[ TYPE ] TIME+   TIME-    LIVE     FIND
```

Refer to Subsection 3.2 "DISPLAYING THE RUNTIME MONITOR" so that an image and the Generating Measurement Program screen can be seen simultaneously.   The following explains an example of displaying an image and the Generating Measurement Program screen simultaneously on *i*Pendant.   The display on the teach pendant is shown below.

```
UTILITIES iRCalibration            iRVision Runtime Display
Vision Mastering: Create Program    4/10
  Robot Group[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:         SONY XC-56

  2 Focal Distance:        12.0   mm
  3 Grid Spacing:          15.0   mm
  4 Exposure Time:         33.33  ms
  5 Reference Pose:        UNINIT
  6 Measure Camera Position  (Not Done)
    Camera Position:
    X:     0.0 Y:     0.0 Z:    0.0
    W:     0.0 P:     0.0 R:    0.0
    Calibration Grid Position:
    X:     0.0 Y:     0.0 Z:    0.0

  7 Swing Angle W:         20.0   deg
  8            P:          20.0   deg
  9            R:          30.0   deg
 10 Create Program         (Not Done)
    Evaluation Index of Program: 99.9

    [ TYPE ]     TIME+      TIME-      LIVE      FIND
```

Set Exposure Time on this screen by using function keys.

Function key functions
F2 (TIME+):   Increases the "Exposure Time" value.
F3 (TIME-):   Decreases the "Exposure Time" value.
F4 (LIVE):   Displays the live image.
F5 (FIND):   Detects the calibration grid.   If the detection has succeeded, a + mark is displayed on the dot detected.   If the detection has failed, an error message is displayed.

> Tips
> When the F2 or the F3 is pressed while holding down the SHIFT key, the rate of
> the value change becomes larger.

> **NOTE**
> Vision mastering uses the exposure time set in this screen.
> The exposure time set in "Parameter Setting Screen" or "Model Training Screen"
> of Vision Data Setup Screen does not applied to Vision Mastering.
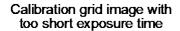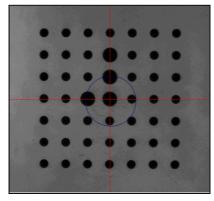
Appropriate exposure time:

Adjust the exposure time so that the image doesn't become pure white but rather gray in the lightest area of on the calibration grid.   Also, adjust the exposure time such that the white background and black circles can be clearly distinguished.
Some image samples with different exposure time are shown below.

Calibration grid image with too short exposure time	Calibration grid image with appropriate exposure time	Calibration grid image with too long exposure time

> **NOTE**
> On R-30*i*B Plus controller, 'Image Trimming' is added as an item to be set.
> When using a KOWA monochrome camera SC130EF2, the time to process an
> image may be longer than that of usual and/or it may become easier to detect
> false at the end of the image because the number of pixels of this camera is
> larger than existing cameras. In order to deal with such a problem, the number of
> pixels of cameras can be reduced by setting the value of 'Image Trimming' in a
> range from 0% to 75%.

```
UTILITIES iRCalibration
Vision Mastering: Create Program    6/12
  Robot Group[ 1]
  Work Tool Frame[ 9]
1 Camera Type:          iRVision camera
2                       1: SC130EF2
3 Focal Distance:       12.0    mm
4 Grid Spacing:         15.0    mm
5 Exposure Time:        33.33   ms
6 Image Trimming        50 %
7 Reference Pose:       UNINIT
8 Measure Camera Position  (Not Done)


[ TYPE ]    +         -      LIVE    FIND
```

6   Move the robot and teach the reference pose so that the origin of the target is near the center of the
     camera image.

Move the cursor to "Reference Pose" on the measurement program generation screen, and then press
the SHIFT key and the F5 (RECORD) together.
The current position is stored as reference pose.   The display on the teach pendant is shown below.
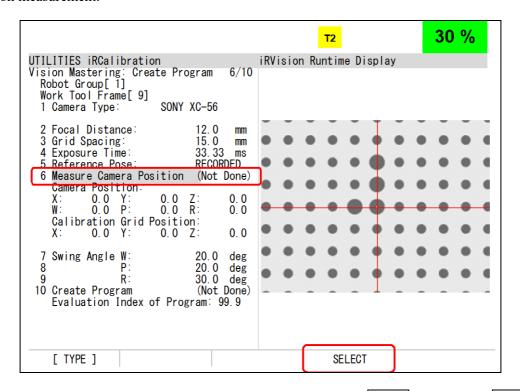
Tips
    You can move the robot to the "Reference Pose" if the position is "RECORDED"
    by pressing F4(MOVE TO) while holding down the SHIFT key.
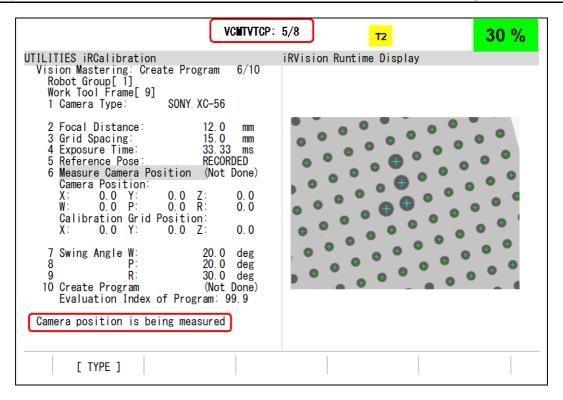
---

7   Set the override of the robot to 30% or less when T2 or AUTO mode is selected, and then measure the camera position.   If T1 mode is selected, the override can be improved more than 30%.
The camera position is measured while the robot automatically moves into multiple poses, with the reference pose as a measurement start pose, in which the pose is changed by several centimeters in the directions orthogonal to X, Y, and Z and by about 15 degrees in the pose directions of W, P, and R.   The camera position and calibration grid position are calculated based on the results of the vision measurement.

Move the cursor to "Measure Camera Position", then press the SHIFT key and the F4(SELECT) together.
The camera position will be measured.   During measurement, the teach pendant displays the following screen.

```
VCMTVTCP: 5/8        T2           30 %

UTILITIES iRCalibration              iRVision Runtime Display
 Vision Mastering: Create Program    6/10
   Robot Group[ 1]
   Work Tool Frame[ 9]
   1 Camera Type:          SONY XC-56

   2 Focal Distance:       12.0    mm
   3 Grid Spacing:         15.0    mm
   4 Exposure Time:        33.33   ms
   5 Reference Pose:       RECORDED
   6 Measure Camera Position  (Not Done)
     Camera Position:
     X:    0.0  Y:    0.0  Z:    0.0
     W:    0.0  P:    0.0  R:    0.0
     Calibration Grid Position:
     X:    0.0  Y:    0.0  Z:    0.0

   7 Swing Angle W:        20.0   deg
   8            P:         20.0   deg
   9            R:         30.0   deg
  10 Create Program        (Not Done)
     Evaluation Index of Program: 99.9
 Camera position is being measured

        [ TYPE ]
```

NOTE
1 If the camera attachment position or the calibration grid position is changed, measure the camera position again.
2 Keep pressing the SHIFT key during the measurement. For 7DC3/09 (V8.30P/09) or earlier software, if pressing the SHIFT key is interrupted, resuming the measurement makes it restart from the beginning. For 7DC3/10 (V8.30P/10) or later software, when you resume the measurement after the interruption, if a part of the measurement has been completed, a confirmation message to select "RESUME" or "RESTART" is displayed. Then, if "RESUME" is selected, the measurement is resumed. If "RESTART" is selected, the measurement is restarted from the beginning. If the camera attachment position or the calibration grid position is changed, select "RESTART".
3 An attempt to perform camera position measurement during execution of another program causes an error with the following error message displayed: "INTP-313 (Z_VCLIB2,384) Motion statement failed, PROG-040 Already locked by other task"
In this case, select "ABORT (ALL)" on the FCTN menu to terminate the program.

When the measurement is finished, the display on the teach pendant screen is as follows:
- The "Measure Camera Position" status is "Done".
- A message "Camera position is measured" appears in the prompt window.
- The result of the measurement is displayed.
  Measurement result:
  - Camera Position: Position of visual TCP
  - Calibration Grid Position: Origin position of calibration grid

```
                                            T2        30 %
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Mastering: Create Program   6/10
  Robot Group[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:         12.0   mm
  3 Grid Spacing:           15.0   mm
  4 Exposure Time:          33.33  ms
  5 Reference Pose:        RECORDED
  6 Measure Camera Position  (Done    )
    Camera Position:
    X:   275.4  Y:     0.0  Z:     0.0
    W:     0.0  P:    -0.0  R:     0.0
    Calibration Grid Position:
    X:  1674.8  Y:    -0.0  Z:   884.8

  7 Swing Angle W:          20.0   deg
  8             P:          20.0   deg
  9             R:          30.0   deg
 10 Create Program          (Not Done)
    Evaluation Index of Program: 99.9

  Camera position is measured


         [ TYPE ]                        SELECT
```

8   Set the swing angles W, P, and R of measuring poses for Vision Mastering. For details on measuring poses, please refer to "4.3.1 Outline of Measuring Poses".

```
                                            T2        30 %
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Mastering: Create Program   7/10
  Robot Group[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:         12.0   mm
  3 Grid Spacing:           15.0   mm
  4 Exposure Time:          33.33  ms
  5 Reference Pose:        RECORDED
  6 Measure Camera Position  (Done    )
    Camera Position:
    X:   275.4  Y:     0.0  Z:     0.0
    W:     0.0  P:    -0.0  R:     0.0
    Calibration Grid Position:
    X:  1674.8  Y:    -0.0  Z:   884.8

  7 Swing Angle W:          20.0   deg
  8             P:          20.0   deg
  9             R:          30.0   deg
 10 Create Program          (Not Done)
    Evaluation Index of Program: 99.9



         [ TYPE ]      DISP_IMG
```

For Vision Mastering with only the mastering parameters adjusted
The recommended range for "Swing Angle W/P" is 20 to 45 degrees.
The recommended range for "Swing Angle R" is 30 to 45 degrees.

```
Tips
    Increasing the swing angle improves the accuracy of adjustment of mastering
    parameters but requires a wider operating range.
```

```
NOTE
    If swing angle W or P exceeds 45 degrees, it may be impossible to perform
    vision measurement.   Do not allow swing angle W or P to exceed 45 degrees.
```

9   Generate a measurement program.
     Move the cursor to "Create Program", then press the F4 (SELECT) or the ENTER key.

Upon completion of the generation of the measurement program, the screen on the teach pendant changes as shown below.
- The "Create Program" status becomes "Done".
- The message "Program is created" is displayed.

When robot group is 1, TP program VMAST11 and VMDATA11 are generated.   The first number following VMAST and VMDATA indicates a robot group; the second one indicates a payload number.

10   Check the evaluation index and, if it is greater than 4.2, start at Step 8 over again and increase the values of Swing Angle.   If the Evaluation Index still is not improved, teach the reference pose to set the camera away from the target, and start at Step 6 again.

Tips
   Smaller value of Evaluation Index of Program means higher accuracy of Vision Mastering result may be achieved by using this program.

If a measurement program is generated with one already existing, the teach pendant displays the following message.

If the F4 (YES) is selected, a new measurement program is generated.
If the F5 (NO) is selected, a new measurement program is not generated, but the Evaluation Index of an existing program is recalculated.

11   When generating is finished, select the PREV key to return to Vision Mastering screen.

4.5.5   Executing the Measurement Program
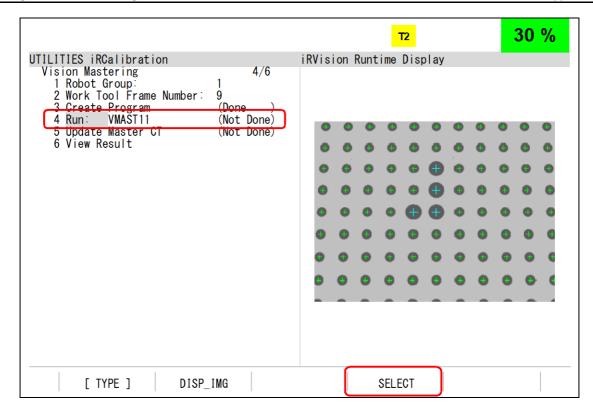
Procedure 4-3   Executing the measurement program
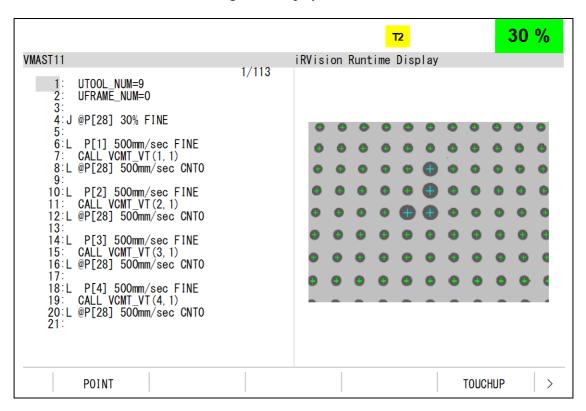
Condition
- Make sure that the "Create Program" status is "Done".

Step
1   Move the cursor to "RUN", then press the F4 (SELECT) or the ENTER key.

The Edit Screen of Measurement Program is displayed.

2   Set the override of the robot to 30% or less when T2 or AUTO mode is selected, then run the program displayed.   If T1 mode is selected, the override can be improved more than 30%.

> **Tips**
> If the robot cannot move to any of positions [1] to [27] during execution of the
> measurement program, make sure that the calibration grid resides within the
> field of view of the camera, then re-teach a position to which the robot can move,
> and continue the measurement from the re-taught position.

> **NOTE**
> For 7DC3/10 (V8.30P/10) or later software, call instructions of the program
> VCRSM_CHECK, label instructions, and jump instructions are added to the TP
> program so that efficient resuming of the measurement can be done. For details,
> refer to "4.7.1 TP Program".
> For 7DC3/10 (V8.30P/10) or later software, when the measurement is
> interrupted by the release of the SHIFT key, the occurrence of an alarm or other
> reasons, re-execute the TP program after moving the cursor to the first line. If a
> part of the measurement has been completed, a message "Press 0 (restart) or 9
> (resume)" appears. Press the 0 key to restart the measurement from the
> beginning or the 9 key to resume the measurement.

> **NOTE**
> If the camera attachment position or the calibration grid position is changed,
> measure the camera position and generate the measurement program in "4.5.4
> Generating a Measurement Program" again.

3   When the measurement has been completed, please refer to "4.5.2 Displaying the Vision Mastering
     Screen" to display the Vision Mastering screen.

4.5.6   Updating Mastering Data
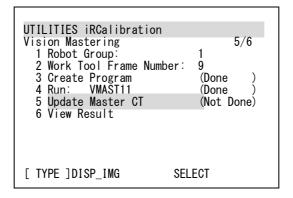
Procedure 4-4   Updating mastering data

Condition
- Make sure that the "Run" status of the measurement program for the selected payload is "Done".

Step
1   Move the cursor to "Update Master CT", then press the F4 (SELECT) or the ENTER key.

```
UTILITIES iRCalibration
Vision Mastering                         5/6
 1 Robot Group:            1
 2 Work Tool Frame Number: 9
 3 Create Program          (Done    )
 4 Run:    VMAST11          (Done    )
 5 Update Master CT        (Not Done)
 6 View Result



[ TYPE ]DISP_IMG            SELECT
```

The teach pendant displays the mastering data update screen as shown below.

```
UTILITIES iRCalibration
Vision Mastering: Update Master CT
  Robot Group[ 1]
  Compensation Angles:
   J1:    0.000  J2:   -0.025
   J3:    0.048  J4:   -0.003
   J5:   -0.020  J6:    0.000

  Evaluation Index of Program: 3.3
  Mean Error of Calibration:    .1
  Max Error of Calibration:     .3

[ TYPE ]           UPDATE
```

> **NOTE**
> Mastering parameters are not updated at this point.

2   Confirm the items displayed. If there is no problem, press the F3 (UPDATE) while holding down the SHIFT key to update mastering data.

Display items on Updating Mastering Data screen

Compensation Angles
   The compensation angles for the angular displacement shifted from the zero position for each rotation axis [degree].

Evaluation Index of Program
   Evaluation Index of the actual measurement poses.

Mean Error of Calibration
   The mean value (calculated value) [mm] of visual TCP positions in 27 measurement poses after calibration.

Max Error of Calibration
   The maximum value (calculated value) [mm] of visual TCP positions in 27 measurement poses after calibration.

Confirmation

- Confirm that Compensation Angles is 1° or less.
  If Compensation Angles is exceeding 1°, update mastering data and run the measurement program again, then confirm that the value of Compensation Angles displayed on Updating Mastering Data screen becomes smaller.
- If you do not adjust Gravity Compensation parameters, check whether the evaluation index is 4.2 or less.
  If Evaluation Index is exceeding 4.2, there is a possibility that the calculation error of mastering parameters is large. Re-generate the measurement program with the maximum swing angle increased on the "Create Program" screen, then re-execute the program.
- Confirm the Max Error of Calibration.
  The approximate maximum error of calibration is as follows:
  - When the transportable mass of the robot is 100 kg or less, "Max Error of Calibration" is 1.5 mm or less.
  - When the transportable mass of the robot is 200 kg or less, "Max Error of Calibration" is 2 mm or less.

If the maximum error of calibration is considerably larger than the above value, possible causes are that the lens or camera is not secured, the lens is out of focus, and that the target is not secured.   Check these causes again.

Tips
  With a heavy payload, "Max Error of Calibration" can be larger than the above
  approximate value.   In this case, update mastering data, run the measurement
  program again, and confirm "Compensation Angles" and "Max Error of
  Calibration" on Updating Mastering Data screen again.   Even though "Max Error
  of Calibration" has not changed, if "Compensation Angles" becomes smaller, the
  result of Vision Mastering is fine.

3   After updating the mastering data, set the reference position for Quick Mastering again, preparing
     for future Quick Mastering. If it has not been set, set it as all the axes' angles are 0 degree. For
     details of Quick Mastering, please refer to "R-30*i*B / R-30*i*B Mate OPERATOR'S MANUAL(Basic
     Operation)B-83284EN" and "Mechanical Unit Operator's Manual".

NOTE
  In the following software versions, a notification "Ref. Pos. for Quick Mastering
  Not Set" will be displayed on the notifications screen when you execute Vision
  Mastering. This notification will be cleared when you set a quick mastering
  reference point.
      - 7DF1/34(V9.10P/34) or later
      - 7DF3/17(V9.30P/17) or later
      - 7DF5/14(V9.40P/14) or later

4.5.7   Viewing and Saving Mastering Results

Procedure 4-5   Viewing and saving mastering results

Step
1   Move the cursor to "View Result", then press the F4 (SELECT) or the ENTER key.

```
UTILITIES iRCalibration
Vision Mastering                      6/6
  1 Robot Group:          1
  2 Work Tool Frame Number:  9
  3 Create Program         (Done    )
  4 Run:    VMAST11        (Done    )
  5 Update Master CT       (Done    )
  6 View Result



[ TYPE ]DISP_IMG          SELECT
```

     The teach pendant displays the mastering result display screen as shown below.

```
UTILITIES iRCalibration
Vision Mastering: View Result Page 1
  Robot Group[ 1]
  Compensation Angles:
   J1:    0.000   J2:   -0.025
   J3:    0.048   J4:   -0.003
   J5:   -0.020   J6:    0.000

  Evaluation Index of Program: 3.3
  Mean Error of Calibration:   .1
  Max Error of Calibration:    .3

[ TYPE ]                      NEXTPAGE OUTPUT
```

Function key

F4 (NEXTPAGE):   Go to the next page.

F5 (OUTPUT):   Save VCMT_LOG.TXT, the Vision Mastering results logging file to the file I/O devices (a memory card, an USB memory, etc). For details of selecting the file I/O devices in the file menu, please refer to "R-30*i*B / R-30*i*B Mate OPERATOR'S MANUAL(Basic Operation)B-83284EN".

Tips
   If VCMT_LOG.TXT already exists, the new results are appended to the current contents.

4.5.8   Viewing Update Log

"View Update Log" is supported from R-30*i*B Plus controller. On R-30*i*B / R-30*i*B Mate controller, "View Update Log" is not displayed on the Vision Mastering screen,

---

Procedure 4-6   Viewing update log

Step

1   Move the cursor to "View Update Log", then press the F4 (SELECT) or the ENTER key.

```
UTILITIES iRCalibration
Vision Mastering                    7/7
  1 Robot Group:           1
  2 Work Tool Frame Number: 9
  3 Create Program         (Done    )
  4 Run:    VMAST11        (Done    )
  5 Update Master CT       (Done    )
  6 View Result
  7 View Update Log



[ TYPE ]DISP_IMG          SELECT
```

The teach pendant displays the update log display screen as shown below. The logs recorded when the mastering data was updated by Vision Mastering are displayed on the screen.

```
UTILITIES iRCalibration
Vision Mastering: View Update Log  1/10
         Update Time        Robot Group
  1   2016/04/01 12:00     [1]
  2   2016/04/02 12:00     [2]
  3   ****************     [0]
  4   ****************     [0]
  5   ****************     [0]
  6   ****************     [0]
  7   ****************     [0]
  8   ****************     [0]
  9   ****************     [0]
 10   ****************     [0]


[ TYPE ]           DETAIL        CLEAR
```

Function key
F3 (DETAIL):   The detail screen of the selected log is displayed if the log is recorded.
F5 (CLEAR):   The selected log is cleared if recorded.

The procedure is detailed below.

Procedure 4-7   Viewing the detail screen of an update log

Step

1   Move the cursor to the log whose detail you want to display, then press the F3 (DETAIL) or the
     ENTER key on the update log display screen.

```
UTILITIES iRCalibration
Vision Mastering: View Update Log  1/10
         Update Time        Robot Group
  1   2016/04/01 12:00     [1]
  2   2016/04/02 12:00     [2]
  3   ****************     [0]
  4   ****************     [0]
  5   ****************     [0]
  6   ****************     [0]
  7   ****************     [0]
  8   ****************     [0]
  9   ****************     [0]
 10   ****************     [0]


[ TYPE ]           DETAIL        CLEAR
```

The teach pendant displays the detail screen of the log as shown below.

```
UTILITIES iRCalibration
Vision Mastering: View Log Detail Page 1
   Log  1  2016/04/01 12:00    Group[1]
   Compensation Angles:
     J1:    0.000   J2:   -0.025
     J3:    0.048   J4:   -0.003
     J5:   -0.020   J6:    0.000

   Evaluation Index of Program: 3.3
   Mean Error of Calibration:    .1
   Max Error of Calibration:     .3

[ TYPE ]                   NEXTPAGE
```

2   Press the F4 (NEXTPAGE) key to display the next page.

```
UTILITIES iRCalibration
Vision Mastering: View Log Detail Page 2
  Master Counts:
                 New           Original
    [1]: [      123456] [       123456]
    [2]: [      123678] [       144876]
    [3]: [      123789] [       145987]
    [4]: [     1238889] [      1249880]
    [5]: [      123889] [       155883]
    [6]: [    12345678] [      12345778]
    [7]: [           0] [            0]
    [8]: [           0] [            0]
    [9]: [           0] [            0]

[ TYPE ]                   NEXTPAGE
```

Procedure 4-8   Clearing an update log
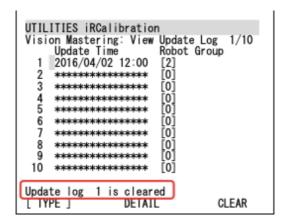
Step

1   Move the cursor to the log you want to clear, then press the F5 (CLEAR) key on the update log display screen.

```
UTILITIES iRCalibration
Vision Mastering: View Update Log   1/10
            Update Time       Robot Group
    1  2016/04/01 12:00   [1]
    2  2016/04/02 12:00   [2]
    3  ****************   [0]
    4  ****************   [0]
    5  ****************   [0]
    6  ****************   [0]
    7  ****************   [0]
    8  ****************   [0]
    9  ****************   [0]
   10  ****************   [0]


[ TYPE ]        DETAIL        CLEAR
```

A confirmation message is displayed.

```
UTILITIES iRCalibration
Vision Mastering: View Update Log   1/10
            Update Time       Robot Group
    1  2016/04/01 12:00   [1]
    2  2016/04/02 12:00   [2]
    3  ****************   [0]
    4  ****************   [0]
    5  ****************   [0]
    6  ****************   [0]
    7  ****************   [0]
    8  ****************   [0]
    9  ****************   [0]
   10  ****************   [0]

Clear update log  1?
[ TYPE ]              YES       NO
```

2   Press the F4 (YES) key to clear the log.

```
UTILITIES iRCalibration
Vision Mastering: View Update Log  1/10
        Update Time       Robot Group
 1  2016/04/02 12:00     [2]
 2  ***************      [0]
 3  ***************      [0]
 4  ***************      [0]
 5  ***************      [0]
 6  ***************      [0]
 7  ***************      [0]
 8  ***************      [0]
 9  ***************      [0]
10  ***************      [0]

Update log  1 is cleared
[ TYPE ]          DETAIL          CLEAR
```

> **NOTE**
> Do not clear a log if the taught positions of a program that had been taught before Vision Mastering was executed are to be modified by Mastering Shift, and the log was recorded by Vision Mastering that was first executed after the program had been taught. For details of Mastering Shift, please refer to "4.8 PROGRAM SHIFT (MASTERING SHIFT FUNCTION)".

4.6   OPERATION OF VISION MASTERING WITH THE GRAVITY COMPENSATION FUNCTION ENABLED

This section describes the procedure for Vision Mastering with the Gravity Compensation function enabled.

4.6.1   Vision Mastering Functions, Including Adjustment of Gravity Compensation Parameters

Although this is not always appropriate as the robot is used in various conditions, favorable positioning accuracy can be obtained by executing Vision Mastering with Gravity Compensation parameters adjusted generally in the following conditions:

- The transportable mass of the robot exceeds 100 kg.
- The payload attached to the hand section exceeds 1/2 of the transportable mass of the robot.
- If an object that is mounted to the J3 mounting surface has a mass that is sufficiently lighter than the payload mass of the hand section of the robot.

In practice, it is advisable for you to examine the application of Vision Mastering according to robot operating conditions to check its effects before starting a robot system.

When two or more types of payloads are applied to the hand section of the robot or the robot work range is relatively wide, increasing the number (described later) of payloads used by Vision Mastering is apt to yield desired results.

Tips
    If the adjusted Gravity Compensation parameters do not improve positioning
    accuracy, you need to reset the Gravity Compensation parameters back to their
    default values and redo the Vision Master again.
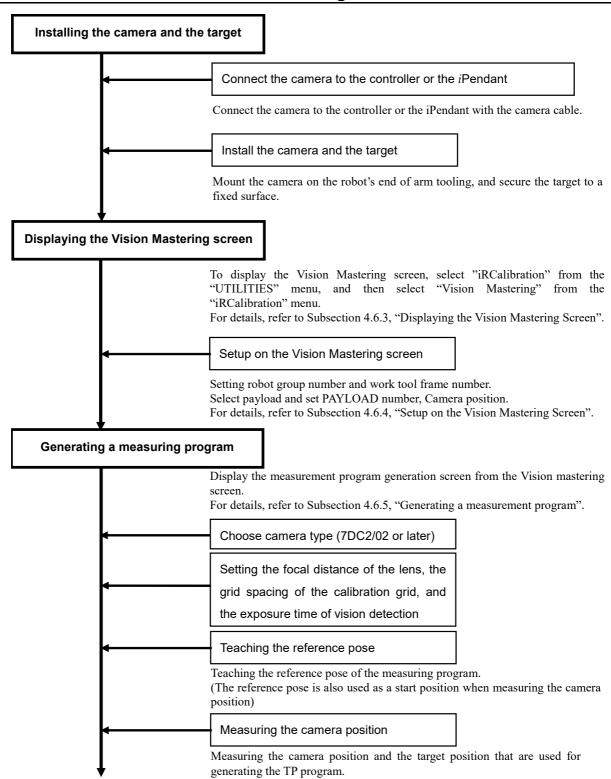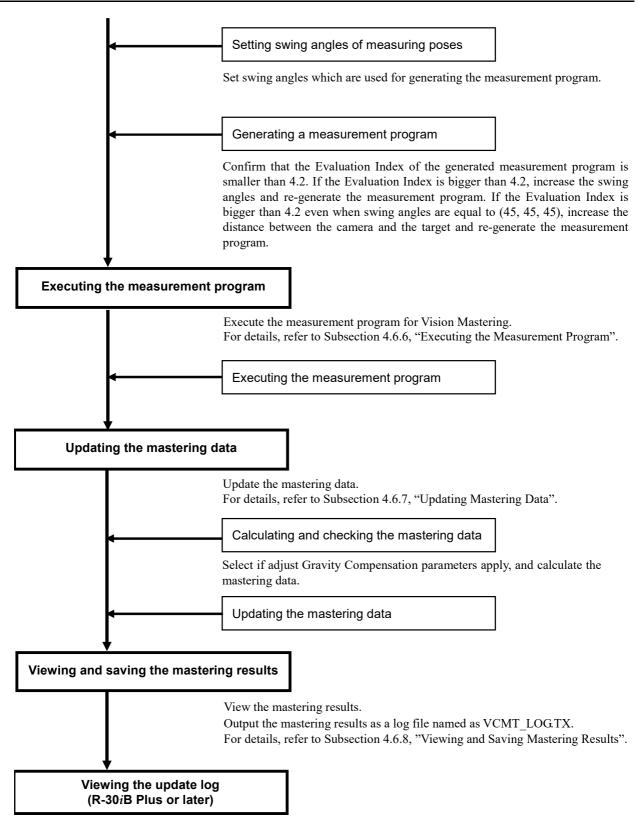
    The default value is 0 for $GRAVC_GRP[n].$MODE_SW and
    GRAVC_GRP[n].$SPCONS[1-9]. The n denotes the group number. You need to
    recycle power after setting these parameters.

NOTE
    With just one light payload, the measurement and update of Vision Mastering
    should be repeated until compensation results become small.   For details,
    please refer to "4.6.7, Updating Mastering Data".

4.6.2   Outline of the Vision Mastering Procedure

```
┌─────────────────────────────────────┐
│  Installing the camera and the target │
└─────────────────────────────────────┘
        │
        │        ┌──────────────────────────────────────────────┐
        │◄───────│ Connect the camera to the controller or the iPendant │
        │        └──────────────────────────────────────────────┘
```

Connect the camera to the controller or the iPendant with the camera cable.

```
        │        ┌──────────────────────────────────┐
        │◄───────│ Install the camera and the target │
        │        └──────────────────────────────────┘
```

Mount the camera on the robot's end of arm tooling, and secure the target to a fixed surface.

```
┌─────────────────────────────────────┐
│ Displaying the Vision Mastering screen │
└─────────────────────────────────────┘
```

To display the Vision Mastering screen, select "iRCalibration" from the "UTILITIES" menu, and then select "Vision Mastering" from the "iRCalibration" menu.
For details, refer to Subsection 4.6.3, "Displaying the Vision Mastering Screen".

```
        │        ┌──────────────────────────────────────┐
        │◄───────│ Setup on the Vision Mastering screen  │
        │        └──────────────────────────────────────┘
```

Setting robot group number and work tool frame number.
Select payload and set PAYLOAD number, Camera position.
For details, refer to Subsection 4.6.4, "Setup on the Vision Mastering Screen".

```
┌─────────────────────────────────────┐
│   Generating a measuring program     │
└─────────────────────────────────────┘
```

Display the measurement program generation screen from the Vision mastering screen.
For details, refer to Subsection 4.6.5, "Generating a measurement program".

```
        │        ┌──────────────────────────────────────────┐
        │◄───────│ Choose camera type (7DC2/02 or later)      │
        │        └──────────────────────────────────────────┘

        │        ┌──────────────────────────────────────────┐
        │◄───────│ Setting the focal distance of the lens, the │
        │        │ grid spacing of the calibration grid, and   │
        │        │ the exposure time of vision detection       │
        │        └──────────────────────────────────────────┘

        │        ┌──────────────────────────────────────────┐
        │◄───────│ Teaching the reference pose                │
        │        └──────────────────────────────────────────┘
```

Teaching the reference pose of the measuring program.
(The reference pose is also used as a start position when measuring the camera position)

```
        │        ┌──────────────────────────────────────────┐
        │◄───────│ Measuring the camera position              │
        │        └──────────────────────────────────────────┘
        ▼
```

Measuring the camera position and the target position that are used for generating the TP program.

Setting swing angles of measuring poses

Set swing angles which are used for generating the measurement program.

Generating a measurement program

Confirm that the Evaluation Index of the generated measurement program is smaller than 4.2. If the Evaluation Index is bigger than 4.2, increase the swing angles and re-generate the measurement program. If the Evaluation Index is bigger than 4.2 even when swing angles are equal to (45, 45, 45), increase the distance between the camera and the target and re-generate the measurement program.

Executing the measurement program

Execute the measurement program for Vision Mastering.
For details, refer to Subsection 4.6.6, "Executing the Measurement Program".

Executing the measurement program

Updating the mastering data

Update the mastering data.
For details, refer to Subsection 4.6.7, "Updating Mastering Data".

Calculating and checking the mastering data

Select if adjust Gravity Compensation parameters apply, and calculate the mastering data.

Updating the mastering data

Viewing and saving the mastering results

View the mastering results.
Output the mastering results as a log file named as VCMT_LOG.TX.
For details, refer to Subsection 4.6.8, "Viewing and Saving Mastering Results".

**Viewing the update log
(R-30iB Plus or later)**

View the update log of the mastering data.
For details, refer to Subsection 4.6.9, "Viewing Update Log".

4.6.3   Displaying the Vision Mastering Screen

Procedure 4-6   Displaying the Vision Mastering screen

Step
1   Press the MENU key.
2   Select "UTILITIES".
3   Press the F1 (TYPE).
4   Select "*i*RCalibration".

The following screen appears on the teach pendant.
An available item list of *i*RCalibration functions is displayed in this screen. The items to be displayed are different depending on the states of options.

```
UTILITIES iRCalibration
                                    1/2
 1 Vision Mastering
 2 Vision Master Recovery




[ TYPE ]DISP_IMG DETAIL
```

5   Move the cursor to "Vision Mastering", then press the F3 (DETAIL) or the ENTER key.
The following "Vision Mastering" screen appears on teach pendant.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  1/19
  1 Robot Group:             1
  2 Work Tool Frame Number:  9
 Payload 1
  3 Select Payload 1:        FALSE
  4 PAYLOAD number:          0
  5 Camera Position(1-3):    0
  6 Create Program           (--------)
  7 Run:    VMAST11          (--------)
 Payload 2
  8 Select Payload 2:        FALSE
  9 PAYLOAD number:          0

[ TYPE ]DISP_IMG
```

Select and execute each item on the screen sequentially from the top so that the mastering parameters can be adjusted.

NOTE
    If Gravity Compensation is loaded, the menu's title shows "Vision Mastering with Gravity Com". If the controller has the Gravity Compensation option loaded but it is disabled, you can enable the Gravity Compensation by setting $PARAM_GROUP[n].$SV_DMY_LNK[8] (n: robot group) to "TRUE", and then cycle the power.

4.6.4   Setup on Vision Mastering Screen

There are two setup items on the Vision Mastering screen.
- Robot Group Number
- Work Tool Frame Number

> **NOTE**
> With 7DF1/04 (V9.10P/04) or later software, 27 or 8 can be selected as the number of measuring poses. It is recommended to select 8 poses to shorten the measurement time.

Set Robot Group Number

Move the cursor to "Robot Group" on the Vision Mastering screen, then enter the group number of the robot to be calibrated.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  1/19
 1 Robot Group:              1
 2 Work Tool Frame Number:   9
Payload 1
 3 Select Payload 1:         FALSE
 4 PAYLOAD number:           0
 5 Camera Position(1-3):     0
 6 Create Program            (--------)
 7 Run:    VMAST11           (--------)
Payload 2
 8 Select Payload 2:         FALSE
 9 PAYLOAD number:           0

[ TYPE ]DISP_IMG
```

Set Work Tool Frame Number

Move the cursor to "Work Tool Frame Number" on the Vision Mastering screen and enter the tool frame number to be used for the vision measurement.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  2/19
 1 Robot Group:              1
 2 Work Tool Frame Number:   9
Payload 1
 3 Select Payload 1:         FALSE
 4 PAYLOAD number:           0
 5 Camera Position(1-3):     0
 6 Create Program            (--------)
 7 Run:    VMAST11           (--------)
Payload 2
 8 Select Payload 2:         FALSE
 9 PAYLOAD number:           0

[ TYPE ]DISP_IMG
```

Select Payload

Move the cursor to "Select Payload" corresponding to the payload to be used for Vision Mastering, then press the F4 (TRUE).

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  3/19
  1 Robot Group:              1
  2 Work Tool Frame Number:   9
Payload 1
  3 Select Payload 1:         FALSE
  4 PAYLOAD number:           0
  5 Camera Position(1-3):     0
  6 Create Program           (--------)
  7 Run:   VMAST11           (--------)
Payload 2
  8 Select Payload 2:         FALSE
  9 PAYLOAD number:           0

[ TYPE ]                   TRUE    FALSE
```

The screen on the teach pendant changes as follows, indicating that the measurement using the selected payload can be performed.   You can disable that payload by pressing the F5 (FALSE).

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  3/19
  1 Robot Group:              1
  2 Work Tool Frame Number:   9
Payload 1
  3 Select Payload 1:         TRUE
  4 PAYLOAD number:           0
  5 Camera Position(1-3):     0
  6 Create Program           (Not Done)
  7 Run:   VMAST11           (Not Done)
Payload 2
  8 Select Payload 2:         FALSE
  9 PAYLOAD number:           0

[ TYPE ]                   TRUE    FALSE
```

Set "PAYLOAD number"

Move the cursor to "PAYLOAD number" corresponding to the payload to be used for Vision Mastering, then enter a number.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  4/19
  1 Robot Group:              1
  2 Work Tool Frame Number:   9
Payload 1
  3 Select Payload 1:         TRUE
  4 PAYLOAD number:           1
  5 Camera Position(1-3):     0
  6 Create Program           (Not Done)
  7 Run:   VMAST11           (Not Done)
Payload 2
  8 Select Payload 2:         FALSE
  9 PAYLOAD number:           0

[ TYPE ]
```

⚠ **CAUTION**
1 The meaning of "PAYLOAD number" is as same as the "PAYLOAD number" in the motion performance menu
2 The payload should be set correctly in the motion performance menu before executing Vision Mastering.
3 "PAYLOAD number" is used as the value of "PAYLOAD" command in measurement program. See section "4.7.1 TP program" for detail.

Set "Camera Position"

Move the cursor to "Camera Position" corresponding to the payload to be used for Vision Mastering, then enter a number.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  5/19
  1 Robot Group:              1
  2 Work Tool Frame Number:   9
Payload 1
  3 Select Payload 1:         TRUE
  4 PAYLOAD number:           1
  5 Camera Position(1-3):     1
  6 Create Program            (Not Done)
  7 Run:    VMAST11           (Not Done)
Payload 2
  8 Select Payload 2:         FALSE
  9 PAYLOAD number:           0

[ TYPE ]
```

> Tips
>
> If the robot is used in multiple payload conditions, for example, in which the robot holds different types of workpieces, use two or more payloads in Vision Mastering as well.   Vision Mastering can be executed with up to three types of payloads.

> ⚠ **CAUTION**
> 1 When the camera position does not change even though different payloads are used, specify the same "Camera Position" value for each of the payloads.
> 2 If the camera position changes for each of different payloads to be used, be sure to specify different "Camera Position" values.

4.6.5   Generating a Measurement Program

Procedure 4-10   Generating a measurement program

Step

1   Move the cursor to "Create Program" on the Vision Mastering screen, then press the F4 (SELECT) or the ENTER key.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  6/19
  1 Robot Group:              1
  2 Work Tool Frame Number:   9
Payload 1
  3 Select Payload 1:         TRUE
  4 PAYLOAD number:           1
  5 Camera Position(1-3):     1
  6 Create Program            (Not Done)
  7 Run:    VMAST11           (Not Done)
Payload 2
  8 Select Payload 2:         FALSE
  9 PAYLOAD number:           0

[ TYPE ]                 SELECT
```

The teach pendant displays a measurement program generation screen as shown below.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  1/10
Create Program for Payload 1
  Robot Group[ 1]            PAYLOAD[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:          12.0    mm
  3 Grid Spacing:            15.0    mm
  4 Exposure Time:           33.33   ms
  5 Reference Pose:          UNINIT
  6 Measure Camera Position  (Not Done)
    Camera Position  [1]:

[ TYPE ]                  [CHOICE]
```

2   Set the camera type. (7DC2/02 (V8.20P02) or later)
      Below items can be selected as camera type.

   SONY XC-56
       Choose this when using "SONY XC-56" camera that connects to JRL7 port on the main board
       or JRL7A port on the multiplexer. This camera type can be selected on only R-30*i*B / R-30*i*B
       Mate controller.
   BASLER acA640-20um
       Choose this when BASLER *i*Pendant USB camera ac640-20um is used.
   KOWA SC36MF
       Choose this when KOWA *i*Pendant USB camera SC36MF is used. This camera type can be
       selected on only R-30*i*B / R-30*i*B Mate controller.
   *i*RVision Camera
       Choose this camera type when using KOWA monochrome camera SC130EF2 (only R-30*i*B
       Plus controller) or a camera for *i*RVision.

For details, please refer to "3.5 USING *i*RVision CAMERA".

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  1/10
Create Program for Payload 1
  Robot Group[ 1]            PAYLOAD[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:          12.0    mm
  3 Grid Spacing:            15.0    mm
  4 Exposure Time:           33.33   ms
  5 Reference Pose:          UNINIT
  6 Measure Camera Position  (Not Done)
    Camera Position  [1]:

[ TYPE ]                  [CHOICE]
```

3   Set the focal distance (mm) of the camera lens

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  2/10
Create Program for Payload 1
  Robot Group[ 1]          PAYLOAD[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:         12.0   mm
  3 Grid Spacing:           15.0   mm
  4 Exposure Time:          33.33  ms
  5 Reference Pose:         UNINIT
  6 Measure Camera Position  (Not Done)
    Camera Position  [1]:

[ TYPE ]DISP_IMG
```

4   Set the grid spacing (mm) of the calibration grid.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  3/10
Create Program for Payload 1
  Robot Group[ 1]          PAYLOAD[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:         12.0   mm
  3 Grid Spacing:           15.0   mm
  4 Exposure Time:          33.33  ms
  5 Reference Pose:         UNINIT
  6 Measure Camera Position  (Not Done)
    Camera Position  [1]:

[ TYPE ]DISP_IMG
```

5   Set the exposure time (ms) for the vision measurement.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com  4/10
Create Program for Payload 1
  Robot Group[ 1]          PAYLOAD[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:         12.0   mm
  3 Grid Spacing:           15.0   mm
  4 Exposure Time:          33.33  ms
  5 Reference Pose:         UNINIT
  6 Measure Camera Position  (Not Done)
    Camera Position  [1]:

[ TYPE ] TIME+   TIME-    LIVE    FIND
```

Refer to Subsection 3.2 "DISPLAYING THE RUNTIME MONITOR" so that an image and the Generating Measurement Program screen can be seen simultaneously.   The following explains the example of displaying an image and the Generating Measurement Program screen simultaneously on *i*Pendant.   The display on the teach pendant is shown below.

Set Exposure Time on this screen by using function keys.

Function key functions

F2 (TIME+):   Increases the "Exposure Time" value.

F3 (TIME-):   Decreases the "Exposure Time" value.

F4 (LIVE):   Displays the live image.

F5 (FIND):   Detects the calibration grid.   If the detection has succeeded, a + mark is displayed
               on the dot detected.   If the detection has failed, an error message is displayed.

Tips
  Holding down   SHIFT   key when pressing   F2   or   F3   the value changes in
  larger increment..

NOTE
  Vision Mastering uses the exposure time set in this screen. Vision Mastering
  does not use exposure time setting in "Parameter Setting screen" or "Mode
  Teach screen" of "Vision Setup"..

Appropriate exposure time:
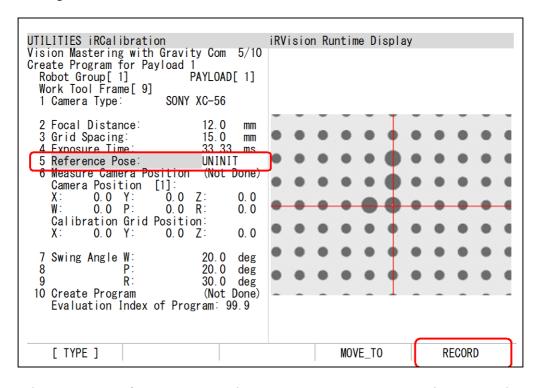
Adjust the exposure time so that the image doesn't become pure white but rather gray in the lightest
area of on the calibration grid.   And, adjust the exposure time such that the white background and
black circles can be clearly distinguished.   For details, please refer to "4.5.4 Generating a
Measurement Program".

> **NOTE**
> On R-30*i*B Plus controller, 'Image Trimming' is added as an item to be set. When using a KOWA monochrome camera SC130EF2, the time to process an image may be longer than that of usual and/or it may become easier to detect false at the end of the image because the number of pixels of this camera is larger than existing cameras. In order to deal with such a problem, the number of pixels of cameras can be reduced by setting the value of 'Image Trimming' in a range from 0% to 75%.
>
> ```
> UTILITIES iRCalibration
> Vision Mastering with Gravity Com  6/12
> Create Program for Payload 1
>   Robot Group[ 1]          PAYLOAD[ 1]
>   Work Tool Frame[ 9]
>   1 Camera Type:           iRVision camera
>   2                          1: SC130EF2
>   3 Focal Distance:         12.0    mm
>   4 Grid Spacing:           15.0    mm
>   5 Exposure Time:          33.33   ms
>   6 Image Trimming          50 %
>   7 Reference Pose:         UNINIT
>   8 Measure Camera Position  (Not Done)
>
> [ TYPE ]    +      -     LIVE    FIND
> ```

6 Move the robot and teach the reference pose so that the origin of the target is in the center of the camera image.

```
UTILITIES iRCalibration            iRVision Runtime Display
Vision Mastering with Gravity Com  5/10
Create Program for Payload 1
  Robot Group[ 1]          PAYLOAD[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:      SONY XC-56

  2 Focal Distance:        12.0    mm
  3 Grid Spacing:          15.0    mm
  4 Exposure Time:         33.33   ms
  5 Reference Pose:        UNINIT
  6 Measure Camera Position  (Not Done)
  Camera Position   [1]:
    X:     0.0  Y:     0.0  Z:     0.0
    W:     0.0  P:     0.0  R:     0.0
  Calibration Grid Position:
    X:     0.0  Y:     0.0  Z:     0.0

  7 Swing Angle W:         20.0  deg
  8           P:           20.0  deg
  9           R:           30.0  deg
 10 Create Program        (Not Done)
    Evaluation Index of Program: 99.9


   [ TYPE ]                          MOVE_TO      RECORD
```

Move the cursor to "Reference Pose" on the measurement program generation screen, then press the SHIFT key and the F5 (RECORD) together.
The current position is stored as reference pose. The display on the teach pendant is shown below.

```
UTILITIES iRCalibration           iRVision Runtime Display
Vision Mastering with Gravity Com  5/10
Create Program for Payload 1
  Robot Group[ 1]          PAYLOAD[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:         12.0    mm
  3 Grid Spacing:           15.0    mm
  4 Exposure Time:          33.33   ms
  5 Reference Pose:       RECORDED
  6 Measure Camera Position   (Not Done)
    Camera Position   [1]:
    X:     0.0  Y:      0.0  Z:      0.0
    W:     0.0  P:      0.0  R:      0.0
    Calibration Grid Position:
    X:     0.0  Y:      0.0  Z:      0.0

  7 Swing Angle W:          20.0   deg
  8            P:          20.0   deg
  9            R:          30.0   deg
 10 Create Program          (Not Done)
    Evaluation Index of Program: 99.9



     [ TYPE ]                        MOVE_TO        RECORD
```

Tips
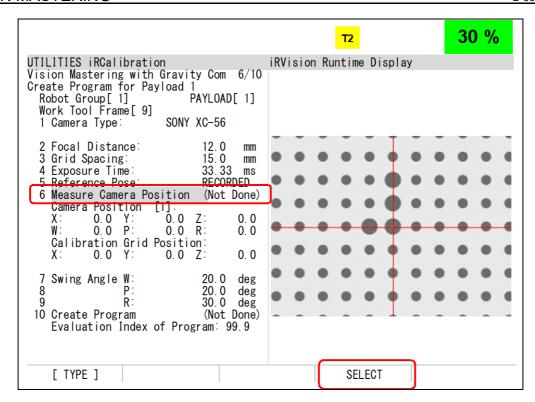
If the "Reference Pose" is "RECORDED", you can move the robot to the recorded position by holding down the SHIFT key and press F4 (MOVE_TO) when the cursor is at the "Reference Pose".

7   Set the override of the robot to 30% or less when T2 or AUTO mode is selected, and then measure the camera position. If T1 mode is selected, the override can be improved more than 30%.
The camera position is measured while the robot automatically moves into multiple poses, with the reference pose as a measurement start pose, in which the pose is changed by several centimeters in the directions orthogonal to X, Y, and Z and by about 15 degrees in the pose directions of W, P, and R. The camera position and calibration grid position are calculated based on the results of the vision measurement.
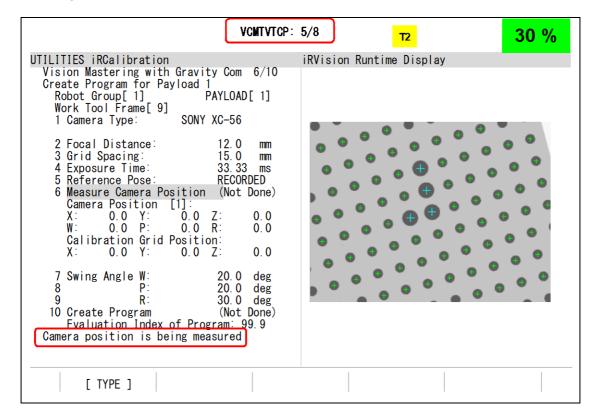
⚠ **CAUTION**

Measuring a camera position influences all the payload conditions using the same camera position number.   If you re-measure an already measured camera position, you have to generate and execute the measurement program again for all the payloads which use that camera position number.

Move the cursor to "Measure Camera Position", then press SHIFT key and the F4(SELECT) together.
The camera position will be measured. During measurement, the teach pendant displays the following screen.

> **NOTE**
> 1 If the camera attachment position or the calibration grid position is changed, measure the camera position again.
> 2 Keep pressing the SHIFT key during the measurement. For 7DC3/09 (V8.30P/09) or earlier software, if pressing the SHIFT key is interrupted, resuming the measurement makes it restart from the beginning. For 7DC3/10 (V8.30P/10) or later software, when you resume the measurement after the interruption, if a part of the measurement has been completed, a confirmation message to select "REMSUME" or "RESTART" is displayed. Then, if "RESUME" is selected, the measurement is resumed. If "RESTART" is selected, the measurement is restarted from the beginning. If the camera attachment position or the calibration grid position is changed, select "RESTART".
> 3 An attempt to perform camera position measurement during execution of another program causes an error with the following error message displayed: "INTP-313 (Z_VCLIB2,384) Motion statement failed, PROG-040 Already locked by other task "
> In this case, select " ABORT (ALL)" on the FCTN menu to terminate the program being executed.
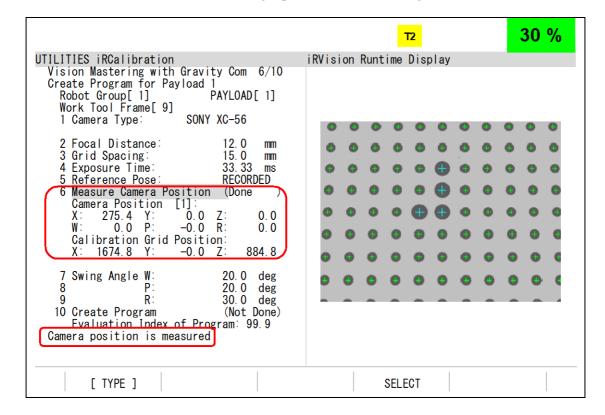
When the measurement is finished, the display on the teach pendant screen becomes as follows:
- The status of "Measure Camera Position" becomes "Done".
- The message "Camera position is measured" appears.
- The result of the measurement is displayed.
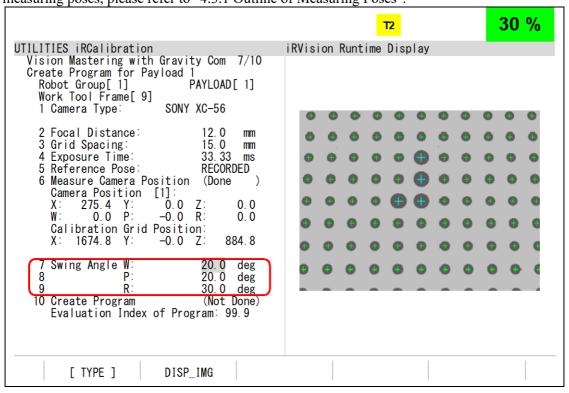
  Measurement result:
  - Camera Position: Position of visual TCP
  - Calibration Grid Position: Origin position of calibration grid

8   Set the swing angles W, P, and R of measuring poses for Vision Mastering. For details on measuring poses, please refer to "4.3.1 Outline of Measuring Poses".


```
                                                        T2        30 %

UTILITIES iRCalibration                iRVision Runtime Display
   Vision Mastering with Gravity Com  7/10
   Create Program for Payload 1
   Robot Group[ 1]          PAYLOAD[ 1]
   Work Tool Frame[ 9]
 1 Camera Type:          SONY XC-56

 2 Focal Distance:          12.0   mm
 3 Grid Spacing:           15.0   mm
 4 Exposure Time:          33.33  ms
 5 Reference Pose:        RECORDED
 6 Measure Camera Position  (Done    )
   Camera Position  [1]:
   X:  275.4  Y:    0.0  Z:    0.0
   W:    0.0  P:   -0.0  R:    0.0
   Calibration Grid Position:
   X: 1674.8  Y:   -0.0  Z:  884.8

 7 Swing Angle W:          20.0   deg
 8           P:           20.0   deg
 9           R:           30.0   deg
10 Create Program          (Not Done)
   Evaluation Index of Program: 99.9



        [ TYPE ]    DISP_IMG
```

For Vision Mastering with only the mastering parameters adjusted
The recommended range for "Swing Angle W/P" is 20 to 45 degrees.
The recommended range for "Swing Angle R" is 30 to 45 degrees.

For Vision Mastering including the adjustment of Gravity Compensation parameters
The recommended range for "Swing Angle W/P" is 35 to 45 degrees.
The recommended range for "Swing Angle R" is 45 degrees.

Tips
   Increasing the swing angle improves the accuracy of adjustment of mastering parameters but requires a wider operating range.

NOTE
   If swing angle W or P exceeds 45 degrees, it may be impossible to perform vision measurement.   Do not allow swing angle W or P to exceed 45 degrees.

---

9   Generate a measurement program.
     Move the cursor to "Create Program", then press the F4 (SELECT) or ENTER key.

```
                                              T2            30 %
UTILITIES iRCalibration          iRVision Runtime Display
 Vision Mastering with Gravity Com 10/10
 Create Program for Payload 1
  Robot Group[ 1]          PAYLOAD[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:         SONY XC-56

  2 Focal Distance:         12.0   mm
  3 Grid Spacing:           15.0   mm
  4 Exposure Time:          33.33  ms
  5 Reference Pose:         RECORDED
  6 Measure Camera Position  (Done   )
    Camera Position  [1]:
    X:   275.4  Y:    0.0  Z:    0.0
    W:    0.0   P:   -0.0  R:    0.0
    Calibration Grid Position:
    X:  1674.8  Y:   -0.0  Z:   884.8

  7 Swing Angle W:          20.0   deg
  8            P:           20.0   deg
  9            R:           30.0   deg
 10 Create Program          (Not Done)
    Evaluation Index of Program: 99.9


        [ TYPE ]                          SELECT
```

Upon completion of generation of the measurement program, the screen on the teach pendant changes as shown below.

- The "Create Program" status becomes "Done".
- The message "Program is created" is displayed.

```
                                              T2            30 %
UTILITIES iRCalibration          iRVision Runtime Display
 Vision Mastering with Gravity Com 10/10
 Create Program for Payload 1
  Robot Group[ 1]          PAYLOAD[ 1]
  Work Tool Frame[ 9]
  1 Camera Type:         SONY XC-56

  2 Focal Distance:         12.0   mm
  3 Grid Spacing:           15.0   mm
  4 Exposure Time:          33.33  ms
  5 Reference Pose:         RECORDED
  6 Measure Camera Position  (Done   )
    Camera Position  [1]:
    X:   275.4  Y:    0.0  Z:    0.0
    W:    0.0   P:   -0.0  R:    0.0
    Calibration Grid Position:
    X:  1674.8  Y:   -0.0  Z:   884.8

  7 Swing Angle W:          20.0   deg
  8            P:           20.0   deg
  9            R:           30.0   deg
 10 Create Program          (Done   )
    Evaluation Index of Program: 4.9
 Program is created


        [ TYPE ]                          SELECT
```
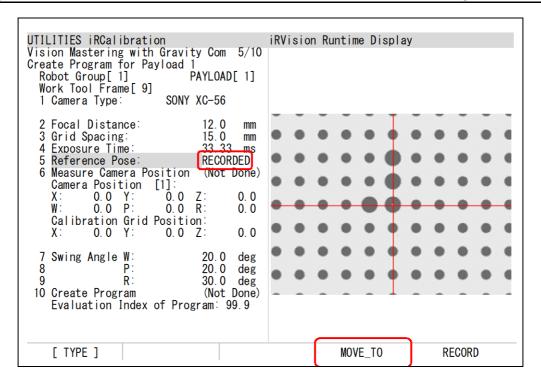
When robot group is 1, TP program VMAST11 and VMDATA11 are generated.   The first number following VMAST and VMDATA indicates a robot group; the second one indicates a payload number.

10   Check the evaluation index and, if it is greater than 4.2, start at Step 8 over again and increase the values of Swing Angle.   If the Evaluation Index still is not improved, teach the reference pose to set the camera away from the target, and start at Step 6 again.

> Tips
>   Smaller value of Evaluation Index of Program means higher accuracy of Vision Mastering result may be achieved by using this program.

If a measurement program is generated with one already existing, the teach pendant displays the following message.

If F4 (YES) is selected, a new measurement program is generated.
If F5 (NO) is selected, a new measurement program is not generated, but the Evaluation Index of an existing program is recalculated.

11   When generating is finished, select the PREV key to return to Vision Mastering screen.

4.6.6   Executing the Measurement Program

Procedure 4-8   Executing the measurement program

Condition
- Make sure that the "Create Program" status is "Done".

Step

1   Move the cursor to "RUN", then press the F4 (SELECT) or the ENTER key.

```
                                                    T2          30 %
UTILITIES iRCalibration            iRVision Runtime Display
  Vision Mastering with Gravity Com  7/19
    1 Robot Group:           1
    2 Work Tool Frame Number:  9
  Payload 1
    3 Select Payload 1:       TRUE
    4 PAYLOAD number:         1
    5 Camera Position(1-3):   1
    6 Create Program          (Done     )
    7 Run:    VMAST11         (Not Done)
  Payload 2
    8 Select Payload 2:       FALSE
    9 PAYLOAD number:         0
   10 Camera Position(1-3):   0
   11 Create Program          (-------)
   12 Run:    VMAST12         (-------)
  Payload 3
   13 Select Payload 3:       FALSE
   14 PAYLOAD number:         0
   15 Camera Position(1-3):   0
   16 Create Program          (-------)
   17 Run:    VMAST13         (-------)



        [ TYPE ]                       SELECT
```

The Edit Screen of Measurement Program is displayed.

```
                                                    T2          30 %
VMAST11                            iRVision Runtime Display
                        1/114
     1:    UTOOL_NUM=9
     2:    UFRAME_NUM=0
     3:    PAYLOAD[1]
     4:
     5:J @P[28] 30% FINE
     6:
     7:L  P[1] 500mm/sec FINE
     8:    CALL VCMT_VT(1,1)
     9:L @P[28] 500mm/sec CNT0
    10:
    11:L  P[2] 500mm/sec FINE
    12:    CALL VCMT_VT(2,1)
    13:L @P[28] 500mm/sec CNT0
    14:
    15:L  P[3] 500mm/sec FINE
    16:    CALL VCMT_VT(3,1)
    17:L @P[28] 500mm/sec CNT0
    18:
    19:L  P[4] 500mm/sec FINE
    20:    CALL VCMT_VT(4,1)
    21:L @P[28] 500mm/sec CNT0


        POINT                          TOUCHUP    >
```

2   Set the override of the robot to 30% or less when T2 or AUTO mode is selected, then run the program displayed. If T1 mode is selected, the override can be improved more than 30%.

Tips
> If the robot cannot move to any of positions [1] to [27] during execution of the measurement program, make sure that the calibration grid resides within the field of view of the camera, then re-teach a position to which the robot can move.

NOTE
> For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the TP program so that efficient resuming of the measurement can be done. For details, refer to "4.7.1 TP Program".
>
> For 7DC3/10 (V8.30P/10) or later software, when the measurement is interrupted by the release of the SHIFT key, the occurrence of an alarm or other reasons, re-execute the TP program after moving the cursor to the first line. If a part of the measurement has been completed, a message "Press 0 (restart) or 9 (resume)" appears. Press the 0 key to restart the measurement from the beginning or the 9 key to resume the measurement.

NOTE
> If the camera attachment position or the calibration grid position is changed, measure the camera position and generate the measurement program in "4.6.5 Generating a Measurement Program" again.

3   When the measurement has been completed, refer to Subsection 4.6.3, "Displaying the Vision Mastering Screen" to display the Vision Mastering screen.

4.6.7   Updating Mastering Data
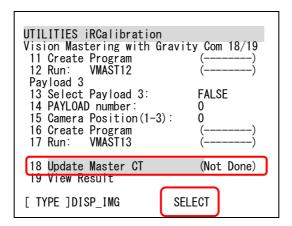
Procedure 4-9   Updating mastering data

Condition
- Make sure that the "Run" status of the measurement program for the selected payload is "Done".

Step
1   Move the cursor to "Updating mastering data", then press the F4 (SELECT) or the ENTER key.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com 18/19
 11 Create Program          (————————)
 12 Run:    VMAST12          (————————)
 Payload 3
 13 Select Payload 3:        FALSE
 14 PAYLOAD number:          0
 15 Camera Position(1-3):    0
 16 Create Program           (————————)
 17 Run:    VMAST13          (————————)

 18 Update Master CT         (Not Done)
 19 View Result

[ TYPE ]DISP_IMG        SELECT
```

The teach pendant will display the prompt "OK to Update Gravity Comp. parameters?".

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com 18/19
 11 Create Program              (--------)
 12 Run:    VMAST12             (--------)
Payload 3
 13 Select Payload 3:          FALSE
 14 PAYLOAD number:            0
 15 Camera Position(1-3):      0
 16 Create Program              (--------)
 17 Run:    VMAST13             (--------)

 18 Update Master CT           (Not Done)
 19 View Result
OK to Update Gravity Comp. parameters?
[ TYPE ]                    YES      NO
```

To adjust Gravity Compensation parameters, press the F4 (YES).

To adjust only mastering parameters without adjusting Gravity Compensation parameters, press the F5 (NO).

> ⚠ **CAUTION**
> When Vision Mastering is performed with only mastering parameters adjusted, only one type of payload can be selected. In that case, do not set the status of more than one payload to "TRUE".

To adjust Gravity Compensation parameters as well

If you press the F4 (YES) at the prompt asking whether to update Gravity Compensation parameters, the teach pendant displays the mastering data update screen as shown below.

```
UTILITIES iRCalibration
Vision Mastering: Update Master CT
 Robot Group[ 1]
 Update GC Paramters:       TRUE
 Compensation Angles:
  J1:    0.000   J2:   -0.065
  J3:    0.148   J4:   -0.023
  J5:   -0.022   J6:    0.000

 Evaluation Index of Program: 5.2
 Mean Error of Calibration:   .1
 Max Error of Calibration:    .2


[ TYPE ]        UPDATE
```

To adjust only mastering parameters

If you press the F5 (NO) at the prompt asking whether to update Gravity Compensation parameters, the teach pendant displays the mastering data update screen as shown below.

```
UTILITIES iRCalibration
Vision Mastering: Update Master CT
 Robot Group[ 1]
 Update GC Paramters:      FALSE
 Compensation Angles:
  J1:    0.000   J2:   -0.035
  J3:    0.158   J4:   -0.013
  J5:   -0.020   J6:    0.000

 Evaluation Index of Program: 3.3
 Mean Error of Calibration:   .1
 Max Error of Calibration:    .3


[ TYPE ]            UPDATE
```

NOTE
    Mastering parameters are not updated at this point.
---

2   Confirm the items displayed. If there is no problem, press the F3 (UPDATE) while holding down
     the SHIFT key to update mastering data.

Display items on Updating Mastering Data screen

Compensation Angles
     A compensation angles for the angular displacement shifted from the zero position for each rotation
     axis [degree].

Evaluation Index of Program
     Evaluation Index of actual measurement poses

Mean Error of Calibration
     The mean value (calculated value) [mm] of visual TCP positions in 27 measurement poses after
     calibration.

Max Error of Calibration
     The maximum value (calculated value) [mm] of visual TCP positions in 27 measurement poses after
     calibration.

Confirmation

- Confirm that maximum of Compensation Angles is 1° or less.
  If maximum of Compensation Angles is exceeding 1°, update mastering data and run the
  measurement program again, then confirm that the value of Compensation Angles displayed on
  Updating Mastering Data screen becomes smaller.
- If you do not adjust Gravity Compensation parameters, check whether the evaluation index is 4.2 or
  less.
  If Evaluation Index is exceeding 4.2, there is a possibility that the calculation error of mastering
  parameters is large. Re-generate the measurement program with the maximum swing angle increased
  on the "Create Program" screen, then re-execute the program.
- If you adjust Gravity Compensation parameters, check whether the evaluation index is 5.5 or less.
  If the evaluation index exceeds 5.5, mastering parameters may have a substantial calibration error.
  After increasing the maximum swing value and generating a measurement program again, run the
  program on "Create Program" screen.
- Confirm the Max Error of Calibration.
  The approximate maximum error of mastering is as follows:
  - When the transportable mass of the robot is 200 kg or less, "Max Error of Calibration" is 1.5
    mm or less.

If the maximum error of mastering is considerably larger than the above value, possible causes are that the lens or camera is not secured, the lens is out of focus, and that the target is not secured. Check these causes again.

NOTE

1   If the Gravity Compensation parameters are adjusted as well and only one type of payload is applied, it's necessary to execute measurement and update of Vision Mastering twice.

2   Please confirm that maximum of Compensation Angles of second calibration is around 0.020. However, the value 0.020 is affected by robot type and payload, so if the value is bigger than 0.020, please execute measurement again and check if the value is static.

Tips

With heavy payload, the "Max Error of Calibration" can be larger than the approximate value. For this case, please update mastering data, run the measurement program, and check "Compensation Angles" and "Max Error of Calibration" on Updating Mastering Data screen again. If "Max Error of Calibration" does not change, but "Compensation Angles" is smaller, the robot is mastered...

---

3   When Vision Mastering is performed with Gravity Compensation parameters adjusted, pressing the F3 (UPDATE) while holding down the SHIFT key in the above procedure displays the following screen on the teach pendant. Follow the on-screen instruction to turn the controller back on.

```
UTILITIES iRCalibration
Vision Mastering: Update Master CT

              CAUTION

  To make the updated data effective,
  please cycle power.
```

4   After updating the mastering data, set the reference position for Quick Mastering again, preparing for future Quick Mastering. If it has not been set, set it as all the axes' angles are 0 degree. For details of Quick Mastering, please refer to "OPERATOR'S MANUAL(Basic Operation)B-83284EN" and "Mechanical Unit Operator's Manual".

NOTE
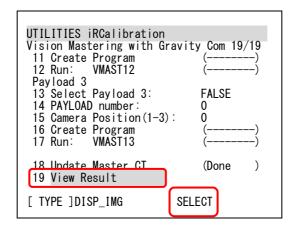
In the following software versions, a notification "Ref. Pos. for Quick Mastering Not Set" will be displayed on the notifications screen when you execute Vision Mastering. This notification will be cleared when you set a quick mastering reference point.
    - 7DF1/34(V9.10P/34) or later
    - 7DF3/17(V9.30P/17) or later
    - 7DF5/14(V9.40P/14) or later

4.6.8   Viewing and Saving Mastering Results
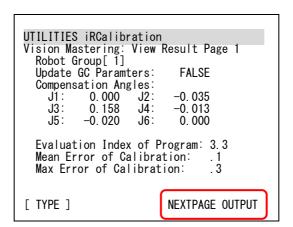
Procedure 4-10   Viewing and saving mastering results

Step

1   Move the cursor to "View Result", then press the F4 (SELECT) or the ENTER key.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com 19/19
 11 Create Program              (--------)
 12 Run:    VMAST12             (--------)
 Payload 3
 13 Select Payload 3:           FALSE
 14 PAYLOAD number:             0
 15 Camera Position(1-3):       0
 16 Create Program              (--------)
 17 Run:    VMAST13             (--------)

 18 Update Master CT            (Done   )
 19 View Result

[ TYPE ]DISP_IMG            SELECT
```

The teach pendant displays the mastering result display screen as shown below.

```
UTILITIES iRCalibration
Vision Mastering: View Result Page 1
  Robot Group[ 1]
  Update GC Paramters:    FALSE
  Compensation Angles:
   J1:    0.000   J2:    -0.035
   J3:    0.158   J4:    -0.013
   J5:   -0.020   J6:     0.000

  Evaluation Index of Program: 3.3
  Mean Error of Calibration:    .1
  Max Error of Calibration:     .3

[ TYPE ]                 NEXTPAGE OUTPUT
```

Function key
F4 (NEXTPAGE): Go to the next page.
F5 (OUTPUT):   Pressing this with a memory card plugged in the controller writes
                VCMT_LOG.TXT, a log file saving the Vision Mastering results, to the
                memory card. For details of selecting the file I/O devices in the file menu, please
                refer to "OPERATOR'S MANUAL (Basic Operation) B-83284EN".

Tips
  If VCMT_LOG.TXT already exists, the new results are appended to the current
  contents.

4.6.9   Viewing Update Log

"View Update Log" is supported from R-30*i*B Plus controller. On R-30*i*B / R-30*i*B Mate controller, "View Update Log" is not displayed on the Vision Mastering screen,

Procedure 4-14   Viewing update log
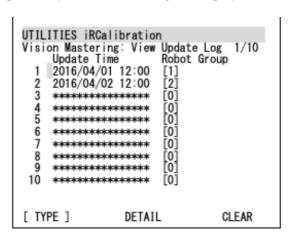
Step

1   Move the cursor to "View Update Log", then press the F4 (SELECT) or the ENTER key.

```
UTILITIES iRCalibration
Vision Mastering with Gravity Com 20/20
 12 Run:    VMAST12              (————————)
Payload 3
 13 Select Payload 3:           FALSE
 14 PAYLOAD number:             0
 15 Camera Position(1-3):       0
 16 Create Program             (————————)
 17 Run:    VMAST13             (————————)

 18 Update Master CT           (Done    )
 19 View Result
 20 View Update Log

[ TYPE ]DISP_IMG               SELECT
```

The teach pendant displays the update log display screen as shown below. The logs recorded when the mastering data was updated by Vision Mastering are displayed on the screen.

```
UTILITIES iRCalibration
Vision Mastering: View Update Log  1/10
      Update Time        Robot Group
  1  2016/04/01 12:00    [1]
  2  2016/04/02 12:00    [2]
  3  ****************    [0]
  4  ****************    [0]
  5  ****************    [0]
  6  ****************    [0]
  7  ****************    [0]
  8  ****************    [0]
  9  ****************    [0]
 10  ****************    [0]


[ TYPE ]          DETAIL          CLEAR
```

Function key
F3 (DETAIL):   The detail screen of the selected log is displayed if the log is recorded.
F5 (CLEAR):   The selected log is cleared if recorded.

The procedure is detailed below.

Procedure 4-15   Viewing the detail screen of an update log

Step

1   Move the cursor to the log whose detail you want to display, then press the F3 (DETAIL) or the ENTER key on the update log display screen.

```
UTILITIES iRCalibration
Vision Mastering: View Update Log  1/10
          Update Time        Robot Group
   1  2016/04/01 12:00   [1]
   2  2016/04/02 12:00   [2]
   3  ***************   [0]
   4  ***************   [0]
   5  ***************   [0]
   6  ***************   [0]
   7  ***************   [0]
   8  ***************   [0]
   9  ***************   [0]
  10  ***************   [0]


[ TYPE ]          DETAIL          CLEAR
```

The teach pendant displays the detail screen of the log as shown below.

```
UTILITIES iRCalibration
Vision Mastering: View Log Detail Page 1
    Log  1  2016/04/01 12:00   Group[1]
  Compensation Angles:
    J1:     0.000   J2:    -0.025
    J3:     0.048   J4:    -0.003
    J5:    -0.020   J6:     0.000

  Evaluation Index of Program: 3.3
  Mean Error of Calibration:   .1
  Max Error of Calibration:    .3
[ TYPE ]              NEXTPAGE
```

2   Press the F4 (NEXTPAGE) key to display the next page.

```
UTILITIES iRCalibration
Vision Mastering: View Log Detail Page 2
  Master Counts:
            New          Original
    [1]: [    123456] [    123456]
    [2]: [    123678] [    144876]
    [3]: [    123789] [    145987]
    [4]: [   1238889] [   1249880]
    [5]: [    123889] [    155883]
    [6]: [  12345678] [  12345778]
    [7]: [         0] [         0]
    [8]: [         0] [         0]
    [9]: [         0] [         0]
[ TYPE ]              NEXTPAGE
```

Procedure 4-16   Clearing an update log
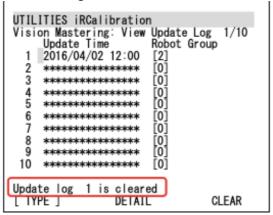
Step

1   Move the cursor to the log you want to clear, then press the F5 (CLEAR) key on the update log display screen.

```
UTILITIES iRCalibration
Vision Mastering: View Update Log  1/10
          Update Time      Robot Group
     1  2016/04/01 12:00    [1]
     2  2016/04/02 12:00    [2]
     3  ****************     [0]
     4  ****************     [0]
     5  ****************     [0]
     6  ****************     [0]
     7  ****************     [0]
     8  ****************     [0]
     9  ****************     [0]
    10  ****************     [0]


[ TYPE ]          DETAIL         CLEAR
```

A confirmation message is displayed.

```
UTILITIES iRCalibration
Vision Mastering: View Update Log  1/10
          Update Time      Robot Group
     1  2016/04/01 12:00    [1]
     2  2016/04/02 12:00    [2]
     3  ****************     [0]
     4  ****************     [0]
     5  ****************     [0]
     6  ****************     [0]
     7  ****************     [0]
     8  ****************     [0]
     9  ****************     [0]
    10  ****************     [0]

Clear update log  1?
[ TYPE ]                  YES      NO
```

2   Press the F4 (YES) key to clear the log.

```
UTILITIES iRCalibration
Vision Mastering: View Update Log  1/10
          Update Time      Robot Group
     1  2016/04/02 12:00    [2]
     2  ****************     [0]
     3  ****************     [0]
     4  ****************     [0]
     5  ****************     [0]
     6  ****************     [0]
     7  ****************     [0]
     8  ****************     [0]
     9  ****************     [0]
    10  ****************     [0]

Update log  1 is cleared
[ TYPE ]          DETAIL         CLEAR
```

> **NOTE**
> If a program had been taught before Vision Mastering was executed and the taught positions of the program are to be modified by Mastering Shift, do not clear the log of Vision Mastering that was first executed after the program had been taught. For details of Mastering Shift, please refer to "4.8 PROGRAM SHIFT (MASTERING SHIFT FUNCTION)".

4.7 DETAILS OF TP PROGRAMS AND LOG FILE

4.7.1 TP Program

TP Program for Measurement

VMAST*nx*(*n*: robot group, *x*: payload number)

```
                    0    LINE
                        G1     JOINT  10 %
    1:  UTOOL_NUM=9 ;
    2:  UFRAME_NUM=0 ;
    3:  PAYLOAD[1] ;
    4:  ;
    5:J P[28] 30% FINE     ;
    6:  ;
    7:L P[1] 500mm/sec FINE       ;
    8:  CALL VCMT_VT(1,1) ;
    9:L P[28] 500mm/sec CNT0      ;
   10:  ;
   11:L P[2] 500mm/sec FINE       ;
   12:  CALL VCMT_VT(2,1) ;
   13:L P[28] 500mm/sec CNT0      ;
   14:  ;
          ...
  107:L P[26] 500mm/sec FINE      ;
  108:  CALL VCMT_VT(26,1) ;
  109:L P[28] 500mm/sec CNT0      ;
  :
  111:L P[27] 500mm/sec FINE      ;
  112:  CALL VCMT_VT(27,1) ;
  113:L P[28] 500mm/sec CNT0      ;
  [END]
```

In position 1 to 27, the initial positions for measurements are recorded.
In position 28, the reference positions are recorded. (In the measurement it is used as start position for each measuring position)
VCMT_VT :   Karel program for positioning by vision
     VCMT_VT(position number, PAYLOAD number)

> **Tips**
>   If Gravity Compensation function is available and PAYLOAD number is set as 0,
>   there is not a command of PAYLOAD[ ](line 3).

For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the TP program as below so that efficient resuming of the measurement can done.

```
                        0    LINE
                            G1     JOINT  10 %
  1:   CALL VCRSM_CHECK('START') ;
  2:   UTOOL_NUM=9 ;
  3:   UFRAME_NUM=0 ;
  4:   PAYLOAD[1] ;
  5:      ;
  6:   IF $VCRSM_CFG.$STEP_NUM>=2,
       JMP LBL[2] ;
  7:   CALL VCRSM_CHECK(1) ;
  8:J P[28] 30% FINE       ;
  9:L P[1] 500mm/sec FINE     ;
 10:   CALL VCMT_VT(1,1) ;
 11:      ;
 12:   LBL[2] ;
 13:   IF $VCRSM_CFG.$STEP_NUM>=3,
       JMP LBL[3] ;
 14:   CALL VCRSM_CHECK(2) ;
 15:L P[28] 500mm/sec CNT0     ;
 16:L P[2] 500mm/sec FINE     ;
 17:   CALL VCMT_VT(2,1) ;
       ...
180:   LBL[26] ;
181:   IF $VCRSM_CFG.$STEP_NUM>=27,
       JMP LBL[27] ;
182:   CALL VCRSM_CHECK(26) ;
183:L P[28] 500mm/sec CNT0     ;
184:L P[26] 500mm/sec FINE     ;
185:   CALL VCMT_VT(26,1) ;
186:      ;
187:   LBL[27] ;
188:   CALL VCRSM_CHECK(27) ;
189:L P[28] 500mm/sec CNT0     ;
190:L P[27] 500mm/sec FINE     ;
191:   CALL VCMT_VT(27,1) ;
192:      ;
193:   CALL VCRSM_CHECK('END') ;
194:L P[28] 500mm/sec CNT0     ;
[END]
```

VCRSM_CHECK :   Karel program related to the resuming of the measurement.
                     The argument is to be 'START', 'END' or measurement number.

TP Program for Recording the Measuring Results
VMDATA*nx* (*n* : robot group, *x* : PAYLOAD number)

```
                        0    LINE
                            G1     JOINT  10 %
  1:   UTOOL_NUM=9 ;
  2:   UFRAME_NUM=0 ;
  3:   PAYLOAD[1] ;
  4:      ;
  5:L P[1] 500mm/sec FINE     ;
  6:L P[2] 500mm/sec FINE     ;
       ...
 30: L P[26] 500mm/sec FINE     ;
 31: L P[27] 500mm/sec FINE     ;
[END]
```

In position 1 to 27, the positioning results are recorded

> Tips
>   If Gravity Compensation function is available and PAYLOAD number is set as 0,
>   there is not a command of PAYLOAD[ ](line 3).

4.7.2   Log File

Log File of the Vision Mastering Result

VCMT_LOG.TXT

```
iRCalibration Vision Mastering Log File

Robot Group [1]
Robot Model :  R2000iB/165F
Robot Number: F00000
Soft Version: V8.20P/12
Master Time:     29-MAY-14 11:46
Log Time:        29-MAY-14 11:49

Gravity Compensation: ON
Update GC Parameter:   TRUE

Number of PAYLOAD:  1
PAYLOAD[ 1]
  Payload:          8.000kg
  Payload Center:
    X:        5.772mm
    Y:        0.000mm
    Z:       10.456mm

Camera Position:1
  X:   105.376  Y:   213.557  Z:   1030.357
  W:      .132  P:     3.223  R:    180.342

Focal Distance:     12.0mm
Grid Spacing:       15.0mm

Target Position:
  X:  1674.800  Y:     -.000  Z:    884.800

New Master Counts:
[1]:       123456
[2]:       123678
[3]:       123789
[4]:      1238889
[5]:       123889
[6]:     12345678
[7]:            0
[8]:            0
[9]:            0

Compensation Angles:
[1]:    0.000 [2]:    0.200  [3]:    0.300
[4]:    0.400 [5]:    0.500  [6]:    0.000

Evaluation Index:     3.0
Mean Residual Error:   .170
Max Residual Error:    .370

Origin Master Counts:
[1]:       123456
[2]:       144876
[3]:       145987
[4]:      1249880
[5]:       155883
[6]:     12345778
[7]:            0
[8]:            0
[9]:            0
```

4.8   PROGRAM SHIFT (MASTERING SHIFT FUNCTION)

This section describes the operation of the Mastering Shift function to shift the taught positions of a robot program after the mastering data has been updated by Vision Mastering. This function adjusts the taught positions so that a robot moves to the same positions and postures as before the update of the mastering data. The Mastering Shift function is available on R-30*i*B Plus controller, but is not available on R-30*i*B / R-30*i*B Mate controller.

Mastering Shift

When a program is executed after Vision Mastering has been executed, the positions or postures where a robot moves may change from the taught positions or postures because the mastering data has been updated by Vision Mastering. Mastering Shift is a function that modifies the user specified taught positions in a program after Vision Mastering has been executed. The taught positions of the program are modified so that the robot moves to the same position and posture as before the execution of Vision mastering. After executing Vision Mastering the user selects the positions in a selected program to be shifted. The taught points are automatically shifted based on the results selected in the update log of Vision Mastering.

The Mastering Shift functions allows positions changed by Vision Mastering to be quickly updated; typically without manual touchup.

With the Mastering Shift function:
- The user can select a range of positions to be shifted in the program editor on the teach pendant.
- The user can see the details of each error in the shift operation.
- The shift operation can be canceled after it is performed, undoing position shifts.

NOTE
Do not perform the Mastering Shift function in the following cases because the positions modified by Mastering Shift may have a substantial error in these cases.
- The Gravity Compensation status is different between now and when the positions were taught.
- The Gravity Compensation parameters have been adjusted by Vision Mastering.
- The values of the tool frame or the user frame change programmatically in the program.
- The mastering data of some axes is lost for some reason such as the drops of the voltage of the backup battery for the Pulsecoder or exchanging of the Pulsecoder after the positions have been taught.

NOTE
After performing the Mastering Shift function, execute the program with a low speed override and check the position of each taught point. Make fine position adjustments if necessary.
Check carefully If the gravity compensation function is enabled, because the positions modified by Mastering Shift may have a slight error caused by the change of gravity compensation value.

> **NOTE**
>   Tool frames and user frames are not offset by Mastering Shift. It may be necessary to reteach the frames after executing Vision Mastering. For example, if the tool frame has been taught using the Three Point Method, when the robot moves to the reference point after the mastering data has been updated, the position where the robot moves may be different from the taught reference point. Therefore, it is recommended to manually reteach the frames after the mastering data has been updated.
>   By using coordinate system change shift functions when setting the tool frame or the user frame again, the tool coordinate system or user coordinate system number in the position data of the taught position can be changed without changing the position where a robot moves. For details of coordinate system change shift functions, please refer to "9.3 COORDINATE SYSTEM CHANGE SHIFT FUNCTIONS" of "OPERATOR'S MANUAL (Basic Operation)B-83284EN".

4.8.1   Specifying a Program for Shift Operation

The Mastering Shift function shifts the currently selected program.
Select a program to be shifted on the program list screen of the teach pendant beforehand.

> **NOTE**
>   Be sure to select a program to be shifted, from the program list.
>   When a subprogram is being called, the subprogram cannot be shifted with the Mastering Shift function.
>   To shift a subprogram, select the subprogram from the program list beforehand.

4.8.2   Mastering Shift Operation
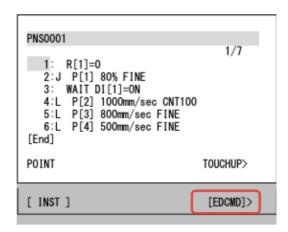
Mastering Shift operation

Procedure 4-17   Performing a Mastering Shift operation

Step

1   With the selected program open in the editor, press the F5 [EDCMD] key on the second page of the edit screen.
Select "Master sft" from the menu.
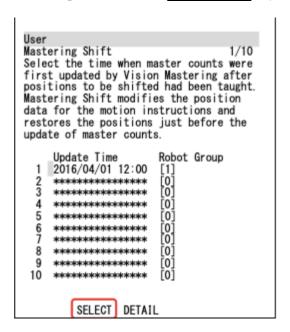
2   The Mastering Shift screen as shown below is displayed. The logs recorded when the mastering data is updated by Vision Mastering are displayed on the screen.

```
User
Mastering Shift                    1/10
Select the time when master counts were
first updated by Vision Mastering after
positions to be shifted had been taught.
Mastering Shift modifies the position
data for the motion instructions and
restores the positions just before the
update of master counts.

      Update Time        Robot Group
   1  2016/04/01 12:00   [1]
   2  ****************   [0]
   3  ****************   [0]
   4  ****************   [0]
   5  ****************   [0]
   6  ****************   [0]
   7  ****************   [0]
   8  ****************   [0]
   9  ****************   [0]
  10  ****************   [0]


        SELECT   DETAIL
```

3   Move the cursor to the log of Vision Mastering that was first executed after positions to be shifted had been taught. Then, press the F2 (SELECT) key.
The Mastering Shift function shifts the taught positions by using the compensation angles of each axis calculated from the difference of the mastering data between now and just before the update time of the log where the cursor is placed when the F2 (SELECT) key is pressed.

```
User
Mastering Shift                    1/10
Select the time when master counts were
first updated by Vision Mastering after
positions to be shifted had been taught.
Mastering Shift modifies the position
data for the motion instructions and
restores the positions just before the
update of master counts.

      Update Time        Robot Group
   1  2016/04/01 12:00   [1]
   2  ****************   [0]
   3  ****************   [0]
   4  ****************   [0]
   5  ****************   [0]
   6  ****************   [0]
   7  ****************   [0]
   8  ****************   [0]
   9  ****************   [0]
  10  ****************   [0]


       [SELECT]  DETAIL
```

Tips
When the F3 (DETAIL) key is pressed on the Mastering Shift screen, the detail screen of the log at the cursor is displayed if the log is recorded. The compensation angles of each axis by Mastering Shift are displayed on the screen.

4   The compensation angles of each axis by Mastering Shift are displayed.
     If the compensation angles of all axes are 5° or less, a message "OK to execute Mastering Shift?" is
     displayed.
     If the compensation angle of some axes exceeds 5°, a message "Compensation angle exceeds 5
     degree" is displayed, and a message "OK to execute Mastering Shift?" is displayed after the F4
     (CONFIRM) key is pressed.
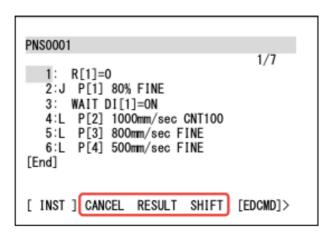
```
UTILITIES iRCalibration
Mastering
    Log  1  2016/04/01 12:00  Group[1]
Compensation Angles by Mastering Shift
    J1:    0.000   J2:   -0.025
    J3:    0.048   J4:   -0.003
    J5:   -0.020   J6:    0.000




OK to execute Mastering Shift?
                          YES      NO
```

Press the F5 (NO) key to return to the Mastering Shift screen.
Press the F4 (YES) key to return to the second page of the edit screen and to display the F2 through
F4 keys for the Mastering Shift operation.   By using the F2 through F4 keys, the Mastering Shift
operation can be performed.

```
PNS0001
                                      1/7
   1:   R[1]=0
   2:J   P[1] 80% FINE
   3:   WAIT DI[1]=ON
   4:L   P[2] 1000mm/sec CNT100
   5:L   P[3] 800mm/sec FINE
   6:L   P[4] 500mm/sec FINE
[End]


[ INST ] CANCEL  RESULT  SHIFT  [EDCMD]>
```

5   Press the F4 (SHIFT) key.

```
PNS0001
                                      1/7
   1:   R[1]=0
   2:J   P[1] 80% FINE
   3:   WAIT DI[1]=ON
   4:L   P[2] 1000mm/sec CNT100
   5:L   P[3] 800mm/sec FINE
   6:L   P[4] 500mm/sec FINE
[End]


[ INST ] CANCEL  RESULT  SHIFT  [EDCMD]>
```

The F2 through F4 keys change as shown below, and a message is displayed.

```
PNS0001
                                      1/7
   1:  R[1]=0
   2:J  P[1] 80% FINE
   3:  WAIT DI[1]=ON
   4:L  P[2] 1000mm/sec CNT100
   5:L  P[3] 800mm/sec FINE
   6:L  P[4] 500mm/sec FINE
[End]

Specify start/end line and do convert
[ INST ]STR      END        CONV  [EDCMD]>
```

6   Specify a shift start line. Move the cursor to a desired shift start line then press the ⎡F2 (STR)⎤ key.
     The specified shift start line is displayed after the "STR" text above of the F2 key.

```
PNS0001
                                      4/7
   1:  R[1]=0
   2:J  P[1] 80% FINE
   3:  WAIT DI[1]=ON
   4:L  P[2] 1000mm/sec CNT100
   5:L  P[3] 800mm/sec FINE
   6:L  P[4] 500mm/sec FINE
[End]

Specify start/end line and do convert
[ INST ]STR    4 END        CONV  [EDCMD]>
```

7   Next, specify a shift end line. Move the cursor to a desired shift end line then press the ⎡F3 (END)⎤ key.
     The specified shift end line is displayed after the "END" text above the F3 key.

```
PNS0001
                                      6/7
   1:  R[1]=0
   2:J  P[1] 80% FINE
   3:  WAIT DI[1]=ON
   4:L  P[2] 1000mm/sec CNT100
   5:L  P[3] 800mm/sec FINE
   6:L  P[4] 500mm/sec FINE
[End]

Specify start/end line and do convert
[ INST ]STR    4 END    6   CONV  [EDCMD]>
```
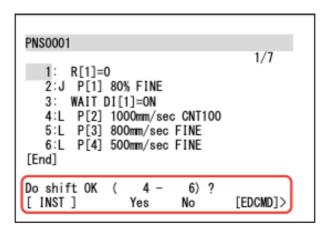
8   Press the F4 (CONV) key.

```
PNS0001
                               6/7
   1:  R[1]=0
   2:J  P[1] 80% FINE
   3:   WAIT DI[1]=ON
   4:L  P[2] 1000mm/sec CNT100
   5:L  P[3] 800mm/sec FINE
   6:L  P[4] 500mm/sec FINE
[End]

Specify start/end line and do convert
[ INST ]STR   4 END   6   CONV  [EDCMD]>
```
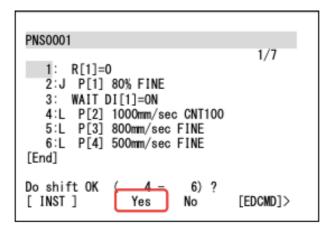
The F2 through F4 keys change as shown below, and a message is displayed.

```
PNS0001
                               1/7
   1:  R[1]=0
   2:J  P[1] 80% FINE
   3:   WAIT DI[1]=ON
   4:L  P[2] 1000mm/sec CNT100
   5:L  P[3] 800mm/sec FINE
   6:L  P[4] 500mm/sec FINE
[End]

Do shift OK  (   4 -   6) ?
[ INST ]        Yes    No     [EDCMD]>
```

9   Press the F3 (Yes) key.

```
PNS0001
                               1/7
   1:  R[1]=0
   2:J  P[1] 80% FINE
   3:   WAIT DI[1]=ON
   4:L  P[2] 1000mm/sec CNT100
   5:L  P[3] 800mm/sec FINE
   6:L  P[4] 500mm/sec FINE
[End]

Do shift OK  (   4 -   6) ?
[ INST ]        Yes    No     [EDCMD]>
```

The program is shifted. Upon completion of the shift, the F2 through F4 keys disappear, and a message indicating that the program shift operation is completed is displayed together with the number of errors that occurred during the conversion.

```
PNS0001
                                        1/7

  1:  R[1]=0
  2:J  P[1] 80% FINE
  3:  WAIT DI[1]=ON
  4:L  P[2] 1000mm/sec CNT100
  5:L  P[3] 800mm/sec FINE
  6:L  P[4] 500mm/sec FINE
[End]

Program shift was done(Err    1)
[ INST ]                          [EDCMD]>
```

If the Mastering Shift operation is performed once, the F2 through F4 keys for the Mastering Shift operation disappear. To perform the Mastering Shift operation again, press the F5 key ([EDCMD]) then select "Master sft".

To stop using the Mastering Shift function, press the [PREV] key. The F2 through F4 keys for the Mastering Shift operation disappear.

To check the details of errors that occurred during the conversion, see Section 4.8.3, "Checking the Result of Shift Operation".

4.8.3   Checking the Result of Shift Operation

Checking the detailed result of shift operation

After the points are shifted, a message indicating that the program shift operation is completed is displayed together with the number of errors that occurred during the conversion.
Details of errors that occurred during the conversion can be checked using the procedure below.

Procedure 4-18   Checking the detailed result of shift operation

Step

1   Press the F5[EDCMD] key on the second page of the edit screen.
2   Select "Master sft" from the menu.
3   Move the cursor to the recorded log and press the F2 (SELECT) key. Then, press the F4 (YES) key when a message "OK to execute Mastering Shift?" is displayed.
4   Press the F3 (RESULT) key.

```
PNS0001
                                        1/7

  1:  R[1]=0
  2:J  P[1] 80% FINE
  3:  WAIT DI[1]=ON
  4:L  P[2] 1000mm/sec CNT100
  5:L  P[3] 800mm/sec FINE
  6:L  P[4] 500mm/sec FINE
[End]


[ INST ] CANCEL  RESULT  SHIFT  [EDCMD]>
```
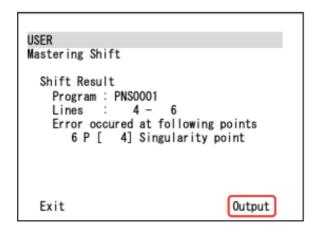
The conversion information and details of the errors that occurred during the conversion are displayed.
Whether the positions where errors occurred during the conversion are shifted or not depends on the representation of the position data. If the position data is represented by joint coordinates, the positions with errors are still shifted. If the position data is represented by Cartesian coordinates, the positions with errors remain unshifted.

If one page cannot display all the errors that occurred during the conversion, F4 displays "NextPage".
Press F4 to display details of the errors that cannot be displayed on the first page.

```
USER
Mastering Shift

  Shift Result
    Program : PNS0001
    Lines   :   4 -   6
    Error occured at following points
      6 P [   4] Singularity point




  Exit                          Output
```

Outputting the result of shift operation

Press the F5 (Output) key to output the result of shift operation as a text file to an external device. The file name is program-name.TXT. (In this example, the file name is PNS0001.TXT.)

4.8.4   Canceling a Shift Operation

The last shift operation can be canceled.
The program returns to the state immediately before the last shift operation.

Procedure 4-19   Canceling the last shift operation

Step
1   Press the F5[EDCMD] key on the second page of the edit screen.
     Select "Master sft" from the menu.
2   Move the cursor to the recorded log and press the F2 (SELECT) key. Then, press the F4 (YES) key when a message "OK to execute Mastering Shift?" is displayed.
3   Press the F2 (CANCEL) key.
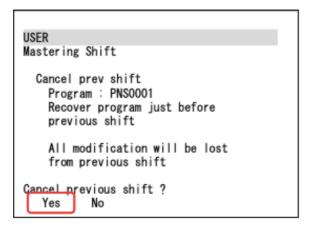
```
PNS0001
                                1/7

   1:   R[1]=0
   2:J  P[1] 80% FINE
   3:   WAIT DI[1]=ON
   4:L  P[2] 1000mm/sec CNT100
   5:L  P[3] 800mm/sec FINE
   6:L  P[4] 500mm/sec FINE
[End]


[ INST ] CANCEL  RESULT  SHIFT  [EDCMD]>
```
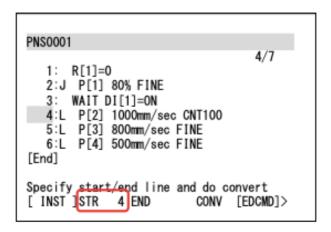
The shift cancellation confirmation screen is displayed.

4   Pressing the F1 (Yes) key returns the program to the state immediately before the last shift operation.

```
USER
Mastering Shift

  Cancel prev shift
    Program : PNS0001
    Recover program just before
    previous shift

    All modification will be lost
    from previous shift

Cancel previous shift ?
    Yes     No
```

⚠**CAUTION**
1.   If the last shift operation is canceled using this function, the program returns to the state immediately before the last shift operation. Note that all modifications made after the last shift operation are lost.
2.   Only the last shift operation performed can be canceled.

4.9 AVAILABLE TARGET

The available target is the calibration grid for Vision Mastering.

4.9.1 Calibration Grid

The available calibration grid for Vision Mastering should satisfy the specification shown as below.
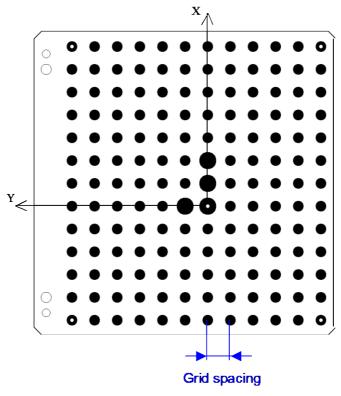
Fig. 4.9.1 Calibration Grid

All of the black circles are arranged so that they are uniformly spaced horizontally and perpendicularly. Four larger black circles placed in the vicinity of the center indicate the origin and directions of a coordinate system as shown. The ratio of the diameter of a large circle to that of a small circle is about 10:6.

The size of the calibration grid should be selected to fit the view field of the camera.
The aim of selection is set as below:
When the standoff (the distance between the lens of the camera and the target) is set as about 400mm, the longest distance among three larger black circles along the X-axis is equal to 1/3 to 1/4 of the length of the view filed of the camera.

The calibration grids for *i*RVision shown as below are available.

Table 4.9.1 Calibration Grid (for *i*RVision)

Type	Size (mm)	Grid Spacing (mm)
Camera Calibration Plate A	□100	7.5
Camera Calibration Plate B	□200	15
Camera Calibration Plate C	□400	30

5   GENKOTSU VISION MASTERING

5.1   GENKOTSU VISION MASTERING

What is Genkotsu Vision Mastering?

Genkotsu Vision Mastering enhances positional accuracy of the Genkotsu-Robot by using a camera to measure a target (that is attached to the tip of the robot tool). The measurements are used to calculate the kinematic parameters of the Genkotsu-Robot to compensate for motion control. This function is effective for enhancing the accuracy of the TCP setting and positional compensations by *i*Rvision.

Features and Limitations of Genkotsu Vision Mastering

- This function is only applicable to the M-1*i*A/0.5S (4-axis model) and M-1*i*A/0.5SL (4-axis model with long arm) and is not applicable to other M-1*i*A models (6- and 3-axis models), M-2*i*A, and M-3*i*A. This function is only applicable when the installation angle of the robot is 0º.
- The robot must have been mastered using a mastering fixture to apply this function.
- The robot moves in wide range during vision measurement. Please ensure that there is sufficient operating area available.

> **NOTE**
> 1 As to the M-1*i*A/0.5S and M-1*i*A/0.5SL shipped in 2015 and later, this function was applied before shipment, so you do not need to apply this function. However, if you have replaced a part and performed the mastering using a mastering fixture, reapplication of this function has an effect.
> 2 You can see whether or not this function has been applied through the value of system variable $GNKT_V_GRP[g].$GNKT_V_SW (where "g" is the group number of the robot). When this value is not zero, this function has been applied.

5.2   OVERVIEW OF GENKOTSU VISION MASTERING

5.2.1   System Configuration

The Genkotsu Vision Mastering system of the M-1iA/0.5S and M-1iA/0.5SL consists of a robot controller, an iPendant, a camera (SONY XC-56, BASLER acA640-20um, BASLER acA640-750umFNC, or KOWA SC36MF), a 12mm Fanuc lens, an extension ring 0.5mm thick, a camera cable, a target, and a positional pin.
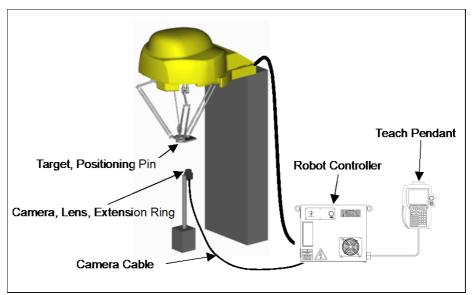
Fig. 5.2.1 System configuration of Genkotsu Vision Mastering (M-1iA/0.5S, M-1iA/0.5SL)

NOTE
1 The camera (SONY XC-56, BASLER acA640-20um, BASLER acA640-750umFNC, or KOWA SC36MF), the 12mm Fanuc lens, the target for Genkotsu Vision Mastering, and a positional pin are available from FANUC.
2 The customer should prepare a jig for holding the camera such as a tripod, a magnetic stand, or other device.

5.2.2 TP Program to Execute Vision Measurement

- The vision measurement is executed by running the TP program "VCGMM05S" (Fig. 5.2.2).
- The camera needs to be set to four positions to execute vision measurement. The four setting positions are called "camera position 1", "camera position 2", "camera position 3", and "camera position 4".
- The camera can be moved between the vision measurements of each position, therefore four cameras are not necessary to be prepared.
- For details, refer to subsection 5.3.5, "Execute Vision Measurement".

```
VCGMM05S
VCGMM05S                          JOINT 10%
                                      1/29
  1:   !Genkotsu Vision Mastering
  2:   !Program for M-1iA/0.5S
  3:
  4:   !Set Camera Type
  5:   !  1: SONY   XC-56
  6:   !  2: BASLER acA640-20um
  7:   !  3: KOWA   SC36MF
  8:   CALL VT_M05S('CAMERA', 1)
  9:   !Set Group Number
 10:   CALL VT_M05S('GROUP', 1)
 11:   !Set Exposure Time (msec)
 12:   CALL VT_M05S('EXPOS', 80)
 13:   !Display Image
 14:   CALL VT_M05S('DISPLAY')
 15:   PAUSE
 16:
 17:   !Start Measurement
 18:   OVERRIDE=30%
 19:   CALL VT_M05S('MOVE', 1)
 20:   PAUSE
 21:   CALL VT_M05S('VTOUCH', 1)
 22:   PAUSE
 23:   CALL VT_M05S('MOVE', 2)
 24:   PAUSE
 25:   CALL VT_M05S('VTOUCH', 2)
 26:   PAUSE
 27:   CALL VT_M05S('MOVE', 3)
 28:   PAUSE
 29:   CALL VT_M05S('VTOUCH', 3)
 30:   PAUSE
 31:   CALL VT_M05S('MOVE', 4)
 32:   PAUSE
 33:   CALL VT_M05S('VTOUCH', 4)
[End]
```

Set the camera type

Set robot group number

Set exposure time of camera

*i*Pendant configuration turns into "Double" pane and the runtime monitor screen is displayed on the right-hand screen.

Execute vision measurement at camera position 1

Execute vision measurement at camera position 2

Execute vision measurement at camera position 3

Execute vision measurement at camera position 4

Fig. 5.2.2 TP program VCGMM05S for executing vision measurement (M-1*i*A/0.5S, M-1*i*A/0.5SL)
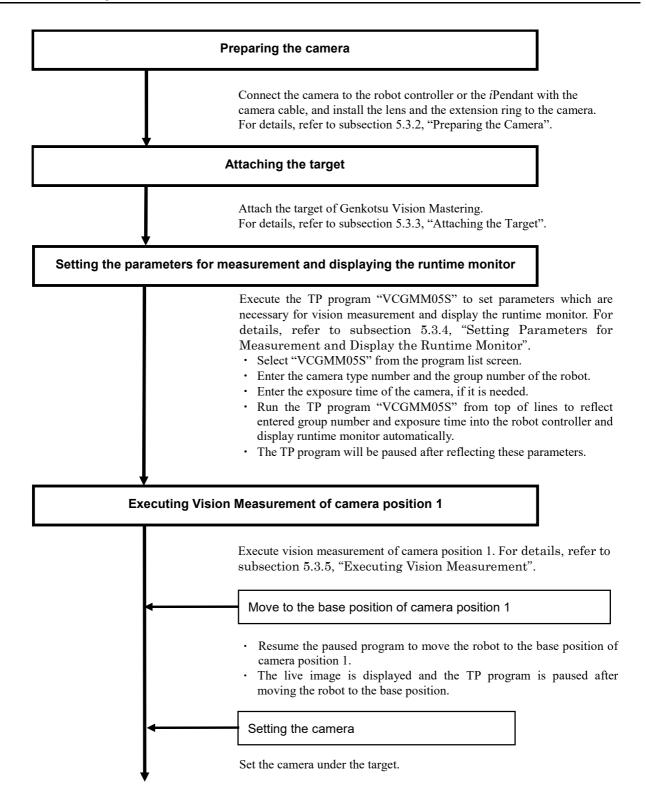
> ⚠ **CAUTION**
> The TP program "VCGMM05S" is paused sometimes when the program is running.
> Please don't jog the robot or execute the other programs when this program is pausing.
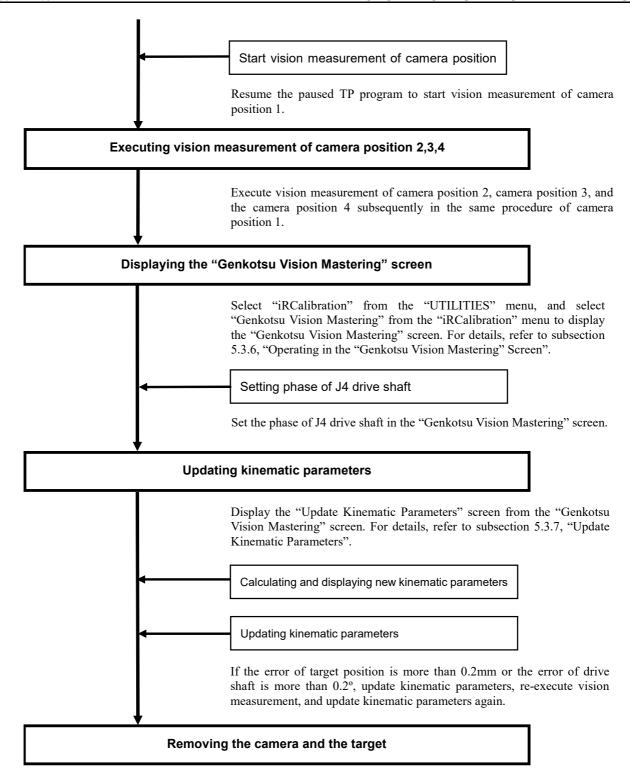
5.3   OPERATION OF GENKOTSU VISION MASTERING

This section describes the procedure for Genkotsu Vision Mastering.

5.3.1   Operation Procedure

Preparing the camera

Connect the camera to the robot controller or the *i*Pendant with the camera cable, and install the lens and the extension ring to the camera. For details, refer to subsection 5.3.2, "Preparing the Camera".

Attaching the target

Attach the target of Genkotsu Vision Mastering.
For details, refer to subsection 5.3.3, "Attaching the Target".

Setting the parameters for measurement and displaying the runtime monitor

Execute the TP program "VCGMM05S" to set parameters which are necessary for vision measurement and display the runtime monitor. For details, refer to subsection 5.3.4, "Setting Parameters for Measurement and Display the Runtime Monitor".
- Select "VCGMM05S" from the program list screen.
- Enter the camera type number and the group number of the robot.
- Enter the exposure time of the camera, if it is needed.
- Run the TP program "VCGMM05S" from top of lines to reflect entered group number and exposure time into the robot controller and display runtime monitor automatically.
- The TP program will be paused after reflecting these parameters.

Executing Vision Measurement of camera position 1

Execute vision measurement of camera position 1. For details, refer to subsection 5.3.5, "Executing Vision Measurement".

Move to the base position of camera position 1

- Resume the paused program to move the robot to the base position of camera position 1.
- The live image is displayed and the TP program is paused after moving the robot to the base position.

Setting the camera

Set the camera under the target.

```
                    ┌──────────────────────────────────────────┐
      ←─────────────│  Start vision measurement of camera position  │
      │             └──────────────────────────────────────────┘
      │
      │             Resume the paused TP program to start vision measurement of camera
      │             position 1.
      │
┌─────────────────────────────────────────────────────────────────┐
│       Executing vision measurement of camera position 2,3,4       │
└─────────────────────────────────────────────────────────────────┘
      │
      │             Execute vision measurement of camera position 2, camera position 3, and
      │             the camera position 4 subsequently in the same procedure of camera
      │             position 1.
      │
┌─────────────────────────────────────────────────────────────────┐
│        Displaying the "Genkotsu Vision Mastering" screen          │
└─────────────────────────────────────────────────────────────────┘
      │
      │             Select "iRCalibration" from the "UTILITIES" menu, and select
      │             "Genkotsu Vision Mastering" from the "iRCalibration" menu to display
      │             the "Genkotsu Vision Mastering" screen. For details, refer to subsection
      │             5.3.6, "Operating in the "Genkotsu Vision Mastering" Screen".
      │
      │             ┌──────────────────────────────────────────┐
      ←─────────────│         Setting phase of J4 drive shaft          │
      │             └──────────────────────────────────────────┘
      │
      │             Set the phase of J4 drive shaft in the "Genkotsu Vision Mastering" screen.
      │
┌─────────────────────────────────────────────────────────────────┐
│                   Updating kinematic parameters                   │
└─────────────────────────────────────────────────────────────────┘
      │
      │             Display the "Update Kinematic Parameters" screen from the "Genkotsu
      │             Vision Mastering" screen. For details, refer to subsection 5.3.7, "Update
      │             Kinematic Parameters".
      │
      │             ┌──────────────────────────────────────────┐
      ←─────────────│  Calculating and displaying new kinematic parameters  │
      │             └──────────────────────────────────────────┘
      │
      │             ┌──────────────────────────────────────────┐
      ←─────────────│         Updating kinematic parameters            │
      │             └──────────────────────────────────────────┘
      │
      │             If the error of target position is more than 0.2mm or the error of drive
      │             shaft is more than 0.2°, update kinematic parameters, re-execute vision
      │             measurement, and update kinematic parameters again.
      │
┌─────────────────────────────────────────────────────────────────┐
│                  Removing the camera and the target               │
└─────────────────────────────────────────────────────────────────┘
```

5.3.2   Preparing the Camera

- Connect the camera to the robot controller or the *i*Pendant with the camera cable. For details, refer to subsection 3.1.2, "Connecting the Camera to the Robot Controller or the *i*Pendant".
- "SONY XC-56", "BASLER acA640 20um", "BASLER A640-750umFNC", or "KOWA SC36MF" can be used as the camera.
- Install the extension ring 0.5mm thick and 12mm FANUC lens to the camera.
- Adjust the focus and the aperture of the lens as shown in Fig. 5.3.2.
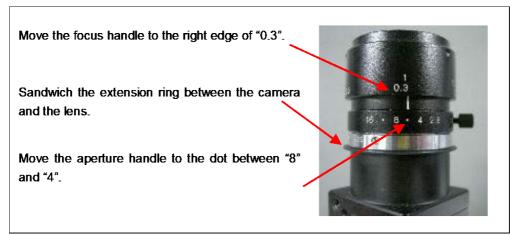
Fig. 5.3.2   A lens and an extension ring installed on a camera (M-1*i*A/0.5S, M-1*i*A/0.5S)

5.3.3   Attaching the Target

The shape of the target of Genkotsu Vision Mastering for M-1*i*A/0.5S and M-1*i*A/0.5SL is shown in Fig. 5.3.3(a). The same target of Genkotsu Vision Mastering is used for M-1*i*A/0.5S and M-1*i*A/0.5SL.
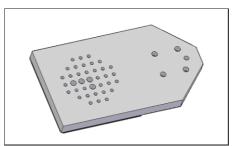
Fig. 5.3.3(a) Target of Genkotsu Vision Mastering for M-1*i*A/0.5S and M-1*i*A/0.5SL

Install the target of Genkotsu Vision Mastering as shown in Fig. 5.3.3(b) (The robot is at the zero position). Insert the positioning pin and the target into the flange of the robot securely, and tighten the four screws.
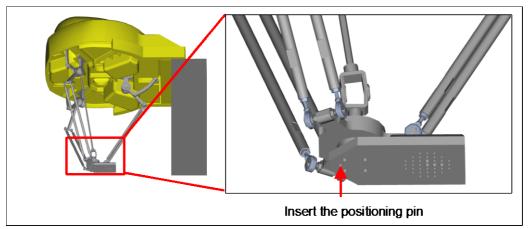
Fig.5.3.3(b) Attaching the target of Genkotsu Vision Mastering
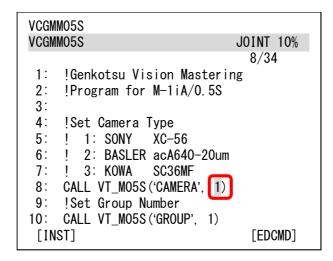
5.3.4 Setting Parameters for Measurement and Display the Runtime Monitor

Set the camera type, the group number of the robot which is to be measured by vision, adjust the exposure time of the camera, and display the runtime monitor on the *i*Pendant by executing the TP program "VCGMM05S".

Procedure 5-1   Setting parameters for measurement and display the runtime monitor

Step
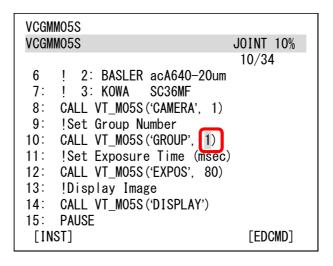
1   Display the edit screen of the TP program "VCGMM05S" by displaying the program list screen and selecting "VCGMM05S" from the program list.

2   Move the cursor to the part which is surrounded by the frame at "CALL VT_M05S('CAMERA', 1)" of the following figure, and enter the camera type number. Camera type numbers corresponds to the cameras as follows.

      1: SONY XC-56
      2: BASLER acA640-20um
      3: KOWA SC36MF
      4: BASLER acA640-750umFNC
      5: KOWA SC130E B/W
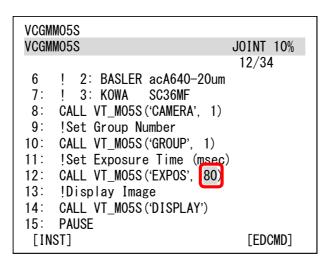
> **NOTE**
> The values that are set in the TP program cannot be changed if the teach pendant is disabled. Change the value with the teach pendant is enabled.

3   Move the cursor to the part which is surrounded by the frame at "CALL VT_M05S('GROUP', 1)" of the following figure, and enter the group number of the robot that is to perform Genkotsu Vision Mastering.

```
VCGMM05S
VCGMM05S                          JOINT 10%
                                    10/34
 6   !  2: BASLER acA640-20um
 7:  !  3: KOWA    SC36MF
 8:  CALL VT_M05S('CAMERA', 1)
 9:  !Set Group Number
10:  CALL VT_M05S('GROUP', 1)
11:  !Set Exposure Time (msec)
12:  CALL VT_M05S('EXPOS', 80)
13:  !Display Image
14:  CALL VT_M05S('DISPLAY')
15:  PAUSE
 [INST]                          [EDCMD]
```
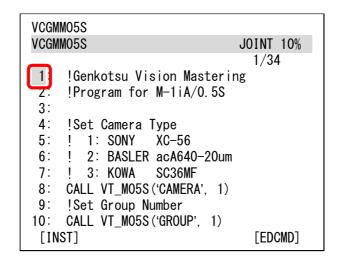
4   Move the cursor to the part which is surrounded by the frame at "CALL VT_M05S('EXPOS', 80)" of the following figure, and enter the exposure time of the camera (unit: ms) if it should be adjusted.

```
VCGMM05S
VCGMM05S                          JOINT 10%
                                    12/34
 6   !  2: BASLER acA640-20um
 7:  !  3: KOWA    SC36MF
 8:  CALL VT_M05S('CAMERA', 1)
 9:  !Set Group Number
10:  CALL VT_M05S('GROUP', 1)
11:  !Set Exposure Time (msec)
12:  CALL VT_M05S('EXPOS', 80)
13:  !Display Image
14:  CALL VT_M05S('DISPLAY')
15:  PAUSE
 [INST]                          [EDCMD]
```
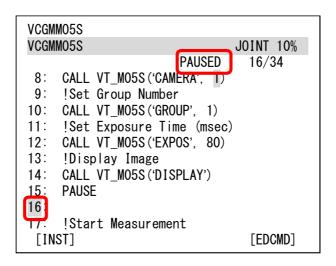
> **Tips**
> Start vision measurement and set the exposure time to 80 ms. If the image obtained during the measurement is too bright or too dark, change the exposure time and restart the vision measurement.

5   Move the cursor to the top line of the TP program and run the TP program "VCGMM05S".

```
VCGMM05S
VCGMM05S                          JOINT 10%
                                     1/34
  1:  !Genkotsu Vision Mastering
  2:  !Program for M-1iA/0.5S
  3:
  4:  !Set Camera Type
  5:  !  1: SONY    XC-56
  6:  !  2: BASLER acA640-20um
  7:  !  3: KOWA    SC36MF
  8:  CALL VT_MO5S('CAMERA', 1)
  9:  !Set Group Number
 10:  CALL VT_MO5S('GROUP', 1)
 [INST]                          [EDCMD]
```

The entered group number and exposure time will be reflected on the robot controller and the TP program will be paused. The *i*Pendant displays "Double" pane mode and the right pane displays the runtime monitor screen.

```
VCGMM05S
VCGMM05S                          JOINT 10%
                           PAUSED    16/34
  8:  CALL VT_MO5S('CAMERA', 1)
  9:  !Set Group Number
 10:  CALL VT_MO5S('GROUP', 1)
 11:  !Set Exposure Time (msec)
 12:  CALL VT_MO5S('EXPOS', 80)
 13:  !Display Image
 14:  CALL VT_MO5S('DISPLAY')
 15:  PAUSE
 16:
 17:  !Start Measurement
 [INST]                          [EDCMD]
```

5.3.5   Executing Vision Measurement

Use the camera to execute vision measurement and execute the TP program "VCGMM05S". There are four setting positions of the camera.

Procedure 5-2   Executing vision measurement for camera position 1

Step

1   Resume the paused TP program "VCGMM05S" to move the robot to the base position of camera position 1 via the home position.

> ⚠ **CAUTION**
> Be sure that the target and the robot do not interfere with peripheral devices during robot movement.

Tips
1 The home position is the position such as (J1,J2,J3,J4) = (25º, 25º, 25º, 0º).
2 For the M-1iA/0.5S, the base position of camera position 1 is the position as
   (J1,J2,J3,J4) = (-6º, -27º, -34º, -165º). (These values are the value before
   applying kinematic parameters which are calculated by Genkotsu Vision
   Mastering, and are rounded to integers.)
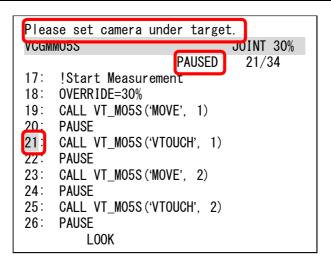
The teach pendant is shown as follows while moving to the home position.

```
Moving to home position ...
VCGMM05S                      JOINT 30%
                                 19/34
 17:   !Start Measurement
 18:   OVERRIDE=30%
 19:   CALL VT_M05S('MOVE', 1)
 20:   PAUSE
 21:   CALL VT_M05S('VTOUCH', 1)
 22:   PAUSE
 23:   CALL VT_M05S('MOVE', 2)
 24:   PAUSE
 25:   CALL VT_M05S('VTOUCH', 2)
 26:   PAUSE
          LOOK
```

The teach pendant is shown as follows while moving to the base position of the camera position 1.

```
Moving to base position ...
VCGMM05S                      JOINT 30%
                                 19/34
 17:   !Start Measurement
 18:   OVERRIDE=30%
 19:   CALL VT_M05S('MOVE', 1)
 20:   PAUSE
 21:   CALL VT_M05S('VTOUCH', 1)
 22:   PAUSE
 23:   CALL VT_M05S('MOVE', 2)
 24:   PAUSE
 25:   CALL VT_M05S('VTOUCH', 2)
 26:   PAUSE
          LOOK
```

2   After moving to the base position, "Set camera under target." is displayed on the top line of the teach
     pendant, the live image is displayed on the runtime monitor, and the TP program is paused.

```
┌─────────────────────────────────────────────────┐
│ Please set camera under target.                   │
│ VCGMMO5S                          JOINT 30%        │
│                          PAUSED     21/34          │
│  17:  !Start Measurement                           │
│  18:  OVERRIDE=30%                                 │
│  19:  CALL VT_MO5S('MOVE', 1)                      │
│  20:  PAUSE                                        │
│  21:  CALL VT_MO5S('VTOUCH', 1)                    │
│  22:  PAUSE                                        │
│  23:  CALL VT_MO5S('MOVE', 2)                      │
│  24:  PAUSE                                        │
│  25:  CALL VT_MO5S('VTOUCH', 2)                    │
│  26:  PAUSE                                        │
│         LOOK                                       │
└─────────────────────────────────────────────────┘
```

⚠ **CAUTION**
  Do not jog the robot or execute the other program while the TP program "VCGMM05S"
  is paused.

3   Mount the camera under the target. The position of the camera needs to satisfy the following
     conditions:

•   Locate the camera so that the distance between the target and the tip of the lens is in following
     range.

        SONY XC-56:   110-130mm
        BASLER acA640-20um: 145-170mm
        BASLER acA640-750umFNC: 165-195mm
        KOWA SC36MF: 135-160mm
        KOWA SC130E B/W: 155-180mm
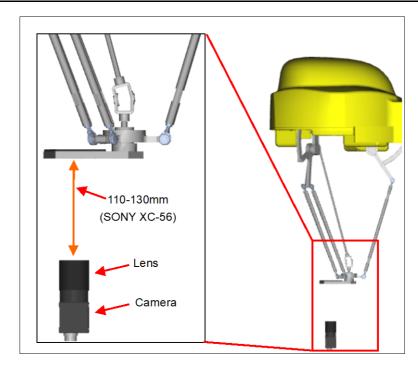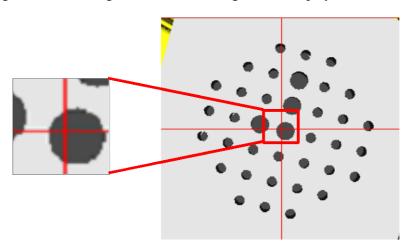
•   Locate the camera as the camera and target face each other squarely as possible. The tilt of the
     camera relative to the target needs to be within 3 degrees.

- Position the camera so that the center dot is located near the intersection of the red crosshairs in the camera's image, while watching the live camera image on the display.

NOTE
1   If outlines of the dots are blurred, check the focus and aperture setting on the lens. Make sure the lens and the extension ring are securely installed to the camera (For details of lens setting, refer to subsection 5.3.2, "Preparing camera".)
2   If the target image is too bright, check the aperture setting of the lens and/or reduce the exposure time.

4   Resume the paused TP program to start the vision measurement of camera position 1 after setting the camera.

⚠ **CAUTION**
1   Be sure that the target and the robot do not interfere with the peripheral devices while the robot is moving.
2   Do not move the fixed camera.
3   Set the robot override to 30% or less while executing vision measurement.

At first, the vision measurement checks whether the camera position and the target position are valid. Subsequently, vision measurement is executed at twelve postures by moving the robot as the target is rotated by 30º from 0º to 330º on the optical axis of the camera.

The number that indicates which posture is measured by vision is displayed on the top line of the teach pendant as shown in the following screen. (In case of the following screen, the third posture is measured by vision.)

```
[ 3/12]Detecting ... Don't move camera
VCGMM05S                        JOINT 30%
                                 21/34
17:   !Start Measurement
18:   OVERRIDE=30%
19:   CALL VT_M05S('MOVE', 1)
20:   PAUSE
21:   CALL VT_M05S('VTOUCH', 1)
22:   PAUSE
23:   CALL VT_M05S('MOVE', 2)
24:   PAUSE
25:   CALL VT_M05S('VTOUCH', 2)
26:   PAUSE
          LOOK
```

When the measurement is completed, "[1/4] Measurement has been completed." is displayed on the top line of the teach pendant.

```
[1/4]Measurement has been completed.
VCGMM05S                        JOINT 30%
                       PAUSED    23/34
17:   !Start Measurement
18:   OVERRIDE=30%
19:   CALL VT_M05S('MOVE', 1)
20:   PAUSE
21:   CALL VT_M05S('VTOUCH', 1)
22:   PAUSE
23:   CALL VT_M05S('MOVE', 2)
24:   PAUSE
25:   CALL VT_M05S('VTOUCH', 2)
26:   PAUSE
 [INST]                        [EDCMD]
```

Procedure 5-3   Executing vision measurement for camera Position 2, camera position 3, and camera position 4

The robot will move to the base position of camera position 2 via the home position by resuming the paused TP program "VCGMM05S" after the measurement of camera position 1 is completed. The procedure of the vision measurement of camera position 2, camera position3, and camera position 4 are the same as the vision measurement of camera position 1, so execute the measurements by referring to subsection "Procedure 5-2   Executing vision measurement for camera position 1".

> **Tips**
> 1 For the M-1iA/0.5S, the base position of camera position 2 is the position as (J1,J2,J3,J4) = (12º, 33º, 23º, -165º).
> 2 For the M-1iA/0.5S, the base position of camera position 3 is the position as (J1,J2,J3,J4) = (-44º, -16º, 14º, -165º).
> 3 For the M-1iA/0.5S, the base position of camera position 4 is the position as (J1,J2,J3,J4) = (40º, 17º, -25º, -165º).
>   (These values are the value before applying kinematic parameters which are calculated by Genkotsu Vision Mastering, and are rounded to integers.)

5.3.6   Operation in "Genkotsu Vision Mastering" Screen

Procedure 5-4   Operation in "Genkotsu Vision Mastering" screen

Condition
- Vision measurement should be completed before the "Genkotsu Vision Mastering" screen is displayed.
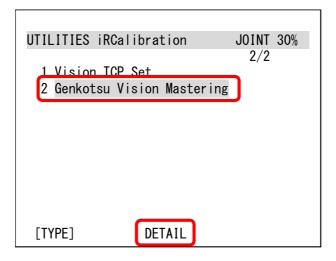
Step
1   Press the MENU key and select "UTILITIES" in the pop-up menu.
2   Press the F1[TYPE] key and select "*i*RCalibration" in the pop-up menu.

The following screen is displayed on the teach pendant.
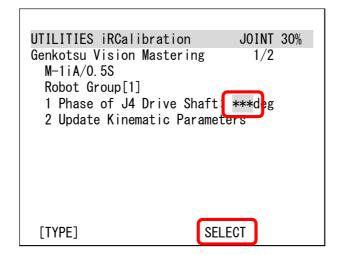
3   Move the cursor to "Genkotsu Vision Mastering" and press the F3[DETAIL] key or the ENTER key.

```
UTILITIES iRCalibration        JOINT 30%
                                    2/2
 1 Vision TCP Set
 2 Genkotsu Vision Mastering




 [TYPE]               DETAIL
```

The "Genkotsu Vision Mastering" screen is displayed on the teach pendant as follows.

4   Move the cursor to "Phase of J4 Drive Shaft" and press the F4[SELECT] key.

5   Select the phase of J4 drive shaft from "-60", "-30", "0", "+30", "+60", or "+90" in the displayed
     pop-up list. The phase of the J4 drive shaft can be judged by moving the J4 axis of the robot to 0º
     and viewing the end of the J4 drive shaft which is indicated in Fig. 5.3.6(a) from the front.
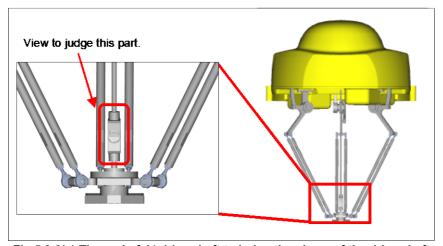
Fig.5.3.6(a) The end of J4 drive shaft to judge the phase of the drive shaft

The Fig. 5.3.6(b) is the diagram of the shape of the end of the drive shaft that is viewed by the front when
the J4 is 0º. Move the J4 axis of the robot to 0º, and select the phase of the drive shaft based on
Fig.5.3.6(b).   Enter the phase of the drive shaft into the Phase of Drive shaft field.
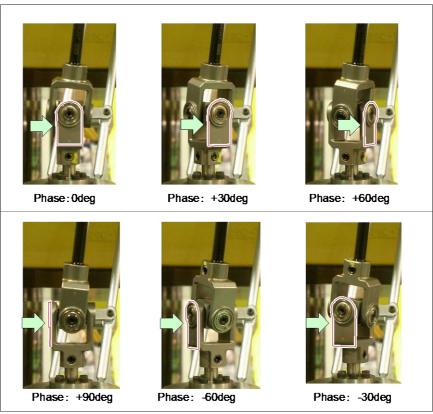
Fig.5.3.6(b) The shape of the end and the phase of J4 drive shaft

5.3.7   Updating Kinematic Parameters
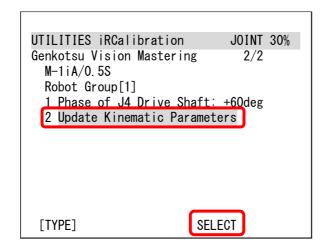
Procedure 5-5   Updating kinematic parameters

Condition
- The phase of the J4 drive shaft needs to be set before updating kinematic parameters of the robot.

Step
1   Move the cursor to "Update Kinematic Parameters" in the "Genkotsu Vision Mastering" screen and press the F4[SELECT] key and ENTER key.
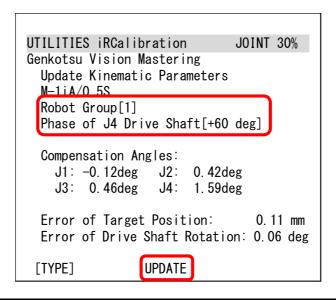
Kinematic parameters of the robot are calculated, and the "Update Kinematic Parameters" screen is displayed if the calculation is completed successfully.

> **NOTE**
> When "Calculation has failed." is displayed on the bottom line of the teach pendant, the "Update Kinematic Parameters" screen can't be displayed. Check if the attachment of the target and the setting of the camera and lens are correct again and re-execute vision measurement.

2   Check if the displayed settings of the group number and the phase of J4 drive shaft are correct, and press the F3[UPDATE] key while holding down the SHIFT key to update kinematic parameters.

```
UTILITIES iRCalibration        JOINT 30%
Genkotsu Vision Mastering
  Update Kinematic Parameters
  M-1iA/0.5S
  Robot Group[1]
  Phase of J4 Drive Shaft[+60 deg]

  Compensation Angles:
    J1: -0.12deg   J2:  0.42deg
    J3:  0.46deg   J4:  1.59deg

  Error of Target Position:      0.11 mm
  Error of Drive Shaft Rotation: 0.06 deg

  [TYPE]              UPDATE
```

> **NOTE**
> When either "Error of target position is too big", "Error of drive shaft rotation is too big", or "Calculated parameters are invalid" are displayed on the bottom line of the teach pendant, Kinematic parameters can't be updated. Check if the attachment of the target and the setting of the camera and lens are correct again and re-execute vision measurement.

"Kinematic parameters has been updated" is displayed in the bottom line of the teach pendant after kinematic parameters is updated.

```
UTILITIES iRCalibration        JOINT 30%
Genkotsu Vision Mastering
  Update Kinematic Parameters
  M-1iA/0.5S
  Robot Group[1]
  Phase of J4 Drive Shaft[+60 deg]

  Compensation Angles:
    J1: -0.12deg   J2:  0.42deg
    J3:  0.46deg   J4:  1.59deg

  Error of Target Position:      0.11 mm
  Error of Drive Shaft Rotation: 0.06 deg
Kinematic parameters has been updated.
  [TYPE]
```

> **Tips**
> 1 Mastering data (The values of $DMR_GRP[g].$MASTER_COUN[a]) are not changed by applying Genkotsu Vision Mastering.
> 2 If the error of the target position is more than 0.2mm or the error of drive shaft rotation is more than 0.2mm, vision measurement may not have been executed correctly. Therefore, in this case, re-execute vision measurement and update kinematic parameters again after you update kinematic parameters.

. Genkotsu Vision Mastering is complete.
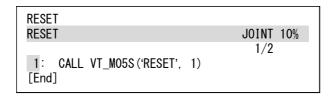
5.4 RESETTING KINEMATIC PARAMETERS

This section describes how to reset kinematic parameters and deal with re-mastering.

5.4.1 Resetting Kinematic Parameters
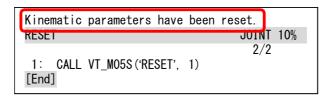
To reset updated kinematic parameters to the previous state, perform the following operations.

1 Create a TP program as following screen. When the program "VT_M05S" is called, set the first parameter to 'RESET', and the second parameter to the group number of the robot that is to be reset kinematic parameters.

```
RESET
RESET                                      JOINT 10%
                                              1/2

 1:  CALL VT_M05S('RESET', 1)
[End]
```

2 Run this TP program.

"Kinematic parameters have been reset" is displayed on the teach pendant.

```
Kinematic parameters have been reset.
RESET                                      JOINT 10%
                                              2/2

 1:  CALL VT_M05S('RESET', 1)
[End]
```

5.4.2 Re-mastering after Replacement of Mechanical Parts

After the robot is re-mastered for replacement of mechanical parts, the kinematic parameters that were calculated by Genkotsu Vision Mastering will be disabled.

The user should:
• Reset kinematic parameters in the method described above.
• Re-execute vision measurement.
• Update kinematic parameters again.

6   VISION MASTER RECOVERY

6.1   VISION MASTER RECOVERY

What is Vision Master Recovery?

If robot parts (motors and reducers, etc.) are replaced, the mastering data (zero positions of rotational axes) of corresponding axes become invalid, and the mastering status of the robot is lost. Vision Master Recovery automatically measures a fixed calibration grid by using a camera attached to the tool of a robot while changing the posture of the robot before and after replacement of the robot parts.   It also recovers the mastering status of the robot precisely by calculating new mastering data from the measuring results.

Features of Vision Master Recovery

- This function can be used by only a 6-axis. A 4-axis or 5-axis robot or a Genkotsu robot cannot use this function.
- Operations other than camera installation are performed automatically. Manual operations are therefore simplified, and the operation results do not depend on the skill of the operator.
- When the parts of plural axes are replaced, Vision Master Recovery recovers the mastering status of these plural axes one at a time.
- This function requires that the robot can move just before replacement of robot parts.
- This function executes vision measurement by using a camera and a calibration grid before and after replacement of robot parts. Installed or fixed positions of the camera and the calibration grid when executing vision measurement before replacement and installed or fixed positions of the camera and the calibration grid when executing vision measurement after replacement must be equal respectively. Therefore, installed or fixed positions of the camera and the calibration grid must not be changed until the vision measurement after replacement has been done.

TP programs used for Vision Master Recovery

Vision Master Recovery uses robot operation programs (hereinafter referred to as TP programs) to perform a sequence of operations.

When Vision Master Recovery is performed, these TP programs are generated automatically.   TP programs can also be created beforehand with offline programming.   This can further reduce production down time.

For details of TP programs, see subsection 6.6.1 "TP program" in this manual.

6.2 SYSTEM CONFIGURATION

6.2.1 Overall Configuration

The Vision Master Recovery system consists of a robot controller, a teach pendant (*i*Pendant), a camera, a lens, a camera cable, and a calibration grid.
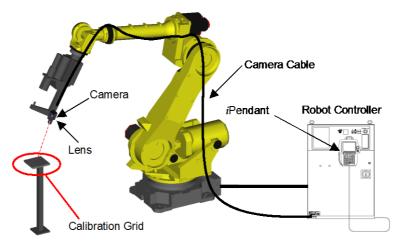
Fig. 6.2.1 System configuration of Vision Master Recovery
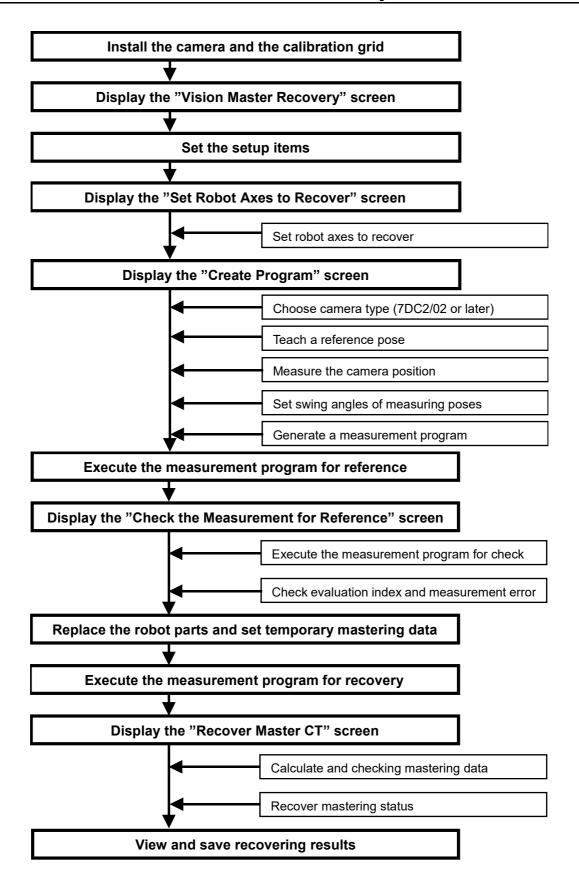
NOTE
1 FANUC standard cameras, lenses, and calibration grids are available in several sizes.
2 The customer is responsible for fabricating a jig for holding the camera and a jig for holding the calibration grid.

Tips
For controllers with 7DC2/02(8.20P/02) or later software, cameras not described in "2.1 COMPONENTS" can be used. For details, please refer to "3.5 USING *i*RVision CAMERA".

6.2.2　　Outline of the Vision Master Recovery Procedure

```
┌─────────────────────────────────────────────────────┐
│        Install the camera and the calibration grid    │
└─────────────────────────────────────────────────────┘
                          ↓
┌─────────────────────────────────────────────────────┐
│        Display the "Vision Master Recovery" screen     │
└─────────────────────────────────────────────────────┘
                          ↓
┌─────────────────────────────────────────────────────┐
│                   Set the setup items                  │
└─────────────────────────────────────────────────────┘
                          ↓
┌─────────────────────────────────────────────────────┐
│        Display the "Set Robot Axes to Recover" screen  │
└─────────────────────────────────────────────────────┘
                          ↓          ┌──────────────────────────────────┐
                          ←──────────│       Set robot axes to recover    │
                          ↓          └──────────────────────────────────┘
┌─────────────────────────────────────────────────────┐
│              Display the "Create Program" screen       │
└─────────────────────────────────────────────────────┘
                          ↓          ┌──────────────────────────────────┐
                          ←──────────│  Choose camera type (7DC2/02 or later) │
                          ↓          └──────────────────────────────────┘
                          ↓          ┌──────────────────────────────────┐
                          ←──────────│        Teach a reference pose       │
                          ↓          └──────────────────────────────────┘
                          ↓          ┌──────────────────────────────────┐
                          ←──────────│       Measure the camera position   │
                          ↓          └──────────────────────────────────┘
                          ↓          ┌──────────────────────────────────┐
                          ←──────────│     Set swing angles of measuring poses │
                          ↓          └──────────────────────────────────┘
                          ↓          ┌──────────────────────────────────┐
                          ←──────────│     Generate a measurement program  │
                          ↓          └──────────────────────────────────┘
┌─────────────────────────────────────────────────────┐
│         Execute the measurement program for reference  │
└─────────────────────────────────────────────────────┘
                          ↓
┌─────────────────────────────────────────────────────┐
│   Display the "Check the Measurement for Reference" screen │
└─────────────────────────────────────────────────────┘
                          ↓          ┌──────────────────────────────────┐
                          ←──────────│  Execute the measurement program for check │
                          ↓          └──────────────────────────────────┘
                          ↓          ┌──────────────────────────────────┐
                          ←──────────│  Check evaluation index and measurement error │
                          ↓          └──────────────────────────────────┘
┌─────────────────────────────────────────────────────┐
│   Replace the robot parts and set temporary mastering data │
└─────────────────────────────────────────────────────┘
                          ↓
┌─────────────────────────────────────────────────────┐
│        Execute the measurement program for recovery    │
└─────────────────────────────────────────────────────┘
                          ↓
┌─────────────────────────────────────────────────────┐
│            Display the "Recover Master CT" screen      │
└─────────────────────────────────────────────────────┘
                          ↓          ┌──────────────────────────────────┐
                          ←──────────│   Calculate and checking mastering data │
                          ↓          └──────────────────────────────────┘
                          ↓          ┌──────────────────────────────────┐
                          ←──────────│       Recover mastering status      │
                          ↓          └──────────────────────────────────┘
┌─────────────────────────────────────────────────────┐
│            View and save recovering results            │
└─────────────────────────────────────────────────────┘
```

6.3   MEASURING POSES FOR VISION MASTER RECOVERY

6.3.1   Outline of Measuring Poses

Fig. 6.3.1 Measuring Poses

Vision Master Recovery uses two or more measuring poses.   These poses are automatically generated based on a reference pose (initial value).

The measuring poses are generated as detailed below.

- The number of measuring poses is 27. But with 7DF1/04 (V9.10P/04) or later software, 27 or 8 can be selected as the number of measuring poses.
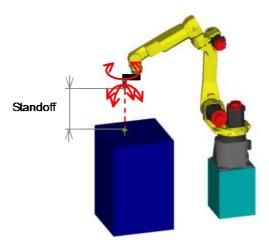- When the number of measuring poses is 27, a total of 27 measuring poses are generated by adding three different swing angles, or a positive maximum swing angle, negative maximum swing angle, and 0, to each of the postures (W, P, R) of the reference pose. (Thus 3 times 3 times 3 = 27)
- When the number of measuring poses is 8, a total of 8 measuring poses are generated by combining two different swing angles, (a positive maximum swing angle and negative maximum swing angle), about each axis of orientation (W, P, R) of the reference pose. (Thus 2 times 2 times 2 = 8)
- The robot is adjusted so that the standoff (the distance between the camera and the calibration grid) at each measurement pose matches the reference pose standoff.

NOTE
   With 7DF1/04 (V9.10P/04) or later software, It is recommended to select 8 poses to shorten the measurement time.

6.3.2   Example of Reference Pose

Reference pose example in which the robot can operate relatively easily

Setting the reference pose as shown below results in a large maximum swing angle for the measuring pose.

1   The J2-axis and J4-axis angles are around 0 degrees.
2   The J3-axis angle is negative.
3   The wrist flange surface of the robot faces down.
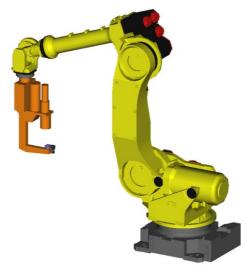
Fig. 6.3.2   Reference pose in which the robot can operate relatively easily

6.4 INSTALLATION OF THE CAMERA AND CALIBRATION GRID

6.4.1 Installing the Camera

Secure the camera to the tool of the robot.

> **NOTE**
> The camera can be set to arbitrary position on the tool. Fix it securely so that it does not move during the operation of Vision Master Recovery.

Install the camera such that the dash line (the visual TCP indicated below) is offset from the center line of the J6 axis (solid line). An offset of at least 100 mm is recommended.

The recommended value of standoff (distance between the camera and the calibration grid) is 500 mm.
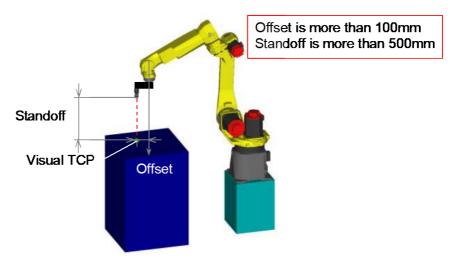
Fig. 6.4.1(a) Installing the camera

Keep the camera and the tool away from the base section of the robot and tilt the J3 arm downward as shown below, so that the wrist section hardly causes interference.
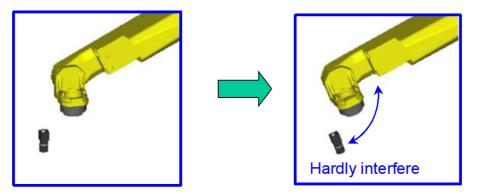
Fig. 6.4.1(b) Wrist pose in which the camera hardly interferes with the robot

If the camera or tool is close to the base section of the robot or if the J3 arm is tilted upward in contrast, the wrist section is liable to cause interference.   In that case, the swing angle of measuring pose must be reduced, involving a risk of degrading recovering results of mastering status.
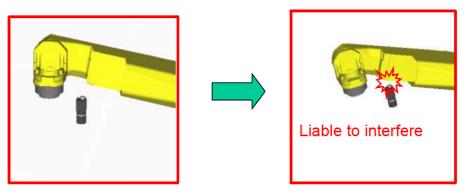
Fig. 6.4.1 (c) Wrist pose in which the camera is liable to interfere with the robot

Check these examples for reference to appropriately install the camera and select the reference pose of the robot.

6.4.2 Installing the Calibration Grid

Place the calibration grid at a position where it can be installed in a stable condition.
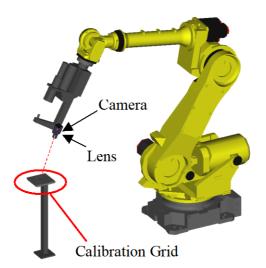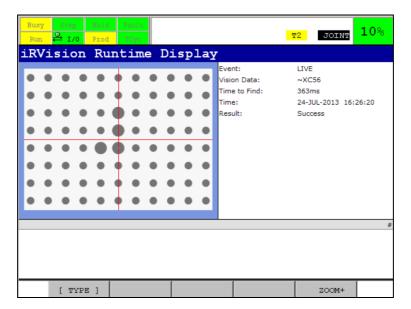
Fig. 6.4.2 Installation of calibration grid

Displaying camera image for installing the calibration grid

- Install the calibration grid such that the X-axis direction of the calibration grid (See subsection 6.7.1, "Calibration Grid") comes upward in the camera image.   (For displaying the image, see Section 3.2, "DISPLAYING THE RUNTIME MONITOR".)
- Install the calibration grid with its face approximately perpendicular to the optical axis of the camera.
- Install the calibration grid so that four large black circles of the grid are as close to the center of the camera image as possible when they are snapped.

```
Tips
    The calibration grid should be placed near the center of the field of view.
    Roughly placing the calibration in the center of the field of view is sufficient; its
    placement does not require a high level of precision.
```

```
NOTE
    Install the calibration grid securely so that it does not move during the operation
    of Vision Master Recovery.
```

6.5 OPERATION OF VISION MASTER RECOVERY

This section describes the procedure for Vision Master Recovery.

6.5.1 Operation Procedure

```
┌─────────────────────────────────────────────────┐
│      Install the camera and the calibration grid │
└─────────────────────────────────────────────────┘
         │
         │◄──────┌──────────────────────────────────────────────┐
         │       │  Connect the camera to the controller or iPendant │
         │       └──────────────────────────────────────────────┘
         │
         │       Connect the camera to the controller or the iPendant with a camera cable.
         │
         │◄──────┌──────────────────────────────────────────────┐
         │       │  Install the camera and the calibration grid  │
         │       └──────────────────────────────────────────────┘
         │
         │       Mount the camera on the robots end of arm tooling, and secure the
         │       calibration grid to a fixed surface.
         ▼
┌─────────────────────────────────────────────────┐
│   Display the "Vision Master Recovery" screen    │
└─────────────────────────────────────────────────┘
         │
         │       Select "iRCalibratiion" from the "UTILITIES" menu, and select "Vision
         │       Master Reocovery" from the "iRCalibration" menu to display the "Vision
         │       Master Recovery" screen.
         │       For details, refer to subsection 6.5.2, "Displaying the "Vision Master
         │       Recovery" Screen".
         │
         │◄──────┌──────────────────────────────────────────────┐
         │       │  Setup on the "Vision Master Recovery" screen │
         │       └──────────────────────────────────────────────┘
         │
         │       Set robot group number and work tool frame number.
         │       For details, refer to subsection 6.5.3, "Setup on the "Vision Master
         │       Recovery" Screen".
         ▼
┌─────────────────────────────────────────────────┐
│   Display the "Set Robot Axes to Recover" screen │
└─────────────────────────────────────────────────┘
         │
         │       Display the "Set Robot Axes to Recover" screen from the "Vision Master
         │       Recovery" screen.
         │       For details, refer to subsection 6.5.4, "Setting Robot Axes to Recover".
         │
         │◄──────┌──────────────────────────────────────────────┐
         │       │  Setup on the "Set Robot Axes to Recover" screen │
         │       └──────────────────────────────────────────────┘
         │
         │       Set robot axes to recover.
         ▼
┌─────────────────────────────────────────────────┐
│       Display the "Create Program" screen        │
└─────────────────────────────────────────────────┘
         │
         │       Display the "Create Program" screen from the "Vision Master
         │       Recovery" screen.
         │       For details, refer to subsection 6.5.5, "Generating a Measurement
         │       Program".
         ▼
```
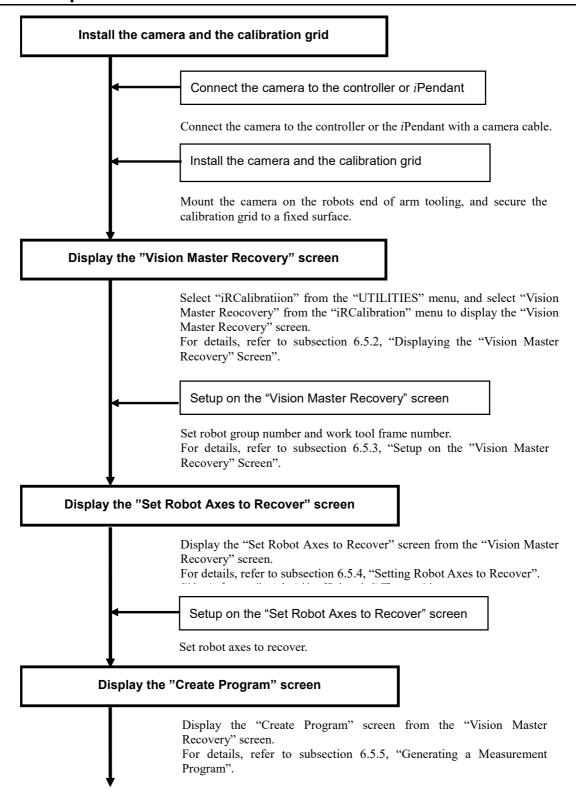
Choose camera type (7DC2/02 or later)

Set the focal distance of lens, the grid spacing of the calibration grid, the exposure time of vision detection.

Teach the reference pose

Teach the reference pose of the measuring program. (The reference pose is also used as a start position when measuring the camera position.)

Measure the camera position

Measure the camera position and the calibration grid position that are used for generating the TP program.

Set swing angles of measuring poses

Set swing angles which are used for generating the measurement program.

Generate measurement program

Confirm the evaluation index of reference and the evaluation index of recovery are smaller than 4.2. If the evaluation index of reference or/and the evaluation index of recovery is/are bigger than 4.2, increase the swing angles and re-generate the measurement program. If the evaluation index of reference or/and the evaluation index of recovery is/are bigger than 4.2 even when swing angles are equal to (45, 45, 45), increase the distance between the camera and the calibration grid and re-generate the measurement program.

Execute the measurement program for reference

Execute the measurement program for reference.
For details, refer to subsection 6.5.6, "Executing the Measurement Program for Reference".

Execute the measurement program for reference.

Display "Check the Measurement for Reference " screen

Display the "Check the Measurement for Reference" screen from the "Vision Master Recovery" screen.
For details, refer to subsection 6.5.7, "Executing the Measurement Program for Check".

Execute the measurement program for check.

Execute the measurement program to check if the measurement program for reference completed successfully. If the evaluation index of reference is bigger than 4.2, re-generate the measurement program. If the max measurement error is bigger than 0.5mm, execute the measurement for reference again.

Replace robot parts and set temporary mastering data

Replace robot parts. Please do not change installed or fixed positions of the camera and the calibration grid during replacement of robot parts. After replacing robot parts, set temporary mastering data to the axes the mastering status of which are invalid.
For details, refer to subsection 6.5.8, "Replacing Robot Parts and Set Temporary Mastering Data".

Execute the measurement program for recovery

Execute the measurement program for recovery.
For details, refer to subsection 6.5.9, "Executing the Measurement Program for Recovery".

Execute the measurement program for recovery

Recover mastering status

Recover mastering status.
For details, refer to subsection 6.5.10, "Recovering Mastering Status".

Calculate and check mastering data

Update mastering data

If maximum absolute value of calculated compensation angles is bigger than 1 degree and/or the max recovery error is bigger than 0.5mm, execute the measurement program for recovery again after updating mastering data.

View and save recovering results

View the recovering results.

Output the recovering results as a log file named as VCMR_LOG.TXT.
For details, refer to subsection 6.5.11, "Viewing and Saving Recovering Results".

6.5.2 Displaying the "Vision Master Recovery" Screen

Procedure 6-1 Displaying the "Vision Master Recovery" screen

Step
1 Press the MENU key.
2 Select "UTILITIES".
3 Press F1 [TYPE].
4 Select "*i*RCalibration".

The following screen appears on the teach pendant.
The available item list of *i*RCalibration functions is displayed in this screen.   The items to be displayed are different depending on which options are installed.

```
UTILITIES iRCalibration
                                        2/2
  1 Vision Mastering
  2 Vision Master Recovery




[ TYPE ]DISP_IMG DETAIL
```

Move the cursor to "Vision Master Recovery", then press the F3 (DETAIL) or the ENTER key.

The following "Vision Master Recovery" screen is displayed on the teach pendant.

```
UTILITIES iRCalibration
Vision Master Recovery            1/9
  1 Robot Group:             1
  2 Work Tool Frame Number:     9
  3 Set Robot Axes to Recover (Not Done)
  4 Create Program           (Not Done)
  5 Run for Reference:VMRCV1  (Not Done)
  6 Check the Measurement for Reference
  7 Run for Recovery: VMRCV1  (Not Done)
  8 Recover Master CT         (Not Done)
  9 View Result


[ TYPE ]DISP_IMG
```

Select and execute each item on the screen sequentially from the top so that the mastering status can be recovered. Robot parts will be replaced between "Check the Measurement for Reference" and "Run for Recovery".

6.5.3   Setup on the "Vision Master Recovery" Screen

There are two setup items on the "Vision Master Recovery" screen
- Robot Group Number
- Work Tool Frame Number
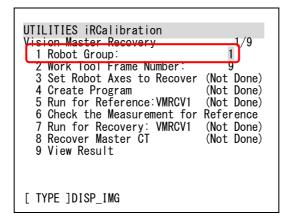
> **NOTE**
> With 7DF1/04 (V9.10P/04) or later software, 27 or 8 can be selected as the number of measuring poses. It is recommended to select 8 poses to shorten the measurement time.
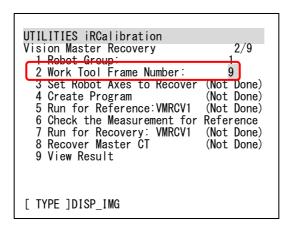
Set Robot Group Number
Move the cursor to "Robot Group" on the "Vision Master Recovery" screen, and enter the group number of the robot to have its mastering status recovered.

```
UTILITIES iRCalibration
Vision Master Recovery          1/9
1 Robot Group:                    1
2 Work Tool Frame Number:         9
3 Set Robot Axes to Recover  (Not Done)
4 Create Program             (Not Done)
5 Run for Reference:VMRCV1   (Not Done)
6 Check the Measurement for Reference
7 Run for Recovery: VMRCV1   (Not Done)
8 Recover Master CT          (Not Done)
9 View Result


[ TYPE ]DISP_IMG
```

Set Work Tool Frame Number

Move the cursor to "Work Tool Frame Number" on the "Vision Master Recovery" screen, and then enter the tool frame number to be used for vision measurement.

```
UTILITIES iRCalibration
Vision Master Recovery          2/9
1 Robot Group:                    1
2 Work Tool Frame Number:         9
3 Set Robot Axes to Recover  (Not Done)
4 Create Program             (Not Done)
5 Run for Reference:VMRCV1   (Not Done)
6 Check the Measurement for Reference
7 Run for Recovery: VMRCV1   (Not Done)
8 Recover Master CT          (Not Done)
9 View Result


[ TYPE ]DISP_IMG
```
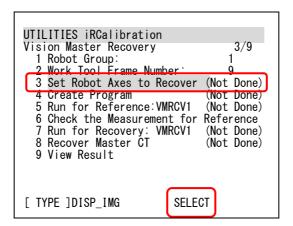
6.5.4   Setting Robot Axes to Recover
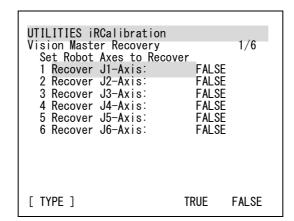
Procedure 6-2   Setting robot axes to recover

Step
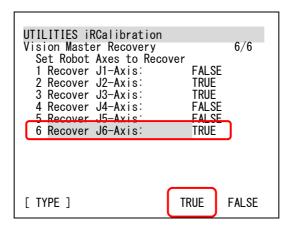
1   Move the cursor to "Set Robot Axes to Recover" on the "Vision Master Recovery" screen, and press the F4 (SELECT) or the ENTER key.

```
UTILITIES iRCalibration
Vision Master Recovery          3/9
1 Robot Group:                    1
2 Work Tool Frame Number:         9
3 Set Robot Axes to Recover  (Not Done)
4 Create Program             (Not Done)
5 Run for Reference:VMRCV1   (Not Done)
6 Check the Measurement for Reference
7 Run for Recovery: VMRCV1   (Not Done)
8 Recover Master CT          (Not Done)
9 View Result


[ TYPE ]DISP_IMG          SELECT
```

The teach pendant displays the "Set Robot Axes to Recover" screen as shown below.

```
UTILITIES iRCalibration
Vision Master Recovery               1/6
   Set Robot Axes to Recover
   1 Recover J1-Axis:        FALSE
   2 Recover J2-Axis:        FALSE
   3 Recover J3-Axis:        FALSE
   4 Recover J4-Axis:        FALSE
   5 Recover J5-Axis:        FALSE
   6 Recover J6-Axis:        FALSE




[ TYPE ]                     TRUE   FALSE
```

2   The axis to recover can be set by moving the cursor to the axis and pressing the SHIFT key and the
     F4 (TRUE) key together. Plural axes can be set as the axes to recover. The setting of the axis to
     recover can be cancelled by pressing the SHIFT key and the F5 (FALSE) key together.

```
UTILITIES iRCalibration
Vision Master Recovery               6/6
   Set Robot Axes to Recover
   1 Recover J1-Axis:        FALSE
   2 Recover J2-Axis:        TRUE
   3 Recover J3-Axis:        TRUE
   4 Recover J4-Axis:        FALSE
   5 Recover J5-Axis:        FALSE
   6 Recover J6-Axis:        TRUE




[ TYPE ]                     TRUE   FALSE
```

3   When setting robot axes to recover is completed, press the PREV key to display the "Vision Master
     Recovery" screen.

6.5.5   Generating a Measurement Program

Procedure 6-3   Generating a measurement program
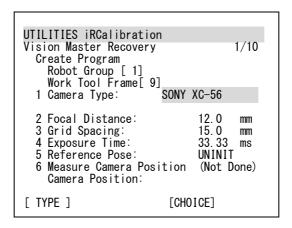
Condition
   • Make sure that the status of "Set Robot Axes to Recover" is "Done".

Step
1   Move the cursor to "Create Program" on the "Vision Master Recovery" screen, and press the F4
     (SELECT) key or the ENTER key.

```
UTILITIES iRCalibration
Vision Master Recovery              4/9
  1 Robot Group:                     1
  2 Work Tool Frame Number:          9
  3 Set Robot Axes to Recover  (Done    )
  4 Create Program             (Not Done)
  5 Run for Reference:VMRCV1   (Not Done)
  6 Check the Measurement for Reference
  7 Run for Recovery: VMRCV1   (Not Done)
  8 Recover Master CT          (Not Done)
  9 View Result


[ TYPE ]DISP_IMG             SELECT
```

The teach pendant displays the "Create Program" screen as shown below.

```
UTILITIES iRCalibration
Vision Master Recovery             1/10
  Create Program
    Robot Group [ 1]
    Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:         12.0   mm
  3 Grid Spacing:           15.0   mm
  4 Exposure Time:          33.33  ms
  5 Reference Pose:         UNINIT
  6 Measure Camera Position  (Not Done)
    Camera Position:

[ TYPE ]                   [CHOICE]
```

2   Set the camera type. (7DC2/02 (V8.20/P02) or later)
    Below items can be selected as camera type.

    SONY XC-56
        Choose this when using "SONY XC-56" camera that connects to JRL7 port on the main board
        or JRL7A port on the multiplexer. This camera type can be selected on only R-30*i*B / R-30*i*B
        Mate controller.
    BASLER acA640-20um
        Choose this when BASLER *i*Pendant USB camera ac640-20um is used.
    KOWA SC36MF
        Choose this when KOWA *i*Pendant USB camera SC36MF is used. This camera type can be
        selected on only R-30*i*B / R-30*i*B Mate controller.
    *i*RVision Camera
        Choose this camera type when using KOWA monochrome camera SC130EF2 (only R-30*i*B
        Plus controller) or a camera for *i*RVision.

        For details, please refer to "3.5 USING *i*RVision CAMERA".

```
UTILITIES iRCalibration
Vision Master Recovery          1/10
   Create Program
     Robot Group [ 1]
     Work Tool Frame[ 9]
 1 Camera Type:        SONY XC-56

 2 Focal Distance:          12.0   mm
 3 Grid Spacing:            15.0   mm
 4 Exposure Time:           33.33  ms
 5 Reference Pose:          UNINIT
 6 Measure Camera Position  (Not Done)
     Camera Position:

[ TYPE ]                [CHOICE]
```

3   Set the focal distance (mm) of the camera lens to be used.

```
UTILITIES iRCalibration
Vision Master Recovery          2/10
   Create Program
     Robot Group [ 1]
     Work Tool Frame[ 9]
 1 Camera Type:        SONY XC-56

 2 Focal Distance:          12.0   mm
 3 Grid Spacing:            15.0   mm
 4 Exposure Time:           33.33  ms
 5 Reference Pose:          UNINIT
 6 Measure Camera Position  (Not Done)
     Camera Position:

[ TYPE ]DISP_IMG
```

4   Set the grid spacing (mm) of the calibration grid to be used.

```
UTILITIES iRCalibration
Vision Master Recovery          3/10
   Create Program
     Robot Group [ 1]
     Work Tool Frame[ 9]
 1 Camera Type:        SONY XC-56

 2 Focal Distance:          12.0   mm
 3 Grid Spacing:            15.0   mm
 4 Exposure Time:           33.33  ms
 5 Reference Pose:          UNINIT
 6 Measure Camera Position  (Not Done)
     Camera Position:

[ TYPE ]DISP_IMG
```

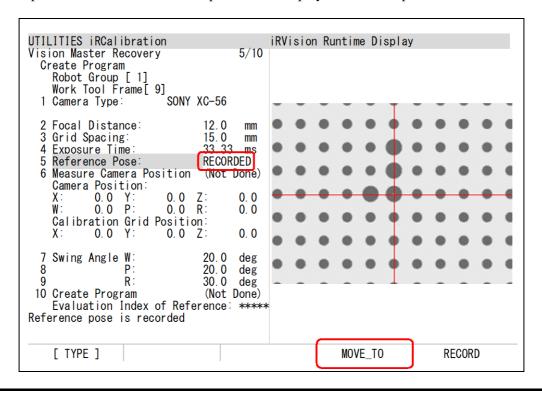5   Set the exposure time (ms) for vision measurement.

```
UTILITIES iRCalibration
Vision Master Recovery              4/10
   Create Program
     Robot Group [ 1]
     Work Tool Frame[ 9]
  1 Camera Type:           SONY XC-56

  2 Focal Distance:          12.0   mm
  3 Grid Spacing:            15.0   mm
  4 Exposure Time:           33.33  ms
  5 Reference Pose:          UNINIT
  6 Measure Camera Position  (Not Done)
     Camera Position:

[ TYPE ] TIME+   TIME-    LIVE    FIND
```

Refer to subsection 3.2 "DISPLAYING THE RUNTIME MONITOR" so that an image and the "Create Program" screen can be seen simultaneously. The following explains an example of displaying an image and the "Create Program" screen simultaneously on *i*Pendant. The display on the teach pendant is shown below.

```
UTILITIES iRCalibration                iRVision Runtime Display
Vision Master Recovery              4/10
   Create Program
     Robot Group [ 1]
     Work Tool Frame[ 9]
  1 Camera Type:           SONY XC-56

  2 Focal Distance:          12.0   mm
  3 Grid Spacing:            15.0   mm
  4 Exposure Time:           33.33  ms
  5 Reference Pose:          UNINIT
  6 Measure Camera Position  (Not Done)
     Camera Position:
     X:    0.0  Y:    0.0  Z:    0.0
     W:    0.0  P:    0.0  R:    0.0
     Calibration Grid Position:
     X:    0.0  Y:    0.0  Z:    0.0

  7 Swing Angle W:           20.0   deg
  8            P:            20.0   deg
  9            R:            30.0   deg
 10 Create Program           (Not Done)
     Evaluation Index of Reference: *****


      [ TYPE ]      TIME+        TIME-         LIVE          FIND
```

Set the exposure time on this screen by using function keys.
Function key functions

  F2 (TIME+):   Increases the "Exposure Time" value.
  F3 (TIME-):   Decreases the "Exposure Time" value.
  F4 (LIVE):   Displays the live image.
  F5 (FIND):   Detects the calibration grid.   If the detection has succeeded, a + mark is displayed on the dot detected.   If the detection has failed, an error message is displayed.

Tips

Pressing the F2 or the F3 key while holding down the SHIFT key changes the value at a faster rate.

> **NOTE**
>   Vision Master Recovery uses the exposure time set in this screen.
>   The exposure time setting in "Parameter Setting Screen" or "Mode Teaching
>   Screen" of the Vision Data Setup Screen does not apply here.
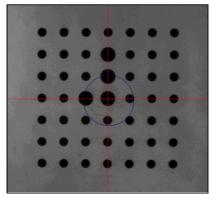
Appropriate exposure time:

Adjust the exposure time so that the image does not become pure white but rather gray in the lightest area of on the calibration grid.   And, adjust the exposure time such that the white background and black circles can be clearly distinguished.

Some image samples with different exposure times are shown below.

Calibration grid image with too short exposure time	Calibration grid image with appropriate exposure time	Calibration grid image with too long exposure time

> **NOTE**
>   On R-30*i*B Plus controller, 'Image Trimming' is added as an item to be set.
>   When using a KOWA monochrome camera SC130EF2, the time to process an
>   image may be longer than that of usual and/or it may become easier to detect
>   false at the end of the image because the number of pixels of this camera is
>   larger than existing cameras. In order to deal with such a problem, the number of
>   pixels of cameras can be reduced by setting the value of 'Image Trimming' in a
>   range from 0% to 75%.

```
UTILITIES iRCalibration
Vision Master Recovery            6/12
   Create Program
     Robot Group [ 1]
     Work Tool Frame[ 9]
  1 Camera Type:        iRVision camera
  2                        1: SC130EF2
  3 Focal Distance:       12.0   mm
  4 Grid Spacing:         15.0   mm
  5 Exposure Time:        33.33  ms
  6 Image Trimming:       50 %
  7 Reference Pose:       UNINIT
  8 Measure Camera Position  (Not Done)

[ TYPE ]   +       −      LIVE   FIND
```

6   Move the robot and teach the reference pose so that the origin of the calibration grid is near the center of the camera image.

```
UTILITIES iRCalibration          iRVision Runtime Display
Vision Master Recovery           5/10
  Create Program
    Robot Group [ 1]
    Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:        12.0   mm
  3 Grid Spacing:          15.0   mm
  4 Exposure Time:         33.33  ms
  5 Reference Pose:        UNINIT
  6 Measure Camera Position  (Not Done)
    Camera Position:
    X:    0.0 Y:    0.0 Z:    0.0
    W:    0.0 P:    0.0 R:    0.0
    Calibration Grid Position:
    X:    0.0 Y:    0.0 Z:    0.0

  7 Swing Angle W:        20.0   deg
  8           P:          20.0   deg
  9           R:          30.0   deg
 10 Create Program        (Not Done)
    Evaluation Index of Reference: *****


    [ TYPE ]                              MOVE_TO        RECORD
```

Move the cursor to "Reference Pose" on the "Create Program" screen, and then press the SHIFT key and the F5 (RECORD) key together.
The current position is stored as reference pose.   The display on the teach pendant is shown below.

```
UTILITIES iRCalibration          iRVision Runtime Display
Vision Master Recovery           5/10
  Create Program
    Robot Group [ 1]
    Work Tool Frame[ 9]
  1 Camera Type:        SONY XC-56

  2 Focal Distance:        12.0   mm
  3 Grid Spacing:          15.0   mm
  4 Exposure Time:         33.33  ms
  5 Reference Pose:        RECORDED
  6 Measure Camera Position  (Not Done)
    Camera Position:
    X:    0.0 Y:    0.0 Z:    0.0
    W:    0.0 P:    0.0 R:    0.0
    Calibration Grid Position:
    X:    0.0 Y:    0.0 Z:    0.0

  7 Swing Angle W:        20.0   deg
  8           P:          20.0   deg
  9           R:          30.0   deg
 10 Create Program        (Not Done)
    Evaluation Index of Reference: *****
Reference pose is recorded


    [ TYPE ]                              MOVE_TO        RECORD
```
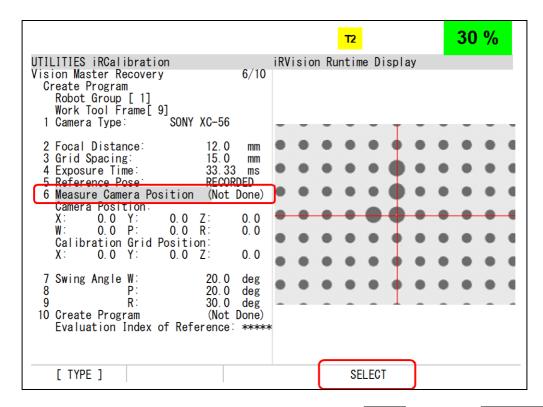
Tips
   If the "Reference Pose is "Recorded", you can move the robot to the reference
   position by pressing the F4 (MOVE_TO) key while holding down the SHIFT
   key ..
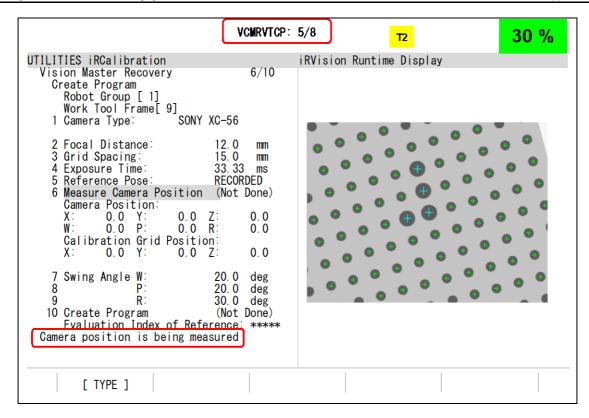
7   Set the override of the robot to 30% or less when T2 or AUTO mode is selected, and measure the camera position. If T1 mode is selected, the override can be improved more than 30%.

The camera position is measured while the robot automatically moves into multiple poses, with the reference pose as a measurement start pose.   The robot automatically moves several centimeters in the directions orthogonal to X, Y, and Z and by about 15 degrees in the pose directions of W, P, and R.   The camera position and calibration grid position are calculated based on the results of the vision measurement.

Move the cursor to "Measure Camera Position", then press the SHIFT key and the F4(SELECT) key together.

The camera position will be measured.   During measurement, the teach pendant displays the following screen.

NOTE
1   If the camera attachment position or the calibration grid position is changed, measure the camera position again.
2   Keep pressing the [SHIFT] key during the measurement. For 7DC3/09 (V8.30P/09) or earlier software, if pressing the SHIFT key is interrupted, resuming the measurement makes it restart from the beginning. For 7DC3/10 (V8.30P/10) or later software, when you resume the measurement after the interruption, if a part of the measurement has been completed, a confirmation message to select "RESUME" or "RESTART" is displayed. Then, if "RESUME" is selected, the measurement is resumed. If "RESTART" is selected, the measurement is restarted from the beginning. If the camera attachment position or the calibration grid position is changed, select "RESTART".
3   An attempt to perform camera position measurement during execution of another program causes an error with the following error message displayed: "INTP-313 (Z_VCLIB2,384) Motion statement failed, PROG-040 Already locked by other task"
    In this case, select "ABORT (ALL)" on the FCTN menu to terminate the program.

When the measurement is finished, the display on the teach pendant screen is as follows:
- The status of "Measure Camera Position" becomes "Done".
- The message "Camera position is measured" appears.
- The result of the measurement is displayed.

    Measurement result:
    - Camera Position: Position of visual TCP
    - Calibration Grid Position: Origin position of calibration grid

```
                                              T2            30 %

UTILITIES iRCalibration              iRVision Runtime Display
 Vision Master Recovery       6/10
   Create Program
     Robot Group [ 1]
     Work Tool Frame[ 9]
   1 Camera Type:        SONY XC-56

   2 Focal Distance:          12.0    mm
   3 Grid Spacing:            15.0    mm
   4 Exposure Time:           33.33   ms
   5 Reference Pose:          RECORDED
   6 Measure Camera Position  (Done    )
     Camera Position:
     X:   275.4  Y:      0.0  Z:      0.0
     W:    -0.0  P:      0.0  R:      0.0
     Calibration Grid Position:
     X:  1674.8  Y:      0.0  Z:    884.8

   7 Swing Angle W:           20.0   deg
   8           P:             20.0   deg
   9           R:             30.0   deg
   10 Create Program          (Not Done)
     Evaluation Index of Reference: *****
Camera position is measured

         [ TYPE ]                        SELECT
```

8   Set the swing angles W, P, and R of measuring poses for Vision Master Recovery.   For details on
     measuring poses, see subsection 6.3.1, "Outline of Measuring Poses".

```
                                              T2            30 %

UTILITIES iRCalibration              iRVision Runtime Display
 Vision Master Recovery       7/10
   Create Program
     Robot Group [ 1]
     Work Tool Frame[ 9]
   1 Camera Type:        SONY XC-56

   2 Focal Distance:          12.0    mm
   3 Grid Spacing:            15.0    mm
   4 Exposure Time:           33.33   ms
   5 Reference Pose:          RECORDED
   6 Measure Camera Position  (Done    )
     Camera Position:
     X:   275.4  Y:      0.0  Z:      0.0
     W:    -0.0  P:      0.0  R:      0.0
     Calibration Grid Position:
     X:  1674.8  Y:      0.0  Z:    884.8

   7 Swing Angle W:           20.0   deg
   8           P:             20.0   deg
   9           R:             30.0   deg
   10 Create Program          (Not Done)
     Evaluation Index of Reference: *****

         [ TYPE ]       DISP_IMG
```

The recommended range for "Swing Angle W/P" is 20 to 45 degrees.
The recommended range for "Swing Angle R" is 30 to 45 degrees.
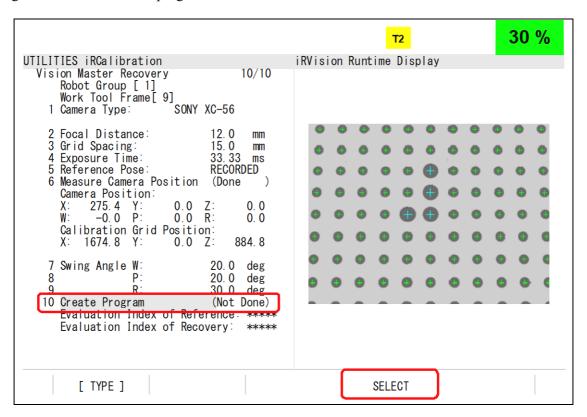
> **Tips**
> Increasing the swing angle improves the recovery accuracy of the mastering
> status but requires a wider operating range.
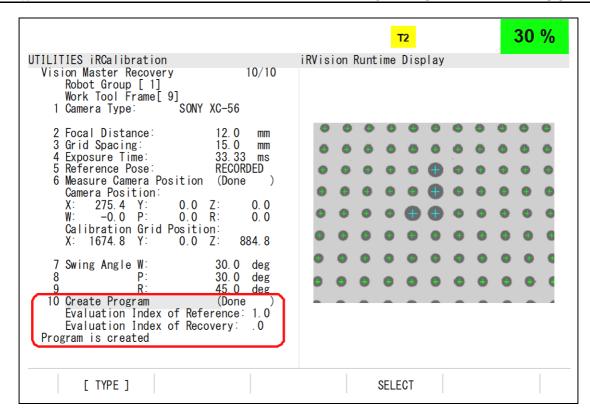
> **NOTE**
> If swing angle W or P exceeds 45 degrees, it may be impossible to perform
> vision measurement.   Do not allow swing angle W or P to exceed 45 degrees.

9   Move the cursor to "Create Program", then press the $\boxed{\text{F4 (SELECT)}}$ key or the $\boxed{\text{ENTER}}$ key to generate a measurement program.

Upon completion of the generation of the measurement program, the screen on the teach pendant changes as shown below.

- The "Create Program" status becomes "Done".
- The message "Program is created" is displayed.

```
                                                    T2            30 %

UTILITIES iRCalibration              iRVision Runtime Display
  Vision Master Recovery        10/10
    Robot Group [ 1]
    Work Tool Frame[ 9]
  1 Camera Type:       SONY XC-56

  2 Focal Distance:        12.0   mm
  3 Grid Spacing:          15.0   mm
  4 Exposure Time:         33.33  ms
  5 Reference Pose:        RECORDED
  6 Measure Camera Position (Done   )
    Camera Position:
    X:   275.4  Y:     0.0  Z:     0.0
    W:    -0.0  P:     0.0  R:     0.0
    Calibration Grid Position:
    X:  1674.8  Y:     0.0  Z:   884.8

  7 Swing Angle W:         30.0   deg
  8            P:          30.0   deg
  9            R:          45.0   deg
 10 Create Program         (Done   )
    Evaluation Index of Reference: 1.0
    Evaluation Index of Recovery:   .0
 Program is created

    [ TYPE ]                    SELECT
```
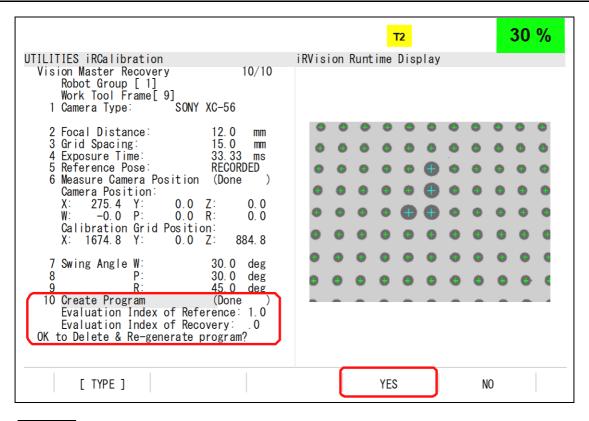
When robot group is 1, TP program VMRCV1, VMRDAT11, VMRDAT12, and VMRDAT13 are generated.   The first number of VMRCV1, VMRDAT11, VMRDAT12, and VMRDAT13 indicates a robot group.

10   Check the evaluation index of reference and the evaluation index of recovery. If the evaluation index of reference and/or the evaluation index of recovery are/is greater than 4.2, start at Step 8 over again. If the Evaluation Indices still are not improved, re-teach the reference pose to set the camera away from the calibration grid, and start at Step 6 again.

If a measurement program is generated with one already existing, the teach pendant displays the following message.

If the F4 (YES) key is selected, a new measurement program is generated.
If the F5 (NO) key is selected, a new measurement program is not generated, but the Evaluation Indices of an existing program are recalculated.

11   When generating is finished, select the PREV key to display the "Vision Master Recovery" screen.

6.5.6   Executing the Measurement Program for Reference
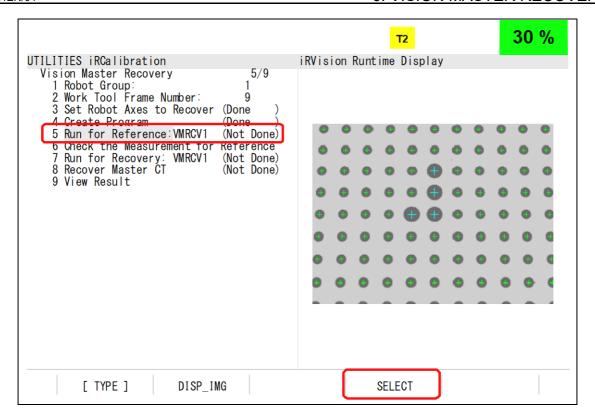
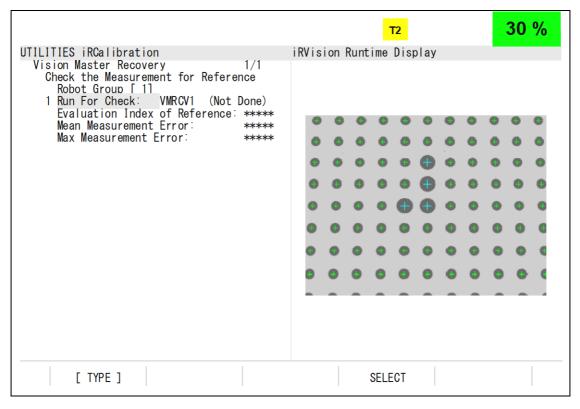### Procedure 6-4   Execute the measurement program for reference

Condition
- Make sure that the status of "Create Program" is "Done".
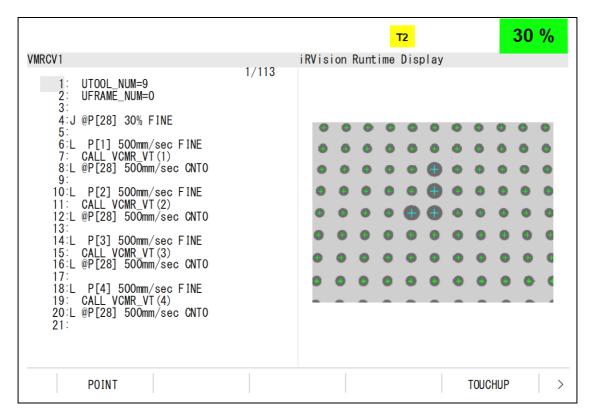
Step
1   Move the cursor to "Run for Reference", and press the F4 (SELECT) key or the ENTER key.

```
                                                    T2        30 %

UTILITIES iRCalibration              iRVision Runtime Display
  Vision Master Recovery           5/9
  1 Robot Group:                   1
  2 Work Tool Frame Number:        9
  3 Set Robot Axes to Recover  (Done    )
  4 Create Program              (Done    )
  5 Run for Reference:VMRCV1     (Not Done)
  6 Check the Measurement for Reference
  7 Run for Recovery: VMRCV1     (Not Done)
  8 Recover Master CT            (Not Done)
  9 View Result



    [ TYPE ]       DISP_IMG                 SELECT
```

The measurement program edit screen is displayed.

```
                                                    T2        30 %

VMRCV1                               iRVision Runtime Display
                             1/113
    1:   UTOOL_NUM=9
    2:   UFRAME_NUM=0
    3:
    4:J @P[28] 30% FINE
    5:
    6:L  P[1] 500mm/sec FINE
    7:   CALL VCMR_VT(1)
    8:L @P[28] 500mm/sec CNT0
    9:
   10:L  P[2] 500mm/sec FINE
   11:   CALL VCMR_VT(2)
   12:L @P[28] 500mm/sec CNT0
   13:
   14:L  P[3] 500mm/sec FINE
   15:   CALL VCMR_VT(3)
   16:L @P[28] 500mm/sec CNT0
   17:
   18:L  P[4] 500mm/sec FINE
   19:   CALL VCMR_VT(4)
   20:L @P[28] 500mm/sec CNT0
   21:

     POINT                              TOUCHUP       >
```

2   Set the override of the robot to 30% or less when T2 or AUTO mode is selected, and run the program displayed. If T1 mode is selected, the override can be improved more than 30%.

Tips
> If the robot cannot move to any of positions [1] to [27] during execution of the
> measurement program, make sure that the calibration grid resides within the
> field of view of the camera, then re-teach a position to which the robot can move.

NOTE
> For 7DC3/10 (V8.30P/10) or later software, call instructions of the program
> VCRSM_CHECK, label instructions, and jump instructions are added to the TP
> program so that efficient resuming of the measurement can be done. For details,
> refer to "6.6.1 TP Program".
> For 7DC3/10 (V8.30P/10) or later software, when the measurement is
> interrupted by the release of the SHIFT key, the occurrence of an alarm or other
> reasons, re-execute the TP program after moving the cursor to the first line. If a
> part of the measurement has been completed, a message "Press 0 (restart) or 9
> (resume)" appears. Press the 0 key to restart the measurement from the
> beginning or the 9 key to resume the measurement.

NOTE
> If the camera attachment position or the calibration grid position is changed,
> measure the camera position and generate the measurement program in "6.5.5
> Generating a Measurement Program" again.

3   When the measurement has been completed, display the "Vision Master Recovery" screen (see
Section 6.5.2, "Displaying the "Vision Master Recovery" screen").

6.5.7   Execute the Measurement Program for Check
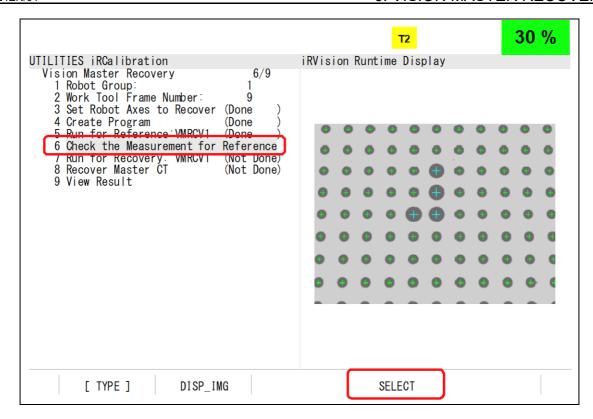
Procedure 6-5   Execute the measurement program for check

Condition
- Make sure that the status of "Run for Reference" is "Done".

Step
Move the cursor to "Check the Measurement for Reference", and then press the F4 (SELECT) or the
ENTER key.
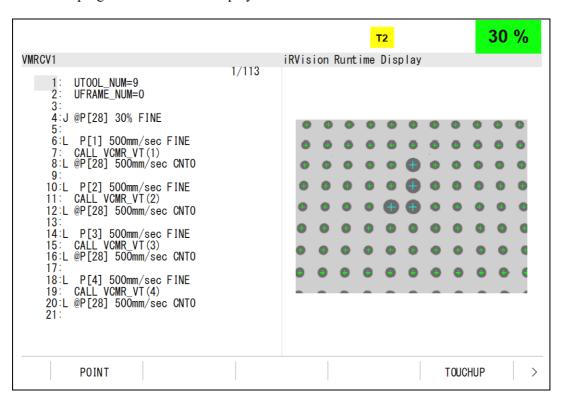
The teach pendant displays the "Check the Measurement for Reference" screen as shown below.

2   Press the F4 (SELECT) key or the ENTER key.

The measurement program edit screen is displayed.

3   Set the override of the robot to 30% or less when T2 or AUTO mode is selected, then run the displayed program. If T1 mode is selected, the override can be improved more than 30%.

⚠ **CAUTION**
    Please don't re-teach positions [1] to [27] of measurement program when this program is executed for check.

NOTE

For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the TP program so that efficient resuming of the measurement can be done. For details, refer to "6.6.1 TP Program".

For 7DC3/10 (V8.30P/10) or later software, when the measurement is interrupted by the release of the SHIFT key, the occurrence of an alarm or other reasons, re-execute the TP program after moving the cursor to the first line. If a part of the measurement has been completed, a message "Press 0 (restart) or 9 (resume)" appears. Press the 0 key to restart the measurement from the beginning or the 9 key to resume the measurement.

NOTE

If the camera attachment position or the calibration grid position is changed, measure the camera position and generate the measurement program in "6.5.5 Generating a Measurement Program", and execute the measurement program for reference in "6.5.6 Executing the Measurement Program for Reference" again.

---

4   When the measurement has been completed, display the "Vision Master Recovery" screen (see Section 6.5.2, "Displaying the "Vision Master Recovery" screen").

5   Move the cursor to "Check the Measurement for Reference", then press the F4 (SELECT) key or the ENTER key to display the "Check the Measurement for Reference" screen again.

The values of evaluation index of reference, mean measurement error, and max measurement error are displayed on the teach pendant.

Display items on "Check the Measurement for Reference" screen

Evaluation Index of Reference

This item indicates the evaluation index of the actual poses of the measurement program for reference

Mean Measurement Error

This item indicates the mean value [mm] of difference between visual TCP positions which are calculated by executing the measurement program for reference and visual TCP positions which are calculated by executing the measurement program for check (27 measurement poses).

Max Measurement Error

This item indicates the max value [mm] of difference between visual TCP positions which are calculated by executing the measurement program for reference and visual TCP positions which are calculated by executing the measurement program for check (27 measurement poses).

Confirmation

- Confirm that the evaluation index of reference is 4.2 or less.
  If the evaluation index of reference exceeds 4.2, there is a possibility that the calculation error of mastering parameters is large. Re-generate the measurement program with the maximum swing angle increased on the "Create Program" screen, and execute the program for reference and the program for check again.
- Confirm that the max measurement error is about 0.5mm or less.
  If the max measurement error is considerably larger than the above value, possible causes are that the lens or camera is not secured, the lens is out of focus, and that the calibration grid is not secured. Check these causes and execute the program for reference and the program for check again.

6   When the confirmation of evaluation index of reference, mean measurement error, and max measurement error have been finished, press the PREV key to display the "Vision Master Recovery" screen.

6.5.8   Replacing Robot Parts and Set Temporary Mastering Data

Procedure 6-6   Replacing robot parts and set temporary mastering data

Condition

- Make sure that the status of "Run For Check" on "Check the Measurement for reference" screen is "Done".

Step

1   Replace robot parts. For details on replacing robot parts, contact your local FANUC representative.

⚠ **CAUTION**
Installed or fixed positions of the camera and the calibration grid when executing the measurement program for reference and installed or fixed positions of the camera and the calibration grid when executing the measurement program for recovery must be equal respectively. Please do not change installed or fixed positions of the camera and the calibration grid during replacement of robot parts.

---

2   After replacement of robot parts, set temporary mastering data to the axes the mastering status of which are/is invalid by using single axis mastering etc., and perform calibration.

Tips
    Temporary mastering does not require a high level of precision.

6.5.9   Executing the Measurement Program for Recovery

Procedure 6-7   Executing the measurement program for recovery

Condition
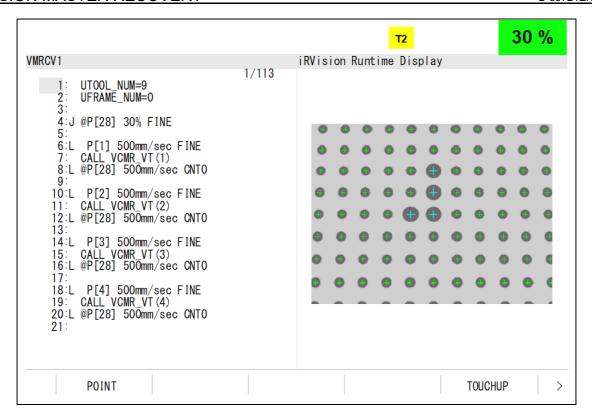
- Make sure that robot parts have been replaced and temporary mastering data have been set.

Step

1   Move the cursor to "Run for Recovery", and press the F4 (SELECT) key or the ENTER key.

The measurement program edit screen is displayed.

2   Set the override of the robot to 30% or less when T2 or AUTO mode is selected, then run the displayed program. If T1 mode is selected, the override can be improved more than 30%.

⚠ **CAUTION**
Please do not re-teach positions [1] to [27] of the measurement program when this program is executed for recovery.

NOTE
If the result of temporary mastering differs too much from the status of mastering before replacement of robot parts, one of four big circles may be out of the field of view.   The error, "CVIS-20 Big circles cannot be distinguished" is posted. If such a case occurs, please retry setting temporary mastering data.

NOTE
For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the TP program so that efficient resuming of the measurement can be done. For details, refer to "6.6.1 TP Program".
For 7DC3/10 (V8.30P/10) or later software, when the measurement is interrupted by the release of the SHIFT key, the occurrence of an alarm or other reasons, re-execute the TP program after moving the cursor to the first line. If a part of the measurement has been completed, a message "Press 0 (restart) or 9 (resume)" appears. Press the 0 key to restart the measurement from the beginning or the 9 key to resume the measurement.

---

3   When the measurement has been completed, display the "Vision Master Recovery" screen (see Section 6.5.2, "Displaying the "Vision Master Recovery" screen").

6.5.10   Recovering Mastering Status

Procedure 6-8   Recovering mastering status

Condition
- Make sure that the status of "Run for Recovery" is "Done".

Step
1   Move the cursor to "Recover Master CT", and press the F4 (SELECT) or the ENTER key.

```
UTILITIES iRCalibration
Vision Master Recovery              8/9
  1 Robot Group:                    1
  2 Work Tool Frame Number:         9
  3 Set Robot Axes to Recover (Done    )
  4 Create Program            (Done    )
  5 Run for Reference:VMRCV1  (Done    )
  6 Check the Measurement for Reference
  7 Run for Recovery: VMRCV1  (Done    )
  8 Recover Master CT          (Not Done)
  9 View Result


[ TYPE ]DISP_IMG              SELECT
```

The teach pendant displays the "Recover Master CT" screen as shown below.

```
UTILITIES iRCalibration
Vision Master Recovery
  Recover Master CT
    Robot Group [ 1]
    Evaluation Index of Recovery:  .7
    Mean Recovery Error:          .002
    Max Recovery Error:           .030
    Compensation Angles:
    J1:    0.000    J2:   -0.000
    J3:    0.000    J4:    0.000
    J5:    0.000    J6:   -0.000



[ TYPE ]              UPDATE
```

> **NOTE**
> The mastering status is not recovered yet at this point.

2   Confirm the items displayed. If there is no problem, update mastering data by pressing the F3 (UPDATE) key while holding down the SHIFT key.

Display items on Recover Master CT screen
Compensation Angles
    This item indicates the compensation angles for the angular displacement shifted from the zero position for each rotation axis [degree].

Evaluation Index of Recovery
    This item indicates the evaluation Index of the actual poses of the measurement program for recovery

Mean Recovery Error
This item indicates the mean value [mm] of difference between visual TCP positions which are calculated by executing the measurement program for reference and visual TCP positions which are calculated by executing the measurement program for recovery (27 measurement poses).

Max Recovery Error
This item indicates the max value [mm] of the difference between visual TCP positions which are calculated by executing the measurement program for reference and visual TCP positions which are calculated by executing the measurement program for recovery (27 measurement poses).

Confirmation
- Confirm that absolute values of compensation angles are 1° or less.
  If either absolute values of compensation angle are exceeding 1°, update mastering data and execute the measurement program for recovery again, and confirm that the absolute value of compensation angles displayed on "Recover Master CT" screen becomes smaller.
- Confirm that the max recovery error is about 0.5mm or less.
  If the max recovery error is considerably larger than the above value, possible causes are that the lens or camera is not secured, the lens is out of focus, and that the calibration grid is not secured. Check these causes and execute the program for recovery again.

Tips
 "Max Recovery Error" can be larger than the above approximate value in these cases:
- Tool attached to the robot is heavy.
- Robot holds heavy workpieces.
- Individual difference between the robot parts before replacement and the robot parts after replacement is large.
- Update mastering data.
- Execute the measurement program for recovery.
- Confirm "Compensation Angles" and "Max Recovery Error" on "Recover Master CT" screen.

Even though "Max Recovery Error" has not changed, if "Compensation Angles" becomes smaller, the result of Vision Master Recovery can be regarded as OK.

---

3   After updating the mastering data, set the reference position for Quick Mastering again, preparing for future Quick Mastering. If it has not been set, set it as all the axes' angles are 0 degree. For details of Quick Mastering, please refer to "R-30*i*B / R-30*i*B Mate OPERATOR'S MANUAL (Basic Operation)B-83284EN" and "Mechanical Unit Operator's Manual".

NOTE
In the following software versions, a notification "Ref. Pos. for Quick Mastering Not Set" will be displayed on the notifications screen when you execute Vision Master Recovery. This notification will be cleared when you set a quick mastering reference point.
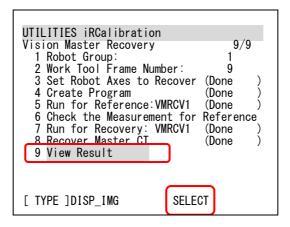   - 7DF1/34(V9.10P/34) or later
   - 7DF3/17(V9.30P/17) or later
   - 7DF5/14(V9.40P/14) or later
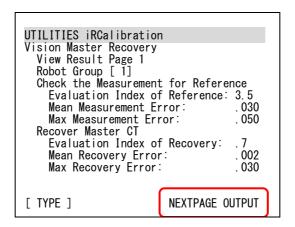

6.5.11   Viewing and Saving Recovering Results

Procedure 6-9   Viewing and saving recovering results

Step

1   Move the cursor to "View Result", then press the F4 (SELECT) key or the ENTER key.

```
UTILITIES iRCalibration
Vision Master Recovery             9/9
  1 Robot Group:                   1
  2 Work Tool Frame Number:        9
  3 Set Robot Axes to Recover (Done    )
  4 Create Program            (Done    )
  5 Run for Reference:VMRCV1   (Done    )
  6 Check the Measurement for Reference
  7 Run for Recovery: VMRCV1   (Done    )
  8 Recover Master CT          (Done    )
  9 View Result



[ TYPE ]DISP_IMG           SELECT
```

The teach pendant displays the "View Result" screen as shown below.

```
UTILITIES iRCalibration
Vision Master Recovery
  View Result Page 1
  Robot Group [ 1]
  Check the Measurement for Reference
    Evaluation Index of Reference: 3.5
    Mean Measurement Error:        .030
    Max Measurement Error:         .050
  Recover Master CT
    Evaluation Index of Recovery:  .7
    Mean Recovery Error:           .002
    Max Recovery Error:            .030


[ TYPE ]                   NEXTPAGE OUTPUT
```

Function key

F4(NEXTPAGE):   Displays the next page.

F5(OUTPUT):   Saves the results of Vision Master Recovery to VCMR_LOG.TXT. You can use the File I/O menu to set the device (memory card or USB memory) where the file is located. For details of using the file I/O menu, please refer to "R-30*i*B / R-30*i*B Mate OPERATOR'S MANUAL (Basic Operation)B-83284EN".

Tips
  If VCMR_LOG.TXT already exists, the new results are appended to the current contents.

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6.6 DETAILS OF TP PROGRAMS AND LOG FILE

6.6.1 TP Program

TP Program for Measurement

VMRCV*n* (*n*: robot group)

```
                 0    LINE
                    G1      JOINT   10 %
 1:  UTOOL_NUM=9 ;
 2:  UFRAME_NUM=0 ;
 3:  ;
 4:J P[28] 30% FINE    ;
 5:  ;
 6:L P[1] 500mm/sec FINE      ;
 7:  CALL VCMR_VT(1) ;
 8:L P[28] 500mm/sec CNT0      ;
 9:  ;
10:L P[2] 500mm/sec FINE      ;
11:  CALL VCMR_VT(2) ;
12:L P[28] 500mm/sec CNT0      ;
13:  ;
          ...
106:L P[26] 500mm/sec FINE      ;
107:  CALL VCMR_VT(26) ;
108:L P[28] 500mm/sec CNT0      ;
;
110:L P[27] 500mm/sec FINE      ;
111:  CALL VCMR_VT(27) ;
112:L P[28] 500mm/sec CNT0      ;
[END]
```

In position 1 to 27, the initial positions for measurements are recorded.
In position 28, the reference positions are recorded. (In the measurement it is used as start position for each measuring position)
VCMR_VT :   Karel program for positioning by vision
VCMR_VT (position number)

For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the TP program as below so that efficient resuming of the measurement can be done.

```
                0    LINE
                  G1     JOINT  10 %
  1:   CALL VCRSM_CHECK('START')  ;
  2:   UTOOL_NUM=9 ;
  3:   UFRAME_NUM=0 ;
  4:     ;
  5:   IF $VCRSM_CFG.$STEP_NUM>=2,
       JMP LBL[2]  ;
  6:   CALL VCRSM_CHECK(1)  ;
  7:J P[28] 30% FINE     ;
  8:L P[1] 500mm/sec FINE     ;
  9:   CALL VCMR_VT(1,0)  ;
 10:     ;
 11:   LBL[2]  ;
 12:   IF $VCRSM_CFG.$STEP_NUM>=3,
       JMP LBL[3]  ;
 13:   CALL VCRSM_CHECK(2)  ;
 14:L P[28] 500mm/sec CNT0     ;
 15:L P[2] 500mm/sec FINE     ;
 16:   CALL VCMR_VT(2,0)  ;
      ...
179:   LBL[26]  ;
180:   IF $VCRSM_CFG.$STEP_NUM>=27,
       JMP LBL[27]  ;
181:   CALL VCRSM_CHECK(26)  ;
182:L P[28] 500mm/sec CNT0     ;
183:L P[26] 500mm/sec FINE     ;
184:   CALL VCMR_VT(26,0)  ;
185:     ;
186:   LBL[27]  ;
187:   CALL VCRSM_CHECK(27)  ;
188:L P[28] 500mm/sec CNT0     ;
189:L P[27] 500mm/sec FINE     ;
190:   CALL VCMR_VT(27,0)  ;
191:     ;
192:   CALL VCRSM_CHECK('END')  ;
193:L P[28] 500mm/sec CNT0     ;
[END]
```

VCRSM_CHECK :　　　　　　　　Karel program related to the resuming of the measurement.
　　　　　　　　　　　　　　　　The argument is to be 'START', 'END' or measurement number.

TP Program for Recording the Measuring Results

VMRDAT*nm* (*n*: robot group, m=1: for reference, m=2: for recovery, m=3: for check)

```
                0    LINE
                  G1     JOINT  10 %
  1:   UTOOL_NUM=9 ;
  2:   UFRAME_NUM=0 ;
  3:   ;
  4:L P[1] 500mm/sec FINE     ;
  5:L P[2] 500mm/sec FINE     ;
      ...
 29: L P[26] 500mm/sec FINE     ;
 30: L P[27] 500mm/sec FINE     ;
[END]
```

In position 1 to 27, the positioning results are recorded.

6.6.2   Log File

Log File of the Vision Master Recovery Result

VCMR_LOG.TXT

```
iRCalibration VM Recovery Log File

Robot Group [1]
Robot Model:              R-2000iB/165F
Robot Number:             F00000
Soft Version:             V8.20P/12
Measure Time:             28-MAR-14 21:35
Log Time:                 28-MAR-14 21:35

Robot Axes to Recover
[1]: 0 [2]: 1 [3]: 1
[4]: 0 [5]: 0 [6]: 0

Camera Position:
  X:  -166.886  Y:   -10.091  Z:  1215.119
  W:     -.887  P:      .555  R:  -176.844

Focal Distance:               12.0mm
Grid Spacing:                 15.0mm

Target Position:
  X:  1223.023  Y:   -31.160  Z:  -334.992

New Master Counts:
[1]:          -888
[2]:        654004
[3]:      -1491513
[4]:     138859409
[5]:        818453
[6]:      16451966
[7]:             0
[8]:             0
[9]:             0

Compensation Angles:
[1]:    0.000 [2]:     .196 [3]:     .101
[4]:    0.000 [5]:    0.000 [6]:    0.000

Run for Reference
Evaluation Index:          4.1
Mean Measurement Error: .140
Max Measurement Error:  .213

Run for Recovery
Evaluation Index:          1.2
Mean Recovery Error:    .061
Max Recovery Error:     .212

Origin Master Counts:
[1]:          -888
[2]:        737100
[3]:      -1374420
[4]:     138859409
[5]:        818453
[6]:      16451966
[7]:             0
[8]:             0
[9]:             0
```

6.7   AVAILABLE TARGET

The available target is the calibration grid for Vision Master Recovery.

6.7.1   Calibration Grid

The available calibration grid for Vision Master Recovery should satisfy the specification shown as below.
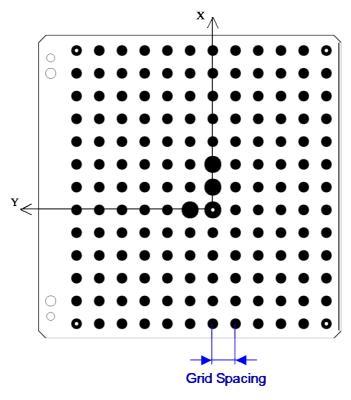
Fig. 6.7.1 Calibration Grid

All of the black circles are arranged so that they are uniformly spaced horizontally and perpendicularly. Four larger black circles placed in the vicinity of the center indicate the origin and directions of a coordinate system as shown.   The ratio of the diameter of a large circle to that of a small circle is about 10:6.

The size of the calibration grid should be selected to fit the view field of the camera.
The aim of selection is set as below:
    When the standoff (the distance between the lens of the camera and the calibration grid) is set as about 500mm, the longest distance among three larger black circles along the X-axis is equal to 1/4 to 1/5 of the length of the view filed of the camera.

The calibration grids for *i*RVision shown as below are available.

List 6.7.1 Calibration Grid (for *i*RVision)

Type	Size (mm)	Grid Spacing (mm)
Camera Calibration Plate A	100	7.5
Camera Calibration Plate B	200	15
Camera Calibration Plate C	400	30

7 VISION AXIS MASTER

7.1 VISION AXIS MASTER

What is Vision Axis Master?

If mastering data of the robot is lost during maintenance or replacement of items such as the motor, the Vision Axis Master can recover the mastering status by aligning the target mark that is attached to the robot by vision measurement. This function can be also used if the voltage of the backup battery for encoders drops low and mastering data is lost. This function can play a role that is achieved by using vernier marks or mark-off lines for zero point.

Features and Limitations of Vision Axis Master

- Manual operations are simplified. In addition, this function recovers the mastering status precisely without depending on the skill of the operator.
- This function requires the target mark and the AMU (Axis Measuring Unit).

7.2 OVERVIEW OF VISION AXIS MASTER

7.2.1 System Configuration

The Vision Axis Master system consists of a robot controller, a teach pendant (*i*Pendant), an AMU, a camera cable, and target marks.
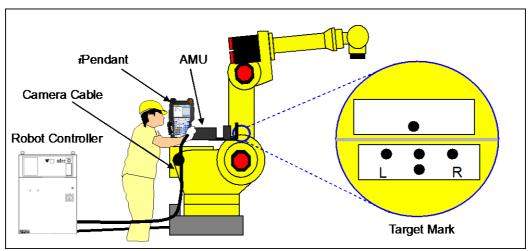
Fig. 7.2.1   System configuration of Vision Axis Master

7.2.2 Overview of Target Mark

- The target mark is attached to each axis of the robot.
- The target mark is detected by vision measurement of Vision Axis Master.
- The target marks are an option of the mechanical unit of the robot. Therefore, when the robot is ordered, target marks need to be ordered together.
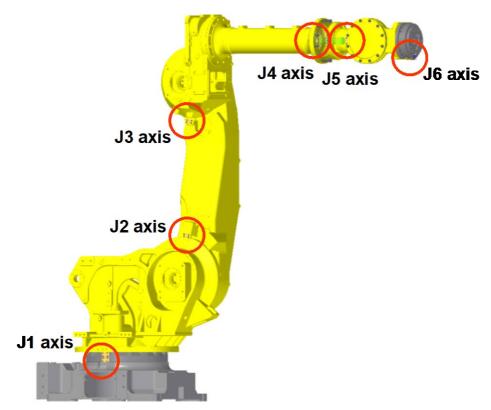
Fig. 7.2.2(a) Attaching positions of target mark sets (R-2000*i*B/250F)

Target sticker and target fixture

- Target marks can be classified into 2 types, "target sticker" and "target fixture".
- Target stickers are stuck on the robot when shipping the robot. The target stickers are protected by cover plates that prevent damage and dirt. Please detach the cover plate before measurement.
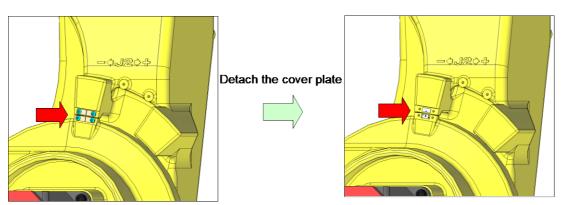

Detach the cover plate

Fig. 7.2.2(b) J2 axis of R-2000*i*B/250F (target sticker)

⚠ **CAUTION**
  Please do not peel the target stickers from the robot.

- Target fixtures are attached to the robot by screws or magnets. The target fixtures are attached only when the measurement is executed, not to be broken or dirty, and not to be interfered with cables. Target fixtures can be shared between robots of the same type.

Fig. 7.2.2(c) J6 axis of R-2000*i*B/250F (target fixture)

> **NOTE**
> The specification of the target mark depends on the type of the robot and the axis for measurement. For details, refer to the "Mechanical Unit Operator's Manual".

Part A and part B of target mark

- Target mark consists of two parts, "part A" and "part B" as shown in Fig. 7.2.2(d).
- Part B of the target mark has one dot for vision measurement.
- Part A of the target mark has four dots for vision measurement, which are located as the capital "T". The capital "L" and "R" are printed on part A of the target mark to identify the direction of the target mark easily.
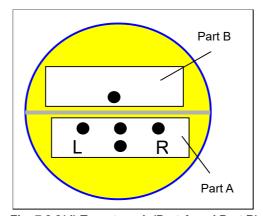

Fig. 7.2.2(d) Target mark (Part A and Part B)

CV number of target fixture

- Some types of the target fixture have a CV (calibration value) number printed on a sticker. If such a target fixture is used for the vision measurement, the CV number needs to be entered on the teach pendant before measurement to reduce the influence of individual difference of the target fixture.
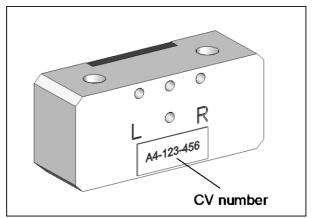
Fig. 7.2.2(e) CV number of target fixture (part A for J4 axis of R-2000iB/250F)

7.2.3   Overview of AMU

- AMU (Axis Measuring Unit) is the camera unit for Vision Axis Master.
- A red LED light is attached to the AMU. This LED light illuminates when the AMU is connected to the robot controller and the robot controller is powered.
- There are two types of the bracket for the AMU. One is for measurement from the front side and the other is for step measurement.

NOTE

There are two types of AMU. One is for R-30iB/R-30iB Mate controller, and the other is for R-30iB Plus controller. Please prepare an AMU that matches the controller.
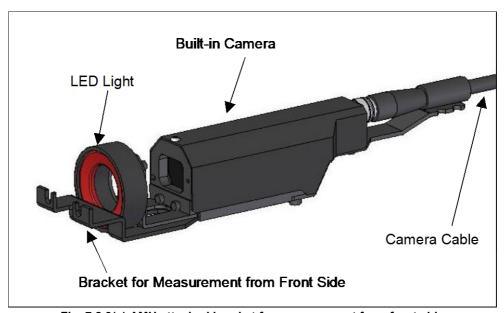

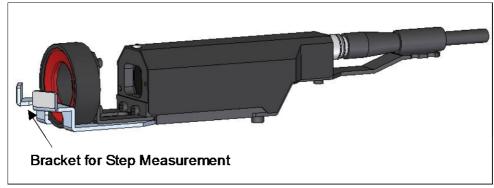**Fig. 7.2.3(a) AMU attached bracket for measurement from front side**

Fig. 7.2.3(b) AMU attached bracket for step measurement

- As shown in Fig. 7.2.3(c), the operator manually holds the AMU in place. The bracket allows the operator to maintain the proper standoff distance and tilt angle with respect to part A.
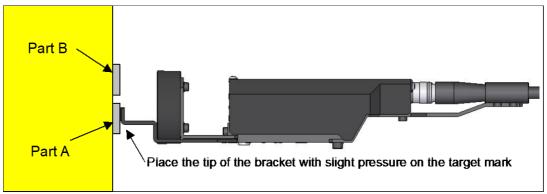

Fig. 7.2.3(c) Target mark and AMU

7.2.4   Overview of Vision Measurement

There are two types of vision measurement. One is "measurement from front side" and the other is "measurement from right side and left side".

Overview of measurement from front side

- As shown in Fig. 7.2.4(a), the bracket for the AMU is aligned with the front of the target mark.

Fig. 7.2.4(a) Position of AMU during measurement from front side

- The axis will move automatically to align the Part B dot with the Part A dots. Vision provides feedback to the program for measurements that move the axis in the correct direction.
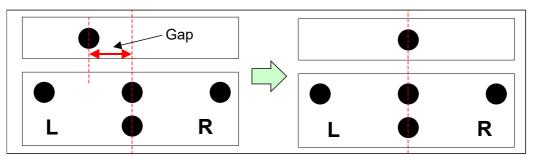- The marks oscillate until a minimum threshold is satisfied and the adjustment is considered complete.

Fig. 7.2.4(b) Measurement from front side (moving to reference position)

Overview of measurement from right side and left side

- As shown in Fig 7.2.4(c), the AMU is aligned with the right side of the target mark for a while, and then aligned with the left side of the target mark for a while.
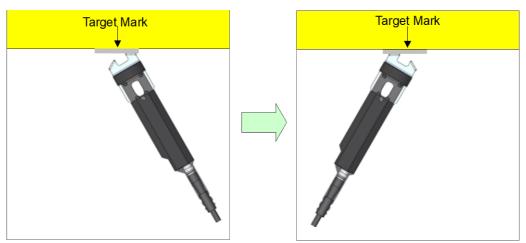

Fig. 7.2.4(c) Position of AMU during measurement from right side and left side

The front measurement bracket ensures the AMU is at a zero degree tilt, however the AMU can still be off centered. Knowing the step interval value allows a perspective correction for the off center value.
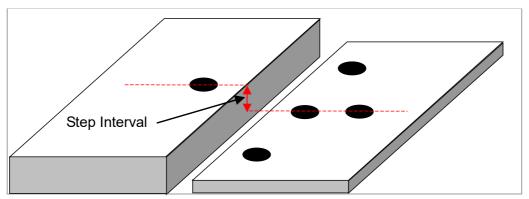

Fig. 7.2.4(d) Step interval is measured by measurement from right side and left side

7.2.5   Basic Functions

Vision Axis Master provides four basic functions:
1.   *Reference Data Setting*
2.   *1-Axis Mastering*
3.   *Encoder Mastering*
4.   *Step Measurement*

Reference data setting function

- When executing the *reference data setting* function, the measurement from the front side is executed to align the axis which has a valid mastering status. The position of the axis is saved after the measurement is completed as the reference data in the robot controller. The unit of reference data is a "deg" (rotational axis) or "mm" (linear axis). The *Reference Data Setting* function must be performed before the *1-Axis Mastering* function or the *Encoder Mastering* function.

- The *Reference data setting* function is executed in the FANUC robot factory before the robot is shipped. There is not tool attached. However, the weight of a tool can cause an error in the reference data. After a tool is attached, the *reference data setting* function should be performed and saved again. (This new reference data needs to be used if the mastering status needs to be recovered.)

> **NOTE**
> 1   Reference data of a robot consists of "reference data 1", "reference data 2", … "reference data 10".
> 2   Each reference data stores the measured reference data for all axes.
> 3   The reference positions that are set in the FANUC robot factory (mentioned above) are stored in reference data 10. (Known as the factory data.)
> 4   The reference data number should correspond with the tool number.

> **NOTE**
> *Reference data setting* cannot be executed if the mastering status of at least axis is invalid.

1-axis mastering function

When the mastering status is lost by replacement of the motor etc. it can be recovered using *1-axis mastering*, the measurement from the front side is executed to align the invalid axis. The mastering status of the axis is recovered by calculating mastering data from reference data. *1-axis mastering* recovers the mastering status accurately, quickly, and independent of the skill of the operator.

> **NOTE**
> 1   *1-axis mastering* cannot be applied if a robot arm or the wrist unit is replaced.
> 2   To reduce the influence of the tool weight on the mastering status, use reference data that was set with the same tool.

Encoder mastering function

The *Encoder mastering* function is used when the mastering status is lost by the drop of the voltage of the backup battery for encoders. By executing *encoder mastering* function, the measurement from the front side is executed to align the axis. Next, the mastering status of the axis is recovered by calculating mastering data from the reference data. The mastering result is the same as the traditional "Quick mastering". However, encoder mastering has an advantage over quick mastering since it is not necessary to jog the robot precisely to the reference position.

> **NOTE**
> 1 *Encoder mastering* cannot be applied if a robot arm, the wrist unit, a reducer, a motor, or a pulse coder is replaced.
> 2 To reduce the influence of the tool weight on the mastering status of the axis to be recovered, use reference data that was defined with the same tool.

Step measurement function

The step measurement function is used to measure the reference position and the step interval. The front measurement and the right side left side measurements are made. This function is performed before shipping from the factory and rarely needs to be repeated.
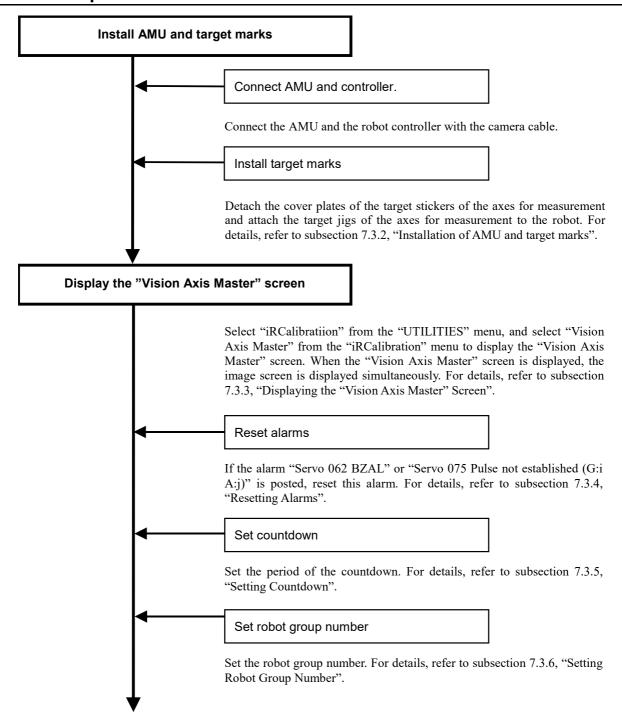
> **NOTE**
> 1 The step interval will be changed if a robot arm or a reducer is replaced, therefore the *step measurement* function will need to be executed again.
> 2 The step measurement cannot be executed if there is at least one axis with an invalid mastering status.
> 3 No tool is attached to the robot when the step measurement is executed.
> 4 The all reference positions of the axis should be set again after the *step measurement* function is performed.
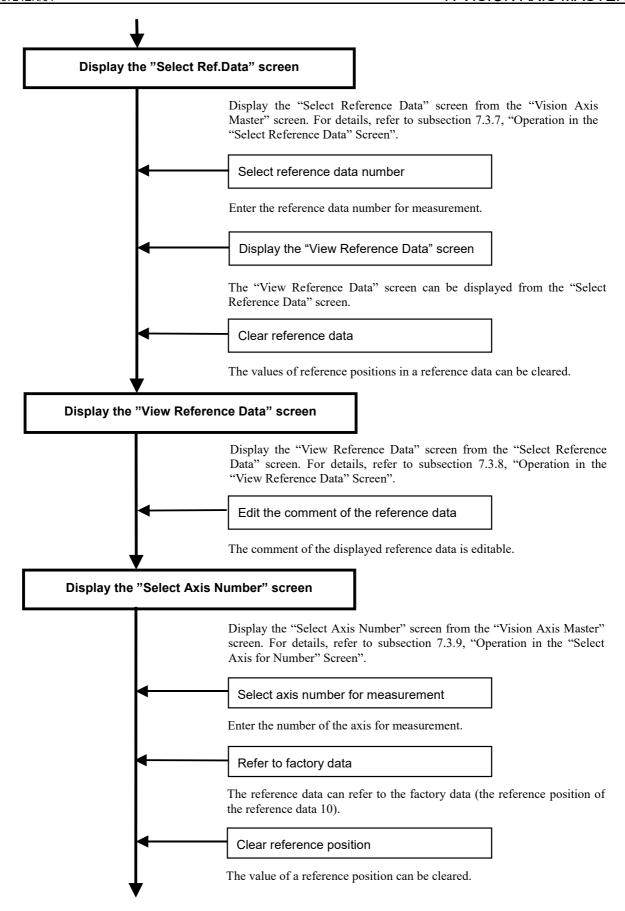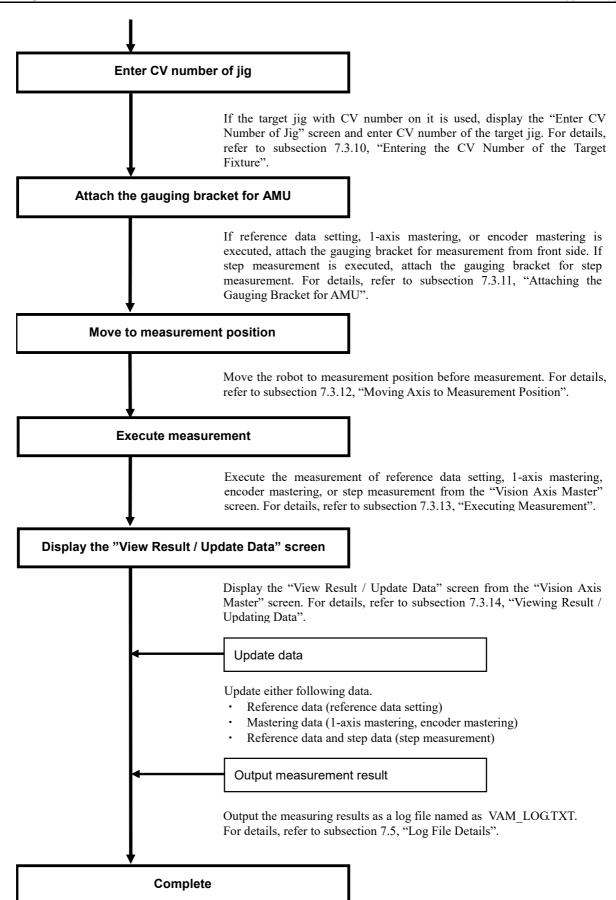
7.3   OPERATION OF VISION AXIS MASTER

This section describes the procedure for Vision Axis Master.

7.3.1   Operation Procedure

```
┌─────────────────────────────────────────────┐
│        Install AMU and target marks          │
└─────────────────────────────────────────────┘
              │
              │         ┌──────────────────────────────────┐
              │◄────────│   Connect AMU and controller.     │
              │         └──────────────────────────────────┘
              │
              │   Connect the AMU and the robot controller with the camera cable.
              │
              │         ┌──────────────────────────────────┐
              │◄────────│   Install target marks            │
              │         └──────────────────────────────────┘
              │
              │   Detach the cover plates of the target stickers of the axes for measurement
              │   and attach the target jigs of the axes for measurement to the robot. For
              │   details, refer to subsection 7.3.2, "Installation of AMU and target marks".
              ▼
┌─────────────────────────────────────────────┐
│    Display the "Vision Axis Master" screen    │
└─────────────────────────────────────────────┘
              │
              │   Select "iRCalibratiion" from the "UTILITIES" menu, and select "Vision
              │   Axis Master" from the "iRCalibration" menu to display the "Vision Axis
              │   Master" screen. When the "Vision Axis Master" screen is displayed, the
              │   image screen is displayed simultaneously. For details, refer to subsection
              │   7.3.3, "Displaying the "Vision Axis Master" Screen".
              │
              │         ┌──────────────────────────────────┐
              │◄────────│   Reset alarms                    │
              │         └──────────────────────────────────┘
              │
              │   If the alarm "Servo 062 BZAL" or "Servo 075 Pulse not established (G:i
              │   A:j)" is posted, reset this alarm. For details, refer to subsection 7.3.4,
              │   "Resetting Alarms".
              │
              │         ┌──────────────────────────────────┐
              │◄────────│   Set countdown                   │
              │         └──────────────────────────────────┘
              │
              │   Set the period of the countdown. For details, refer to subsection 7.3.5,
              │   "Setting Countdown".
              │
              │         ┌──────────────────────────────────┐
              │◄────────│   Set robot group number          │
              │         └──────────────────────────────────┘
              │
              │   Set the robot group number. For details, refer to subsection 7.3.6, "Setting
              │   Robot Group Number".
              ▼
```

Display the "Select Ref.Data" screen

Display the "Select Reference Data" screen from the "Vision Axis Master" screen. For details, refer to subsection 7.3.7, "Operation in the "Select Reference Data" Screen".

Select reference data number

Enter the reference data number for measurement.

Display the "View Reference Data" screen

The "View Reference Data" screen can be displayed from the "Select Reference Data" screen.

Clear reference data

The values of reference positions in a reference data can be cleared.

Display the "View Reference Data" screen

Display the "View Reference Data" screen from the "Select Reference Data" screen. For details, refer to subsection 7.3.8, "Operation in the "View Reference Data" Screen".

Edit the comment of the reference data

The comment of the displayed reference data is editable.

Display the "Select Axis Number" screen

Display the "Select Axis Number" screen from the "Vision Axis Master" screen. For details, refer to subsection 7.3.9, "Operation in the "Select Axis for Number" Screen".

Select axis number for measurement

Enter the number of the axis for measurement.

Refer to factory data

The reference data can refer to the factory data (the reference position of the reference data 10).

Clear reference position

The value of a reference position can be cleared.

```
                    ┌────────────────────────────────────┐
                    │      Enter CV number of jig          │
                    └────────────────────────────────────┘
```

If the target jig with CV number on it is used, display the "Enter CV Number of Jig" screen and enter CV number of the target jig. For details, refer to subsection 7.3.10, "Entering the CV Number of the Target Fixture".

```
                    ┌────────────────────────────────────┐
                    │   Attach the gauging bracket for AMU │
                    └────────────────────────────────────┘
```

If reference data setting, 1-axis mastering, or encoder mastering is executed, attach the gauging bracket for measurement from front side. If step measurement is executed, attach the gauging bracket for step measurement. For details, refer to subsection 7.3.11, "Attaching the Gauging Bracket for AMU".

```
                    ┌────────────────────────────────────┐
                    │      Move to measurement position    │
                    └────────────────────────────────────┘
```

Move the robot to measurement position before measurement. For details, refer to subsection 7.3.12, "Moving Axis to Measurement Position".

```
                    ┌────────────────────────────────────┐
                    │          Execute measurement         │
                    └────────────────────────────────────┘
```

Execute the measurement of reference data setting, 1-axis mastering, encoder mastering, or step measurement from the "Vision Axis Master" screen. For details, refer to subsection 7.3.13, "Executing Measurement".

```
                    ┌────────────────────────────────────┐
                    │ Display the "View Result / Update Data" screen │
                    └────────────────────────────────────┘
```

Display the "View Result / Update Data" screen from the "Vision Axis Master" screen. For details, refer to subsection 7.3.14, "Viewing Result / Updating Data".

```
                              ┌──────────────────────────┐
                    ◄─────────│        Update data         │
                              └──────────────────────────┘
```

Update either following data.
- Reference data (reference data setting)
- Mastering data (1-axis mastering, encoder mastering)
- Reference data and step data (step measurement)

```
                              ┌──────────────────────────┐
                    ◄─────────│   Output measurement result │
                              └──────────────────────────┘
```

Output the measuring results as a log file named as VAM_LOG.TXT. For details, refer to subsection 7.5, "Log File Details".

```
                    ┌────────────────────────────────────┐
                    │              Complete                │
                    └────────────────────────────────────┘
```

7.3.2   Installation of AMU and Target Marks

Connect the AMU, which is the camera unit for Vision Axis Master, to the robot controller. In case of R-30*i*B controller, the way to connect the AMU is the same as for SONY XC-56.   In case of R-30*i*B Plus controller, the way to connect the AMU is the same as for KOWA SC130EF2. So for details, refer to section 3.1.2, "Connecting the Camera to the Robot Controller or the *i*Pendant".

> **NOTE**
>   Make sure that the LED light of the AMU is illuminated on after the AMU is connected on the robot controller and that the robot controller is on.

Detach the cover plates of the target stickers of the axes for measurement and attach the target fixtures to the axes for measurement. The specification of target fixtures depends on the robot model and the axis for measurement. For details, refer to "Mechanical Unit Operator's Manual".

7.3.3   Displaying the "Vision Axis Master" Screen
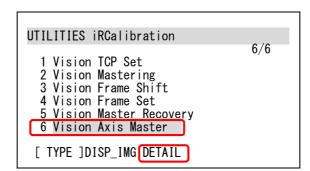
Procedure 7-1   Displaying the "Vision Axis Master" screen

Step
1   Press the MENU key, move the cursor to "UTILITIES", and press the ENTER key.

2   Press the F1[TYPE] key, move the cursor to "*i*RCalibration", and press the ENTER key.
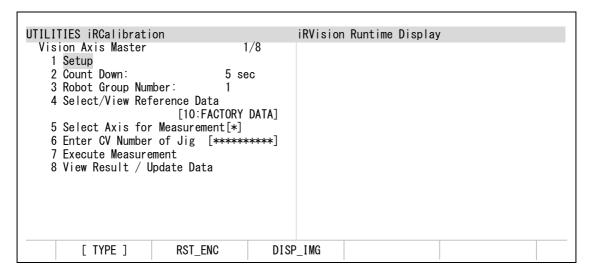
The following screen appears on the teach pendant.
The available item list of *i*RCalibration functions is displayed in this screen. The items to be displayed are different depending on which options are installed.

```
UTILITIES iRCalibration
                                          6/6
  1 Vision TCP Set
  2 Vision Mastering
  3 Vision Frame Shift
  4 Vision Frame Set
  5 Vision Master Recovery
  6 Vision Axis Master

[ TYPE ]DISP_IMG DETAIL
```

3   Move the cursor to "Vision Axis Master" and press the F3(DETAIL) key or the ENTER key.

The window of the teach pendant is divided in two automatically, and the "Vision Axis Master" screen and the image screen are displayed simultaneously, as shown below.

```
UTILITIES iRCalibration               iRVision Runtime Display
 Vision Axis Master            1/8
   1 Setup
   2 Count Down:           5 sec
   3 Robot Group Number:      1
   4 Select/View Reference Data
                    [10:FACTORY DATA]
   5 Select Axis for Measurement[*]
   6 Enter CV Number of Jig  [**********]
   7 Execute Measurement
   8 View Result / Update Data




        [ TYPE ]       RST_ENC       DISP_IMG
```

7.3.4   Resetting Alarms
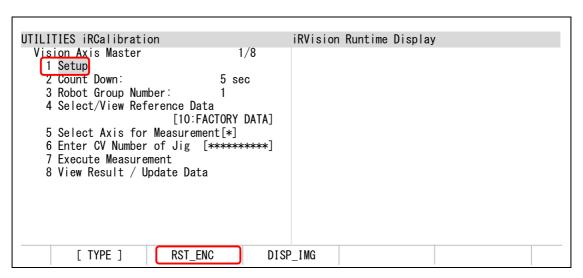
Procedure 7-2   Resetting alarms

Condition

- If the alarm "Servo 062 BZAL" or "Servo 075 Pulse not established (G:i A:j)" is posted after the replacement of the batteries or robot parts, reset these alarms by using the following procedure.

Step

1   To reset the alarm "Servo 062 BZAL", move the cursor to "Setup", press the F2(RST_ENC) key, and cycle controller power.

```
UTILITIES iRCalibration               iRVision Runtime Display
 Vision Axis Master            1/8
   1 Setup
   2 Count Down:           5 sec
   3 Robot Group Number:      1
   4 Select/View Reference Data
                    [10:FACTORY DATA]
   5 Select Axis for Measurement[*]
   6 Enter CV Number of Jig  [**********]
   7 Execute Measurement
   8 View Result / Update Data




        [ TYPE ]       RST_ENC       DISP_IMG
```

2   To reset the alarm "Servo 075 Pulse not established (G:i A:j)", jog the axis which is indicated by the alarm message by about 10 degrees in either direction.
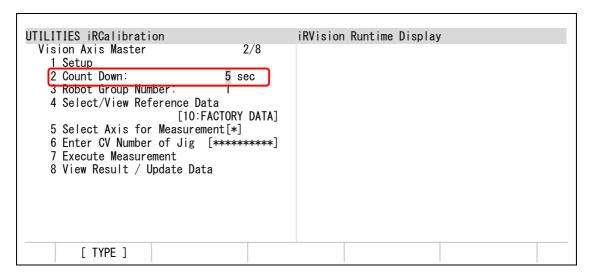
7.3.5   Setting Countdown

As soon as the item "7 Execute Measurement" is executed, a message will be displayed in the bottom of the screen as "Move camera to front side.   5", "4", "3", "2", "1", and the vision detection will be started after the countdown. The tip of the gauging bracket for AMU should be placed on the target mark with slight pressure by the end of the countdown to prevent the misdetection. The default period of countdown is 5 sec, and the period of the countdown can be adjusted in the "Vision Axis Master" screen.

Procedure 7-3   Setting countdown

Step

1   The period of the countdown can be changed by moving the cursor to "Countdown" on the "Vision Axis Master" screen and entering the period of the countdown.

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master          2/8
   1 Setup
   2 Count Down:             5 sec
   3 Robot Group Number:       1
   4 Select/View Reference Data
                    [10:FACTORY DATA]
   5 Select Axis for Measurement[*]
   6 Enter CV Number of Jig  [*********]
   7 Execute Measurement
   8 View Result / Update Data



         [ TYPE ]
```
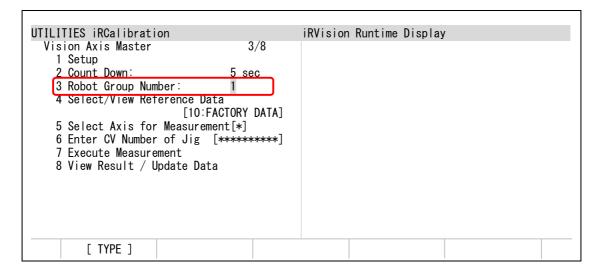
7.3.6   Setting Robot Group Number

Procedure 7-4   Setting robot group number

Step

1   Move the cursor to "Robot Group Number" on the "Vision Axis Master" screen, and enter the robot group number.

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master          3/8
   1 Setup
   2 Count Down:             5 sec
   3 Robot Group Number:       1
   4 Select/View Reference Data
                    [10:FACTORY DATA]
   5 Select Axis for Measurement[*]
   6 Enter CV Number of Jig  [*********]
   7 Execute Measurement
   8 View Result / Update Data



         [ TYPE ]
```
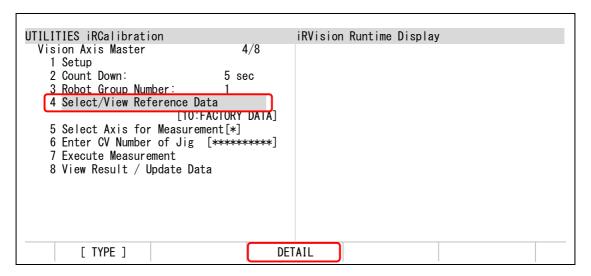
7.3.7   Operation in the "Select Reference Data" Screen

Procedure 7-5   Operation in the "Select Reference Data" screen

Condition
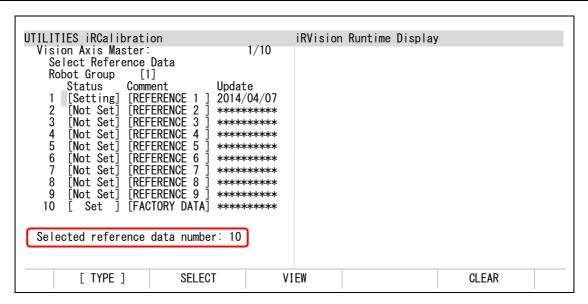
- Make sure that robot group number is set before the operation in the "Select Reference Data" screen.

Step

1   Move the cursor to "Select/View Reference Data" on the "Vision Axis Master" screen, and press the
F3(DETAIL) key or the ENTER key.

```
UTILITIES iRCalibration                iRVision Runtime Display
  Vision Axis Master            4/8
    1 Setup
    2 Count Down:            5 sec
    3 Robot Group Number:       1
    4 Select/View Reference Data
                      [10:FACTORY DATA]
    5 Select Axis for Measurement[*]
    6 Enter CV Number of Jig  [*********]
    7 Execute Measurement
    8 View Result / Update Data




        [ TYPE ]                DETAIL
```

The teach pendant displays the "Select Reference Data" screen as shown below.

```
UTILITIES iRCalibration                iRVision Runtime Display
  Vision Axis Master:            1/10
    Select Reference Data
    Robot Group    [1]
      Status    Comment       Update
    1  [Setting] [REFERENCE 1 ] 2014/04/07
    2  [Not Set] [REFERENCE 2 ] *********
    3  [Not Set] [REFERENCE 3 ] *********
    4  [Not Set] [REFERENCE 4 ] *********
    5  [Not Set] [REFERENCE 5 ] *********
    6  [Not Set] [REFERENCE 6 ] *********
    7  [Not Set] [REFERENCE 7 ] *********
    8  [Not Set] [REFERENCE 8 ] *********
    9  [Not Set] [REFERENCE 9 ] *********
   10  [ Set  ] [FACTORY DATA] *********

  Selected reference data number: 10


        [ TYPE ]     SELECT      VIEW             CLEAR
```

The selected reference data number is displayed in the bottom of the screen.

```
UTILITIES iRCalibration                    iRVision Runtime Display
  Vision Axis Master:                  1/10
   Select Reference Data
   Robot Group     [1]
      Status   Comment       Update
   1  [Setting] [REFERENCE 1 ] 2014/04/07
   2  [Not Set] [REFERENCE 2 ] **********
   3  [Not Set] [REFERENCE 3 ] **********
   4  [Not Set] [REFERENCE 4 ] **********
   5  [Not Set] [REFERENCE 5 ] **********
   6  [Not Set] [REFERENCE 6 ] **********
   7  [Not Set] [REFERENCE 7 ] **********
   8  [Not Set] [REFERENCE 8 ] **********
   9  [Not Set] [REFERENCE 9 ] **********
  10  [ Set  ] [FACTORY DATA] **********

  Selected reference data number: 10


       [ TYPE ]      SELECT        VIEW              CLEAR
```

The reference data status is displayed in three ways as shown below.
- [Set] means reference data of all axes are set.
- [Not Set] means none of the axes are set.
- [Setting] means some of the axes are set and the rest are not.
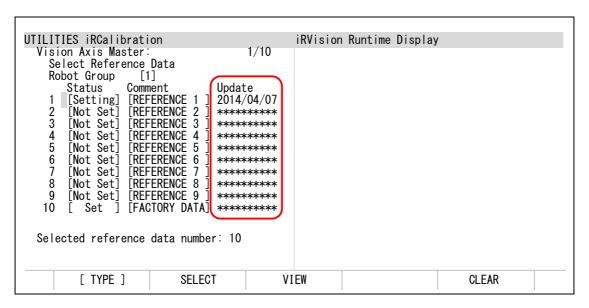
```
UTILITIES iRCalibration                    iRVision Runtime Display
  Vision Axis Master:                  1/10
   Select Reference Data
   Robot Group     [1]
      Status   Comment       Update
   1  [Setting] [REFERENCE 1 ] 2014/04/07
   2  [Not Set] [REFERENCE 2 ] **********
   3  [Not Set] [REFERENCE 3 ] **********
   4  [Not Set] [REFERENCE 4 ] **********
   5  [Not Set] [REFERENCE 5 ] **********
   6  [Not Set] [REFERENCE 6 ] **********
   7  [Not Set] [REFERENCE 7 ] **********
   8  [Not Set] [REFERENCE 8 ] **********
   9  [Not Set] [REFERENCE 9 ] **********
  10  [ Set  ] [FACTORY DATA] **********

  Selected reference data number: 10


       [ TYPE ]      SELECT        VIEW              CLEAR
```

The status of reference data 10 is [Set] from the beginning because it is set in the FANUC factory. For details, refer to "Setting reference data" of subsection 7.2.5, "Basic Functions".

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```
UTILITIES iRCalibration                iRVision Runtime Display
  Vision Axis Master:              1/10
   Select Reference Data
   Robot Group    [1]
     Status   Comment      Update
  1 [Setting] [REFERENCE 1 ] 2014/04/07
  2 [Not Set] [REFERENCE 2 ] **********
  3 [Not Set] [REFERENCE 3 ] **********
  4 [Not Set] [REFERENCE 4 ] **********
  5 [Not Set] [REFERENCE 5 ] **********
  6 [Not Set] [REFERENCE 6 ] **********
  7 [Not Set] [REFERENCE 7 ] **********
  8 [Not Set] [REFERENCE 8 ] **********
  9 [Not Set] [REFERENCE 9 ] **********
 10 [  Set  ] [FACTORY DATA] **********

   Selected reference data number: 10



       [ TYPE ]      SELECT        VIEW                    CLEAR
```

The date when reference data has been finally updated is displayed in "Update" list.

```
UTILITIES iRCalibration                iRVision Runtime Display
  Vision Axis Master:              1/10
   Select Reference Data
   Robot Group    [1]
     Status   Comment      Update
  1 [Setting] [REFERENCE 1 ] 2014/04/07
  2 [Not Set] [REFERENCE 2 ] **********
  3 [Not Set] [REFERENCE 3 ] **********
  4 [Not Set] [REFERENCE 4 ] **********
  5 [Not Set] [REFERENCE 5 ] **********
  6 [Not Set] [REFERENCE 6 ] **********
  7 [Not Set] [REFERENCE 7 ] **********
  8 [Not Set] [REFERENCE 8 ] **********
  9 [Not Set] [REFERENCE 9 ] **********
 10 [  Set  ] [FACTORY DATA] **********

   Selected reference data number: 10



       [ TYPE ]      SELECT        VIEW                    CLEAR
```

2   Press the F2(SELECT) key to display "Enter reference data number" in the bottom of the screen, enter a reference data number which is to be selected, and press the ENTER key.

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master:              1/10
   Select Reference Data
   Robot Group     [1]
      Status    Comment        Update
   1  [Setting] [REFERENCE 1 ] 2014/04/07
   2  [Not Set] [REFERENCE 2 ] **********
   3  [Not Set] [REFERENCE 3 ] **********
   4  [Not Set] [REFERENCE 4 ] **********
   5  [Not Set] [REFERENCE 5 ] **********
   6  [Not Set] [REFERENCE 6 ] **********
   7  [Not Set] [REFERENCE 7 ] **********
   8  [Not Set] [REFERENCE 8 ] **********
   9  [Not Set] [REFERENCE 9 ] **********
  10  [  Set  ] [FACTORY DATA] **********

  Enter reference data number:       2

       [ TYPE ]        SELECT        VIEW                   CLEAR
```

> ⚠ **CAUTION**
> Step measurement can be executed only if the selected reference data number
> is 10.

3   The "View Reference data" screen can be displayed by moving the cursor to the number of the
     reference data which you want to view and pressing the F3(VIEW) key. For details, refer to
     subsection 7.3.8, "Operation in "View Reference Data" Screen".

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master:              1/10
   Select Reference Data
   Robot Group     [1]
      Status    Comment        Update
   1  [Setting] [REFERENCE 1 ] 2014/04/07
   2  [Not Set] [REFERENCE 2 ] **********
   3  [Not Set] [REFERENCE 3 ] **********
   4  [Not Set] [REFERENCE 4 ] **********
   5  [Not Set] [REFERENCE 5 ] **********
   6  [Not Set] [REFERENCE 6 ] **********
   7  [Not Set] [REFERENCE 7 ] **********
   8  [Not Set] [REFERENCE 8 ] **********
   9  [Not Set] [REFERENCE 9 ] **********
  10  [  Set  ] [FACTORY DATA] **********

  Selected reference data number:  2

       [ TYPE ]        SELECT        VIEW                   CLEAR
```

4   The reference data (reference positions of all axes) status of which is "Set" or "Setting" can be
     cleared by moving the cursor to reference data which you want to clear, pressing the F5(CLEAR)
     key, and pressing the F4(YES) key subsequently.

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master:              1/10
   Select Reference Data
   Robot Group     [1]
      Status    Comment       Update
    1  [Setting] [REFERENCE 1 ] 2014/04/07
    2  [Not Set] [REFERENCE 2 ] **********
    3  [Not Set] [REFERENCE 3 ] **********
    4  [Not Set] [REFERENCE 4 ] **********
    5  [Not Set] [REFERENCE 5 ] **********
    6  [Not Set] [REFERENCE 6 ] **********
    7  [Not Set] [REFERENCE 7 ] **********
    8  [Not Set] [REFERENCE 8 ] **********
    9  [Not Set] [REFERENCE 9 ] **********
   10  [  Set  ] [FACTORY DATA] **********

  Selected reference data number:  2


        [ TYPE ]      SELECT        VIEW                 CLEAR
```

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master:              1/10
   Select Reference Data
   Robot Group     [1]
      Status    Comment       Update
    1  [Setting] [REFERENCE 1 ] 2014/04/07
    2  [Not Set] [REFERENCE 2 ] **********
    3  [Not Set] [REFERENCE 3 ] **********
    4  [Not Set] [REFERENCE 4 ] **********
    5  [Not Set] [REFERENCE 5 ] **********
    6  [Not Set] [REFERENCE 6 ] **********
    7  [Not Set] [REFERENCE 7 ] **********
    8  [Not Set] [REFERENCE 8 ] **********
    9  [Not Set] [REFERENCE 9 ] **********
   10  [  Set  ] [FACTORY DATA] **********

  Clear reference data[ 1]?


        [ TYPE ]                          YES           NO
```

5   If the reference data has been selected, press the PREV key to display the "Vision Axis Master"
     screen.

7.3.8   Operation in the "View Reference Data" Screen

Procedure 7-6   Operation in the "View Reference Data" screen

Step

1   If you want to display the "View Reference Data" screen, move the cursor to the number of
     reference data which you want to view on the "Select Reference Data" screen, and press the
     F3(VIEW) key.

```
UTILITIES iRCalibration              iRVision Runtime Display
 Vision Axis Master:              1/10
  Select Reference Data
  Robot Group     [1]
     Status   Comment       Update
 1   [Setting] [REFERENCE 1 ] 2014/04/07
 2   [Not Set] [REFERENCE 2 ] **********
 3   [Not Set] [REFERENCE 3 ] **********
 4   [Not Set] [REFERENCE 4 ] **********
 5   [Not Set] [REFERENCE 5 ] **********
 6   [Not Set] [REFERENCE 6 ] **********
 7   [Not Set] [REFERENCE 7 ] **********
 8   [Not Set] [REFERENCE 8 ] **********
 9   [Not Set] [REFERENCE 9 ] **********
 10  [ Set  ] [FACTORY DATA] **********

 Selected reference data number:  2


      [ TYPE ]      SELECT       VIEW              CLEAR
```

The teach pendant displays the "View Reference Data" screen as shown below.

```
UTILITIES iRCalibration              iRVision Runtime Display
 Vision Axis Master:              1/1
  View Reference Data
  Robot Group     [1]
  Reference Data  [ 1:REFERENCE 1 ]

       Referene Position
  J1    -0.007 deg (Factory)
  J2     0.001 deg
  J3  ******** deg
  J4    -0.002 deg (Factory)
  J5  ******** deg
  J6  ******** deg


 Selected reference data number: 2


      [ TYPE ]
```
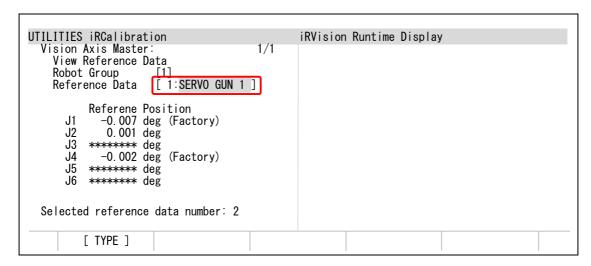
- The value of the reference position is displayed in the Reference Position area if set.
- "********" is displayed in the Reference Position area when not set.
- "(FACTORY)" is displayed on right side of the Reference Position area if reference data of the axis refers to factory data.

```
UTILITIES iRCalibration              iRVision Runtime Display
 Vision Axis Master:              1/1
  View Reference Data
  Robot Group     [1]
  Reference Data  [ 1:REFERENCE 1 ]

       Referene Position
  J1    -0.007 deg (Factory)
  J2     0.001 deg
  J3  ******** deg
  J4    -0.002 deg (Factory)
  J5  ******** deg
  J6  ******** deg


 Selected reference data number: 2


      [ TYPE ]
```

> **Tips**
>
> The time to set reference data can be shortened by referring factory data instead of setting reference data to the axis that is hardly bended by the weight of the tool. (For example, the J1 axis of a serial link type robot such as the R-2000*i*B). The setting of referring to factory data can be done on the "Axis for Measurement" screen.

2   The comment of reference data can be edited by pressing the ENTER key, entering new comment, and pressing the ENTER key again.

```
UTILITIES iRCalibration            iRVision Runtime Display
   Vision Axis Master:           1/1
     View Reference Data
     Robot Group        [1]
     Reference Data  [ 1:SERVO GUN 1 ]

          Referene Position
     J1    -0.007 deg (Factory)
     J2     0.001 deg
     J3   ******** deg
     J4    -0.002 deg (Factory)
     J5   ******** deg
     J6   ******** deg


   Selected reference data number: 2


       [ TYPE ]
```

> **Tips**
>
> The comment of reference data should be the name of tool.

3   Display the "Select Reference Data" screen by pressing the PREV key.

7.3.9   Operation in the "Select Axis Number" Screen
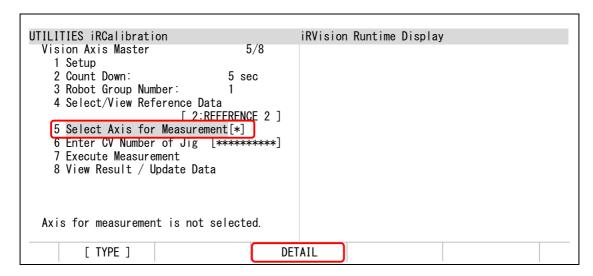
Procedure 7-7   Operation in the "Select Axis Number" screen

Condition

- Make sure that setting robot group number and selecting reference data number are completed before the operation in the "Select Axis Number" screen.

Step

1   Move the cursor to "Select Axis for Measurement" in the "Vision Axis Master" screen, and press the F3(DETAIL) key or the ENTER key.

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master              5/8
    1 Setup
    2 Count Down:              5 sec
    3 Robot Group Number:       1
    4 Select/View Reference Data
                      [ 2:REFFERENCE 2 ]
    5 Select Axis for Measurement[*]
    6 Enter CV Number of Jig  [*********]
    7 Execute Measurement
    8 View Result / Update Data



  Axis for measurement is not selected.

         [ TYPE ]                    DETAIL
```

The teach pendant displays the "Select Axis Number" screen as shown below.
"********" is displayed in the line of the axis the reference data of which is not set.

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master:                1/6
    View Reference Data
    Robot Group       [1]
    Reference Data    [ 2:REFERENCE 2 ]

             Reference Position
    1 J1   ******** deg
    2 J2   ******** deg
    3 J3   ******** deg
    4 J4   ******** deg
    5 J5   ******** deg
    6 J6   ******** deg

  Axis for measurement is not selected.

         [ TYPE ]         SELECT        FACTORY
```
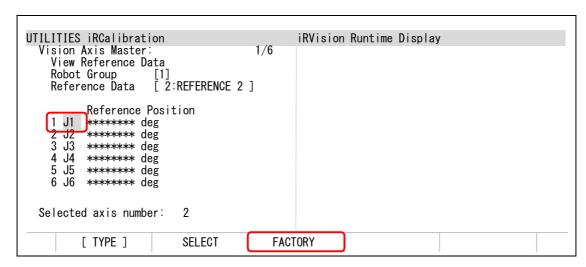
2   Press the F2(SELECT) key to display "Enter Axis Number", enter the number of the axis for
     measurement, and press the ENTER key.

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master:                1/6
    View Reference Data
    Robot Group       [1]
    Reference Data    [ 2:REFERENCE 2 ]

             Reference Position
    1 J1   ******** deg
    2 J2   ******** deg
    3 J3   ******** deg
    4 J4   ******** deg
    5 J5   ******** deg
    6 J6   ******** deg


  Enter axis number:              2

         [ TYPE ]         SELECT        FACTORY
```

If the number of the axis for measurement is selected, the selected number is displayed in the bottom line
of the screen as shown below.

```
UTILITIES iRCalibration                    iRVision Runtime Display
  Vision Axis Master:                 1/6
    View Reference Data
    Robot Group     [1]
    Reference Data  [ 2:REFERENCE 2 ]

            Reference Position
  1 J1  ******** deg
  2 J2  ******** deg
  3 J3  ******** deg
  4 J4  ******** deg
  5 J5  ******** deg
  6 J6  ******** deg

 Selected axis number:   2

        [ TYPE ]       SELECT       FACTORY
```

3   The reference position, which is indicated by the cursor, can be set to refer to factory data by pressing the F3(FACTORY) key. (Factory data is the reference position of reference data 10)
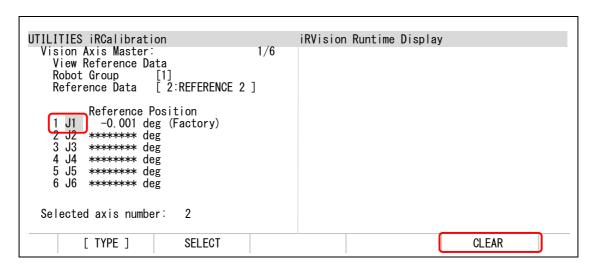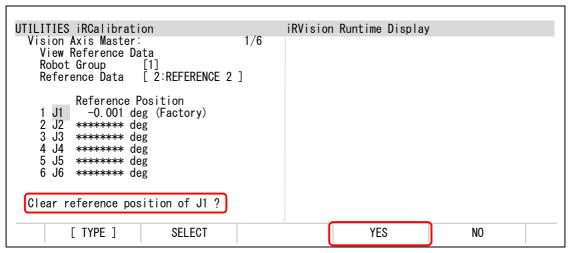
```
UTILITIES iRCalibration                    iRVision Runtime Display
  Vision Axis Master:                 1/6
    View Reference Data
    Robot Group     [1]
    Reference Data  [ 2:REFERENCE 2 ]

            Reference Position
  1 J1  ******** deg
  2 J2  ******** deg
  3 J3  ******** deg
  4 J4  ******** deg
  5 J5  ******** deg
  6 J6  ******** deg

  Selected axis number:   2

        [ TYPE ]       SELECT       FACTORY
```

Tips
   The time to set reference data can be shortened by referring factory data instead
   of setting reference data to the axis that is hardly bended by the weight of the
   tool. (For example, J1 axis of a serial link type robot as R-2000*i*B).

If the reference position is set to refer to the factory data, the value of the reference position (same value as factory data) and "(FACTORY)" are displayed on the line such as below.

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```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master:           1/6
    View Reference Data
    Robot Group       [1]
    Reference Data    [ 2:REFERENCE 2 ]

          Reference Position
  1 J1    -0.001 deg (Factory)
  2 J2  ******** deg
  3 J3  ******** deg
  4 J4  ******** deg
  5 J5  ******** deg
  6 J6  ******** deg

  Selected axis number:    2

         [ TYPE ]      SELECT                            CLEAR
```

4   The value of the reference position which is indicated by the cursor can be cleared by pressing the F5(CLEAR) key and then pressing the F4(YES) key.

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master:           1/6
    View Reference Data
    Robot Group       [1]
    Reference Data    [ 2:REFERENCE 2 ]

          Reference Position
  1 J1    -0.001 deg (Factory)
  2 J2  ******** deg
  3 J3  ******** deg
  4 J4  ******** deg
  5 J5  ******** deg
  6 J6  ******** deg

  Selected axis number:    2

         [ TYPE ]      SELECT                            CLEAR
```

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master:           1/6
    View Reference Data
    Robot Group       [1]
    Reference Data    [ 2:REFERENCE 2 ]

          Reference Position
  1 J1    -0.001 deg (Factory)
  2 J2  ******** deg
  3 J3  ******** deg
  4 J4  ******** deg
  5 J5  ******** deg
  6 J6  ******** deg

  Clear reference position of J1 ?

         [ TYPE ]      SELECT                    YES          NO
```

5   If the axis for measurement is selected, press the PREV key to display the "Vision Axis Master" screen.

7.3.10   Entering the CV Number of the Target Fixture

Procedure 7-8   Entering CV number of target fixture

Condition

- Make sure that setting robot group number, selecting reference data number, and selecting axis for measurement are completed before entering in CV number of the target fixture.
- If two parts (part A and part B) of the target mark of the axis for measurement are target stickers, the status of "Enter CV Number of Fixture" is "Not Needed". In this case, the CV number does not need to be entered.

```
UTILITIES iRCalibration              iRVision Runtime Display
 Vision Axis Master            6/8
   1 Setup
   2 Count Down:              5 sec
   3 Robot Group Number:        1
   4 Select/View Reference Data
                        [ 2:REFERENCE 2 ]
   5 Select Axis for Measurement[*]
   6 Enter CV Number of Jig  [Not Needed]
   7 Execute Measurement
   8 View Result / Update Data




        [ TYPE ]
```

Step

1   If at least one target fixture with the CV number on it is used for measurement, the CV number of the target fixture must be entered. Move the cursor to "Enter CV Number of Fixture" on the "Vision Axis Master" screen and enter the F3(DETAIL) key or the ENTER key.

```
UTILITIES iRCalibration              iRVision Runtime Display
 Vision Axis Master            6/8
   1 Setup
   2 Count Down:              5 sec
   3 Robot Group Number:        1
   4 Select/View Reference Data
                        [ 2:REFERENCE 2 ]
   5 Select Axis for Measurement[*]
   6 Enter CV Number of Jig  [ Not Done ]
   7 Execute Measurement
   8 View Result / Update Data




        [ TYPE ]                      DETAIL
```

The teach pendant displays the "Enter CV Number of Fixture" screen shown below. If two parts of the target mark are target fixtures, two CV numbers need to be entered, and if either one part of the target mark is target fixture, one CV number needs to be entered. The following screen displays when two parts of the target mark are target fixtures.

```
UTILITIES iRCalibration                iRVision Runtime Display
  Vision Axis Master:              1/2
    Enter CV Number of Jig
    Robot Group      [1]
    Referene Data    [ 2:REFERENCE 2 ]
    Axis for Measurement[4]

    1 A4-
    2 B4-



         [ TYPE ]
```

2   Press the ENTER key, enter the CV number which is printed on the sticker which is stuck on the target fixture to the line which is indicated by the cursor, and press the ENTER key again.

```
UTILITIES iRCalibration                iRVision Runtime Display
  Vision Axis Master:              1/2
    Enter CV Number of Jig
    Robot Group      [1]
    Referene Data    [ 2:REFERENCE 2 ]
    Axis for Measurement[4]

    1 A4-
    2 B4-



         [ TYPE ]
```

NOTE
   Please include hyphens for CV number.
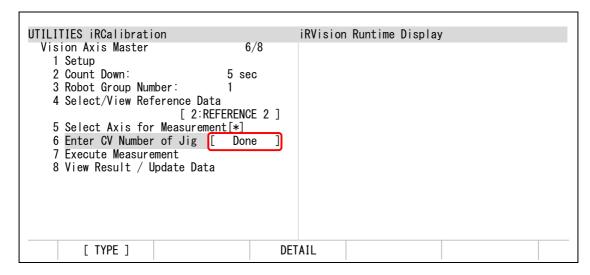
The following screen is an example after entering the CV numbers.

```
UTILITIES iRCalibration                iRVision Runtime Display
  Vision Axis Master:              2/2
    Enter CV Number of Jig
    Robot Group      [1]
    Referene Data    [ 2:REFERENCE 2 ]
    Axis for Measurement[4]

    1 A4-123-456
    2 B4-789



         [ TYPE ]
```
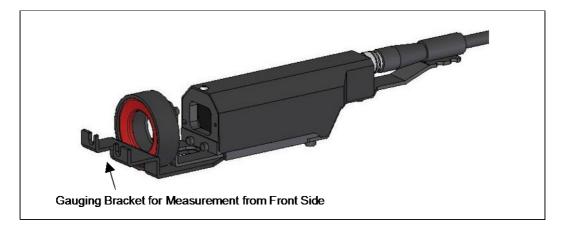
3   After entering the CV numbers of target fixtures, display the "Vision Axis Master" screen by pressing the PREV key and make sure that the status of "Enter CV Number of Fixture" is changed to "Done".

```
UTILITIES iRCalibration              iRVision Runtime Display
  Vision Axis Master              6/8
   1 Setup
   2 Count Down:              5 sec
   3 Robot Group Number:        1
   4 Select/View Reference Data
                       [ 2:REFERENCE 2 ]
   5 Select Axis for Measurement[*]
   6 Enter CV Number of Jig  [   Done   ]
   7 Execute Measurement
   8 View Result / Update Data



         [ TYPE ]                    DETAIL
```
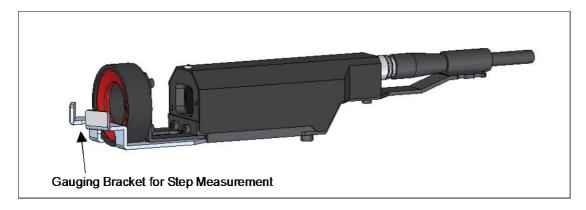
7.3.11 Attaching Gauging Bracket for AMU

- Attach the gauging bracket for measurement from the front side to the AMU when reference data setting, 1-axis mastering, or encoder mastering is executed.

Gauging Bracket for Measurement from Front Side

- Attach the gauging bracket for step measurement to the AMU when step measurement is executed.

Gauging Bracket for Step Measurement

7.3.12 Moving Axis to Measurement Position
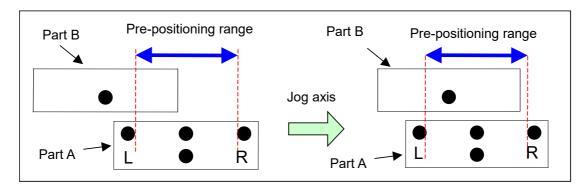
If the position of the robot when recovering mastering status is significantly different from the position of the robot when setting reference data, the recovering accuracy of the mastering status may be low, because the magnitude of the bending of the axis may be changed. To prevent this, move the robot to

measurement position before measurement. For details of measurement position, refer to the mechanical unit operator's manual.

Tips
1   Reference Data 10 is set without any tooling at the factory before shipping.
    The robot is measured by the measurement position that is mentioned in the mechanical unit operator's manual.
2   The positional accuracy of jogging to the measurement position does not require a high level of precision.

NOTE
    Jog the axis for measurement so that the dot on Part B is within the pre-positioning range of Part A. (see the figure below)

7.3.13   Executing Measurement
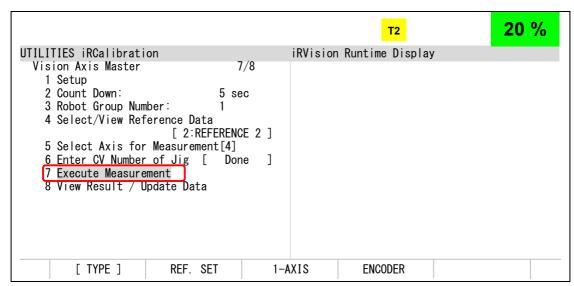
Procedure 7-9   Executing reference data setting, 1-axis mastering, or encoder mastering

Condition
*   Make sure that setting the robot group number, selecting reference data, selecting axis for measurement, and entering CV number of the fixture, are completed before executing measurement.
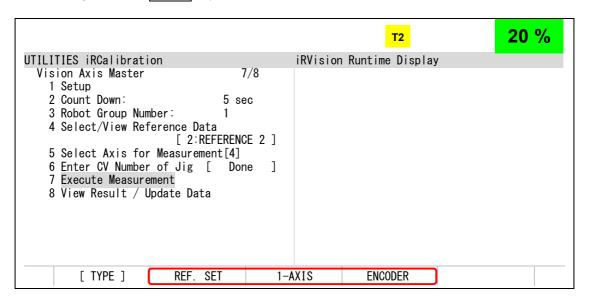
Step
1   Move the cursor to "Execute Measurement" in the "Vision Axis Master" screen and reset alarms to execute the measurement.
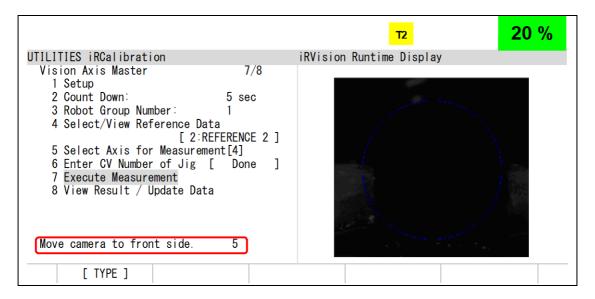
2   Start the measurement for reference data setting, 1-axis mastering, or encoder mastering.

- To execute the measurement for reference data setting, press the F2(REF. SET) key while holding down the SHIFT key.
- To execute the measurement for 1-axis mastering, press the F3(1-AXIS) key while holding down the SHIFT key.
- To execute the measurement for encoder mastering, press the F4(ENCODER) key while holding down the SHIFT key.

```
                                             T2        20 %

UTILITIES iRCalibration              iRVision Runtime Display
 Vision Axis Master            7/8
   1 Setup
   2 Count Down:              5 sec
   3 Robot Group Number:        1
   4 Select/View Reference Data
                  [ 2:REFERENCE 2 ]
   5 Select Axis for Measurement[4]
   6 Enter CV Number of Jig  [   Done   ]
   7 Execute Measurement
   8 View Result / Update Data




         [ TYPE ]      REF. SET      1-AXIS       ENCODER
```

⚠ **CAUTION**
1   The measurement for reference data setting cannot be executed when any mastering status is invalid.
2   The measurement for 1-axis mastering and encoder mastering can't be executed if the reference position of the axis for measurement is not set in selected reference data.
3   When the mastering of plural axes is executed, the mastering of each axis needs to be executed in order of the axis number. (The smaller axis number must be executed first.)
4   The axis for measurement moves automatically during the measurement. For the safety of the operator, the override of the robot will be forced to 20 percent if the override is over 20 percent. When the override is 20 percent, the moving speed of the target mark of each axis is around 3mm/sec. When less than 20%, the speed is not changed.
5   If the Jog/Program override function is valid, active override is changed to "PROG" automatically when the measurements started, and active override and the value of override will be returned to those before the measurement automatically when the measurement is completed or cancelled.
6   The SHIFT key needs to be held down during the measurement. If the measurement is cancelled by releasing the SHIFT key, the measurement needs to be restarted from the beginning.
7   An attempt to start measurement during execution of another program causes an error with the following error message displayed.
    "INTP-313 (VCAXMAST) motion statement failed, PROG-040 Already locked by other task"
    In this case, the other executed program will be terminated compulsory, therefore please restart the measurement.

3   The countdown will be started when the measurement is started. Place the tip of the gauging bracket for the AMU on the target mark with slight pressure from the front side by the end of the countdown.
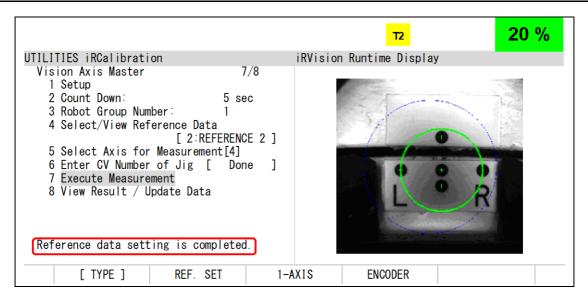
```
                                              T2        20 %
UTILITIES iRCalibration          iRVision Runtime Display
  Vision Axis Master          7/8
   1 Setup
   2 Count Down:              5 sec
   3 Robot Group Number:         1
   4 Select/View Reference Data
                       [ 2:REFERENCE 2 ]
   5 Select Axis for Measurement[4]
   6 Enter CV Number of Jig  [  Done   ]
   7 Execute Measurement
   8 View Result / Update Data


  Move camera to front side.      5


        [ TYPE ]
```

4   During vision measurement, the relative position of the AMU to the target mark must be kept appropriately by watching the image display. For details, refer to subsection "7.4 IMAGE DISPLAY DURING VISION MEASUREMENT". "Detecting …" or "Robot is moving …" is displayed alternately in the bottom of the screen during the measurement.

NOTE
   The tip of the gauging bracket for the AMU should be placed on the target mark with slight pressure during the measurement.

Target Mark

5   If the measurement is completed successfully, "Reference data setting is completed", "1-axis mastering is completed", or "Encoder mastering is completed" is displayed on the bottom of the screen as shown below.

Procedure 7-10   Executing step measurement
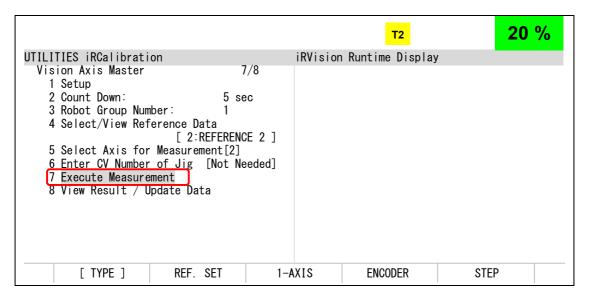
Step measurement is executed when a robot arm or the wrist unit is replaced. For details, refer to "Step measurement" of subsection 7.2.5, "Basic Functions". Step measurement is executed when shipping the robot. It is not necessary to execute step measurement ordinarily.

Condition
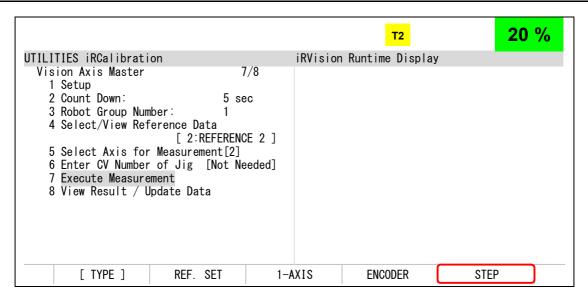
- Make sure that setting robot group number, selecting reference data, selecting axis for measurement, and entering CV number of fixture, are completed before executing measurement.

Step

1   Set TRUE to the system variable $VCAX_REF_GR[g].$REF_STEP[a].$STEP_MS_ENB. (g: group number of the robot for measurement, a: axis number for measurement)

2   Move the cursor to "Execute Measurement" in the "Vision Axis Master" screen and reset alarms to execute the measurement.

3   Start step measurement by pressing the F5(STEP) key while holding down the SHIFT key.

```
                                              T2          20 %

UTILITIES iRCalibration                  iRVision Runtime Display
  Vision Axis Master            7/8
    1 Setup
    2 Count Down:              5 sec
    3 Robot Group Number:        1
    4 Select/View Reference Data
                        [ 2:REFERENCE 2 ]
    5 Select Axis for Measurement[2]
    6 Enter CV Number of Jig  [Not Needed]
    7 Execute Measurement
    8 View Result / Update Data




        [ TYPE ]    REF. SET     1-AXIS      ENCODER       STEP
```

⚠ **CAUTION**
1 Step measurement is executed without an attached tool.
2 When step measurement is executed, "10" needs to be selected as the reference data number.
3 The step measurement cannot be executed if the mastering status of at least one axis is invalid.
4 The axis for measurement moves automatically during the measurement. For the safety of the operator, the override of the robot will be forced to 20 percent if the override is over 20 percent. When the override is 20 percent, the moving speed of the target mark of each axis is around 3mm/sec. When less than 20%, the speed is not changed.
5 If the Jog/Program override function is valid, active override is changed to "PROG" automatically when the measurements started, and active override and the value of override will be returned to those before the measurement automatically when the measurement is completed or cancelled.
6 The SHIFT key needs to be held down during the measurement. If the measurement is cancelled by releasing the SHIFT key, the measurement needs to be restarted from the beginning.
7 An attempt to start measurement during execution of another program causes an error with the following error message displayed.
   "INTP-313 (VCAXMAST) motion statement failed, PROG-040 Already locked by other task"
   In this case, the other executed program will be terminated, therefore please restart step measurement.

4   To measure step data, the measurement from the front side, the measurement from right side, and the measurement from left side needs to be repeated two or three times. During the measurement, the measurement is stopped temporarily and "Press [CONTINUE] and move Cam to FRONT", "Press [CONTINUE] and move Cam to RIGHT", or "Press [CONTINUE] and move Cam to LEFT" is displayed on the bottom of the screen. Press the F4(CONTINUE) key while holding down the SHIFT key in this timing to start countdown, and place the AMU on the target mark with slight pressure from the direction that is indicated by the bottom of the screen by the end of the countdown.
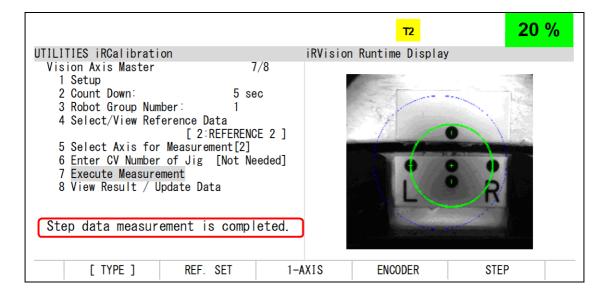
5   During vision measurement, the relative position of the AMU to the target mark must be kept appropriately by watching the image display. For details, refer to subsection "7.4 IMAGE DISPLAY DURING VISION MEASUREMENT". "Detecting …" or "Robot is moving …" is displayed alternately in the bottom of the screen during the measurement.

NOTE
The tip of the gauging bracket for the AMU should be placed on the target mark with slight pressure during the measurement.

---

6   If the measurement is completed successfully, "Step measurement is completed" is displayed on the bottom of the screen as shown below.

⚠ **CAUTION**
If the step measurement failed, check if the target fixture is attached to the robot securely, and re-execute the measurement.

7.3.14　Viewing Results and Updating data

Procedure 7-11　Displaying the "View Result" screen

Step

1　Move the cursor to "View Result / Update Data" in the "Vision Axis Master" screen and press the F3(DETAIL) key or the ENTER key. The teach pendant displays the "View Result" screen.

```
UTILITIES iRCalibration
Vision Axis Master              8/8
  1 Setup
  2 Count Down:              5 sec
  3 Robot Group Number:       1
  4 Select/View Reference Data
                     [ 2:REFERENCE 2 ]
  5 Select Axis for Measurement[2]
  6 Enter CV Number of Jig  [Not Needed]
  7 Execute Measurement
  8 View Result / Update Data


[ TYPE ]            DETAIL
```

Procedure 7-12　Operation after measurement for reference data setting

After the measurement for reference data setting, the "View Result" screen is displayed as shown below.

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result        Page 1/1
  Robot Group        [1]
  Reference Data     [ 2:REFERENCE 2 ]
  Measured Axis      [2]
  [Ref. Data Setting] 2014/04/07 16:45
  Reference Data of Measured Axis:
    Previous Value:        ******* deg
    Current Value:            .139 deg
    Measured Value:           .006 deg
    Diff. Of Above 2:        -.132 deg

[UPDATE] will update reference data.

[ TYPE ]        UPDATE        OUTPUT
```

> **NOTE**
> Reference data has not yet been updated.

Step

1   Check the displayed items, press the $\boxed{\text{F3(UPDATE)}}$ key, and press the $\boxed{\text{F4(YES)}}$ key subsequently to update reference data.

```
UTILITIES iRCalibration
Vision Axis Master:
 View Result        Page 1/1
 Robot Group        [1]
 Reference Data     [ 2:REFERENCE 2 ]
 Measured Axis      [2]
 [Ref. Data Setting]  2014/04/07 16:45
 Reference Data of Measured Axis:
  Previous Value:          ******** deg
  Current Value:               .139 deg
  Measured Value:              .006 deg
  Diff. Of Above 2:           -.132 deg

[UPDATE] will update reference data.

[ TYPE ]              UPDATE       OUTPUT
```

```
UTILITIES iRCalibration
Vision Axis Master:
 View Result        Page 1/1
 Robot Group        [1]
 Reference Data     [ 2:REFERENCE 2 ]
 Measured Axis      [2]
 [Ref. Data Setting]  2014/04/07 16:45
 Reference Data of Measured Axis:
  Previous Value:          ******** deg
  Current Value:               .139 deg
  Measured Value:              .006 deg
  Diff. Of Above 2:           -.132 deg

Update reference data ?

[ TYPE ]                 YES     NO
```

The screen will be updated after updating the mastering data as shown below.

```
UTILITIES iRCalibration
Vision Axis Master:
 View Result        Page 1/1
 Robot Group        [1]
 Reference Data     [ 2:REFERENCE 2 ]
 Measured Axis      [2]
 [Ref. Data Setting]  2014/04/07 16:45
 Reference Data of Measured Axis:
  Previous Value:              .139 deg
  Current Value:               .006 deg
  Measured Value:              .006 deg
  Diff. Of Above 2:           0.000 deg

Reference data has been updated.

[ TYPE ]                          OUTPUT
```

2   If the F5(OUTPUT) key is pressed with the file I/O device (a memory card, a USB memory, etc)
     which is selected in the file screen plugged in the controller, VAMLOG.TXT, a log file saves the
     results to the file I/O device.   For details of the method of selecting the file I/O device in the file
     screen, please refer to the "OPERATOR'S MANUAL (Basic Operation)B-83284EN"

```
UTILITIES iRCalibration
Vision Axis Master:
 View Result        Page 1/1
 Robot Group          [1]
 Reference Data     [ 2:REFERENCE 2 ]
 Measured Axis        [2]
 [Ref. Data Setting]  2014/04/07 16:45
 Reference Data of Measured Axis:
  Previous Value:            .139 deg
  Current Value:             .006 deg
  Measured Value:            .006 deg
  Diff. Of Above 2:         0.000 deg

Reference data has been updated.

[ TYPE ]                         OUTPUT
```

Tips
   IF VAMLOG.TXT already exists, the new results are appended to the current
   contents.

Procedure 7-13   Operation after measurement for 1-axis mastering

After the measurement for 1-axis mastering, the "View Result" screen is displayed as shown below.

```
UTILITIES iRCalibration
Vision Axis Master:
 View Result        Page 1/1
 Robot Group          [1]
 Reference Data     [ 2:REFERENCE 2 ]
 Measured Axis        [2]
 [1-Axis Mastering]   2014/04/07 18:45
 Mastering Count of Measured Axis:
  Previous Value:        ************
  Current Value:             2224789
  Measured Value:            2226259
  Diff. Of Above 2:          .003 deg

[UPDATE] will update mastering data.

[ TYPE ]          UPDATE          OUTPUT
```

Tips
   After executing 1-axis mastering, the difference between measured value and
   the current value of the mastering count is displayed as "Diff. Of Above2". (This
   value is converted into degrees.)

NOTE
   Mastering data has not yet been updated.

Step

1 Check the displayed items, press the F3(UPDATE) key, and then press the F4(YES) key to update mastering data.

```
UTILITIES iRCalibration
Vision Axis Master:
 View Result        Page 1/1
 Robot Group        [1]
 Reference Data     [ 2:REFERENCE 2 ]
 Measured Axis      [2]
 [1-Axis Mastering]  2014/04/07 18:45
 Mastering Count of Measured Axis:
   Previous Value:         ************
   Current Value:              2224789
   Measured Value:             2226259
   Diff. Of Above 2:              .003 deg

[UPDATE] will update mastering data.

[ TYPE ]              UPDATE        OUTPUT
```

```
UTILITIES iRCalibration
Vision Axis Master:
 View Result        Page 1/1
 Robot Group        [1]
 Reference Data     [ 2:REFERENCE 2 ]
 Measured Axis      [2]
 [1-Axis Mastering]  2014/04/07 18:45
 Mastering Count of Measured Axis:
   Previous Value:         ************
   Current Value:              2224789
   Measured Value:             2226259
   Diff. Of Above 2:              .003 deg

Update mastering data ?

[ TYPE ]              YES           NO
```

The screen will be updated after updating the mastering data as shown below.

```
UTILITIES iRCalibration
Vision Axis Master:
 View Result        Page 1/1
 Robot Group        [1]
 Reference Data     [ 2:REFERENCE 2 ]
 Measured Axis      [2]
 [1-Axis Mastering]  2014/04/07 18:45
 Mastering Count of Measured Axis:
   Previous Value:             2224789
   Current Value:              2226259
   Measured Value:             2226259
   Diff. Of Above 2:             0.000 deg

Mastering data has been updated.

[ TYPE ]                            OUTPUT
```

2   If the F5(OUTPUT) key is pressed with a file I/O device plugged in the controller, VAMLOG.TXT, a log file, saves the results to the file I/O device.

```
┌─────────────────────────────────────────┐
│ UTILITIES iRCalibration                   │
│ Vision Axis Master:                       │
│   View Result        Page 1/1            │
│   Robot Group          [1]               │
│   Reference Data       [ 2:REFERENCE 2 ] │
│   Measured Axis        [2]               │
│   [1-Axis Mastering]   2014/04/07 18:45  │
│   Mastering Count of Measured Axis:       │
│     Previous Value:           2224789     │
│     Current Value:            2226259     │
│     Measured Value:           2226259     │
│     Diff. Of Above 2:        0.000 deg    │
│                                           │
│ Mastering data has been updated.          │
│                                           │
│ [ TYPE ]                      OUTPUT      │
└─────────────────────────────────────────┘
```

┌──┐
│ **Tips**   │
│   IF VAMLOG.TXT already exists, the new results are appended to the current │
│   contents.   │
└──┘

3   After updating the mastering data, set the reference position for Quick Mastering again, preparing for future Quick Mastering. If it has not been set, set it as all the axes' angles are 0 degree. For details of Quick Mastering, please refer to "R-30*i*B / R-30*i*B Mate OPERATOR'S MANUAL (Basic Operation)" and "Mechanical Unit Operator's Manual".

┌──┐
│ **NOTE**   │
│   In the following software versions, a notification "Ref. Pos. for Quick Mastering │
│   Not Set" will be displayed on the notifications screen when you execute Vision │
│   Axis Master. This notification will be cleared when you set a quick mastering │
│   reference point.   │
│   - 7DF1/34(V9.10P/34) or later   │
│   - 7DF3/17(V9.30P/17) or later   │
│   - 7DF5/14(V9.40P/14) or later   │
└──┘

Procedure 7-14   Operation after measurement for encoder mastering

After the measurement for encoder mastering, the "View Result" screen is displayed as shown below.

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result       Page 1/1
  Robot Group       [1]
  Reference Data    [ 2:REFERENCE 2 ]
  Measured Axis     [2]
  [Encoder Mastering] 2014/04/07 19:45
  Mastering Count of Measured Axis:
   Previous Value:          2224789
   Current Value:           2226259
   Measured Value:          7469139
   Diff. Of Above 2:         10 rot

[UPDATE] will update mastering data.

[ TYPE ]          UPDATE        OUTPUT
```

Tips
> After executing encoder mastering, the difference between the measured value
> and the current value of the mastering count is displayed as "Diff. Of Above2".
> (This value is converted into rotational number of the motor)

NOTE
> Mastering data has not yet been updated.

Step

1   Check the displayed items, press the F3(UPDATE) key, and then press the F4(YES) key to update mastering data.

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result       Page 1/1
  Robot Group       [1]
  Reference Data    [ 2:REFERENCE 2 ]
  Measured Axis     [2]
  [Encoder Mastering] 2014/04/07 19:45
  Mastering Count of Measured Axis:
   Previous Value:          2224789
   Current Value:           2226259
   Measured Value:          7469139
   Diff. Of Above 2:         10 rot

[UPDATE] will update mastering data.

[ TYPE ]          UPDATE        OUTPUT
```

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result        Page 1/1
  Robot Group        [1]
  Reference Data     [ 2:REFERENCE 2 ]
  Measured Axis      [2]
  [Encoder Mastering]  2014/04/07 19:45
  Mastering Count of Measured Axis:
   Previous Value:          2224789
   Current Value:           2226259
   Measured Value:          7469139
   Diff. Of Above 2:          10 rot

Update mastering data ?

[ TYPE ]                 YES      NO
```

The screen will be updated after updating mastering data as shown below.

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result        Page 1/1
  Robot Group        [1]
  Reference Data     [ 2:REFERENCE 2 ]
  Measured Axis      [2]
  [Encoder Mastering]  2014/04/07 19:45
  Mastering Count of Measured Axis:
   Previous Value:          2226259
   Current Value:           7469139
   Measured Value:          7469139
   Diff. Of Above 2:           0 rot

Mastering data has been updated.

[ TYPE ]                          OUTPUT
```

2   If the F5(OUTPUT) key is pressed with a file I/O device plugged in the controller, VAMLOG.TXT, a log file, saves the results to the file I/O device.

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result        Page 1/1
  Robot Group        [1]
  Reference Data     [ 2:REFERENCE 2 ]
  Measured Axis      [2]
  [Encoder Mastering]  2014/04/07 19:45
  Mastering Count of Measured Axis:
   Previous Value:          2226259
   Current Value:           7469139
   Measured Value:          7469139
   Diff. Of Above 2:           0 rot

Mastering data has been updated.

[ TYPE ]                          OUTPUT
```

> **Tips**
> IF VAMLOG.TXT already exists, the new results are appended to the current
> contents.

3   After updating the mastering data, set the reference position for Quick Mastering again, preparing
     for future Quick Mastering. If it has not been set, set it as all the axes' angles are 0 degree. For
     details of Quick Mastering, please refer to "R-30*i*B / R-30*i*B Mate OPERATOR'S MANUAL (Basic
     Operation)B-83284EN" and "Mechanical Unit Operator's Manual".

> **NOTE**
> In the following software versions, a notification "Ref. Pos. for Quick Mastering
> Not Set" will be displayed on the notifications screen when you execute Vision
> Axis Master. This notification will be cleared when you set a quick mastering
> reference point.
>   - 7DF1/34(V9.10P/34) or later
>   - 7DF3/17(V9.30P/17) or later
>   - 7DF5/14(V9.40P/14) or later

Procedure 7-15   Operation after step measurement

Step

1   The "View Result" screen after step measurement consists of two screens. The displayed screen can
     be switched by pressing the F4(NEXT) key.

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result      Page 1/2
  Robot Group      [1]
  Reference Data   [**:***********]
  Measured Axis    [2]
  [Step Measurement]   2014/04/07 20:45
  Step Data of Measured Axis:
    Previous Value:            ******* mm
    Current Value:               .325 mm
    Measured Value:              .494 mm
    Diff. Of Above 2:            .169 mm

[UPDATE] will update step & ref. data.

[ TYPE ]          UPDATE NEXTPAGE OUTPUT
```

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result      Page 2/2
  Robot Group        [1]
  Reference Data     [10:FACTORY DATA]
  Measured Axis      [2]
  [Step Measurement]  2014/04/07 20:45
  Step Data of Measured Axis:
    Previous Value:         ******** deg
    Current Value:             .604 deg
    Measured Value:            .152 deg
    Diff. Of Above 2:         -.451 deg

[UPDATE] will update step & ref. data.

[ TYPE ]          UPDATE NEXTPAGE OUTPUT
```

NOTE
    Step data and reference data have not yet been updated.

---

2   Check the displayed items, press the F3(UPDATE) key, and then press the F4(YES) key to update
     the step data and reference data.

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result      Page 1/2
  Robot Group        [1]
  Reference Data     [**:***********]
  Measured Axis      [2]
  [Step Measurement]  2014/04/07 20:45
  Step Data of Measured Axis:
    Previous Value:         ******** mm
    Current Value:             .325 mm
    Measured Value:            .494 mm
    Diff. Of Above 2:          .169 mm

[UPDATE] will update step & ref. data.

[ TYPE ]          UPDATE NEXTPAGE OUTPUT
```

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result      Page 1/2
  Robot Group        [1]
  Reference Data     [**:***********]
  Measured Axis      [2]
  [Step Measurement]  2014/04/07 20:45
  Step Data of Measured Axis:
    Previous Value:         ******** mm
    Current Value:             .325 mm
    Measured Value:            .494 mm
    Diff. Of Above 2:          .169 mm

Update step & reference data?

[ TYPE ]                  YES    NO
```

3   If either reference position of the axis for measurement is set in reference data 1, reference data 2, …, or reference data 9, you can choose to initialize these data or not. Please press the F4(YES) key or the F5(NO) key.

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result       Page 1/2
  Robot Group       [1]
  Reference Data    [**:***********]
  Measured Axis     [2]
  [Step Measurement]  2014/04/07 20:45
  Step Data of Measured Axis:
    Previous Value:           ******** mm
    Current Value:               .325 mm
    Measured Value:              .494 mm
    Diff. Of Above 2:            .169 mm

Initialize other reference data ?

[ TYPE ]                    YES    NO
```

> **NOTE**
> After resetting the step data, initializing other reference data of the measured axis is recommended. If other reference data are initialized, please set these reference data again.

The screen will be updated after updating step data and reference data as shown below.

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result       Page 1/2
  Robot Group       [1]
  Reference Data    [**:***********]
  Measured Axis     [2]
  [Step Measurement]  2014/04/07 20:45
  Step Data of Measured Axis:
    Previous Value:              .325 mm
    Current Value:               .494 mm
    Measured Value:              .494 mm
    Diff. Of Above 2:           0.000 mm

Step & reference data have been updated.

[ TYPE ]                    NEXTPAGE OUTPUT
```

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result        Page 2/2
  Robot Group        [1]
  Reference Data     [10:FACTORY DATA]
  Measured Axis      [2]
  [Step Measurement]  2014/04/07 20:45
  Step Data of Measured Axis:
    Previous Value:          .604 deg
    Current Value:           .152 deg
    Measured Value:          .152 deg
    Diff. Of Above 2:       0.000 deg

Step & ref. data are updated already.

[ TYPE ]               NEXTPAGE OUTPUT
```

4   If the F5(OUTPUT) key is pressed with a file I/O device plugged in the controller, VAMLOG.TXT, a log file, saves the results to the file I/O device.

```
UTILITIES iRCalibration
Vision Axis Master:
  View Result        Page 1/2
  Robot Group        [1]
  Reference Data     [**:***********]
  Measured Axis      [2]
  [Step Measurement]  2014/04/07 20:45
  Step Data of Measured Axis:
    Previous Value:          .325 mm
    Current Value:           .494 mm
    Measured Value:          .494 mm
    Diff. Of Above 2:       0.000 mm

Step & ref. data are updated already.

[ TYPE ]               NEXTPAGE OUTPUT
```

Tips
IF VAMLOG.TXT already exists, the new results are appended to the current contents.

7.4   IMAGE DISPLAY DURING VISION MEASUREMENT

During vision measurement, the relative position of the AMU to the target mark must be kept appropriately by watching the image display.

Blue circular window
During vision measurement, the blue circular window at the center of which is equal to the center of the image is displayed in the image as shown in Fig. 7.4(a). Move the AMU to snap five all dots of the target mark in this window.
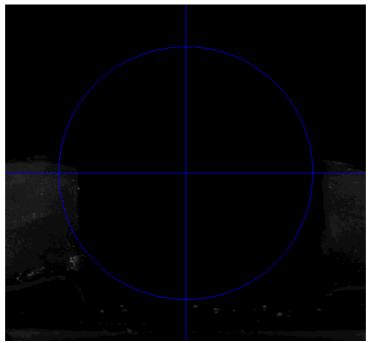
Fig. 7.4(a) Blue circular window

Image display when the target marks is detecting successfully

If all five dots are detected and the position of the AMU is appropriate, a green circle is displayed in the image as shown in Fig. 7.4(b). Keep this AMU position during the measurement.
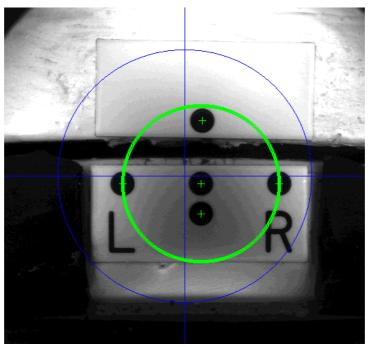

Fig. 7.4(b) Target marks is detecting successfully

Image display when some dots are not detected

When at least one dot is not detected, the green circle such as in Fig. 7.4(b) is not displayed. In Fig. 7.4 (c), a dot duplicates the gauging bracket and the detection fails. In this case, move the AMU so that the dot will not duplicate the bracket.
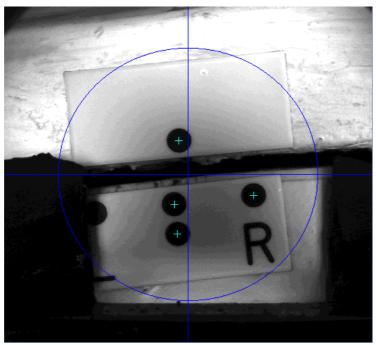
Fig. 7.4(c) Some dots are not detected

Image display when the AMU is too far from the target mark

When the AMU is too far from the target mark, red and green concentric circles are displayed in the image (Red one is smaller than green one) as shown in Fig. 7.4(d). In this case, place the tip of the gauging bracket on the part A of the target mark so that the distance between the AMU and the target mark will be appropriate.
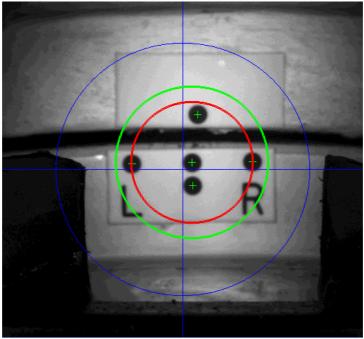
Fig. 7.4(d) The AMU is far from the target mark

Image display when the AMU is too close to the target mark

When the AMU is too close to the target mark, red and green concentric circles are displayed in the image (Red one is bigger than green one) as shown in Fig. 7.4(e). In this case, attach the gauging bracket to the AMU before vision measurement so that the AMU will not be too close to the target mark.

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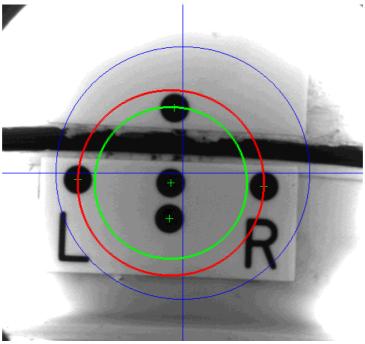
Fig. 7.4(e) The AMU is too close to the target mark

Image display when the tilt of the AMU is invalid

When the tilt of the AMU against the target mark is invalid, the light blue arrow is displayed in the image as shown in Fig. 7.4(f). In this case, move the camera as following the arrow (see Fig. 7.4 (g)).
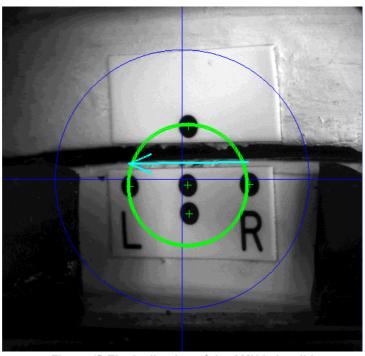
Fig. 7.4(f) The inclination of the AMU is invalid
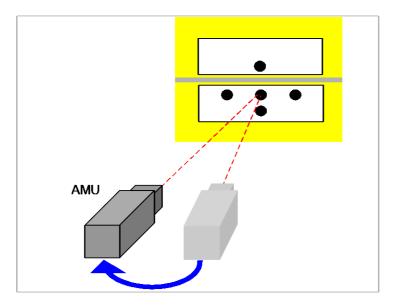
Fig. 7.4(g) The direction of moving the AMU

7.5   LOG FILE DETAILS

The measurement result can be output as a log file named as VAMLOG.TXT.

Log file recorded the result of reference data setting

```
 iRCalibration Vison Axis Master Log File

Robot Model:               R-2000iB/210F
Robot Number:              F00000
Software Version:          V8.30P/02
Measured Time:             2012/03/05 18:10
Output Time:               2012/03/06 19:53
Robot Group:               1
Reference Data:            [ 2:REFERENCE 2]
Measured Axis:             2
Measurement Type:          Reference Data Setting
Reference Data of Measured Axis:
  Previous Value:                  .139 deg
  Current Value:                   .006 deg
  Measured Value:                  .006 deg
  Diff. of Above 2:              0.000 deg
```

Log file recorded the result of 1-axis mastering

```
iRCalibration Vison Axis Master Log File

Robot Model:              R-2000iB/210F
Robot Number:             F00000
Software Version:         V8.30P/02
Measured Time:            2012/03/05 18:10
Output Time:              2012/03/06 19:55
Robot Group:              1
Reference Data:           [ 2:REFERENCE 2]
Measured Axis:            2
Measurement Type:         1-Axis Mastering
Mastering Count of Measured Axis:
  Previous Value:             2224789
  Current Value:              2226259
  Measured Value:             2226259
  Diff. of Above 2:            0.000 deg
```

Log file recorded the result of encoder mastering

```
iRCalibration Vison Axis Master Log File

Robot Model:              R-2000iB/210F
Robot Number:             F00000
Software Version:         V8.30P/02
Measured Time:            2012/03/05 18:10
Output Time:              2012/03/06 19:56
Robot Group:              1
Reference Data:           [ 2:REFERENCE 2]
Measured Axis:            2
Measurement Type:         Encoder Mastering
Mastering Count of Measured Axis:
  Previous Value:             2226259
  Current Value:              7469139
  Measured Value:             7469139
  Diff. of Above 2:             0 rot
```

Log file recorded the result of step measurement

```
iRCalibration Vison Axis Master Log File

Robot Model:              R-2000iB/210F
Robot Number:             F00000
Software Version:         V8.30P/02
Measured Time:            2012/03/05 18:10
Output Time:              2012/03/06 19:46
Robot Group:              1
Reference Data:           [10:FACTORY DATA]
Measured Axis:            2
Measurement Type:         Step Measurement
Step Data of Measured Axis:
  Previous Value:                .325 mm
  Current Value:                 .494 mm
  Measured Value:                .494 mm
  Diff. of Above 2:            0.000 mm
Reference Data of Measured Axis:
  Previous Value:                .604 deg
  Current Value:                 .152 deg
  Measured Value:                .152 deg
  Diff. of Above 2:            0.000 deg
```

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7.6 VISION AXIS MASTER OF EXTENDED AXES

With 7DC3/23 (V8.30P/23) or later software,, you can perform the Vision Axis Master for independent axes and extended axes of 6-axis robots in the same way as each axis of robots.
When you use this function for an extended axis of a model whose mechanical section does not support the mechanical option of the Vision Axis Master, set system variable $VCAX_GRP[n].$VCAX_ENB (where "n" is the robot group number) to TRUE.

NOTE
This function is not applicable to extended axes of robots other than 6-axis robots.

When you use this function for extended axes, the following preparations which are done before shipment from the factory are necessary for each axis of the robot:
- Target mark attachment
- Step measurement

After finishing target mark attachment and step measurement, you can perform the measurement in the same way as the measurement of each axis of the robot.

7.6.1 Target Mark Attachment

To perform the Vision Axis Master for an extended axis, you need to attach target stickers (Figure number: A370-3031-0141) to the extended axis. No mechanical options for target marks such as a cover plate are provided, so design one as necessary.
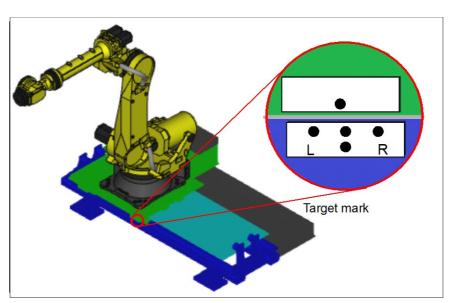
Fig. 7.6.1(a) Example of attachment of target marks to railzone

Attach target stickers to the extended axis as shown below.
- Make sure that the distance between dots shown in the following figure is from 6 mm to 10 mm.
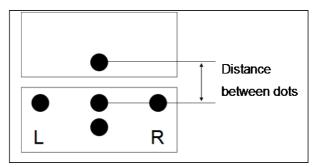
Fig. 7.6.1(b) Distance between dots of target marks

- Reduce the step height shown in the following figure as much as possible. It must be ±1.0 mm or less.
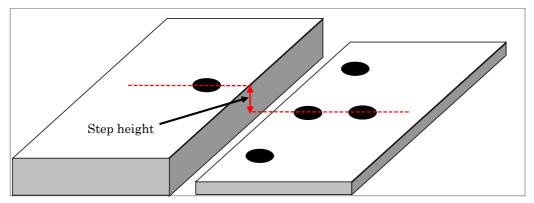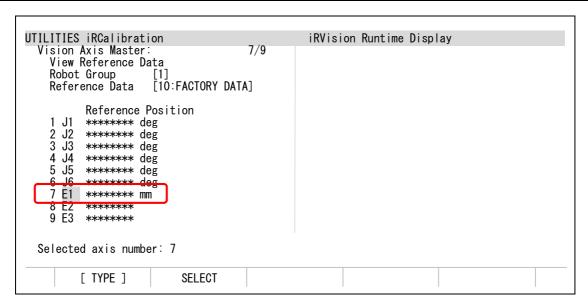
Fig. 7.6.1(c) Step height between 1-dot mark and 4-dot mark

7.6.2   Step Measurement
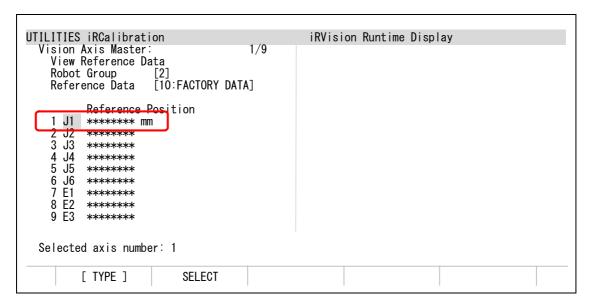
Procedure 7-16   Measuring the step

Step

1   Connect the AMU to the robot controller, and turn on the robot controller.

2   Display the "Vision Axis Master" screen. If an alarm occurs, release it, and adjust the countdown period as necessary.

3   On the "Vision Axis Master" screen, move the cursor to "Robot Group", and enter the group number of the extended axis you want to measure. Enter the group number of the robot when measuring an extended axis of a 6-axis robot. When measuring an independent axis, enter its group number.

4   On the "Select Reference Data" screen, select reference data number 10. On the "Select Axis Number" screen, select the number of the extended axis you want to measure. A unit is displayed for a selectable extended axis number.

- When measuring an extended axis of a 6-axis robot

```
UTILITIES iRCalibration                iRVision Runtime Display
  Vision Axis Master:              7/9
    View Reference Data
    Robot Group      [1]
    Reference Data   [10:FACTORY DATA]

         Reference Position
    1 J1  ******** deg
    2 J2  ******** deg
    3 J3  ******** deg
    4 J4  ******** deg
    5 J5  ******** deg
    6 J6  ******** deg
    7 E1  ******** mm
    8 E2  ********
    9 E3  ********

  Selected axis number: 7
  _____
        [ TYPE ]        SELECT
```

- When measuring an independent axis

```
UTILITIES iRCalibration                iRVision Runtime Display
  Vision Axis Master:              1/9
    View Reference Data
    Robot Group      [2]
    Reference Data   [10:FACTORY DATA]

         Reference Position
    1 J1  ******** mm
    2 J2  ********
    3 J3  ********
    4 J4  ********
    5 J5  ********
    6 J6  ********
    7 E1  ********
    8 E2  ********
    9 E3  ********

  Selected axis number: 1
  _____
        [ TYPE ]        SELECT
```

5   Measure the step height. You do not need to enter the CV number of the jig.

NOTE
   Step measurement can be performed only when mastering has been finished for all the axes.

---

8 ALL-AXIS VISION MASTERING

8.1 ALL-AXIS VISION MASTERING

What is All-Axis Vision Mastering?

All-Axis Vision Mastering can be used for the same purpose of Fixture Mastering.

It performs Mastering equivalent to factory default. It is a function for maintenance, not a function aimed at improving accuracy such as Vision Mastering described in Chapter 4 of this manual. And the robot needs to be mastered with rough accuracy in advance before All-Axis Vision Mastering is applied.

It carries out Mastering for the robot by automatic vision measurement using a special set of parts such as a bracket, a stand, and others.

During vision measurement, the robot changes its orientation widely. Therefore, a wide space is required around the robot.

8.2 PARTS FOR ALL-AXIS VISION MASTERING

In order to execute All-Axis Vision Mastering, it needs a special set of parts such as a bracket, a stand and etc. for each robot model.
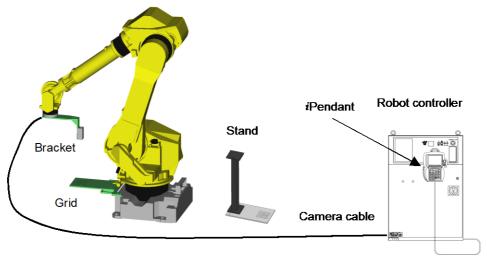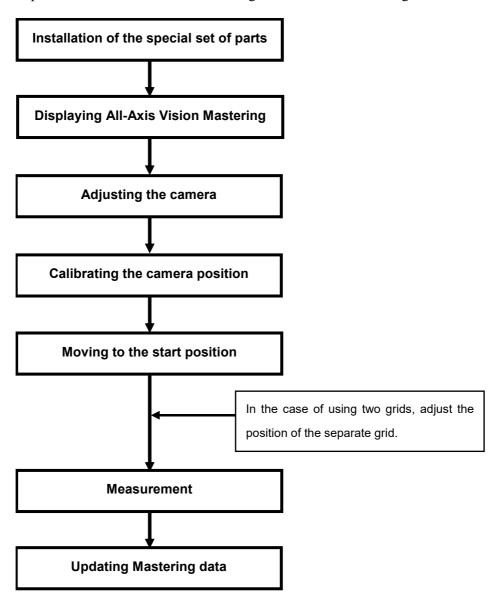
Fig.8.2 Parts for All-Axis Vision Mastering

8.3   OUTLINE OF OPERATION

Outline of the operation of All-Axis Vision Mastering is shown in the following.

```
┌─────────────────────────────────────────┐
│   Installation of the special set of parts│
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│      Displaying All-Axis Vision Mastering │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│            Adjusting the camera           │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│        Calibrating the camera position    │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│          Moving to the start position     │
└─────────────────────────────────────────┘
                    │
                    │        ┌──────────────────────────────────┐
                    │◀───────│ In the case of using two grids, adjust the│
                    │        │ position of the separate grid.            │
                    │        └──────────────────────────────────┘
                    ▼
┌─────────────────────────────────────────┐
│               Measurement                 │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│          Updating Mastering data          │
└─────────────────────────────────────────┘
```

8.4   INSTALLATION OF THE SPECIAL SET OF PARTS

Prepare a bracket, a grid and others dedicated for each robot model, and connect the camera cable.

8.5 DISPLAYING ALL-AXIS VISION MASTERING SCREEN

Procedure 8-1 Displaying the All-Axis Vision Mastering screen

Step
1   Enable the teach pendant.
2   Press the MENU key.
3   Select "UTILITIES".
4   Press the F1 [TYPE] key.
5   Select "*i*RCalibration".
6   Select "All-Axis Vision Mastering".
       "All-Axis Vision Mastering" screen is displayed.

```
UTILITIES iRCalibration              iRVision Runtime Display
All-Axis Vision Mastering        1/4
 1 Robot Group:            1
 2 Exposure Time:          33.3   ms
 3 Cal. Camera pos:
 4 Move to Start pos
   Measure:                Not Done
   Update Master CT

    [ TYPE ]        DISP_IMG
```
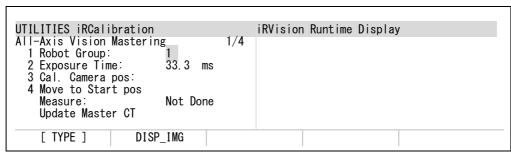
Fig. 8.5 All-Axis Vision Mastering screen

Tips
1 All-Axis Vision Mastering's operations should be made with enabling the Teach Pendant.
2 When the All-Axis Vision Mastering screen is selected from *i*RCalibration screen, the window of the teach pendant is divided in two automatically and All-Axis Vision Mastering screen and Image screen are displayed.
3 Even if the window configuration is changed, the All-Axis Vision Mastering screen and the Image screen can be displayed again in similar fashion by pressing F2 (DISP_IMG) on the All-Axis Vision Mastering screen.

Procedure 8-2 Selecting the robot motion group

Select the robot motion group for which to execute All-Axis Vision Mastering.

Step
1   On the All-Axis Vision Mastering screen, specify the motion group number of the robot, to which All-Axis Vision Mastering will be applied, at the item of "Robot: Group".

8.6 ADJUSTING THE CAMERA

Assemble the bracket with the camera, grid and stand. And, adjust the aperture and focus of the lens, and exposure time of the camera.

Procedure 8-3 Assembling the bracket, grid and stand

Step
1   Refer to the procedure manual for each robot model. And, assemble the bracket, grid and stand.
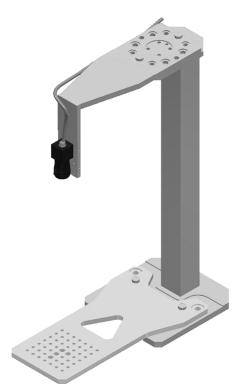
Fig. 8.6 (a)   Example assembly

Procedure 8-4   Adjusting aperture and focus of lens, and exposure time of camera
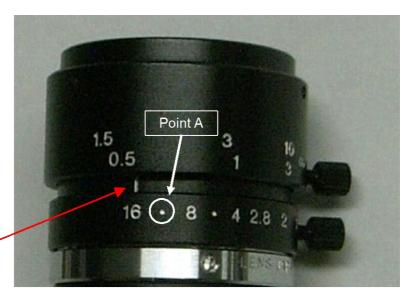
> **NOTE**
> Depending on the robot model, used parts are different, and the procedure might be slightly different from what is shown below.
> For more information, please refer to the procedure manual for each robot model.

Step

1   Set the aperture of the lens to 16.

Fig. 8.6 (b) Lens

2   Move the cursor to "Exposure Time" on the All-Axis Vision Mastering screen, and press the F4 (LIVE) key in order to start LIVE mode. And, adjust the exposure time in order that the LIVE image becomes moderately bright.
If the LIVE image is still dark even with up to 100ms exposure time, set the aperture to the point between 16 and 8 (point A in the picture), or set the aperture to 8, and adjust the exposure time. If it is still dark, increase ambient lighting condition.
Remember the results of the aperture and the exposure time as they will be used in a later step.

dark   moderately bright   too bright
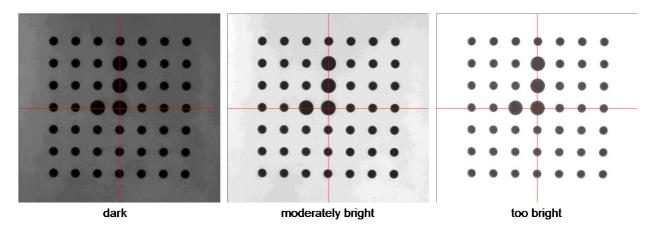
Fig. 8.6(c)   Examples of the brightness of the image

```
UTILITIES iRCalibration
All-Axis Vision Mastering           2/4
  1 Robot Group:        1
  2 Exposure Time:      33.3  ms
  3 Cal. Camera pos:
  4 Move to Start pos
    Measure:            Not Done
    Update Master CT

[ TYPE ] TIME+   TIME-    LIVE    FIND
```

Fig. 8.6 (d) Exposure Time

The exposure time can be input with numerical value directly. Also, it can be changed with the following function keys.
F2 (TIME+)
    Increases the exposure time. If pressing with SHIFT key, the value changes in bigger increments.
F3 (TIME-)
    Decreases the exposure time. If pressing with SHIFT key, the value changes in bigger decrements.

Also, the following operations are possible with the function keys.
F4 (LIVE)
    Toggles between starting displaying LIVE image and stopping LIVE.
F5 (FIND)
    Detects the calibration grid.

3   Once, set the aperture to 1.4, then, the LIVE image becomes bright. And, adjust the exposure time in order that the LIVE image becomes moderately bright.
4   Adjust the focus in order that the LIVE image becomes clear. In this time, fix the aperture handle and move the focus handle only.
5   Put the aperture and the exposure time back as adjusted at the step 2. And, tighten the screws to lock the aperture and the focus rings.

6   Stop LIVE mode by pressing the F4 (LIVE) key again.

8.7   CALIBRATING THE CAMERA POSITION

With the bracket and the grid being assembled on the stand, calibrate the camera position.

Procedure 8-5   Calibrating the camera position

Step

1   Move the cursor to "Cal. Camera pos" on the All-Axis Vision Mastering screen and press the
     SHIFT and F3 (CAL) keys together in order to calibrate the camera position.
     At this time, if the calibration was already done in the past, a confirmation message appears. Then
     select "YES" in order to calibrate the camera position anew.
     When the calibration is completed, the date of calibration is displayed at next to the cursor.

```
UTILITIES iRCalibration
All-Axis Vision Mastering              3/5
  1 Robot Group:          1
  2 Exposure Time:        33.3   ms
  3 Cal. Camera pos:      2013/12/20
  4 Move to Start pos
  5 Measure:              Not Done
    Update Master CT

[ TYPE ]DISP_IMG  CAL
```

Fig. 8.7 Cal. Camera pos

8.8   MOVING TO THE START POSITION

Move the robot to the measurement start position. From this step on, operations involve robot movement.
Please pay careful attention to safety. Override 30% or less is recommended.
In a case that the robot model uses the method that requires two grids for All-Axis Vision Mastering.
Adjust the position of the separately located grid to align with the start position.

Procedure 8-6   Moving to the start position

Step

1   Move the cursor to "Move to Start pos" on the All-Axis Vision Mastering screen, and press the
     SHIFT and F3 (MOVE_TO) keys together in order to move the robot to the measurement start
     position.

```
UTILITIES iRCalibration
All-Axis Vision Mastering              4/5
  1 Robot Group:          1
  2 Exposure Time:        33.3   ms
  3 Cal. Camera pos:      2013/12/20
  4 Move to Start pos
  5 Measure:              Not Done
    Update Master CT

[ TYPE ]DISP_IMG MOVE_TO  LIVE     FIND
```

Fig. 8.8 (a)   Move to Start pos

In a case using two grids

With the robot model that uses two grids for All-Axis Vision Mastering, adjust the position of the
separately located grid to align with the measurement start position.

If there is a grid for a separate location in "PARTS LIST" of the procedure manual for each robot model, it uses two grids. If not, it uses one grid.
In the case of using one grid, skip the following "Procedure 8-7".

Procedure 8-7   Adjusting the position of the separately located grid

Condition
- Calibrating the camera position has been finished.
- The robot has been moved to the start position.

Step
1   Move the cursor to "Move to Start pos" on All-Axis Vision Mastering screen and press the F4 (LIVE) key in order to start LIVE mode.
2   Adjust the position of the grid so that the origin of the grid approximately goes to the center of the LIVE image as shown.
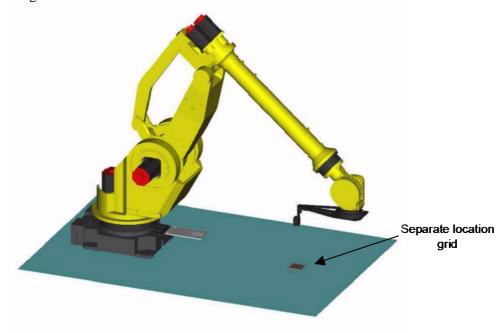
Fig. 8.8 (b)   Separately located grid

Fig. 8.8 (c)   Grid image
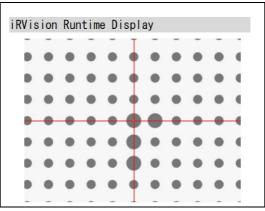
3   Move the cursor to "Move to Start pos" and press the F5 (FIND) key Then, the amount of deviation of the distance between the camera and the grid is displayed at the lower part of the screen in such a manner as "Z=xx.x". Its unit is mm and larger value means a longer distance.

```
UTILITIES iRCalibration
All-Axis Vision Mastering          4/5
  1 Robot Group:          1
  2 Exposure Time:        33.3 ms
  3 Cal. Camera pos:      2013/12/20
  4 Move to Start pos
  5 Measure:              Not Done
    Update Master CT
Z = 11.7
[ TYPE ]DISP_IMG MOVE_TO  LIVE   FIND
```

Fig. 8.8 (d)   Distance between grid and camera

4   Change the position of the grid so as that the above distance value becomes close to 0. And, adjust the position of the grid to within ±50mm by repeating the step 1~3.

8.9   MEASUREMENT

Let the robot execute visual measurements of the grid from various angles.
Because the robot changes its posture greatly during the measuring, it needs large space around the robot.

Procedure 8-8   Measuring

Step

1   Move the cursor to "Measure" on All-Axis Vision Mastering screen and press the SHIFT and F3 (MEASURE) key together in order to start the measurement.
When measuring is completed, the indication changes from "Not Done" to "Done".

```
UTILITIES iRCalibration
All-Axis Vision Mastering          5/5
  1 Robot Group:          1
  2 Exposure Time:        33.3 ms
  3 Cal. Camera pos:      2013/12/20
  4 Move to Start pos
  5 Measure:              Not Done
    Update Master CT

[ TYPE ]DISP_IMG MEASURE
```

Fig. 8.9 Measure

⚠ **CAUTION**
1   The robot changes its posture variously while measuring. Pay attention to the camera cable so as not to interfere the measurement.
2   With the robot model that uses two grids, if the separately located grid moves while measuring, restart measuring from the beginning.
3   You must keep pressing the SHIFT key during the measurement. If the SHIFT key is released, measuring is stopped.
4   Just after measuring is stopped, you can resume measuring by pressing the SHIFT and F3 (MEASURE) keys together When the SHIFT and F3 (MEASURE) keys are pressed together, the confirmation message for resuming is displayed. Then, if "RESUME" is selected, measuring is resumed. If "RESTART" is selected, measuring is restarted from the beginning.
5   If the camera image is dark and vision detection fails and measuring is stopped, you should try changing "Exposure Time" in order to take a bright camera image. And, you can resume measuring.

> **⚠ CAUTION**
> 6 If the Gravity Compensation function is enabled, the confirmation message if payload setting is correct is displayed. Please refer to the procedure manual for each robot model. And, set the correct payload data before measuring.
> 7 If Gravity Compensation status is different between now and when the last mastering was done, the confirmation message if you execute mastering is displayed. If you are sure to execute mastering, please select "Yes" and go ahead with measuring.

8.10   UPDATING MASTERING DATA

Check the results of measuring, and update the mastering data.

Procedure 8-9   Updating the mastering data

Step

1   Move the cursor to "Update Master CT" on All-Axis Vision Mastering screen and press the F3 (DETAIL) key in order to display "Update Master CT" screen.

```
UTILITIES iRCalibration
All-Axis Vision Mastering      6/6
  1 Robot Group:          1
  2 Exposure Time:        33.3  ms
  3 Cal. Camera pos:      2013/12/20
  4 Move to Start pos
  5 Measure:              Done
  6 Update Master CT

[ TYPE ]DISP_IMG DETAIL
```

Fig. 8.10 (a)Update Master CT

2   The results of measurement and identification are displayed. The values in () are standard ranges of errors.
   If there is no problem, press the SHIFT and F3 (UPDATE) keys together in order to update the mastering data.
   Also, if there is an item that is out of its standard range, its notification message is displayed at the lower part of the screen. In addition, updating the mastering data is available even if there is an item that is out of its standard range.

```
UTILITIES iRCalibration
All-Axis Vision Mastering          1/6
Update Master CT
    Robot Group:          1
  1 Compensation Angles [deg]
      J1:    0.300   J2:  -0.254
      J3:    0.172   J4:  -0.239
      J5:   -0.082   J6:   0.326
  2 Residual Error [mm]:   0.58 ( 1.50)
  3 VTCP Error [mm]
      X:   0.10   (± 1.50)
      Z:   0.10   (± 1.00)
  4 Grid Pattern Error [mm]
      X:   0.20   (± 1.00)
      Z:  -0.54   (± 1.50)
  5 Residual Error 2 [mm]: 0.58 ( 1.50)
  6 VTCP Error 2 [mm]
      X:   0.10   (± 1.50)
      Z:   0.10   (± 1.00)

[ TYPE ]          UPDATE
```

Fig. 8.10 (b)Update Master CT screen

About items

Compensation Angles

This item indicates the compensation angles from the previous mastering data.

Residual Error

This item indicates an index of precision if the mastering data is updated with the results of measurement and identification.

In the case of using two grids, it is the value from the measurement of the separately located grid.

If this value is much higher than the standard range, the measurement might have not been done properly.

Check if assemblies of the parts are loose and if the lens is out of focus. And, make another try.

VTCP Error

This is an error of TCP for Vision measurement. It is a difference between the identified value and the design value.

If you are using two grids, it is the value from the measurement of the separately located grid.

If this value is much higher than the standard range, assembly of the bracket might have not been proper or assembly of the grid at "CALIBRATING THE CAMERA POSITION" might have not been proper.

Check if there is anything wrong, and, make another try.

Grid Pattern Error

This is an error of grid position. It is a difference between the identified value and the design value.

If this value is much higher than the standard range, assembly of the grid might have not been proper.

Check if there is anything wrong, and, make another try.

Residual Error 2

If you are not using a separately located grid, it can be neglected.

An index of precision if the mastering data is updated with the results of measurement and identification.

It is the value from the measurement of the grid assembled at the robot base.

If this value is much higher than the standard range, the measurement might have not been done properly.

Check if assemblies of the parts are loose and if the lens is out of focus. And, make another try.

VTCP Error 2

    If you are not using a separately located grid, it can be neglected.

    It is an error of TCP for Vision measurement. It is a difference between the identified value and the design value.

    It is the value from the measurement of the grid assembled at the robot base.

    If this value is much higher than the standard range, the assembly of the bracket might have not been done properly or the assembly of the grid at "CALIBRATING THE CAMERA POSITION" might have not been done properly.

    Check if there is anything wrong and try again.

3   After updating the mastering data, set the reference position for Quick Mastering again, preparing for future Quick Mastering. If it has not been set, set it as all the axes' angles are 0 degree. For details of Quick Mastering, please refer to "R-30iB / R-30iB Mate OPERATOR'S MANUAL (Basic Operation)" and "Mechanical Unit Operator's Manual".

4   Then, All-Axis Vision Mastering is complete.

NOTE

    In the following software versions, a notification "Ref. Pos. for Quick Mastering Not Set" will be displayed on the notifications screen when you execute All-Axis Vision Mastering. This notification will be cleared when you set a quick mastering reference point.
- 7DF1/34(V9.10P/34) or later
- 7DF3/17(V9.30P/17) or later
- 7DF5/14(V9.40P/14) or later

---

9   WRIST-AXIS VISION MASTERING

9.1   WRIST-AXIS VISION MASTERING

What is Wrist-Axis Vision Mastering?

Wrist-Axis Vision Mastering automatically measures a target fixture attached to the end effector mounting face of a robot by using a fixed camera while changing the posture of the robot. It also sets wrist-axis (J4, J5, J6 axis) mastering data equivalent to factory defaults.

It is a function for maintenance, not a function aimed at improving accuracy such as Vision Mastering described in Chapter 4 of this manual.

Features of Wrist-Axis Vision Mastering

- Operations other than installation of a measurement target and a camera are performed automatically. Manual operations are therefore simplified, and the operation results do not depend on the skill of the operator.
- Because this function requires a relatively small robot operation range, it is easy to apply this function for the robot with a limited operation range by the installation location of itself and surroundings.
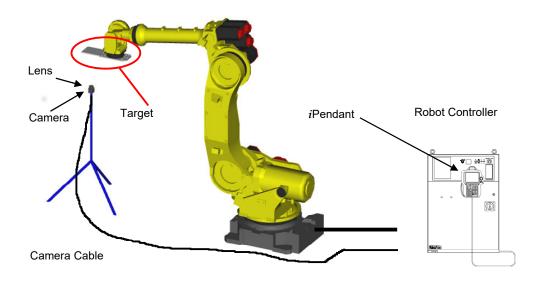
Limitation of Wrist-Axis Vision Mastering

- The robot needs to be mastered with rough accuracy in advance before Wrist-Axis Vision Mastering is applied. The accuracy is satisfied with a visual confirmation such as aligning Vernier Marks or Scribe Marks.
- This function needs a dedicated measurement target with a calibration grid on it for each robot type. The robot types with no available measurement target cannot use this function.
- This function can not be used with an arbitrary robot pose. It needs a base position satisfying some specified condition as the angles of J4 and J6 axis are 0 degree and so on. For details, refer to "9.2.3 Robot Poses".

9.2   SYSTEM CONFIGURATION

9.2.1   Overall Configuration

The Wrist-Axis Vision Mastering system consists of a robot controller, an *i*Pendant, a camera, a lens, and a measurement target.

NOTE
1   The customer is to prepare hardware such as a camera with lens, a measurement target and a jig for holding the camera.
2   Because the measurement target has to be mounted on the end effector mounting face of the robot directly, tools have to be detached from the end effector mounting face.

Tips
   For controllers with 7DC2/02(8.20P/02) or later software, cameras not described in "2.1 COMPONENTS" can be used. For more details, refer to "3.5 USING *i*RVision CAMERA". You can use only FANUC lenses.

9.2.2   Attaching the Measurement Target

This function uses a dedicated measurement target for Wrist-Axis Vision Mastering attached on the end effector mounting face.

The shape of the measurement target is such as shown below. There are holes for positioning pins and screws on the target and a calibration grid on the end of the target.
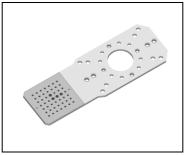
Fig. 9.2.2 (a) A measurement target for Wrist-Axis Vision Mastering

There are four larger circles in the vicinity of the center in the grid. In the following, the center of the circle indicated by an arrow as shown below is called the center of the grid.
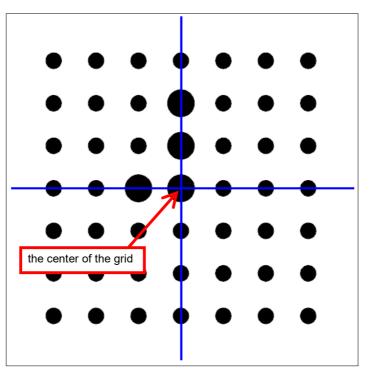
Fig. 9.2.2 (b) Grid

Attach the measurement target in such direction as shown below (The robot is at the zero position). Insert the positioning pins and the measurement target into the end effector mounting face of the robot securely and tighten the screws at specified positions.
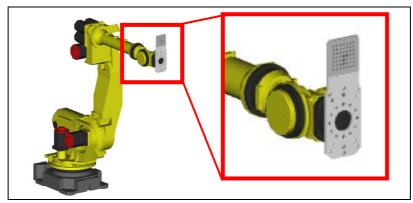
Fig. 9.2.2 (c) Attaching the measurement target

9.2.3   Robot Poses
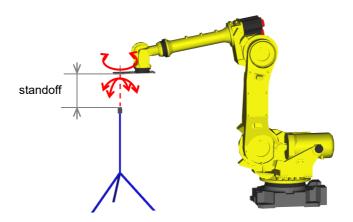
Fig. 9.2.3 measurement poses

Wrist-Axis Vision Mastering uses several types of concepts or terms regarding robot poses: Initial Pose, Reference Pose and Measurement Poses.

Initial Pose

A robot pose determined through jogging operation of the robot by an operator at the very first step. Reference Pose below is automatically generated based on the Initial Pose.

Reference Pose

A robot pose close to the Initial Pose, where the center of the grid coincides with the center of camera view and the robot joint angles meet a certain condition.   The pose is automatically searched by the function through visual detection of the grid by the camera and the robot movement.

Measurement Poses

When Wrist-Axis Vision Mastering starts the measurement for mastering, the robot moves to 9 poses including the Reference Pose itself and 8 derivations from it, poses with orientation variation in W, P and R angles, and visual measurement by the camera is done at each robot pose.   The 9 robot poses are called Measurement Poses.

9.2.3.1   Initial pose

- The initial pose is determined by an operator through jogging operation of the robot.   It has some constraints in the joint angles from J2 to J6 axes.
- In the operation of determining and recording the initial pose, refer to the display as Fig. 9.2.3.1 (a) shown on a teach pendant that provides upper and lower limits of the joint angles.

Tips
    The lower and upper limits vary by the robot type.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering            1/4
  Robot Group [1]
  1 Camera Type:          SONY XC-56

    Focal Distance:            12.0   mm
  Initial Pose Confirmation [deg]
     Lower Limit  Current  Upper Limit
  J2:[  -10.000][     0.000][  -10.000]
  J3:[  -20.000][     0.000][    0.000]
  J4:[   -5.000][     0.000][   -5.000]
  J5:[  -95.000][   -90.000][  -85.000]
  J6:[   -5.000][     0.000][   -5.000]
  2 Initial Pose            UNINIT
  3 Exposure Time:          33.33  ms
  4 Create Reference Pose   (Not Done)

[ TYPE ]                    [CHOICE]
```

Fig. 9.2.3.1 (a) Display related to determining the initial pose

NOTE
    If the angle of J2 or J3 axis can not be between the lower and upper limit shown
    in Fig. 9.2.3.1 (a) in order to avoid interference between the robot and
    peripherals for example, then examine that move of the robot to another position
    by turning J1 axis where the angles of J2 and J3 axis can be between the limits,
    and then record the position as the initial pose.
    If you can not do that, the position where the angle of J2 or J3 axis is not
    between the limits can be recorded as the initial pose, but as the result, it runs
    the risk of degrading mastering results.

- Keep the measurement target away forward from the base section of the robot and tilt the J3 arm downward as shown below so that the wrist section hardly causes interference.
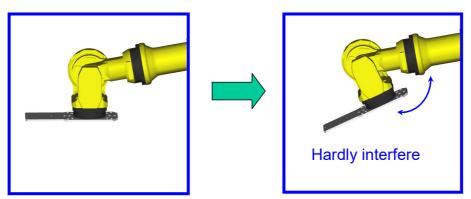
Fig. 9.2.3.1 (b) Wrist pose in which the camera hardly interferes with the robot

- If the measurement target is close backward to the base section of the robot or if the J3 arm is tilted upward in contrast, the wrist section is liable to cause interference. In that case, the swing angles of measuring poses must be reduced, involving a risk of degrading mastering results.
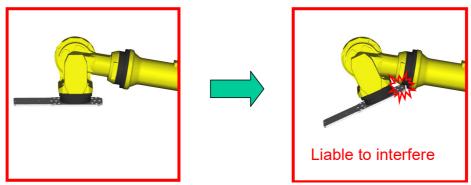
Fig. 9.2.3.1 (c) Wrist pose in which the camera is liable to interfere with the robot

- For example, if the upper and lower limits of each axis are shown in Fig. 9.2.3.1 (a) with floor mount type robot, the pose (J1, J2, J3, J4, J5, J6) = (0 deg, 0 deg, -10 deg, 0 deg, -80 deg, 0 deg) as shown below is a candidate of the initial pose.
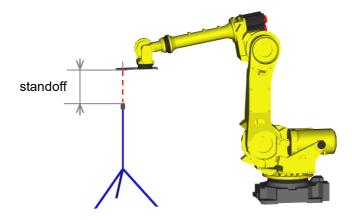
Fig. 9.2.3.1 (d) An example of initial pose

- Check the above for reference to select the initial pose of the robot appropriately.

9.2.3.2   Setting camera

- After determining and recording the initial pose, set the camera on the floor with a tripod, camera stand, and so forth.

- The optical axis of the camera should be almost perpendicular with the face of the grid on the measurement target.

- The recommend standoff (the distance between the camera and the measurement target) is about 400mm.
- The center circle of the grid on the measurement target should be near the center of the camera view.

NOTE
  Although there are no installation precision requirements imposed on relative position between the camera and the measurement target, try to fix them securely so that they do not move during measurement.
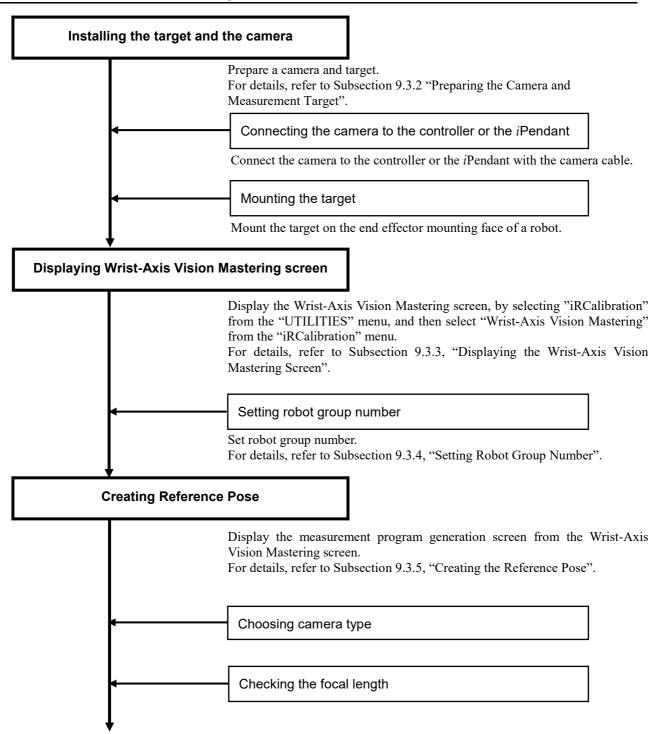
9.2.3.3   Reference pose
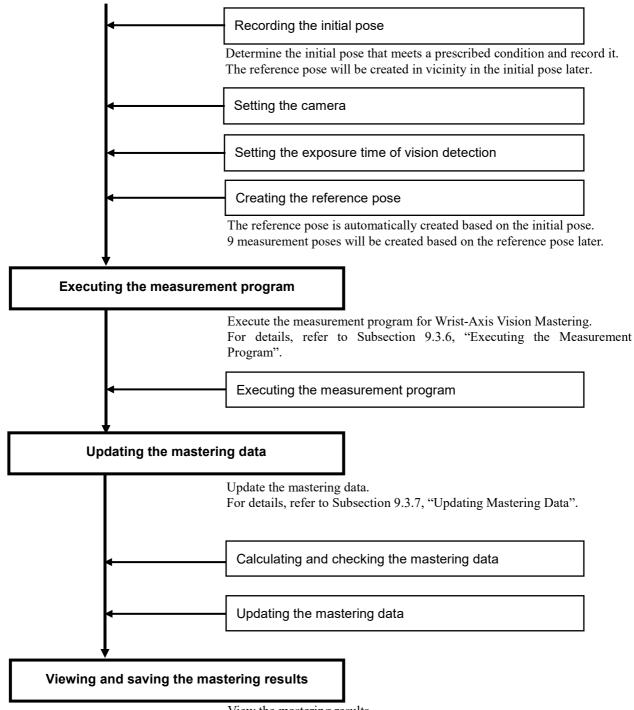
- After setting up the camera, the operation related to creating the reference pose will automatically create it.
- When starting the visual measurement for Wrist-Axis Mastering, 9 sets of the measurement poses are generated based on the reference pose and the robot moves to each.

9.3   OPERATION OF WRIST-AXIS VISION MASTERING

This section describes the procedure for Wrist-Axis Vision Mastering.

9.3.1   Outline of the Operation Procedure

```
┌─────────────────────────────────────────────┐
│        Installing the target and the camera  │
└─────────────────────────────────────────────┘
          │
          │          Prepare a camera and target.
          │          For details, refer to Subsection 9.3.2 "Preparing the Camera and
          │          Measurement Target".
          │
          │        ┌───────────────────────────────────────────────────┐
          │◄───────│ Connecting the camera to the controller or the iPendant │
          │        └───────────────────────────────────────────────────┘
          │
          │         Connect the camera to the controller or the iPendant with the camera cable.
          │
          │        ┌───────────────────────────────────────────────────┐
          │◄───────│ Mounting the target                                │
          │        └───────────────────────────────────────────────────┘
          │
          │         Mount the target on the end effector mounting face of a robot.
          ▼
┌─────────────────────────────────────────────┐
│   Displaying Wrist-Axis Vision Mastering screen │
└─────────────────────────────────────────────┘
          │
          │          Display the Wrist-Axis Vision Mastering screen, by selecting "iRCalibration"
          │          from the "UTILITIES" menu, and then select "Wrist-Axis Vision Mastering"
          │          from the "iRCalibration" menu.
          │          For details, refer to Subsection 9.3.3, "Displaying the Wrist-Axis Vision
          │          Mastering Screen".
          │
          │        ┌───────────────────────────────────────────────────┐
          │◄───────│ Setting robot group number                         │
          │        └───────────────────────────────────────────────────┘
          │
          │         Set robot group number.
          │         For details, refer to Subsection 9.3.4, "Setting Robot Group Number".
          ▼
┌─────────────────────────────────────────────┐
│            Creating Reference Pose            │
└─────────────────────────────────────────────┘
          │
          │          Display the measurement program generation screen from the Wrist-Axis
          │          Vision Mastering screen.
          │          For details, refer to Subsection 9.3.5, "Creating the Reference Pose".
          │
          │        ┌───────────────────────────────────────────────────┐
          │◄───────│ Choosing camera type                               │
          │        └───────────────────────────────────────────────────┘
          │
          │        ┌───────────────────────────────────────────────────┐
          │◄───────│ Checking the focal length                          │
          │        └───────────────────────────────────────────────────┘
          ▼
```

```
┌─────────────────────────────────────────┐
│           Recording the initial pose      │
└─────────────────────────────────────────┘
```

Determine the initial pose that meets a prescribed condition and record it.
The reference pose will be created in vicinity in the initial pose later.

```
┌─────────────────────────────────────────┐
│               Setting the camera           │
└─────────────────────────────────────────┘
```

```
┌─────────────────────────────────────────┐
│   Setting the exposure time of vision detection │
└─────────────────────────────────────────┘
```

```
┌─────────────────────────────────────────┐
│           Creating the reference pose       │
└─────────────────────────────────────────┘
```

The reference pose is automatically created based on the initial pose.
9 measurement poses will be created based on the reference pose later.

```
┌─────────────────────────────────────────┐
│    Executing the measurement program        │
└─────────────────────────────────────────┘
```

Execute the measurement program for Wrist-Axis Vision Mastering.
For details, refer to Subsection 9.3.6, "Executing the Measurement
Program".

```
┌─────────────────────────────────────────┐
│        Executing the measurement program    │
└─────────────────────────────────────────┘
```

```
┌─────────────────────────────────────────┐
│         Updating the mastering data         │
└─────────────────────────────────────────┘
```

Update the mastering data.
For details, refer to Subsection 9.3.7, "Updating Mastering Data".

```
┌─────────────────────────────────────────┐
│   Calculating and checking the mastering data │
└─────────────────────────────────────────┘
```

```
┌─────────────────────────────────────────┐
│         Updating the mastering data         │
└─────────────────────────────────────────┘
```

```
┌─────────────────────────────────────────┐
│    Viewing and saving the mastering results │
└─────────────────────────────────────────┘
```

View the mastering results.

Output the mastering results as a log file named as VCWM_LOG.TXT.
For details, refer to Subsection 9.3.8, "Viewing and Saving Mastering
Results".

9.3.2   Preparing the Camera and Measurement Target

Connect the camera to the robot controller or the *i*Pendant with the camera cable. For details, refer to
Subsection 3.1.2, "Connecting the Camera to the Robot Controller or the *i*Pendant".

Referring to Fig. 9.2.2 (c), mount the measurement target on the end effector mounting face.

9.3.3 Displaying the Wrist-Axis Vision Mastering Screen
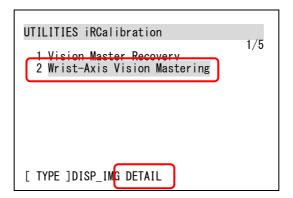
Procedure 9-1 Displaying the Wrist-Axis Vision Mastering screen
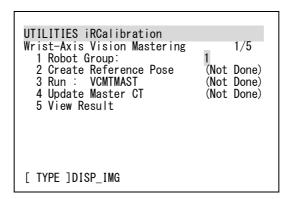
Step

1 Press the MENU key.
2 Select "UTILITIES".
3 Press the F1 〔TYPE〕.
4 Select "*i*RCalibration".

The following screen appears on the teach pendant.
The available item list of *i*RCalibration functions is displayed in this screen. The items to be displayed are different depending on the states of options.

```
UTILITIES iRCalibration
                                    1/5
  1 Vision Master Recovery
  2 Wrist-Axis Vision Mastering




[ TYPE ]DISP_IMG DETAIL
```

5 Move the cursor to "Wrist-Axis Vision Mastering", then press the F3 (DETAIL) or the ENTER key. The following "Wrist-Axis Vision Mastering" screen appears on teach pendant.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering    1/5
  1 Robot Group:           1
  2 Create Reference Pose  (Not Done)
  3 Run :  VCMTMAST         (Not Done)
  4 Update Master CT        (Not Done)
  5 View Result



[ TYPE ]DISP_IMG
```

Select and execute each item on the screen sequentially from the top so that the mastering parameters can be adjusted.

9.3.4 Setting Robot Group Number

Set Robot Group Number

Move the cursor to "Robot Group" on the Wrist-Axis Vision Mastering screen, and then enter the group number of the robot with the wrist-axis to be mastered.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering        1/5
 1 Robot Group:                  1
 2 Create Reference Pose     (Not Done)
 3 Run :  VCMTMAST            (Not Done)
 4 Update Master CT           (Not Done)
 5 View Result



[ TYPE ]DISP_IMG
```
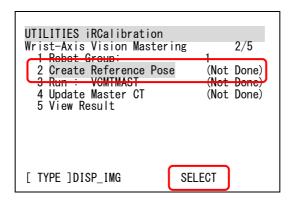
9.3.5   Creating the Reference Pose

Procedure 9-2   Creating the Reference Pose

Step

1   Enter Create Reference Pose screen.
Move the cursor to "Create Reference Pose" on the Wrist-Axis Vision Mastering screen, then press
the F4 (SELECT)   or the ENTER key.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering        2/5
 1 Robot Group:                  1
 2 Create Reference Pose     (Not Done)
 3 Run :  VCMTMAST            (Not Done)
 4 Update Master CT           (Not Done)
 5 View Result



[ TYPE ]DISP_IMG            SELECT
```

The teach pendant displays Creating Reference Pose screen as shown below.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering        1/4
  Robot Group [1]
 1 Camera Type:       SONY XC-56

   Focal Distance:        12.0    mm
   Initial Pose Confirmation [deg]
     Lower Limit  Current  Upper Limit
 J2:[ -10.000][    0.000][  -10.000]
 J3:[ -20.000][    0.000][    0.000]
 J4:[  -5.000][    0.000][   -5.000]
 J5:[ -95.000][  -90.000][  -85.000]
 J6:[  -5.000][    0.000][   -5.000]
 2 Initial Pose            UNINIT
 3 Exposure Time:         33.33  ms
 4 Create Reference Pose   (Not Done)

[ TYPE ]               [CHOICE]
```

2   Set the camera type.

SONY XC-56

Choose this when using "SONY XC-56" camera that connects to JRL7 port on the main board or JRL7A port on the multiplexer. This camera type can be selected on only R-30*i*B / R-30*i*B Mate controller.

BASLER acA640-20um

Choose this when BASLER *i*Pendant USB camera ac640-20um is used.

KOWA SC36MF

Choose this when KOWA *i*Pendant USB camera SC36MF is used. This camera type can be selected on only R-30*i*B / R-30*i*B Mate controller.

*i*RVision Camera

Choose this camera type when using KOWA monochrome camera SC130EF2 (only R-30*i*B Plus controller) a camera for *i*RVision.

For details, refer to "3.5 USING *i*RVision CAMERA".

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering          1/4
  Robot Group [1]
  1 Camera Type:         SONY XC-56

     Focal Distance:           12.0    mm
     Initial Pose Confirmation [deg]
          Lower Limit   Current  Upper Limit
     J2:[  -10.000][    0.000][  -10.000]
     J3:[  -20.000][    0.000][    0.000]
     J4:[   -5.000][    0.000][   -5.000]
     J5:[  -95.000][  -90.000][  -85.000]
     J6:[   -5.000][    0.000][   -5.000]
  2 Initial Pose              UNINIT
  3 Exposure Time:           33.33   ms
  4 Create Reference Pose    (Not Done)

 [ TYPE ]                  [CHOICE]
```

3   Check the focal distance (mm).
     The value of the focal distance can not be changed.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering          1/4
  Robot Group [1]
  1 Camera Type:         SONY XC-56

     Focal Distance:           12.0    mm
     Initial Pose Confirmation [deg]
          Lower Limit   Current  Upper Limit
     J2:[  -10.000][    0.000][  -10.000]
     J3:[  -20.000][    0.000][    0.000]
     J4:[   -5.000][    0.000][   -5.000]
     J5:[  -95.000][  -90.000][  -85.000]
     J6:[   -5.000][    0.000][   -5.000]
  2 Initial Pose              UNINIT
  3 Exposure Time:           33.33   ms
  4 Create Reference Pose    (Not Done)

 [ TYPE ]                  [CHOICE]
```

4   Move the robot and record the initial pose.
     Move the robot to the position to be used as the initial pose, referring to the current joint angle, lower limit and upper limit of each axis shown below.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering        1/4
  Robot Group [1]
  1 Camera Type:        SONY XC-56

    Focal Distance:           12.0   mm
    Initial Pose Confirmation [deg]
       Lower Limit  Current  Upper Limit
    J2:[ -10.000][    0.000][  -10.000]
    J3:[ -20.000][    0.000][    0.000]
    J4:[  -5.000][    0.000][   -5.000]
    J5:[ -95.000][  -90.000][  -85.000]
    J6:[  -5.000][    0.000][   -5.000]
  2 Initial Pose              UNINIT
  3 Exposure Time:            33.33  ms
  4 Create Reference Pose   (Not Done)

[ TYPE ]                    [CHOICE]
```

The initial pose should be determined so that all the joint angles from J2 to J6 are between each lower/upper limits. If the robot and peripherals could interfere with each other, investigate to change the J1 angle to avoid it.   In case that the interference can not be avoided in any way, avoid the interference by allowing J2 and J3 angles to exceed the limits.

NOTE

It runs a risk of degrading mastering results if the angle of J2 or J3 axis of the initial pose is not between the limits.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering        2/4
  Robot Group [1]
  1 Camera Type:        SONY XC-56

    Focal Distance:           12.0   mm
    Initial Pose Confirmation [deg]
       Lower Limit  Current  Upper Limit
    J2:[ -10.000][    0.000][  -10.000]
    J3:[ -20.000][    0.000][    0.000]
    J4:[  -5.000][    0.000][   -5.000]
    J5:[ -95.000][  -90.000][  -85.000]
    J6:[  -5.000][    0.000][   -5.000]
  2 Initial Pose              UNINIT
  3 Exposure Time:            33.33  ms
  4 Create Reference Pose   (Not Done)

[ TYPE ]                      RECORD
```

Move the cursor to "Initial Pose" on the Creating Reference Pose screen, and move the robot to the position to be initial pose with reference to each axis "Lower Limit" and "Upper Limit" on the screen. And then press the SHIFT key and the F5 (RECORD) together.
The current position is recorded as the initial pose. The display on the teach pendant is shown below.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering      2/4
  Robot Group [1]
  1 Camera Type:       SONY XC-56

    Focal Distance:        12.0   mm
    Initial Pose Confirmation [deg]
      Lower Limit   Current  Upper Limit
    J2:[ -10.000][    0.000][ -10.000]
    J3:[ -20.000][    0.000][    0.000]
    J4:[  -5.000][    0.000][   -5.000]
    J5:[ -95.000][  -90.000][  -85.000]
    J6:[  -5.000][    0.000][    5.000]
  2 Initial Pose            RECORDED
  3 Exposure Time:          33.33  ms
  4 Create Reference Pose   (Not Done)
Initial pose has been recorded
[ TYPE ]                       RECORD
```

5   Set the camera.
     Set the camera on the floor with a tripod, camera stand and so on.
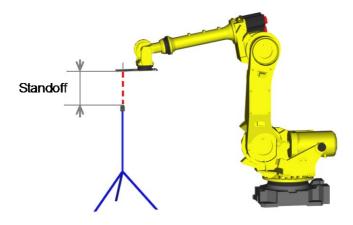
Fig 9.3.5 Setting camera

Set the optical axis of the camera almost perpendicular to the face of the calibration grid on the measurement target.
The recommended standoff (distance between the camera and measurement target) is about 400mm.
Set the center of the grid on the measurement target near the center of the camera image.
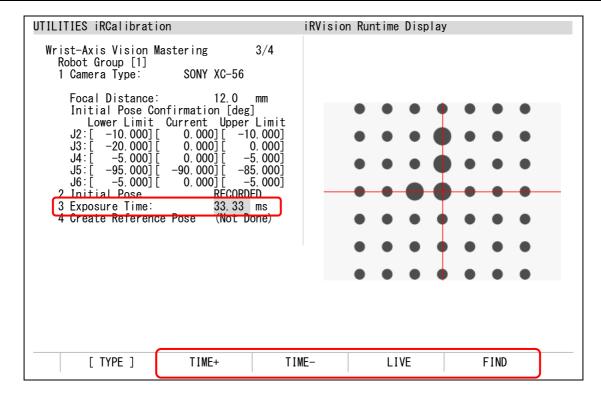
NOTE
   Although there are no installation precision requirements imposed on the
   camera, try to fix it securely so that it does not move during measurement.

---

6   Set the exposure time (ms) for vision measurement.
     Refer to Subsection 3.2 "DISPLAYING THE RUNTIME MONITOR" so that an image and the Creating Reference Pose screen can be seen simultaneously. The following explains an example of displaying an image and the Creating Reference Pose screen simultaneously on *i*Pendant. The display on the teach pendant is shown below.

```
UTILITIES iRCalibration                    iRVision Runtime Display

  Wrist-Axis Vision Mastering      3/4
    Robot Group [1]
  1 Camera Type:        SONY XC-56

    Focal Distance:         12.0   mm
    Initial Pose Confirmation [deg]
      Lower Limit  Current  Upper Limit
    J2:[  -10.000][   0.000][  -10.000]
    J3:[  -20.000][   0.000][    0.000]
    J4:[   -5.000][   0.000][   -5.000]
    J5:[  -95.000][ -90.000][  -85.000]
    J6:[   -5.000][   0.000][   -5.000]
  2 Initial Pose          RECORDED
  3 Exposure Time:          33.33  ms
  4 Create Reference Pose  (Not Done)



     [ TYPE ]    TIME+      TIME-      LIVE      FIND
```

Set the exposure time on this screen by using function keys. Before setting the exposure time adjust the lens focus of the camera so that the grid on the measurement target can be clearly viewed at the initial pose.

Function key functions

F2 (TIME+):   Increases the "Exposure Time" value.

F3 (TIME-):   Decreases the "Exposure Time" value.

F4 (LIVE):   Displays the live image.

F5 (FIND):   Detects the calibration grid on the measurement target. If the detection has succeeded, a + mark is displayed on the dot detected. If the detection has failed, an error message is displayed.

Tips

Pressing the F2 or the F3 key while holding down the SHIFT key changes the value at a faster rate.

NOTE

Wrist-Axis Vision Mastering uses the exposure time set in this screen.
The exposure time set in "Parameter Setting Screen" or "Model Training Screen" of Vision Data Setup Screen does not applied to Wrist-Axis Vision Mastering.
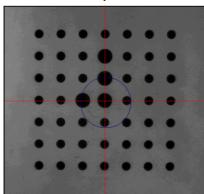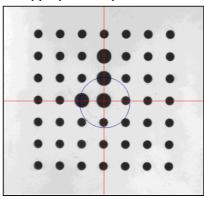
Appropriate exposure time:

Adjust the exposure time so that the image does not become pure white but rather gray in the lightest area of on the calibration grid. Also, adjust the exposure time such that the white background and black circles can be clearly distinguished.

Some image samples with different exposure time are shown below.
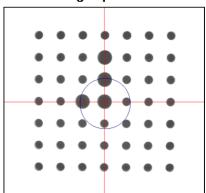
Target image with too short exposure time	Target image with appropriate exposure time	Target image with too long exposure time
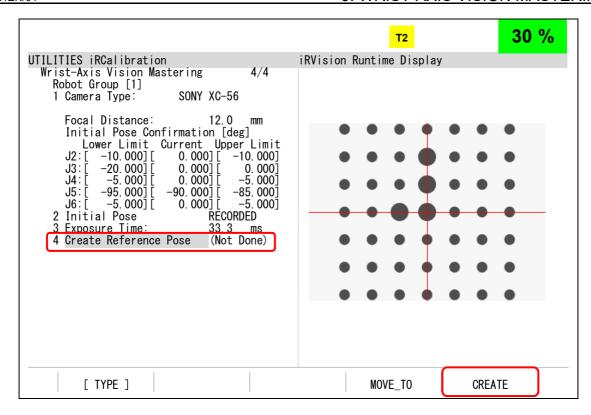
NOTE

On R-30*i*B Plus controller, 'Image Trimming' is added as an item to be set. When using a KOWA monochrome camera SC130EF2, the time to process an image may be longer than that of usual and/or it may become easier to detect false at the end of the image because the number of pixels of this camera is larger than existing cameras. In order to deal with such a problem, the number of pixels of cameras can be reduced by setting the value of 'Image Trimming' in a range from 0% to 75%.
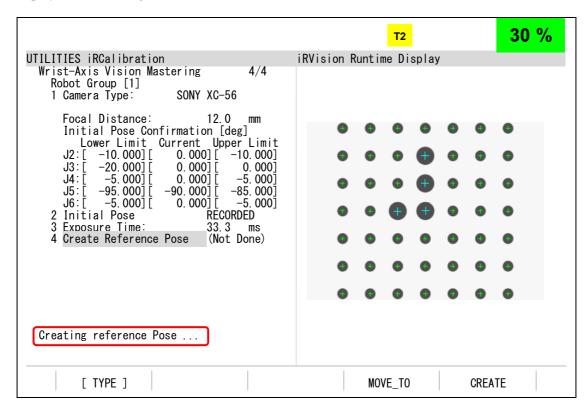
```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering          5/6
  Robot Group [1]
  1 Camera Type:        iRVision camera
  2                     1: SC130EF2
    Focal Distance:        12.0   mm
    Initial Pose Confirmation [deg]
      Lower Limit  Current  Upper Limit
    J2:[ -10.000][    0.000][ -10.000]
    J3:[ -20.000][    0.000][   0.000]
    J4:[  -5.000][    0.000][  -5.000]
    J5:[ -95.000][  -90.000][ -85.000]
    J6:[  -5.000][    0.000][  -5.000]
  3 Initial Pose            UNINIT
  4 Exposure Time:          33.33  ms
  5 Image Trimming:         50 %
  6 Create Reference Pose   (Not Done)

[ TYPE ]    +        -      LIVE    FIND
```

7   Create the reference pose.
     Set the override of the robot to 30% or less when T2 or AUTO mode is selected, and then create a reference pose. If T1 mode is selected, the override can be improved more than 30%.
     Start "Create Reference Pose", and the reference pose is created while the robot automatically moves to multiple poses and performs vision measurements. The reference pose is created based on the results of the vision measurement.

Move the cursor to "Create Reference Pose", then press the SHIFT key and the F5(CREATE) keys together. The creating the reference pose routing begins. During measurement, the teach pendant displays the following screen.
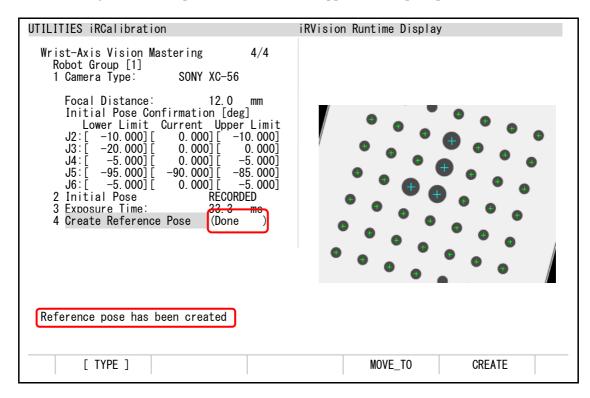
NOTE
1   Keep pressing the SHIFT key during the measurement. If pressing the SHIFT key is interrupted, restart the measurement from the beginning.
2   An attempt to perform camera position measurement during execution of another program causes an error with the following error message displayed: "INTP-313 (VCWMCOMM, 202) Motion statement failed, PROG-040 Already locked by other task"
    In this case, select "ABORT (ALL)" on the FCTN menu to terminate the program.

When the measurement is finished, the display on the teach pendant screen is as follows:
- The "Create Reference Pose" status is "Done".
- A message "Reference pose has been created" appears in the prompt window.

If the error message "J* is near Stroke limit", * is an axis number, appears, the measurement program may stop along the way. It is recommended to re-record another initial pose with a larger margin for J* axis and re-create another reference pose. If there is no space to move the robot to such a position by the surroundings, try to turn J1 axis and move the robot to a place where it can move more easily, and then record the current pose as the new initial pose.

Tips
1   You can move the robot to the reference pose if "Create Reference Pose" is "Done" by pressing the F4(MOVE TO) key while holding down the SHIFT key.
2   If angles of the initial pose are between the lower and upper limits, it is not a problem if ones of the reference pose are not between the limits.

8   When the pose generation is finished, select the PREV key to return to Wrist-Axis Vision Mastering screen.

9.3.6   Executing the Measurement Program
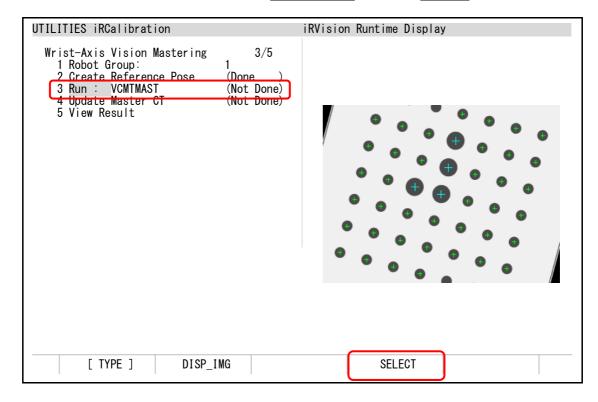
Procedure 9-3   Executing the measurement program

Condition
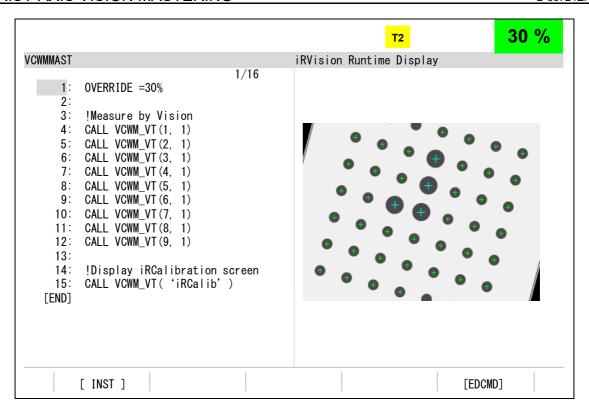
- Make sure that the "Create Reference Pose" status is "Done".

Step

1   Move the cursor to "RUN", then press the F4 (SELECT) key or the ENTER key.

```
UTILITIES iRCalibration                    iRVision Runtime Display

   Wrist-Axis Vision Mastering      3/5
    1 Robot Group:            1
    2 Create Reference Pose      (Done   )
    3 Run :    VCMTMAST          (Not Done)
    4 Update Master CT           (Not Done)
    5 View Result




               [ TYPE ]    DISP_IMG                SELECT
```

The Edit Screen of Measurement Program is displayed.

```
                                                    T2          30 %
 VCWMMAST                              iRVision Runtime Display
                                1/16
      1:  OVERRIDE =30%
      2:
      3:  !Measure by Vision
      4:  CALL VCWM_VT(1, 1)
      5:  CALL VCWM_VT(2, 1)
      6:  CALL VCWM_VT(3, 1)
      7:  CALL VCWM_VT(4, 1)
      8:  CALL VCWM_VT(5, 1)
      9:  CALL VCWM_VT(6, 1)
     10:  CALL VCWM_VT(7, 1)
     11:  CALL VCWM_VT(8, 1)
     12:  CALL VCWM_VT(9, 1)
     13:
     14:  !Display iRCalibration screen
     15:  CALL VCWM_VT( 'iRCalib' )
    [END]



        [ INST ]                                      [EDCMD]
```

2   Set the override of the robot to 30% or less when T2 or AUTO mode is selected, and then run the displayed program. If T1 mode is selected, the override can be improved more than 30%.

NOTE
In case that for any reason the robot can not move to any of the measurement poses during execution of the measurement program, change and re-teach the initial pose and re-create the reference pose
For example, in the case that an operator stops the robot because the robot is going to interfere with the surroundings, re-teach a new initial pose further away from the surroundings. Or in the case that "SRVO-115 Limit error (G:g, A:a)" (g: robot group number, a: axis number) occurs and the robot stops, re-teach a new initial pose with a larger margin of "a" axis. When re-teaching the initial pose and re-creating the reference pose, start at Step 4 of 9.3.5 "Creating the Reference Pose" over again.
In the case that such a new reference pose can not be re-created at the robot's current position, try jogging J1 axis to move the robot to a new place where the robot can move more easily, examine, re-teach the new initial pose and re-create the reference pose there.
If a new reference pose still can not be created after the investigations above, gradually reduce the second argument value of VCWM_VT from one to near zero. The smaller the value is, the smaller the swing angles at the measurement pose is.   As the number gets closer to zero, the accuracy of the mastering is reduced.   For best results, keep the number as close to one as possible.

3   After the measurement completes, the Wrist-Axis Vision Mastering screen is displayed automatically.

9.3.7 Updating Mastering Data
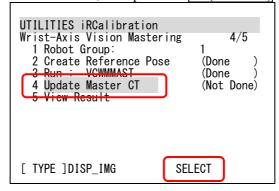
Procedure 9-4   Updating mastering data

Condition

- Make sure that the "Run" status of the measurement program is "Done".

Step

1   Move the cursor to "Update Master CT", then press the F4 (SELECT) key or the ENTER key.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering        4/5
  1 Robot Group:          1
  2 Create Reference Pose      (Done    )
  3 Run :  VCWMMAST          (Done    )
  4 Update Master CT        (Not Done)
  5 View Result


[ TYPE ]DISP_IMG            SELECT
```

The teach pendant displays the mastering data update screen as shown below. The values in parenthesis () are standard ranges of errors. If there is an item that is out of its standard range, its notification message is displayed at the lower part of the screen. Also, updating the mastering data is available even if there is an item that is out of its standard range.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering:        1/4
Update Master CT
  Robot Group [1]
  Compensation Angles: [deg]
    J4:   0.400
    J5:   0.500
    J6:   0.600

  Mean Error of Calibration [mm]:
          0.04
  Max Error of Calibration [mm]:
          0.10   ( 0.50)
  Error of Target Position [mm]
    X:   0.10   (± 1.00)
    Z:   0.10   (± 0.50)

[ TYPE ]             UPDATE
```

NOTE
  Mastering parameters are not updated at this point.

Confirm the items displayed. If there is no problem, press the F3 (UPDATE) key while holding down the SHIFT key to update mastering data.

Tips
  This function compensates mastering data to match following positional information 1 and 2 with respect to a robot coordinate system as much as possible about each measurement pose.
  1: the position of the center of the grid measured by vision
  2: the position of the center of the grid calculated by the joint angles in performing vision measurement

---

Display items on Updating Mastering Data screen

Compensation Angles

This item indicates the compensation angles for the angular displacement shifted from the zero position for each rotation axis [degree]

If at least one of Compensation Angles is exceeding 1°, update mastering data and run the measurement program again, then confirm that the value of Compensation Angles displayed on Updating Mastering Data screen becomes smaller.

Mean Error of Calibration

This item indicates the mean value of distance between above 1 and 2 of every measurement poses after compensating angles [mm]

Max Error of Calibration

This item indicates the max value of distance between above 1 and 2 of every measurement poses after compensating angles [mm]

If this value is much higher than the standard range, the measurement might have not been done properly. Check if the measurement target, the lens or the camera is not secured, and the lens is out of focus. And, make another try.

Error of Target Position

This item indicates the difference of the value got by mastering calculation and the designed value in the design drawing of the measurement target about X and Z components of the center of the grid in the mechanical interface coordinate system [mm]

If this value is much higher than the standard range, the measurement target might have not been secured or the measurement target might have not been fixed at the proper place by inserting the positioning-pins. Check if there is anything wrong, and try again

3   When updating is finished, select the PREV key to return to Wrist-Axis Vision Mastering screen.

4   After updating the mastering data, set the reference position for Quick Mastering again, preparing for future Quick Mastering. If it has not been set, set it as all the axes' angles are 0 degree. For details of Quick Mastering, please refer to "R-30*i*B / R-30*i*B Mate OPERATOR'S MANUAL (Basic Operation)" and "Mechanical Unit Operator's Manual".

NOTE
In the following software versions, a notification "Ref. Pos. for Quick Mastering Not Set" will be displayed on the notifications screen when you execute Wrist-Axis Vision Mastering. This notification will be cleared when you set a quick mastering reference point.
- 7DF1/34(V9.10P/34) or later
- 7DF3/17(V9.30P/17) or later
- 7DF5/14(V9.40P/14) or later
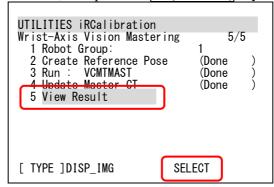
9.3.8   Viewing and Saving Mastering Results
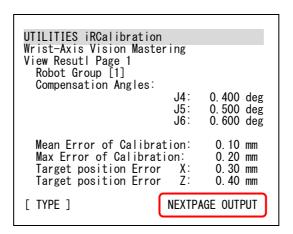
Procedure 9-5   Viewing and saving mastering results

Step

1   Move the cursor to "View Result", then press the F4 (SELECT) key or the ENTER key.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering        5/5
  1 Robot Group:            1
  2 Create Reference Pose      (Done    )
  3 Run :  VCMTMAST           (Done    )
  4 Update Master CT          (Done    )
  5 View Result


[ TYPE ]DISP_IMG              SELECT
```

The teach pendant displays the mastering result display screen as shown below.

```
UTILITIES iRCalibration
Wrist-Axis Vision Mastering
View Resutl Page 1
  Robot Group [1]
  Compensation Angles:
                    J4:   0.400 deg
                    J5:   0.500 deg
                    J6:   0.600 deg

  Mean Error of Calibration:     0.10 mm
  Max Error of Calibration:      0.20 mm
  Target position Error   X:     0.30 mm
  Target position Error   Z:     0.40 mm
[ TYPE ]              NEXTPAGE OUTPUT
```

Function key
F4 (NEXTPAGE): Displays the next page.
F5 (OUTPUT):   Save VCWM_LOG.TXT, the Wrist-Axis Vision Mastering results logging file to the file I/O devices (a memory card, an USB memory, etc). For details of selecting the file I/O devices in the file menu, refer to the "R-30*i*B / R-30*i*B Mate OPERATOR'S MANUAL (Basic Operation)".

Tips
If VCWM_LOG.TXT already exists, the new results are appended to the current contents.
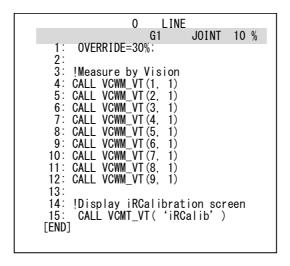
9.4 DETAILS OF TP PROGRAMS AND LOG FILE

9.4.1 TP Program

TP Program for Measurement
VCWMMAST

```
                          0    LINE
                                 G1     JOINT   10 %
              1:  OVERRIDE=30%;
              2:
              3:  !Measure by Vision
              4:  CALL VCWM_VT(1, 1)
              5:  CALL VCWM_VT(2, 1)
              6:  CALL VCWM_VT(3, 1)
              7:  CALL VCWM_VT(4, 1)
              8:  CALL VCWM_VT(5, 1)
              9:  CALL VCWM_VT(6, 1)
             10:  CALL VCWM_VT(7, 1)
             11:  CALL VCWM_VT(8, 1)
             12:  CALL VCWM_VT(9, 1)
             13:
             14:  !Display iRCalibration screen
             15:  CALL VCMT_VT( 'iRCalib' )
             [END]
```

VCWM_VT : This is a KAREL program for positioning by vision
Argument 1: measurement pose number
Argument 2: the value about swing angles at the measurement pose. This is basically 1, but user can modify this between 0 and 1 for example 0.9, 0.8 and so on if needed.
(swing angles at the measurement pose) = (Argument 2) times (maximum swing angles)
And in case Argument 1 is 'iRCalib' and Argument 2 is not used as "VCWM_VT('iRCalib') ", if measurements at all measurement position are done, Wrist-Axis Vision Mastering screen will be displayed.

9.4.2 Log File

Log File of the Wrist-Axis Vision Mastering Result
VCWM_LOG.TXT

```
iRCalibration Wrist-Axis Vision Mastering Log File

Robot Group [1]
Robot Model :  R2000iB/165F
Robot Number:  2538797
Soft Version:  V8.30P/03
Master Time :  14-JUL- 1 18:07
Log Time   :  14-JUL- 1 18:07

Gravity Compensation: OFF

New Master Counts :
[1]:    123456
[2]:    123678
[3]:    123789
[4]:   1238889
[5]:    123889
[6]: 12345678
[7]:         0
[8]:         0
[9]:         0


Compensation Angles:
[4]:    0.400 [5]:    0.500  [6]:    0.600

Mean Residual Error:        .10
Max Residual Error:         .20
Target Position Error X:  -.30
Target Position Error Z:   .40

Origin Master Counts:
[1]:    123456
[2]:    123678
[3]:    123789
[4]:   1249880
[5]:    155883
[6]: 12345778
[7]:         0
[8]:         0
[9]:         0
```

10 VISION TCP SET

10.1 VISION TCP SET

What is Vision TCP Set?

Vision TCP Set automatically sets the tool center point (TCP) of the robot using a camera.
The function sets the TCP at a target position on the tool tip using a camera (vision system).
In case of a 6-axis robot, this function sets XYZWPR of the selected tool frame.
In case of a 4-axis robot, this function sets only X and Y components of the selected tool frame.

Features of Vision TCP Set

Operations other than the camera installation are performed automatically. Manual operations are therefore simplified, and the operation results do not depend on the skill of the operator.

TP programs used for Vision TCP Set

Vision TCP Set uses robot operation programs (hereinafter referred to as TP programs) to perform a sequence of operations.
These TP programs can also be created beforehand with offline programming. This can further reduce work time on the factory floor and accomplish work efficiently in a shorter time.
For details of TP program, see Section 10.4 "Vision TCP Set TP program" in this manual.

10.2 SYSTEM CONFIGURATION

10.2.1 Overall Configuration

The Vision TCP Set system consists of a robot controller, a teach pendant (*i*Pendant), and a camera with lens.
For the specifications of the camera, camera cable and lens, see Section 2.1, "COMPONENTS".
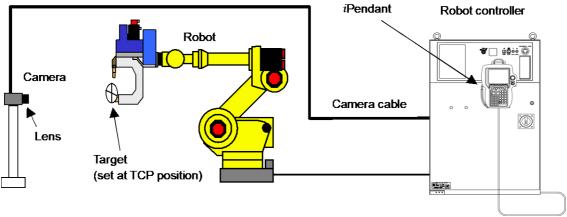
Fig.10.2.1 System configuration of Vision TCP Set

Setting the camera

Set the camera on the floor by using a tripod or camera stand.
Ensure that the camera does not move during execution of Vision TCP Set.

Target

Set a target mark to be detected by the vision function at the tool tip position where TCP is to be set. Ensure that the target does not move during execution of Vision TCP Set.

10.3   VISION TCP SET PROCEDURE

This section describes the procedure for setting TCP with the Vision TCP Set screen.

10.3.1   Outline of the TCP Set Procedure

The Vision TCP Set setup procedure is outlined below.

| Setting of camera and target | Connect the camera then set a target and the camera. |

Connecting camera to robot controller or *i*Pendant

Setting of camera and target

| Setting of TP program creation | Set the parameters for creating a TP program for TCP setting. |

Setting on Setup screen

Set the parameters for creating a TP program for TCP setting. Set a name of a TP program created, Tool Frame number for TCP setting, a work register number, etc.

| Setting of Vision data | Teach a model for target detection with the vision function. For details, see Chapter 3, "BASIC VISION FUNCTION OPERATION". |

Moving to measurement positions

Move to a position (1 point) where the target is measured by the camera. While viewing a camera image, move to a position that enables the target to be in the camera visual field.

Teaching of model

Teach a target model.

| Execution of TCP setting | Create the TP program and execute it to set TCP. |

Fig.10.3.1 Outline of the TCP Set Procedure

10.3.2   Preparation

1   Connect the camera to the robot controller or the *i*Pendant.
2   Check that a camera image can be displayed on the *i*Pendant, according to the procedure described in Chapter 3, "BASIC VISION FUNCTION OPERATION".
3   Secure a target to the tool tip of the robot.
4   Secure the camera.   Although there is no exact specification as to the position where the camera is to be installed, make sure the camera is fixed securely so that it does not move during measurement.

Target mark examples

The following examples are recommended as marks for the target, including a combination of a circle and a cross as shown below.

Fig. 10.3.2 (a) Example 1 of a target mark

Fig. 10.3.2 (b) Example 2 of a target mark
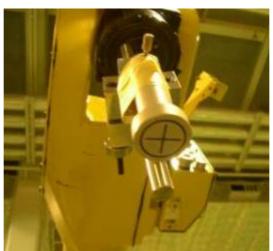
Fig. 10.3.2 (c) Example of setting a target mark

A target should have the following features:
- A flat detection surface.
- A contour that makes it easy to recognize the size of the target. (The circle in the above examples.)
- A contour that makes it easy to recognize rotation within 45 degree range. (The cross in the above examples.)

NOTE
Glossy materials are not recommended.
If a metal target is required, use one with a frosted surface, such as anodized aluminum(duralumin).
A handy way to attach a target mark is to affix a sticker with that mark printed on it.

Installation examples (recommended placement)

When you place a robot, a camera, and a target, it is recommended to place them as shown below if possible:

1   Set the individual axis positions (J1, J2, J3, J4, J5, J6) of the robot approximately to 0, 0, 0, 0, -90, and 0 in degrees.
2   Attach the target mark to the tool tip.
3   Install the camera about 400 mm away from the target mark.
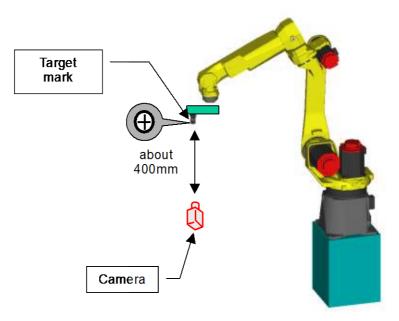
Fig. 10.3.2 (d) Installation example for handling or general use
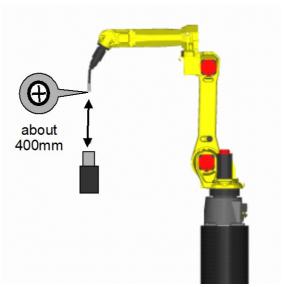
Fig. 10.3.2 (e) Installation example for arc welding
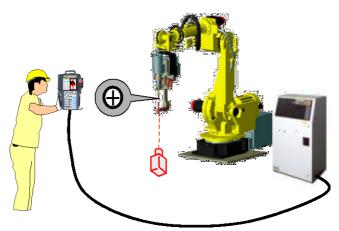
Fig. 10.3.2 (f) Installation example for spot welding

10.3.3 Additional preparation for 4-axis/5-axis Robot

In case of a 4-axis robot or 5-axis robot, Vision TCP Set sets only the X and Y components of the tool frame. Before executing Vision TCP Set, set the Z components of the tool frame manually as precise as possible.
Set W, P, R components of the tool frame manually if necessary.

10.3.4 Additional Preparation for M-1iA/0.5A

In case of an M-1*i*A/0.5A, the appropriate value of some parameters for vision measurement is different from that for the other robot. (For more detail, see Section 8.5 "Vision TCP Set TP program".)
The value of these parameters is automatically changed and you do not have to do anything for M-1*i*A/0.5A.

10.3.5 Vision TCP Set Screen

You can use the Vision TCP Set screen on the robot teach pendant to perform the setting and operation for Vision TCP Set.

Procedure 10-1 Displaying Vision TCP Set screen

Step

1   Press the MENU key on the teach pendant.
2   Select "UTILITIES".
3   Press the F1 [TYPE] key.
4   Select "*i*RCalibration".
         The UTILITIES *i*RCalibration screen is displayed.
5   Select "Vision TCP Set".
         The Vision TCP Set screen is displayed.

To return to the Vision TCP Set screen when another screen is displayed after the Vision TCP Set screen was displayed, steps 1 through 5 above can be used.

Procedure 10-2   Ending the Vision TCP Set screen

Step

Pressing the PREV key on the Vision TCP Set screen exits the Vision TCP Set screen.

When you have finished Vision TCP Set, exit the Vision TCP Set screen. Exiting the Vision TCP Set screen does not lose the values set while the screen was displayed.
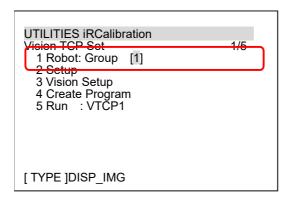
10.3.6   Selecting the Robot Motion Group

Select the robot motion group to be subject to Vision TCP Set. For a system with a single robot, for example, select "1" as the system has only group 1.

Procedure 10-3   Selecting the robot motion group

Step

1   On the Vision TCP Set screen, specify the motion group number of the robot, on which Vision TCP Set will be done, at the item of "Robot: Group"

```
UTILITIES iRCalibration
Vision TCP Set                        1/5
  1 Robot: Group   [1]
  2 Setup
  3 Vision Setup
  4 Create Program
  5 Run   : VTCP1




[ TYPE ]DISP_IMG
```
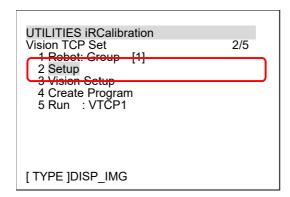
10.3.7   Setting for TP Program

Set a variety of conditions for generating TP programs for Vision TCP Set.

Procedure 10-4   Setting for TP program creation

Step
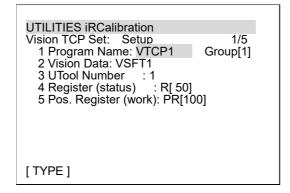
1.   Move the cursor to "Setup" on the Vision TCP Set screen, then press the ENTER key.
      The setup screen will then appear.

```
UTILITIES iRCalibration
Vision TCP Set                        2/5
  1 Robot: Group   [1]
  2 Setup
  3 Vision Setup
  4 Create Program
  5 Run    : VTCP1




[ TYPE ]DISP_IMG
```

2.   Check the contents of the setup screen, and make changes as required.
      When you have completed the setup, press the PREV key to display the Vision TCP Set screen.

```
UTILITIES iRCalibration
Vision TCP Set:   Setup                    1/5
   1 Program Name: VTCP1        Group[1]
   2 Vision Data: VSFT1
   3 UTool Number     : 1
   4 Register (status)   : R[ 50]
   5 Pos. Register (work): PR[100]




[ TYPE ]
```

Details of settings

Program Name
> This item specifies the name of a TP program to serve for execution of Vision TCP Set.
> The TP program having this name will be created later; Vision TCP Set will be performed by executing the program. (Default value: VTCP1)

Vision Data
> This item specifies the name of model data to which to teach a target mark model.
> If a target mark model is taught to model data different from the one specified here later, correct this setting before creating the TP program. (Default value: VSFT1)

Utool Number
> This item specifies the number of a tool frame you want to set the position of a target mark on.
> The tool frame having the number specified here is set by Vision TCP Set. (Default value: 1)

Register (status)
> This item specifies the number of the register to be used for storing a vision detection processing status. (Default value: 50)

Pos. Register (work)
> This item specifies the number of the position register to be used for storing a vision-detected position. (Default value: 100)
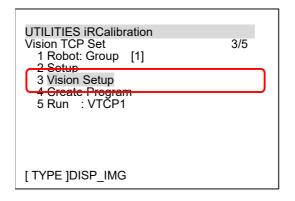
10.3.8   Vision Function Setting

Move the robot to a position where the target can be measured with the camera.
On the vision setup screen, teach the model of the target mark to be detected, and make sure that the target model can be detected. For the procedure, refer to "3.4.4 Model Training Screen".
To enter the vision setup screen, move the cursor to "Vision Setup" on the Vision TCP Set screen, and press the ENTER key.

```
UTILITIES iRCalibration
Vision TCP Set                             3/5
   1 Robot: Group    [1]
   2 Setup
   3 Vision Setup
   4 Create Program
   5 Run    : VTCP1




[ TYPE ]DISP_IMG
```

Position for vision teaching

Vision teaching is performed with the robot moved to a position satisfying the following conditions. Create the TP program later at that same position.

- The target is viewed close to the center of a camera field of view.
- The target plane is almost parallel to the camera lens.
- The distance between the camera and the target is about 400 mm.
- A sufficient space is available to prevent peripheral interference during execution of the TP program.

Lighting the target

If glare appears on the target in the camera image when vision teaching, an inappropriate model may be taught. In such cases, target mark measurement cannot be performed appropriately and Vision TCP Set cannot be performed either.

If that is the case, shade the light from the target to prevent intense lighting or apply a frosted, transparent adhesive tape to the target to suppress reflection so that vision measurement can be performed appropriately.
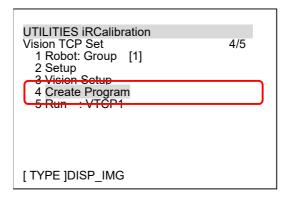
10.3.9   Executing Vision TCP Set

Create and execute the TP program to perform TCP setting.
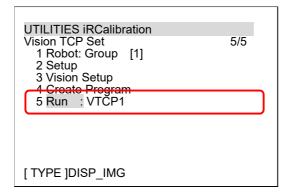
Procedure 10-5   Executing Vision TCP Set

Step

1   Move the robot to a position where the target can be measured with the camera.
(Select a target teaching position as described above, then create and execute the TP program preferably at the same position. During execution of the TP program created here, the robot automatically changes the position and posture of the tool to show the target in different orientations to the camera. Select the position at which the robot does not interfere with its surroundings while moving.)

2   On the Vision TCP Set screen, move the cursor to "Create Program" and press the ENTER key.
You will be asked whether you want to create the TP program. Follow the on-screen instructions by pressing the appropriate keys to create the TP program.

```
UTILITIES iRCalibration
Vision TCP Set                        4/5
  1 Robot: Group   [1]
  2 Setup
  3 Vision Setup
  4 Create Program
  5 Run    : VTCP1



[ TYPE ]DISP_IMG
```

3   Move the cursor to "Run" and press the ENTER key.

```
┌─────────────────────────────────────┐
│ UTILITIES iRCalibration              │
│ Vision TCP Set                  5/5  │
│    1 Robot: Group   [1]              │
│    2 Setup                           │
│    3 Vision Setup                    │
│    4 Create Program                  │
│    5 Run   : VTCP1                    │
│                                      │
│                                      │
│                                      │
│ [ TYPE ]DISP_IMG                     │
└─────────────────────────────────────┘
```

4   The screen changes to the edit screen, displaying the created TP program.
     If you execute the program there, Vision TCP Set is performed. That is, the measured position of the
     target mark is set in the specified tool frame.

┌──┐
│ **NOTE**   │
│   If the "CVIS-021 Exceed VisPool" error stops the execution of the TP program,   │
│   cycle controller power and run the TP program again.   │
└──┘

┌──┐
│ **NOTE**   │
│   For 7DC3/10 (V8.30P/10) or later software, in the case of 6-axis robot, call   │
│   instructions of the program VCRSM_CHECK, label instructions, and jump   │
│   instructions are added to the TP program so that efficient resuming of the   │
│   measurement can be done. When the measurement is interrupted by the release   │
│   of the SHIFT key, the occurrence of an alarm or other reasons, re-execute the   │
│   TP program after moving the cursor to the first line. If a part of the measurement │
│   has been completed, a message "Press 0 (restart) or 9 (resume)" appears.   │
│   Press the 0 key to restart the measurement from the beginning or the 9 key to   │
│   resume the measurement.   │
└──┘

You have now completed Vision TCP Set, but if it is necessary to improve the accuracy of TCP, refer to
Section 10.5 "IMPROVING THE ACCURACY OF TCP".

10.3.10   Result of Vision TCP Set for a 6-axis Robot

If you are using a 6-axis robot, or a Genkotsu-Robot, when the TP program is normally finished, the
optical axis of the camera is normal (at right angles) to the target plane. On the camera image, the target
rotates about the optical axis of the camera so that the target is oriented in the same direction as in model
teaching.
The following positions and directions are obtained by Vision TCP Set on the tool frame:
- TCP (= the origin of the tool frame) is the center of the target.
- The Z axis of the tool frame is perpendicular to the target plane; the direction from the camera to the
  target is Z+.
- The X axis of the tool frame runs vertically (+ upward) on the screen during model teaching.
- The Y axis of the tool frame runs horizontally (+ to the right) on the screen during model teaching.

To change the TCP position or the direction of a coordinate axis of the obtained tool frame, use the
KAREL program VTOFSTUT described later.

10.3.11 Result of Vision TCP Set for 4-axis/5-axis Robot

If you are using a 4-axis robot, including, a Genkotsu-Robot, or a 5-axis robot, when the TP program is normally finished, the target is viewed at the center of the camera screen and its posture is the same as the one before the execution.
The following positions and directions are obtained by Vision TCP Set on the tool frame:
- X and Y components of TCP (= the origin of the tool frame) is the center of the target.
- Z, W, P and R components of the tool frame remain the same as those before the execution.

To change the TCP position or the direction of a coordinate axis of the obtained tool frame, use the KAREL program VTOFSTUT described later.

10.3.12 Offsetting the Tool Frame with VTOFSTUT

VTOFSTUT is a program for offsetting (shifting) the position or direction of the tool frame.
This program sets a tool frame offset by a specified amount from the current tool frame.
This program can be used, for example, "to offset the TCP by Δ mm in the Z direction of the current tool frame" or "to reverse the Z-axis direction of the tool frame".

Usage

VTOFSTUT is a KAREL subprogram installed on the robot controller together with the automatic TCP set function. A TP program calls VTOFSTUT to use it.

```
CALL VTOFSTUT(grp_num, src_ut, dest_ut,
              dx, dy, dz, [dw, dp, dr] )
```

grp_num: Robot group number
src_ut: Input(source) tool frame number
dest_ut: Output(destination) tool frame number
dx,dy,dz: TCP position offset amount (in mm)
dw,dp,dr: [Optional] Tool frame rotation (WPR) offset amount (in deg)
       dw   Angular displacement about the X-axis of the current(input) tool frame
       dp   Angular displacement about the Y-axis of the current(input) tool frame
       dr   Angular displacement about the Z-axis of the current(input) tool frame

Operation

VTOFSTUT offsets the tool frame that belongs to the group specified in "grp_num" and has the number specified in "src_ut" by the offset amount specified in "dx, dy, dz, dw, dp, and dr".
The result is set in the tool frame that has the number specified in "dest_ut".
- The same tool frame number may be specified in "src_ut" and "dest_ut". (In this case, the current tool frame data is overwritten.)
- To offset the TCP position only, the specification of angular displacements (dw, dp, and dr) may be omitted.
- The first argument (for group number specification) must not be omitted. Even if the system has only one robot group, specify "1".

Examples
<Example 1> The Z direction of the tool frame is reversed (without changing the X-axis direction)
This example reverses the direction of the Z-axis without changing the direction of the X-axis.
The current tool frame is rotated 180° about the X-axis to reverse the direction of the Z-axis without changing the direction of the X-axis of the current tool frame.

Offset specification method:
A new tool frame is formed by "rotating the current tool frame 180° about the X-axis (of the current tool frame)". So, specify the following:

dx = dy = dz = 0   No TCP position offset
dw=180,   dp = dr = 0   Rotation by 180° about the X-axis

VTOFSTUT(grp_num, src_ut, dest_ut, 0, 0, 0, 180, 0, 0)

<Example 2> The Z direction of the tool frame is reversed (without changing the Y-axis direction)
This example reverses the direction of the Z-axis without changing the direction of the Y-axis.
The current tool frame is rotated 180° about the Y-axis to reverse the direction of the Z-axis without changing the direction of the Y-axis of the current tool frame.

Offset specification method:
A new tool coordinate system is formed by "rotating the current tool frame 180° about the Y-axis (of the current tool frame)". So, specify the following:

dx = dy = dz = 0   No TCP position offset
dw=0,   dp =180,   dr = 0   Rotation by 180° about the Y-axis

VTOFSTUT(grp_num, src_ut, dest_ut, 0, 0, 0, 0, 180, 0)

<Example 3> The tool frame is copied.
The tool frame can be copied by setting all offset amounts to 0.
VTOFSTUT(grp_num, src_ut, dest_ut, 0, 0, 0, 0, 0, 0)

Supplement: Order of applying W, P, and R offset amounts
When angular displacements about two or more axes are specified using dw, dp, and/or dr, or position and rotation offset amounts are specified simultaneously, the order of the offset application is as follows:
(1)   Parallel shift of the TCP by dx, dy, and dz
(2)   Rotation by dr about the Z-axis
(3)   Rotation by dp about the Y-axis
(4)   Rotation by dw about the X-axis

This means:
    vtofstut(grp_num, 1, 2, dx,dy,dz, dw,dp,dr) has the effect of executing vtofstut in succession in the
        order from <1> to <4> as   indicated below.
    vtofstut(grp_num, 1, 2, dx, dy, dz,   0,   0,   0)   <-- <1>
    vtofstut(grp_num, 2, 2,   0,   0,   0,   0,   0, dr)   <-- <2>
    vtofstut(grp_num, 2, 2,   0,   0,   0,   0, dp,   0)   <-- <3>
    vtofstut(grp_num, 2, 2,   0,   0,   0, dw,   0,   0)   <-- <4>

    <1> Shift of the TCP by (dx,dy,dz) (without changing the tool coordinate system direction)
    <2> Rotation by dr about the Z-axis of the current tool coordinate system
    <3> Rotation by dp about the Y-axis of the new tool coordinate system created by <2>
    <4> Rotation by dw about the X-axis of the new tool coordinate system created by <3>

10.4   AUTOMATIC MEASUREMENT

10.4.1   Vision TCP Set Program (7DC3/09 or earlier)

VSETTCP is the program that performs TCP setting.

Usage

To call this subprogram, specify the arguments below. Arguments 2 through 4 are optional and may be omitted.
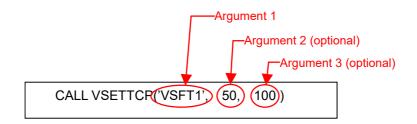
Argument 1: Specify a vision data name (model name) by using a character string.
This argument must be specified at all times.
Argument 2: (Optional) Specify the number of a register for storing the result of detection.
When this argument is omitted, register No.50 (R[50]) is used.
Argument 3: (Optional) Specify the name of a position register for storing a vision detection position. When this argument is omitted, position register No.100 (PR[100]) is used.
Argument 4: (Optional) Specify the group number of a robot used for TCP setting.
When this argument is omitted, group 1 is used. This argument may be omitted when the system has only one robot group.
When VSETTCP is executed, the robot with the specified group number moves.
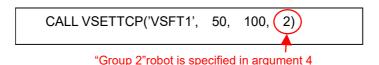
Argument 1
Argument 2 (optional)
Argument 3 (optional)

CALL VSETTCP('VSFT1', 50, 100)

Example) When a robot group other than group 1 is specified in argument 4 in a system with multiple robots

CALL VSETTCP('VSFT1',   50   100,   2)

"Group 2"robot is specified in argument 4

- When a position register number (argument 3) is specified, a register number (argument 2) must also be specified.
- When a robot group number (argument 4) is specified, a register number (argument 2) and a position register number (argument 3) must also be specified.

Operation

When VSETTCP is called, the robot in the group specified in the fourth argument (group 1 by default) automatically performs the vision measurement to calculate TCP and set the specified tool frame active. The operation differs between 6-axis robot and 4-axis/5-axis robot.

10.4.2   Vision TCP Set Program (7DC3/10 or later)

VTCPSET is the program that performs TCP setting.

Usage

To call this subprogram, specify the arguments below. Arguments 2 and 3 are optional and may be omitted.

Argument 1: Specify a vision data name (model name) by using a character string.
This argument must be specified at all times.
Argument 2: (Optional) Specify the group number of a robot used for TCP setting.
When this argument is omitted, group 1 is used. This argument may be omitted when the system has only one robot group.
When VTCPSET is executed, the robot with the specified group number moves.
Argument 3: (Optional) Specify the measurement number of VTCPSET.
For 6-axis robot, the measurement is completed by executing this program with this argument from 1 to 10.

- When a measurement number (argument 3) is specified, a robot group number (argument 2) must also be specified.

Operation

When VTCPSET is called, the robot of the group specified in the second argument (group 1 by default) automatically performs the (argument 3)-th vision measurement to calculate TCP and set the specified tool frame active. If the third argument is omitted, all the measurements to calculate TCP and set the specified tool frame active are performed. The operation differs between 6-axis robot and 4-axis/5-axis robot.

10.4.3   Automatic Measurement for 6-axis Robot

The operation for 6-axis robot is described below.
1   The robot moves so that the target can be viewed at the center of a camera image.
2   The robot moves back and forth along the optical axis of the camera. (See the following table for information about the   moving distance.)
3   The robot moves to rotate the target about the optical axis of the camera. (See the following table for information about the rotation angle.)
4   The robot moves to tilt the target relative to the optical axis. (See the following table for information about tilt angle,.)

In any case, the robot moves while keeping the target placed at the center of a camera image.
The values of above moving distance, rotation angle and tilt angle differ between M-1iA/0.5A and the robot other than M-1iA/0.5A. The following table lists the values of the parameters for M-1iA/0.5A and the robot other than M-1iA/0.5A.

Table 10.4.3 The default values of the parameters for the operation of VTCPSET

	M-1iA/0.5A	Other than M-1iA/0.5A
Moving distance along the optical axis of the camera	+/-15 mm	+/-25 mm
Rotation angle about the optical axis of the camera	+/-5 deg	+/-15 deg
Tilt angle relative to the optical axis of the camera	+/-5 deg	+/-15 deg

10.4.4   Automatic Measurement for 4/5-axis Robot

The operation for the 4-axis/5-axis robot is described below.
1   The robot moves so that the target can be viewed at the center of a camera image.
2   The robot moves to rotate the target about the robot flange axis (about +/-15 deg).

10.5   IMPROVING THE ACCURACY OF TCP

By increasing the rotation angle and division number for vision measurement, it may be possible to improve the accuracy of TCP. If it is necessary to improve the accuracy of TCP, follow these steps below and execute Vision TCP Set program.

> ⚠ **CAUTION**
> Increasing rotation angle can cause interference with the surroundings, cable cutoff , and stroke limit. It is necessary to operate carefully by setting the override lower. To reduce the possibility of these problems, set the initial robot position at approximately the center of the robot motion.

10.5.1   Improving the Accuracy of X and Y Components of TCP

By increasing the rotation angle and division number about the optical axis of the camera, it may be possible to improve the accuracy of X and Y components of TCP. The relevant parameters are shown below. For example, if MOVE_DIST_R is set to 90 deg and DIV_NUM_R is set to 3, vision measurements are executed with rotation angle about the optical axis of the camera -90, -60, -30, 0, +30, +60 and +90 deg.

Table 10.5.1 Parameters for improving the accuracy for X and Y components of TCP

Parameter	Explanation	Default value	Recommended value
MOVE_DIST_R	Rotation angle about the optical axis of the camera	15 deg	60 ~ 90 deg
DIV_NUM_R	Division number for rotating about the optical axis of the camera	1	2 ~ 3

These two parameters are set by calling the program VTCPINIT. Set the arguments described below.
Argument 1:   Specify the name of parameter to set.
Argument 2:   Specify the value to be set.

Add the process to call VTCPINIT as follows. Here is the example of setting MOVE_DIST_R to 90 deg and DIV_NUM_R to 3.
Add following 2 lines after the call instruction of VTCPINIT without an argument in the TP program created in "10.3.9 Executing Vision TCP Set", if the software version is 7DC3/10 (V8.30P/10) or later.
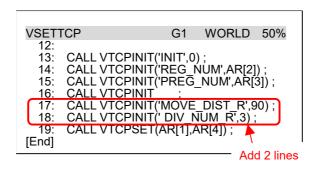
```
VTCP1                    G1    WORLD   50%

     7:J P[1] 30% FINE      ;
     8:   CALL VTCPINIT('INIT',0) ;
     9:   CALL VTCPINIT          ;
    10:   CALL VTCPINIT('MOVE_DIST_R',90) ;
    11:   CALL VTCPINIT(' DIV_NUM_R',3) ;
    12:   CALL VTCPSET('VSFT1',1,1) ;
    13:
```

Add 2 lines

Perform the following operations, if the software version is 7DC3/09 (V8.30P/09) or earlier.
1   Move the cursor to VSETTCP.MR and press F2 (DETAIL) on the program list screen of the teach pendant.
2   Set "Write protect" to "OFF" on the detail screen.
3   Move the cursor to VSETTCP.MR on the program list screen and select it.
4   Add following 2 lines after the call instruction of VTCPINIT without an argument.

```
VSETTCP                  G1    WORLD   50%
    12:
    13:   CALL VTCPINIT('INIT',0) ;
    14:   CALL VTCPINIT('REG_NUM',AR[2]) ;
    15:   CALL VTCPINIT('PREG_NUM',AR[3]) ;
    16:   CALL VTCPINIT          ;
    17:   CALL VTCPINIT('MOVE_DIST_R',90) ;
    18:   CALL VTCPINIT(' DIV_NUM_R',3) ;
    19:   CALL VTCPSET(AR[1],AR[4]) ;
[End]
```

Add 2 lines

5   Reopen the detail screen for VSETTCP.MR, and set "Write protect" to "ON".

10.5.2   Improving the Accuracy of Z Component of TCP

In case of 6-axis robot including Genkotsu-Robot, by increasing tilt angle and division number relative to the optical axis of the camera, it may be possible to improve the accuracy of Z component of TCP. This function doesn't set Z component of TCP for 4-axis robot and 5-axis robot, so this sub-section is only for 6-axis robot.
The relevant parameters are shown below. Two parameters for tilt angle are the rotation angle about X-axis and Y-axis of tool frame described in 10.3.10. For example, if MOVE_DIST_W is set to 40 deg, MOVE_DIST_P is set to 45 deg and DIV_NUM_R is set to 2, vision measurements are executed with rotation angle about X-axis of the tool frame -40, -20, 0, +20, and +40 deg, rotation angle about Y-axis -45, -22.5, 0, +22.5 and +45 deg.

Table 10.5.2 Parameters for improving the accuracy for Z component of TCP

parameter	Explanation	Default value for M-1iA/0.5A	Default value for the robot other than M-1iA/0.5A	Recommended value
MOVE_DIST_W	Tilt angle 1 relative to the optical axis of the camera	5 deg	15 deg	35 ~ 45 deg
MOVE_DIST_P	Tilt angle 2 relative to the optical axis of the camera	5 deg	15 deg	35 ~ 45 deg
DIV_NUM_WP	Division number for tilting relative to the optical axis of the camera	1	1	2 ~ 4 (Don't set to more than 5)

These three parameters are set by calling the program VTCPINIT. Set the arguments described below.
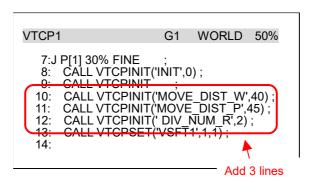
Argument 1: Specify the name of parameter to set.

Argument 2: Specify the value to be set.

Argument 1 — — Argument 2

```
CALL VTCPINIT(MOVE_DIST_W, (40))
```
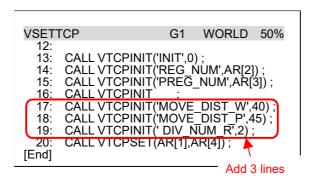
Add the process to call VTCPINIT as follows. Here is the example of setting MOVE_DIST_W to 45 deg, MOVE_DIST_P to 45 deg and DIV_NUM_R to 2.

Add following 3 lines after the call instruction of VTCPINIT without an argument in the TP program created in "10.3.9 Executing Vision TCP Set", if the software version is 7DC3/10 (V8.30P/10) or later.

```
VTCP1                    G1    WORLD   50%

  7:J P[1] 30% FINE      ;
  8:   CALL VTCPINIT('INIT',0) ;
  9:   CALL VTCPINIT        ;
 10:   CALL VTCPINIT('MOVE_DIST_W',40) ;
 11:   CALL VTCPINIT('MOVE_DIST_P',45) ;
 12:   CALL VTCPINIT(' DIV_NUM_R',2) ;
 13:   CALL VTCPSET('VSET1',1,1) ;
 14:
```
Add 3 lines

Perform the following operations, if the software version is 7DC3/09 (V8.30P/09) or earlier.

1   Move the cursor to VSETTCP.MR and press F2 (DETAIL) on the program list screen of the teach pendant.

2   Set "Write protect" to "OFF" on the detail screen.

3   Move the cursor to VSETTCP.MR on the program list screen and select it.

4   Add following 3 lines after the call instruction of VTCPINIT without an argument.

```
VSETTCP                  G1    WORLD   50%
 12:
 13:   CALL VTCPINIT('INIT',0) ;
 14:   CALL VTCPINIT('REG_NUM',AR[2]) ;
 15:   CALL VTCPINIT('PREG_NUM',AR[3]) ;
 16:   CALL VTCPINIT        ;
 17:   CALL VTCPINIT('MOVE_DIST_W',40) ;
 18:   CALL VTCPINIT('MOVE_DIST_P',45) ;
 19:   CALL VTCPINIT(' DIV_NUM_R',2) ;
 20:   CALL VTCPSET(AR[1],AR[4]) ;
[End]
```
Add 3 lines

5   Reopen the detail screen for VSETTCP.MR, and set "Write protect" to "ON".

NOTE

For 7DC1/10(V8.10P/10) or later software, please set DIV_NUM_WP to 5 or less. The same setting applies to the Mate controller with 7DD0/03(V8.13P/03) or later software.

For 7DC1/09(V8.10P/09) or earlier software, set the DIV_NUM_WP to 4 or less. The same setting applies to the Mate controller with 7DD0/02(V8.13P/02) or earlier software.

10.6   TROUBLESHOOTING

10.6.1   An alarm occurs during executing the TP program

An alarm such as 'MOTN-017 Limit error', 'MOTN-018   Position not reachable', or 'MOTN-023 In singularity' may occur during executing the TP program. In such a case, try creating the program again after changing initial position of the camera and the target or initial pose of the robot so that the alarm doesn't occur.

In case that the alarm still occurs even if the above countermeasure has been taken, add some instructions in order to narrow the robot-moving range during executing the TP program so that the alarm doesn't occur. (This method can be used for 6-axis robots except Genkotsu-robots)

The instructions to be added into the TP program are as follows.

➢ Add 5 lines of the instructions after the instruction for calling VTCPSET with no argument as the figure below.
➢ Set 'MOVE_DIST_W', 'MOVE_DIST_P', 'MOVE_DIST_R', 'MOVE_DIST_FW' or 'MOVE_DIST_FP' as the first argument of each instruction respectively. And set a value between 5 and 15 to the second argument of each instruction. Note that the smaller these values are, the less the setting accuracy of the TCP could be, so these values should not be reduced too much.
➢ Each default value of 'MOVE_DIST_W', 'MOVE_DIST_P', 'MOVE_DIST_R', 'MOVE_DIST_FW', and 'MOVE_DIST_FP' is 15.

```
CALL VTCPINIT
CALL VTCPINIT('MOVE_DIST_W',   15)
CALL VTCPINIT('MOVE_DIST_P',   15)
CALL VTCPINIT('MOVE_DIST_R',   15)
CALL VTCPINIT('MOVE_DIST_FW',  15)
CALL VTCPINIT('MOVE_DIST_FP',  15)
CALL VTCPSET('VSFT1',  1,  1)
```

NOTE
For 7DC3/09(V8.30P/09) or earlier software, the instruction for calling VTCPSET with no argument is described in VSETTCP.MR. "Write protect" in the detail screen of the program list screen needs to be set to "OFF" temporarily in order to modify VSETTCP.MR.

11   VISION FRAME SET

This chapter describes Vision Frame Set operation.

11.1   ABOUT VISION FRAME SET

Vision Frame Set

Vision Frame Set semi-automatically sets a user frame using target marks and vision.

Set target marks on three positions including the origin on a fixture for which you want to set a user frame in advance, measure the target marks with the camera attached to a robot, and set a user frame according to the target marks.

During the execution of Vision Frame Set, the robot moves to snap images of the target from various positions with various poses.   Execute Vision Frame Set in a place where enough clearance is available around the target so that the robot does not collide with any object around it when moving.

11.1.1   System Configuration

Overall configuration

Vision Frame Set consists of a robot controller, the teach pendant (*i*Pendant), and a camera.
For the specifications of the camera, camera cable, and lens, see Section 2.1, "COMPONENTS".
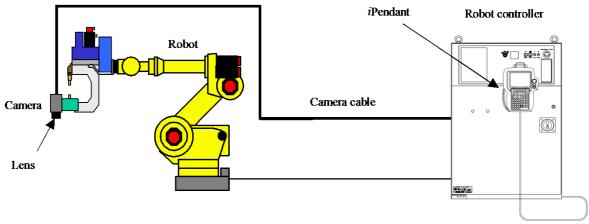
Fig. 11.1.1(a) System configuration of Vision Frame Set

The camera must be attached to the tool tip of the robot. The customer must provide the necessary items including an attachment adaptor to mount the camera.

> **NOTE**
> The customer is to prepare a camera, lens, camera cable, camera attachment adaptor, and so forth.

Target mark

Set target marks to three positions on a fixture for which you want to set a user frame in advance.
Set target marks to the following three positions in the user frame while aligning the center of each target mark to the corresponding position:
(1)   Origin

(2) A point on the X-axis of which the X component is positive
(3) A point on the XY plane of which the Y component is positive

Examples of good target marks are shown below.   A target mark should be made by combining a circle and a cross as shown below.

Fig. 11.1.1 (b) Example 1 of a target mark

Fig. 11.1.1 (c) Example 2 of a target mark

A target should have the following features:
- A flat detection surface.
- A contour that makes it easy to recognize the size of the target. (The circle in the above examples.)
- A contour that makes it easy to recognize rotation within the 45 degree range. (The cross in the above examples.)

NOTE

Glossy materials are not recommended.
If a metal target is required, use one with a frost surface, such as anodized aluminum(duralumin).
A handy way to attach a target mark is to affix a sticker with that mark printed on it.

You should place the three targets such that
- The targets are as far away from each other as possible.
- The targets do not form a straight line. (All inner angles of the triangle made by the three points must be over 30 degrees.)

11.2   VISION FRAME SET PROCEDURE

This section describes the procedure for using Vision Frame set to set the user.

11.2.1   Preparation

1   Plug the camera cable into the robot controller or the *i*Pendant.
2   Check that a camera image can be displayed on the *i*Pendant, according to the procedure described in Chapter 3, "BASIC VISION FUNCTION OPERATION".
3   Secure the camera to the tool tip of the robot.
    No precision is imposed on the position of camera attachment.   However, secure the camera firmly so that the camera does not move during the period from the start to end of the measurements.
4   Teach a mark model to be detected then check that the model can be detected. For the procedure, please refer to "3.4.4 Model Training Screen".
    Keep track of the model taught in this step as it is to be used in the subsequent procedure.

5   Select the user frame you want to set with Vision Frame Set.
     Before opening the vision frame set screen, select the user frame number you want to set as the
     current user frame.
6   Disable the single step mode.
     Before opening the vision frame set screen, disable the single step mode.

NOTE
   Before opening the vision frame set screen, select the number of a user frame
   you want to set. Check that the current user frame number is not 0.   A user
   frame with number 0 cannot be modified.

11.2.2   Vision Frame Set Screen

Use the vision frame set screen on the robot teach pendant to set and operate Vision Frame Set.

Procedure 11-1   Displaying the vision frame set screen

Condition
   •   Select the user frame with a number you want to set as the current user frame.
        Check that the current user frame number is not 0.

Step
1   Press the ⌷ MENU ⌷ key on the teach pendant.
2   Select "UTILITIES".
3   Press the ⌷ F1 [TYPE] ⌷ key.
4   Select "*i*RCalibration".
          The UTILITIES *i*RCalibration screen is displayed.
5   Select "Vision Frame Set".
          The vision frame set screen is displayed.

```
┌──────────────────────────────────────┐
│ iRCalibration Vision Frame Set        │
│                               1/7      │
│  1 Robot: Group [1]  Device: Vision    │
│    Calibration Type: New_UFrame        │
│  2 Setup            (Not Done)         │
│  3 Teach Points     (Not Done)         │
│  4 Create Program   (Not Done)         │
│  5 Run  : VFRM_G1   (Not Done)         │
│  6 Update UFrame[ 1](Not Done)         │
│  7 View Result                         │
│                                        │
│                                        │
│                                        │
│ [ TYPE ]DISP_IMG        SELECT         │
└──────────────────────────────────────┘
```
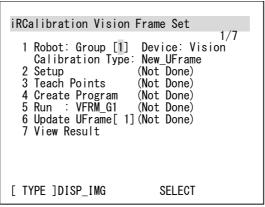
Fig. 11.2.2 Vision Frame Set screen

Procedure 11-2   Ending the vision frame set screen

The user can exit this procedure at any time and return at a later time.

Step
On the vision frame set screen, press the ⌷PREV⌷ key to exit from the screen.
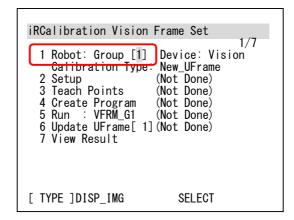
11.2.3 Selecting the Robot Motion Group

Select the robot motion group for which to execute the Vision Frame Set.   For a system having only one robot, select 1 because the system has only group 1.

Procedure 11-3   Selecting the robot motion group

Step

1   On the vision frame set screen, specify the motion group number of the robot, on which Vision Frame Set will be done, at the item of "Robot: Group".

```
iRCalibration Vision Frame Set
                                  1/7
1 Robot: Group [1] Device: Vision
   Calibration Type: New_UFrame
2 Setup            (Not Done)
3 Teach Points     (Not Done)
4 Create Program   (Not Done)
5 Run  : VFRM_G1   (Not Done)
6 Update UFrame[ 1](Not Done)
7 View Result



[ TYPE ]DISP_IMG        SELECT
```
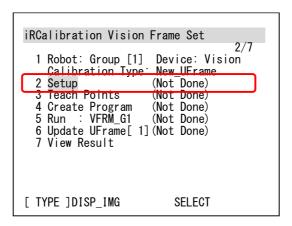
11.2.4 Setup

Set conditions for Vision Frame Set.

Procedure 11-4   Setting Vision Frame Set's settings

Step

1   On the vision frame set screen, move the cursor to "Setup" then press F4 (SELECT).

```
iRCalibration Vision Frame Set
                                  2/7
1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
2 Setup             (Not Done)
3 Teach Points      (Not Done)
4 Create Program    (Not Done)
5 Run  : VFRM_G1    (Not Done)
6 Update UFrame[ 1](Not Done)
7 View Result



[ TYPE ]DISP_IMG        SELECT
```

2   The Setup screen is displayed as shown below.
    Check that the "New" is selected for Calibration Mode.
    Check the settings on the Setup screen and for the Vision Schedule described later, and modify the settings if necessary.   Press the   F1 (DONE) key to return to the vision frame set screen.
    The "Setup" status is updated to "Done".

```
iRCalibration Vision Frame Setup
                                    1/4
  1 Program Name: VFRM_G1      Group[1]
  2 UFrame Number:       1
  3 Calibration Mode:  New
  4 Vision Schedule:     1




  DONE   CANCEL         SELECT
```
Setup screen

Details of settings

Program Name

This item specifies the name of a TP program to be run in Vision Frame Set.

A TP program with this name is created in the subsequent procedure and is internally run to perform frame calibration. (Default: VFRM_Gx. x: Group number)

UFrame Number

This item specifies   the number of a user frame to be set.

When the vision frame set screen is opened, the currently selected user frame number is automatically set.

Calibration Mode

This item specifies   the calibration mode.

Select "New".   (Default: New)

Vision Schedule

For settings related to target mark measurement, 10 types of schedules are available.

Move the cursor to the schedule number, then enter a number to change the schedule number.

Move the cursor to "Vision Schedule", then press the   F4 (SELECT) key to display the Vision Schedule detail screen.

(See Subsection 11.2.5, "Setup – Vision Schedule".)

11.2.5   Setup – Vision Schedule

Check the settings related to target mark measurement, and modify them if necessary.   Press the F1 (DONE) or PREV keys to return to the Setup screen.   The settings are stored even when the PREV key is used to return to the Setup screen.

```
Vision Detection Schedule
                                  1/12
  Vision Detection Schedule[ 1]
  Vision Status Register:      10
  Vision Position Register:  1
  Vision Program:            VSFT1
  Tool Frames:
    Calibrated Utool Number: 8
    Position Utool Number:   9
  Camera Position:
   X: 0.000    Y: 0.000    Z: 0.000
   W: 0.000    P: 0.000    R: 0.000
  Stereo Move Direction: W
  Vision Speed:            50.000  mm/sec
  Vision R Distance:       30.000  degree
  Vision WP Distance:      15.000  degree
  Vision Z Distance:       50.000  mm


  DONE
```

Details of settings

Vision Status Register

This item specifies the register number for storing the vision detection processing state.   (Default: 10)

Vision Position Register

This item specifies the position register number for storing the detected position with vision. (Default: 1)

Vision Program

This item specifies the name of model data to which a target mark model is taught.
When the TP program is run, target marks are detected using model data specified for this item. (Default: VSFT1)
The vision program is set in "Vision Data Setup" Screen. For detail, see "3.4 VISION SET UP SCREEN".

Tool Frames / Calibrated Utool Number

This item specifies the number of the tool frame where the camera attachment position found by camera calibration is stored.   (Default: 8)

```
Tips
    The customer does not have to set the value of "Tool Frames / Calibrated Utool
    Number" in advance. This tool frame is used temporally by Vision Frame Set.
```

Tool Frames / Position Utool Number

This item specifies the number of the tool frame where the initial camera attachment position is stored.   (Default: 9)

```
Tips
    The customer does not have to set the value of "Tool Frames / Position Utool
    Number" in advance. This tool frame is used temporally by Vision Frame Set.
```

Camera Position

This item sets the camera position with respect to the robot faceplate.   Set the camera position in X, Y, and Z.   Set the optical axis direction of the camera in W, P, and R.
The required precision of the position is within about +/-50 mm.   The required precision of direction is within about +/-15 degrees.
(Default for each of X, Y, Z, W, P, and R: 0)

```
⚠CAUTION
    When setting the camera position, ensure that the optical axis (lens center axis)
    of the camera is the Z-axis, and the direction from the camera toward a
    measurement target is the Z+ direction.
    If the direction of the Z-axis or the camera position is incorrect, a measurement
    target can move to the outside of the field of view of the camera when the robot
    moves during measurement.
```

Stereo Move Direction

This item specifies the tilt direction of the camera at the time of the target mark measurement. (Default: W)
W : tilts the camera about the X-axis in the tool coordinate system.
P : tilts the camera about the Y-axis in the tool coordinate system.

Vision Speed
> This item specifies the operation speed at which to perform vision detection several times with different positions and poses during target mark measurement.   (Default: 50)

Vision R Distance
> This item specifies the rotation angle about the optical axis of the camera. (Default: 30)

Vision WP Distance
> This item specifies the tilt angle relative to the optical axis of the camera. (Default: 15)

Vision Z Distance
> This item specifies the moving distance along the optical axis of the camera. (Default: 50)

NOTE
> The Vision R Distance, Vision WP Distance and Vision Z distance are displayed in the following software version:
> - 7DC1/12 (V8.10P/12) or later
> - 7DD0/07 (V8.13P/07) or later
> Earlier software versions do not support modification of these variables.
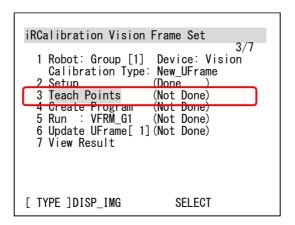
11.2.6   Teach Points

Teach a home position and three positions where three target marks can be measured with the camera.

Procedure 11-5   Teaching the points for measurement
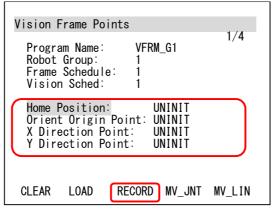
Step

1   On the vision frame set screen, move the cursor to "Teach Points" then press the   F4 (SELECT) key.

```
iRCalibration Vision Frame Set
                                3/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
 2 Setup            (Done    )
 3 Teach Points     (Not Done)
 4 Create Program   (Not Done)
 5 Run  : VFRM_G1    (Not Done)
 6 Update UFrame[ 1](Not Done)
 7 View Result



[ TYPE ]DISP_IMG        SELECT
```

2   The "Points screen" is displayed as shown below .
   On the Points screen, teach the home position and positions where each of the three target marks can be measured (the target mark is inside the field of view of the camera), a total of four positions. Move the robot to a position to be taught, move the cursor to the relevant item, then press SHIFT and F3 (RECORD) keys together to teach the position.
   After teaching all the positions, press the PREV key to return to the vision frame set screen.
   Then, the "Teach Points" status is updated to Done.

```
┌─────────────────────────────────────────┐
│ Vision Frame Points                       │
│                                      1/4  │
│   Program Name:      VFRM_G1              │
│   Robot Group:       1                    │
│   Frame Schedule:    1                    │
│   Vision Sched:      1                    │
│                                           │
│   Home Position:         UNINIT           │
│   Orient Origin Point:   UNINIT           │
│   X Direction Point:     UNINIT           │
│   Y Direction Point:     UNINIT           │
│                                           │
│                                           │
│   CLEAR   LOAD   RECORD  MV_JNT  MV_LIN   │
└─────────────────────────────────────────┘
```
Points screen

Tips
   By opening "Points screen", the tool frame number automatically shifts to the number of "Tool Frames / Position Utool Number" on the Vision Schedule detail screen. Teach the four positions with this tool frame. You don't have to set user frame number to a specific number.

NOTE
1   Teach the four positions with the same user frame number and tool frame number.
2   Select the same user frame number and tool frame number when you create TP programs later. To avoid confusion, after teaching the four positions, proceed to the creation of the TP program without changing the user frame number and tool frame number.

About teach points

Home Position
   For a TP program for Vision Frame Set, the robot moves to the home position before the start of the measurements.   After the completion of the measurements, the robot moves to the home position and the TP program ends.
   This item is the home position.

Orient Origin Point
   In the user frame for calibration, the position where the following can be measured:
   (1)   Target mark set on the origin

X Direction Point
   In the user frame for calibration, the position where the following can be measured:
   (2)   Target mark set on a point on the X-axis of which the X component is positive

Y Direction Point
   In the user frame for calibration, the position where the following can be measured:
   (3)   Target mark set on a point on the XY plane of which the Y component is positive

---

NOTE
   For software versions equal to or earlier than 7DC1/11 (V8.10P/11), 7DD0/06 (V8.13P/06), the "Orient Origin Point", "X Direction Point" and "Y Direction Point" are displayed as "Position 1", "Position 2", "Position 3", but the meaning of these parameters is the same.

About function keys

F1 (CLEAR)

Deletes all taught positions.

F2 (LOAD)

When a TP program for Vision Frame Set has already been created, pressing the F2 (LOAD) key teaches corresponding position data in the TP program as position data on this screen.

F3 (RECORD)

Pressing the SHIFT and F3 (RECORD) keys together teaches position data at the cursor as the current position.

F4 (MV_JNT)

Pressing SHIFT and F4 (MV JNT) keys together moves the robot to the cursor position in the joint mode.

F5 (MV_LIN)

Pressing the SHIFT and F5 (MV LIN) keys together moves the robot to the cursor position in the linear mode.

11.2.7   Creating the TP Program for Vision Frame Set
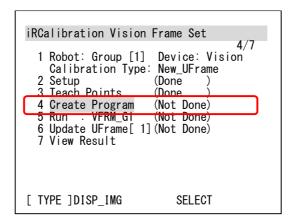
Create a TP program to be run in Vision Frame Set.

Procedure 11-6   Creating the TP program

Step

1   On the vision frame set screen, move the cursor to "Create Program" then press the F4 (SELECT) key.
     Then, a TP program for Vision Frame Set is created.

```
iRCalibration Vision Frame Set
                                    4/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
 2 Setup             (Done    )
 3 Teach Points      (Done    )
 4 Create Program    (Not Done)
 5 Run  : VFRM_G1     (Not Done)
 6 Update UFrame[ 1] (Not Done)
 7 View Result



[ TYPE ]DISP_IMG        SELECT
```

A confirmation message may be displayed in some cases.   Perform the operation as instructed in the message.

11.2.8 Running the TP Program for Vision Frame Set
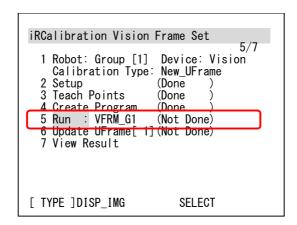
Run the TP program for Vision Frame Set.

Procedure 11-7 Running the TP program

Step

1 On the vision frame set screen, move the cursor to "Run" then press the F4 (SELECT) key.
Then, a confirmation message is displayed. Press the SHIFT and F2 (YES) keys together to run the TP program.
When the execution is normally completed, the "Run" status is updated to "Done".

```
iRCalibration Vision Frame Set
                              5/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
 2 Setup              (Done   )
 3 Teach Points       (Done   )
 4 Create Program     (Done   )
 5 Run  : VFRM_G1     (Not Done)
 6 Update UFrame[ 1] (Not Done)
 7 View Result



[ TYPE ]DISP_IMG        SELECT
```

> ⚠ **CAUTION**
> During execution, the robot moves to snap images of the target from various positions with various poses.
> Run the program in a place where enough clearance is available around the taught positions so that the robot does not collide with any object around it when moving.

> **NOTE**
> Even if "CVIS-021 Exceed VisPool" occurs while the TP program is running, it is no problem if it is normally completed.
> If that error stops the TP program, please cycle the power of the robot controller and run the TP program again.
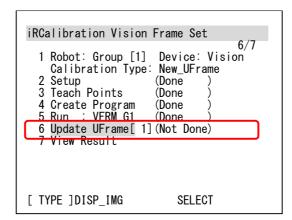
11.2.9 Updating the User Frame

Update the frame calibrated using the target marks and vision to the user frame.

Procedure 11-8 Updating the user frame
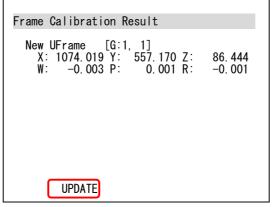
Step

1 On the vision frame set screen, move the cursor to "Update UFrame" then press the F4 (SELECT) ky.

```
┌────────────────────────────────────────────┐
│ iRCalibration Vision Frame Set               │
│                                        6/7   │
│  1 Robot: Group [1]  Device: Vision          │
│    Calibration Type: New_UFrame              │
│  2 Setup             (Done    )              │
│  3 Teach Points      (Done    )              │
│  4 Create Program    (Done    )              │
│  5 Run  : VFRM_G1    (Done    )              │
│  6 Update UFrame[ 1](Not Done)               │
│  7 View Result                               │
│                                              │
│                                              │
│                                              │
│  [ TYPE ]DISP_IMG         SELECT             │
└────────────────────────────────────────────┘
```

2   The "Calibration Result confirmation screen" is displayed as shown below is.
     Press the F2 (UPDATE) key. A confirmation message is displayed.   Press the F2 (YES) key to
     update the user frame settings with the calibration result.
     On the Calibration Result confirmation screen, press the PREV key to display the vision frame set
     screen.

```
┌────────────────────────────────────────────┐
│ Frame Calibration Result                     │
│                                              │
│  New UFrame   [G:1, 1]                        │
│   X: 1074.019 Y:  557.170 Z:    86.444        │
│   W:  −0.003 P:    0.001 R:   −0.001          │
│                                              │
│                                              │
│                                              │
│                                              │
│                                              │
│                                              │
│                                              │
│      UPDATE                                  │
└────────────────────────────────────────────┘
```

Calibration Result confirmation screen

When the user frame is updated, the "Update UFrame" status is updated to "Done".
Now, the execution of Vision Frame Set is completed.
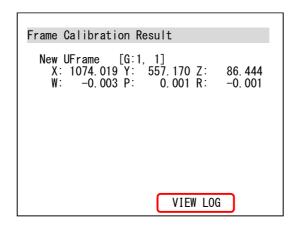
11.2.10   Viewing the Past Results

From the "View Result" menu, past calibration results can be viewed.

On the vision frame set screen, move the cursor to "View Result" then press the   F4 (SELECT) key.
Then, the newest calibration result is displayed.

```
┌────────────────────────────────────────────┐
│ iRCalibration Vision Frame Set               │
│                                        7/7   │
│  1 Robot: Group [1]  Device: Vision          │
│    Calibration Type: New_UFrame              │
│  2 Setup             (Done    )              │
│  3 Teach Points      (Done    )              │
│  4 Create Program    (Done    )              │
│  5 Run  : VFRM_G1    (Done    )              │
│  6 Update UFrame[ 1](Done    )               │
│  7 View Result                               │
│                                              │
│                                              │
│                                              │
│  [ TYPE ]DISP_IMG         SELECT             │
└────────────────────────────────────────────┘
```

On this screen, press the F4 (VIEW LOG) key to display several older calibration results.

```
Frame Calibration Result

 New UFrame   [G:1, 1]
   X: 1074.019 Y:  557.170 Z:    86.444
   W:   -0.003 P:    0.001 R:    -0.001




                                  VIEW LOG
```

On this log display screen, the log can be output to a text file and an old calibration result can be applied to the user frame.

Press the F2 (SAVE)   key to output log data text file ufrm_log.dt to the currently selected file device.

Press the F3 (APPLY) key to apply the calibration result at the cursor to the user frame.
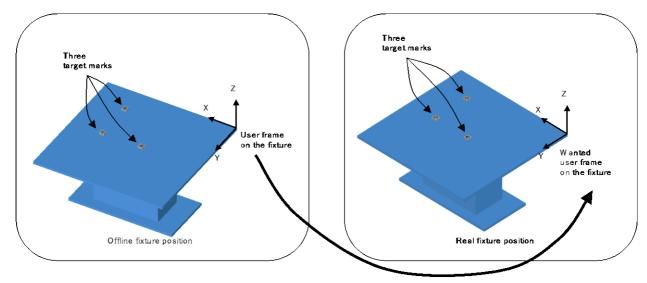
Press the F4 (CLEAR) key to erase all log data on this screen.   When these operations are performed, a confirmation message is displayed.   Perform the operation as instructed in the message.

```
User Frame Log
                                        1/40
   Date    Time     X(W)     Y(P)     Z(R)
 02-JUL-14 16:57    989.3    -3.3    394.1
  UFrame Num[ 1]    -89.9      .0       .5
 No XYZ Data
 No WPR Data
 No XYZ Data
 No WPR Data
 No XYZ Data
 No WPR Data
 No XYZ Data
 No WPR Data

           SAVE    APPLY   CLEAR
```

11.3 MODIFYING A UFRAME ON A REAL ROBOT BASED ON A UFRAME OF AN OFFLINE ROBOT

Vision Frame Set also has a function which modifies a user frame set on an offline programming system for the real system.

In this case, since the positions of the target marks are handled as reference points, any point does not need to match the origin of the user frame.   Set the positions of the three target marks so that they are not on the same straight line (collinear).

Fig. 11.3 Modifying an offline user frame

This section describes the procedure for modifying the user frame set offline for the user frame for a real robot according to the actual measurement result in an environment in which the target marks are set in the same positions in the offline and real systems.

11.3.1   Preparation

1   Plug a camera cable into the robot controller or the *i*Pendant.
2   Check that a camera image can be displayed on the *i*Pendant, according to the procedure described in Chapter 3, "BASIC VISION FUNCTION OPERATION".
3   Secure the camera to the tool tip of the robot.
     No precision is imposed on the position of the camera attachment.   However, secure the camera firmly so that the camera does not move during the period from the start to the end of the measurements.
4   Teach a mark model to be detected, then check that the model can be detected. For the procedure, refer to "3.4.4 Model Training Screen".
     Remember the data name of the model taught in this step since it is to be used in the subsequent procedure.
5   Check the positions of the target marks set offline.
     Since the positions of the target marks in the user frame set offline are used in the subsequent procedure, check them.
6   Select a user frame you want to set with Vision Frame Set.
     Before opening the vision frame set screen, select the user frame with a number you want to set as the current user frame.
7   Disable the single step mode.
     Before opening the vision frame set screen, disable the single step mode.

NOTE
    Before opening the vision frame set screen, select the number of a user frame you want to set and check that the current user frame number is not 0.   A user frame with number 0 cannot be set.

11.3.2   Vision Frame Set Screen

Use the vision frame set screen on the robot teach pendant to set and operate Vision Frame Set.

Procedure 11-9   Displaying the vision frame set screen

Condition
- Select the user frame number you want to set as the current user frame.
  Check that the current user frame number is not 0.

Step
1   Press the ⌐MENU⌐ key on the teach pendant.
2   Select "UTILITIES".
3   Press the ⌐F1 [TYPE]⌐ key.
4   Select "*i*RCalibration".
        The UTILITIES *i*RCalibration screen is displayed.
5   Select "Vision Frame Set".
        The vision frame set screen is displayed.
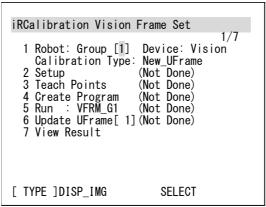
```
iRCalibration Vision Frame Set
                                1/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
 2 Setup            (Not Done)
 3 Teach Points     (Not Done)
 4 Create Program   (Not Done)
 5 Run  : VFRM_G1    (Not Done)
 6 Update UFrame[ 1](Not Done)
 7 View Result



[ TYPE ]DISP_IMG        SELECT
```
Fig. 11.3.2 Vision frame set screen

Procedure 11-10   Ending the vision frame set screen

Step
On the vision frame set screen, press the PREV key to exit from the screen.

11.3.3   Selecting the Robot Motion Group

Select the robot motion group for which to execute Vision Frame Set.   For example, for a system having only one robot, select 1 because the system has only group 1.

Procedure 11-11   Selecting the robot motion group

Step
1   On the vision frame set screen, specify the motion group number of the robot, on which Vision Frame Set will be done, at the item of "Robot: Group".

```
 iRCalibration Vision Frame Set
                                     1/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
 2 Setup            (Not Done)
 3 Teach Points     (Not Done)
 4 Create Program   (Not Done)
 5 Run  : VFRM_G1    (Not Done)
 6 Update UFrame[ 1](Not Done)
 7 View Result



 [ TYPE ]DISP_IMG        SELECT
```
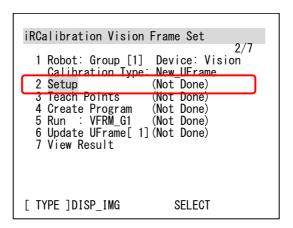
11.3.4   Setup

Set conditions for Vision Frame Set.

Procedure 11-12   Setting Vision Frame Set's settings

Step

1   On the vision frame set screen, move the cursor to "Setup" then press the   F4 (SELECT) key.

```
 iRCalibration Vision Frame Set
                                     2/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
 2 Setup            (Not Done)
 3 Teach Points     (Not Done)
 4 Create Program   (Not Done)
 5 Run  : VFRM_G1    (Not Done)
 6 Update UFrame[ 1](Not Done)
 7 View Result



 [ TYPE ]DISP_IMG        SELECT
```
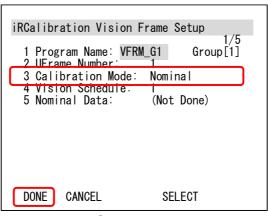
2   The Setup screen is displayed as shown below.
     Set Calibration Mode to "Nominal" and set the values of target mark positions to Nominal Data.
     Check other settings on the Setup screen and settings for Vision Schedule described later and modify
     them if necessary.   Press the   F1 (DONE) key to display the vision frame set screen.
     Then, the "Setup" status is updated to Done.

```
 iRCalibration Vision Frame Setup
                                     1/5
 1 Program Name: VFRM_G1      Group[1]
 2 UFrame Number:      1
 3 Calibration Mode:   Nominal
 4 Vision Schedule:    1
 5 Nominal Data:      (Not Done)








 DONE   CANCEL        SELECT
```

Setup screen

Details of settings

Program Name

This item specifies the name of a TP program to be run in Vision Frame Set.

A TP program with this name is created in the subsequent procedure and is internally run to perform frame calibration. (Default: VFRM_Gx. x: Group number)

UFrame Number

This item specifies the number of a user frame to be set.

When the vision frame set screen is opened, the currently selected user frame number is automatically set.

Calibration Mode

This item specifies the calibration mode.

Select "Nominal". (Default: New)

Vision Schedule

For settings related to target mark measurement, 10 types of schedules are available.

Move the cursor to the schedule number then enter a number to change the schedule number.
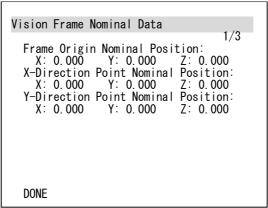
Move the cursor to "Vision Schedule" then press F4 (SELECT) to display the Vision Schedule detail screen.

(See Subsection 11.2.5, "Setup – Vision Schedule".)

Nominal Data

Set the positions of the target marks set offline.

Move the cursor to "Nominal Data" then press F4 (SELECT). The Nominal Data screen as shown below is displayed.

```
┌─────────────────────────────────────┐
│ Vision Frame Nominal Data            │
│                              1/3     │
│  Frame Origin Nominal Position:      │
│   X: 0.000    Y: 0.000    Z: 0.000   │
│  X-Direction Point Nominal Position: │
│   X: 0.000    Y: 0.000    Z: 0.000   │
│  Y-Direction Point Nominal Position: │
│   X: 0.000    Y: 0.000    Z: 0.000   │
│                                      │
│                                      │
│                                      │
│                                      │
│  DONE                                │
└─────────────────────────────────────┘
```
Nominal Data screen

On this screen, set the values of the positions of the target marks viewed from the origin of the user frame. In other words, set the positions of the target marks in the user frame set offline.

Set position data of the target marks for each of the "Frame Origin", "X-Direction", and "Y-Direction" parts. Then, press the F1 (DONE) key to return to the Setup screen.
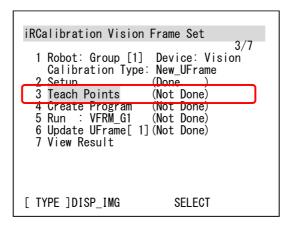
11.3.5　Teach Points

Teach a home position and three positions where three target marks can be measured with the camera.

Procedure 11-13　Teaching the points for measurement
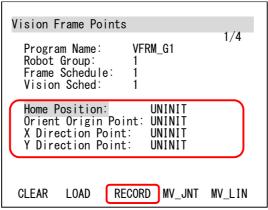
Step

1　On the vision frame set screen, move the cursor to "Teach Points" then press the F4 (SELECT) key.

```
iRCalibration Vision Frame Set
                                 3/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
 2 Setup           (Done    )
 3 Teach Points    (Not Done)
 4 Create Program  (Not Done)
 5 Run  : VFRM_G1  (Not Done)
 6 Update UFrame[ 1](Not Done)
 7 View Result



[ TYPE ]DISP_IMG        SELECT
```

2　The "Points screen" as shown below is displayed.
　　On the Points screen, teach the home position and positions where each of the three target marks can be measured (the target mark is inside the field of view of the camera), a total of four positions. Move the robot to a position to be taught, move the cursor to the relevant item, then press the SHIFT and F3 (RECORD) keys together to teach the position.
　　After teaching all the positions, press the PREV key to display the vision frame set screen.
　　Then, the "Teach Points" status is updated to Done.

```
Vision Frame Points
                                 1/4
 Program Name:     VFRM_G1
 Robot Group:      1
 Frame Schedule:   1
 Vision Sched:     1

 Home Position:       UNINIT
 Orient Origin Point: UNINIT
 X Direction Point:   UNINIT
 Y Direction Point:   UNINIT


 CLEAR   LOAD   RECORD  MV_JNT  MV_LIN
```

Points screen

About teach points

Home Position

　　For a TP program for Vision Frame Set, the robot moves to the home position before the start of the measurements.　After the completion of the measurements, the robot moves to the home position and the TP program ends.
　　This item is the home position.

Orient Origin Point

　　This item indicates the position where the target mark set on reference point 1 can be measured

X Direction Point
> This item indicates the position where the target mark set on reference point 2 can be measured

Y Direction Point
> This item indicates the position where the target mark set on reference point 3 can be measured

> **NOTE**
> For software versions equal or earlier than 7DC1/11 (V8.10P/11), 7DD0/06 (V8.13P/06), the "Orient Origin Point", "X Direction Point" and "Y Direction Point" are displayed as "Position 1", "Position 2", "Position 3", but the meaning of these parameters is same.

About function keys
F1 (CLEAR)
> Deletes all taught positions.

F2 (LOAD)
> When a TP program for Vision Frame Set has already been created, pressing the F2 (LOAD) key teaches corresponding position data in the TP program as position data on this screen.

F3 (RECORD)
> Pressing the SHIFT and F3 (RECORD) keys together teaches position data at the cursor as the current position.

F4 (MV_JNT)
> Pressing the SHIFT and F4 (MV_JNT) keys together moves the robot to the cursor position in the joint mode.

F5 (MV_LIN)
> Pressing the SHIFT and F5 (MV_LIN) keys together moves the robot to the cursor position in the linear mode.

11.3.6   Creating the TP Program for Vision Frame Set
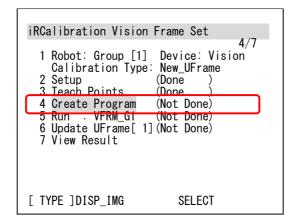
Create a TP program to be run in Vision Frame Set.

Procedure 11-14   Creating the TP program

Step
1   On the vision frame set screen, move the cursor to "Create Program" then press the F4 (SELECT) key.
    Then, a TP program for Vision Frame Set is created.

```
iRCalibration Vision Frame Set
                                       4/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
 2 Setup             (Done    )
 3 Teach Points      (Done    )
 4 Create Program    (Not Done)
 5 Run  : VFRM_G1     (Not Done)
 6 Update UFrame[ 1] (Not Done)
 7 View Result




[ TYPE ]DISP_IMG         SELECT
```

A confirmation message can be displayed in some cases.   Perform the operation as instructed in the message.

11.3.7   Running the TP Program for Vision Frame Set
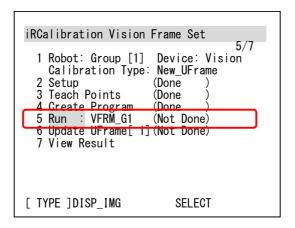
Run the TP program for Vision Frame Set.

Procedure 11-15   Running the TP program

Step

1   On the vision frame set screen, move the cursor to "Run",   then press the F4 (SELECT) key.
Then, a confirmation message is displayed.   Press the SHIFT and F2 (YES) keys together to run the TP program.
When the execution is completed normally, the "Run" status is updated to Done.

```
iRCalibration Vision Frame Set
                                       5/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
 2 Setup             (Done    )
 3 Teach Points      (Done    )
 4 Create Program    (Done    )
 5 Run  : VFRM_G1     (Not Done)
 6 Update UFrame[ 1] (Not Done)
 7 View Result




[ TYPE ]DISP_IMG         SELECT
```

⚠**CAUTION**
1 During the execution, the robot moves to snap images of the target from various directions.
   Run the program in a place where enough clearance is available around the taught positions so that the robot does not collide with any object around it when moving.
2 You must keep pressing the SHIFT key during the measurement. If the SHIFT key is released, the measurement is stopped.
3 If the camera image is too dark or too bright and vision detection fails and the measurement is stopped, try changing the exposure time. Refer to "3.4.4.1 Adjusting the Exposure Time" for more details.
4 For 7DC3/10 (V8.30P/10) or later software, when you resume the measurement after interruption, if a part of the measurement has been completed, the confirmation message to select "RESUME" or "RESTART" is displayed. Then, if "RESUME" is selected, the measurement is resumed. If "RESTART" is selected, the measurement is restarted from the beginning.

NOTE
Even if "CVIS-021 Exceed VisPool" occurs while the TP program is running, it is no problem if it is normally completed.
If that error stops the TP program, cycle controller power, ¥ and run the TP program again.

11.3.8   Updating the User Frame

Update the frame calibrated using the target marks and vision to the user frame.

Procedure 11-16   Updating the user frame

Step

1   On the vision frame set screen, move the cursor to "Update UFrame" then press the F4 (SELECT) key.

```
iRCalibration Vision Frame Set
                                 6/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: New_UFrame
 2 Setup            (Done    )
 3 Teach Points     (Done    )
 4 Create Program   (Done    )
 5 Run  : VFRM G1   (Done    )
 6 Update UFrame[ 1](Not Done)
 7 View Result


[ TYPE ]DISP_IMG        SELECT
```

2   The "Calibration Result confirmation screen" as shown below is displayed.
     Press the F2 (UPDATE) key.   A confirmation message is displayed.   Press the F2 (YES) key to update the user frame settings with the calibration result.
     On the Calibration Result confirmation screen, press the PREV key to display the vision frame set screen.

```
Frame Calibration Result

  New UFrame   [G:1, 1]
    X: 1074.019 Y:   557.170 Z:    86.444
    W:   -0.003 P:     0.001 R:   -0.001




                    [ UPDATE ]
```

Calibration Result confirmation screen
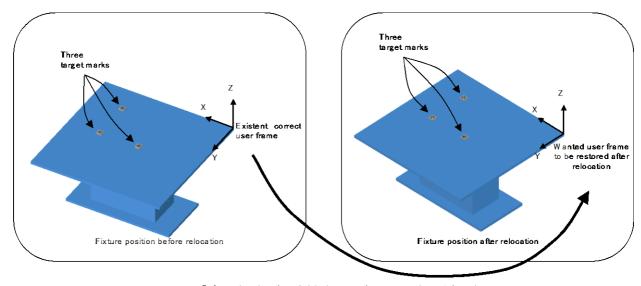
When the user frame is updated, the "Update UFrame" status is updated to Done.
Now, the execution of Vision Frame Set is completed.

11.4   VISION FRAME SHIFT

A function named Vision Frame Shift is also available, which is conceptually similar to Vision Frame Set. It modifies a user frame set offline for a real robot.

Before relocation, the relativity between the target marks and the existent correct user frame is measured and memorized.
After relocation, with that relativity, calculate back to an user frame from measurement results of target marks.

Fig. 11.4 Vision Frame Shift

This function is useful for relocating a system operating with the existing correct user frame.

Set the user frame after relocation of the fixture based on the target with vision by using the relationship between the targets and the user frame before relocation.
Since the positions of the target marks are handled as reference points, any point does not need to match the origin of the user frame.   Set the positions of the three target marks so that they are not on the same straight line, however.

This section describes the procedure for performing measurement before relocation and modifying the user frame after relocation with Vision Frame Shift.

11.4.1   Preparation

1.   Connect a camera to the robot controller or the *i*Pendant.
2.   Check that a camera image can be displayed on the *i*Pendant, according to the procedure described in Chapter 3, "BASIC VISION FUNCTION OPERATION".
3.   Secure the camera to the tool tip of the robot.
      No precision is imposed on the position of camera attachment.   However, secure the camera firmly so that the camera does not move during the period from the start to the end of the measurements.
4.   Teach a mark model to be detected, then check that the model can be detected. For the procedure, refer to "3.4.4 Model Training Screen".
      Remember the data name of the model taught in this step since it is to be used in the subsequent procedure.
5.   Select a user frame you want to set with Vision Frame Shift.
      Before opening the vision frame shift screen, select the user frame number you want to set as the current user frame.
6   Disable the single step mode.
      Before opening the vision frame set screen, disable the single step mode.

> **NOTE**
> Before opening the vision frame shift screen, select the number of a user frame you want to set and check that the current user frame number is not 0.   A user frame with number 0 cannot be set.

11.4.2   Vision Frame Shift Screen

Use the vision frame shift screen on the robot teach pendant to set and operate Vision Frame Shift.

Procedure 11-17   Displaying the vision frame shift screen

Condition
• Select the user frame with a number you want to set as the current user frame.
  A user frame with number 0 cannot be set.

Step
1   Press the ⎡ MENU ⎤ key on the teach pendant.
2   Select "UTILITIES".
3   Press the ⎡ F1 [TYPE] ⎤ key.
4   Select "*i*RCalibration".
         The UTILITIES *i*RCalibration screen is displayed.
5   Select "Vision Frame Shift".
         The vision frame shift screen is displayed.

```
 iRCalibration Vision Frame Shift
                                 1/7
   1 Robot: Group [1]  Device: Vision
     Calibration Type: UFrame_Recovery
   2 Setup             (Not Done)
   3 Teach Points      (Not Done)
   4 Create Program    (Not Done)
   5 Run  : VFRM_G1     (Not Done)
   6 Update UFrame[ 1] (Not Done)
   7 View Result



 [ TYPE ]DISP_IMG        SELECT
```
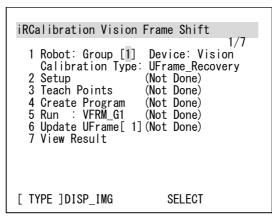
Fig. 11.4.2 Vision frame shift screen

Procedure 11-18   Ending the vision frame shift screen

Step

On the vision frame shift screen, press the PREV key to exit from the screen.

11.4.3   Outline of the Procedure

The following figure outlines the Vision Frame Shift operation procedure after preparation.

```
┌─────────────────────────────┐
│ Selecting the robot motion   │
│         group Setup          │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│ Teach Points for mesuring    │
│        target marks          │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│       Creating TP            │
│        program               │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│ Measuring before relocation  │
│    (Run TP program)          │
└─────────────────────────────┘
               │
               ▼
      Relocation of system
               │
               ▼
┌─────────────────────────────┐
│ Measuring after relocation   │
│    (Run TP program)          │
└─────────────────────────────┘
               │
               ▼
┌─────────────────────────────┐
│  Updating the user frame     │
└─────────────────────────────┘
```

If there isn't a target mark within the view of the camera **after relocation**, the **taught point** for measuring **must be modified**. However,

Don't re-teach points on the vision frame shift screen.
Don't re-create TP program on the vision frame shift screen.

Instead, please open the EDIT screen of the TP program, and modify the position data of the move instruction directly.

If points are re-taught on the vision frame shift screen or the TP program is re-created on the vision frame shift screen, measuring after relocation can not be executed.

Fig. 11.4.3 Vision frame shift procedure

Note the following when operating Vision Frame Shift:
1) Execute "Run" (running a TP program) twice. Run it one time before the relocation of the system (measurement before relocation) and one time after relocation (measurement after relocation).
   (Execute "Run" after relocation in the status in which "Run" is set to Done.)
2) To modify a taught position in the TP program for measurement after the relocation of the system, open the TP program in the EDIT screen and directly modify the taught position in the program.
   (After relocation, do not create any program by executing "Create Program" in the vision frame shift screen.)

⚠**CAUTION**
After the relocation of the system, if it is necessary to modify a taught measurement position, open the TP program on the EDIT screen and directly modify the taught position.
After the relocation of the system, do not modify a taught position or re-create a TP program from the vision frame shift screen.   If a TP program is re-created after the completion of the measurement before relocation, the measurement after relocation cannot be performed, resulting in a Vision Frame Shift failure.
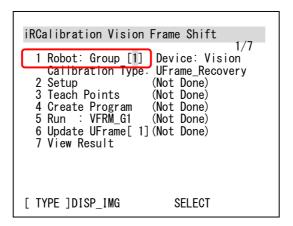
11.4.4   Selecting the Robot Motion Group

Select a robot motion group for which to run Vision Frame Shift.   For example, for a system having only one robot, select 1 because the system has only group 1.

Procedure 11-19   Selecting the robot motion group

Step

1   On the vision frame shift screen, specify the motion group number of the robot, on which Vision Frame Shift will be done, at the item of "Robot: Group".

```
iRCalibration Vision Frame Shift
                                     1/7
 1 Robot: Group [1] Device: Vision
     Calibration Type: UFrame_Recovery
 2 Setup              (Not Done)
 3 Teach Points       (Not Done)
 4 Create Program     (Not Done)
 5 Run  : VFRM_G1      (Not Done)
 6 Update UFrame[ 1](Not Done)
 7 View Result


[ TYPE ]DISP_IMG        SELECT
```
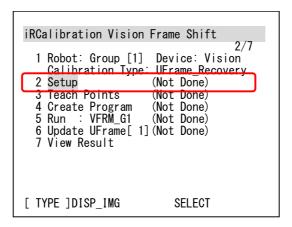
11.4.5   Setup

Set conditions for Vision Frame Shift.

Procedure 11-20   Setting Vision Frame Shift's settings

Step
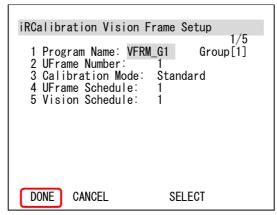
1   On the vision frame shift screen, move the cursor to "Setup" then press F4 (SELECT).

```
iRCalibration Vision Frame Shift
                                     2/7
 1 Robot: Group [1]  Device: Vision
     Calibration Type: UFrame_Recovery
 2 Setup              (Not Done)
 3 Teach Points       (Not Done)
 4 Create Program     (Not Done)
 5 Run  : VFRM_G1      (Not Done)
 6 Update UFrame[ 1](Not Done)
 7 View Result


[ TYPE ]DISP_IMG        SELECT
```

2   The Setup screen is displayed as shown below.
     Check the settings on the Setup screen and for UFrame Schedule and Vision Schedule described later, and modify them if necessary.   Press the F1 (DONE) key to return to the vision frame shift screen.
     The "Setup" status is updated to "Done".

```
┌─────────────────────────────────────────────┐
│ iRCalibration Vision Frame Setup              │
│                                       1/5     │
│   1 Program Name: VFRM_G1      Group[1]       │
│   2 UFrame Number:    1                        │
│   3 Calibration Mode:  Standard                │
│   4 UFrame Schedule:   1                        │
│   5 Vision Schedule:   1                        │
│                                                │
│                                                │
│                                                │
│                                                │
│   ┌──────┐                                      │
│   │ DONE │  CANCEL           SELECT             │
│   └──────┘                                      │
└─────────────────────────────────────────────┘
```

Setup screen

Details of settings

Program Name

Specify the name of a TP program to be run in Vision Frame Shift.

A TP program with this name is created in the subsequent procedure and is internally run to perform frame calibration.   (Default: VFRM_Gx.   x: Group number)

UFrame Number

Specify the number of a user frame to be set.

When the vision frame shift screen is opened, the currently selected user frame number is automatically set.

Calibration Mode

Specify the calibration mode.

Normally, select "Standard".

When the target user frame for Vision Frame Shift is a Dynamic UFrame, select "Dynamic_UFrame".   In this case, also set "CD Pair Number" in UFrame Schedule described later. (Default: Standard)

UFrame Schedule

For settings related to behaviors of Vision Frame Shift, 10 types of schedules are available.

Move the cursor to the schedule number then enter a number to change the schedule number.

Move the cursor to "UFrame Schedule" then press the F4 (SELECT) key to display the UFrame Schedule detail screen.

(See Subsection 11.4.6, "Setup – UFrame Schedule".)

Vision Schedule

For settings related to target mark measurement, 10 types of schedules are available.

Move the cursor to the schedule number then enter a number to change the schedule number.

Move the cursor to "Vision Schedule" then press the F4 (SELECT) key to display the Vision Schedule detail screen.
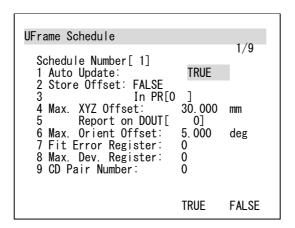
(See Subsection 11.2.5, "Setup – Vision Schedule".)

11.4.6   Setup – UFrame Schedule

Check the settings related to behaviors of Vision Frame Shift and modify them if necessary.   Press the
PREV key to return to the Setup screen.

```
UFrame Schedule
                                    1/9
  Schedule Number[ 1]
  1 Auto Update:              TRUE
  2 Store Offset: FALSE
  3                In PR[0  ]
  4 Max. XYZ Offset:       30.000   mm
  5       Report on DOUT[     0]
  6 Max. Orient Offset:     5.000   deg
  7 Fit Error Register:     0
  8 Max. Dev. Register:     0
  9 CD Pair Number:         0


                            TRUE    FALSE
```

Details of settings

Auto Update
    No setting is required.
    Leave the default.

Store Offset
    When this item is valid, the amount of shift of the measurement result after relocation from the
    measurement result before relocation is output to the position register with the number specified for
    "In PR" below.   (Default: FALSE)
In PR
    This item specifies the register number to output the amount of shift above.   When a value of 0 is
    specified, no data is output.   (Default: 0)

Max. XYZ Offset
    If the amount of shift from the measurement result before relocation to that after relocation is larger
    than expected, Vision Frame Shift can be made to fail.   This item specifies the positional
    component of the allowable shift amount to complete Vision Frame Shift with no failure.   (Default:
    30)

Report on DOUT
    If the shift amount described above exceeds "Max. XYZ Offset" above or "Max. Orient Offset"
    below, a digital I/O can be turned on for 500 ms.   This item specifies the number of the digital I/O
    output.   When a value of 0 is specified, no data is output.   (Default: 0)

Max. Orient Offset
    If the amount of shift from the measurement result before relocation to that after relocation is larger
    than expected, Vision Frame Shift can be made to fail.   This item specifies the posture component
    of the allowable shift amount to complete Vision Frame Shift with no failure.   (Default: 5)

Fit Error Register
    This item specifies the register number to output the average positional error (mm) of calculation for
    calibration.   When a value of 0 is specified, no data is output.   (Default: 0)

Max. Dev. Register
    This item specifies the register number to output the maximum amount of shift (mm) between the
    measurement result of each target mark before relocation and that after relocation.   When a value of
    0 is specified, no data is output.   (Default: 0)

CD Pair Number
    When the target user frame for Vision Frame Shift is a Dynamic UFrame, specify its CD_pair
    number.   (Default: 0)
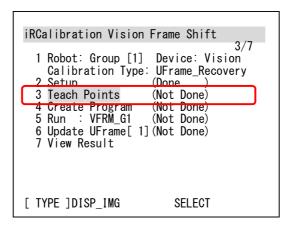
11.4.7   Teach Points

Teach a home position and three positions where three target marks can be measured with the camera.

Procedure 11-21   Teaching the points for measurement

Step

1   On the vision frame shift screen, move the cursor to "Teach Points" then press the F4 (SELECT)
     key.

```
iRCalibration Vision Frame Shift
                                  3/7
  1 Robot: Group [1]  Device: Vision
    Calibration Type: UFrame_Recovery
  2 Setup           (Done    )
  3 Teach Points    (Not Done)
  4 Create Program  (Not Done)
  5 Run  : VFRM_G1   (Not Done)
  6 Update UFrame[ 1](Not Done)
  7 View Result



[ TYPE ]DISP_IMG          SELECT
```

2   The "Points screen" as shown below is displayed.
     On the Points screen, teach the home position and positions where each of the three target marks can
     be measured (the target mark is inside the field of view of the camera), a total of four positions.
     Move the robot to a position to be taught, move the cursor to the relevant item, then press SHIFT
     and   F3 (RECORD) keys together to teach the position.
     After teaching all the positions, press the PREV key to return to the vision frame shift screen.
     Then, the "Teach Points" status is updated to Done.

```
Vision Frame Points
                                  1/4
  Program Name:      VFRM_G1
  Robot Group:       1
  Frame Schedule:    1
  Vision Sched:      1

  Home Position:        UNINIT
  Orient Origin Point: UNINIT
  X Direction Point:    UNINIT
  Y Direction Point:    UNINIT


  CLEAR   LOAD    RECORD  MV_JNT  MV_LIN
```

About teach points
Home Position
> For a TP program for Vision Frame Shift, the robot moves to the home position before the start of the measurements. After the completion of the measurements, the robot moves to the home position and the TP program ends.
> This item is the home position.

Orient Origin Point
> This item indicates the position where the target mark set on reference point 1 can be measured

X Direction Point
> This item indicates the position where the target mark set on reference point 2 can be measured

Y Direction Point
> This item indicates the position where the target mark set on reference point 3 can be measured

---

NOTE
> For software versions equal or earlier than 7DC1/11 (V8.10P/11), 7DD0/06 (V8.13P/06), the "Orient Origin Point", "X Direction Point" and "Y Direction Point" are displayed as "Position 1", "Position 2", "Position 3", but the meaning of these parameters are same.

About function keys
F1 (CLEAR)
> Deletes all taught positions.

F2 (LOAD)
> When a TP program for Vision Frame Shift has already been created, pressing the F2 (LOAD) key teaches corresponding position data in the TP program as position data on this screen.

F3 (RECORD)
> Pressing the SHIFT and F3 (RECORD) keys together teaches position data at the cursor as the current position.

F4 (MV_JNT)
> Pressing the SHIFT and F4 (MV_JNT) keys together moves the robot to the cursor position in the joint mode.

F5 (MV_LIN)
> Pressing the SHIFT and F5 (MV_LIN) keys together moves the robot to the cursor position in the linear mode.

11.4.8   Creating the TP Program for Vision Frame Shift
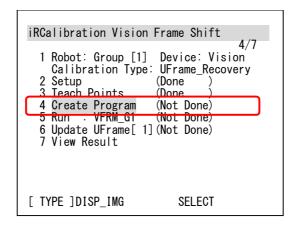
Create a TP program to be run in Vision Frame Shift.

Procedure 11-22   Creating the TP program

Step

1   On the vision frame shift screen, move the cursor to "Create Program" then press the $\boxed{\text{F4}}$ $\boxed{\text{(SELECT)}}$ key.
Then, a TP program for Vision Frame Shift is created.

```
┌──────────────────────────────────────────┐
│ iRCalibration Vision Frame Shift          │
│                                  4/7       │
│  1 Robot: Group [1]  Device: Vision        │
│    Calibration Type: UFrame_Recovery       │
│  2 Setup            (Done    )             │
│  3 Teach Points     (Done    )             │
│  4 Create Program   (Not Done)             │
│  5 Run  : VFRM_G1   (Not Done)             │
│  6 Update UFrame[ 1](Not Done)             │
│  7 View Result                             │
│                                            │
│                                            │
│                                            │
│ [ TYPE ]DISP_IMG         SELECT            │
└──────────────────────────────────────────┘
```

A confirmation message may be displayed in some cases.   Perform the operation as instructed in the message.

⚠**CAUTION**
Create a TP program as described in this step only before relocation; never after relocation.
If a TP program is re-created after relocation, the steps from measurement before relocation must be repeated, otherwise Vision Frame Shift fails.

11.4.9   Running the TP Program for Vision Frame Shift (perform before relocation)

Execute measurement before relocation.
Run the TP program for Vision Frame Shift.

Procedure 11-23   Running the TP program

Step
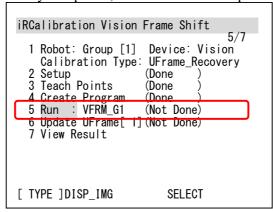
1   On the vision frame shift screen, move the cursor to "Run" then press the $\boxed{\text{F4 (SELECT)}}$ key.

If the TP program has already been run before relocation ("Run" is already set to Done) at this time, a confirmation message is displayed, which asks whether the TP program is to be run after relocation. Since the TP program is to be run before relocation in this step, press the $\boxed{\text{F5 (REMASTER)}}$ key. Another confirmation is displayed, which asks whether to overwrite mastering data.   Press the $\boxed{\text{F2}}$ $\boxed{\text{(YES)}}$ key and proceed to the next step.

Then, a confirmation message is displayed.   Press the $\boxed{\text{SHIFT}}$ and $\boxed{\text{F2 (YES)}}$ keys together to run

the TP program.
When the execution is normally completed, the "Run" status is updated to "Done".

```
iRCalibration Vision Frame Shift
                                  5/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: UFrame_Recovery
 2 Setup            (Done     )
 3 Teach Points     (Done     )
 4 Create Program   (Done     )
 5 Run  : VFRM_G1   (Not Done)
 6 Update UFrame[ 1](Not Done)
 7 View Result



[ TYPE ]DISP_IMG        SELECT
```

⚠**CAUTION**
1 During the execution, the robot moves to snap images of the target from various directions.
   Be sure there is enough clearance around the taught positions to avoid collisions with other fixtures.
2 You must keep pressing the SHIFT key during the measurement. If the SHIFT key is released, the measurement is stopped.
3 If the camera image is too dark or too bright and vision detection fails and the measurement is stopped, you should try changing exposure time. Refer to "3.4.4.1 Adjusting the Exposure Time" for more details.
4 For 7DC3/10 (V8.30P/10) or later software, when you resume the measurement after interruption, if a part of the measurement has been completed, the confirmation message to select "RESUME" or "RESTART" is displayed. Then, if "RESUME" is selected, the measurement is resumed. If "RESTART" is selected, the measurement is restarted from the beginning.

NOTE
   Even if "CVIS-021 Exceed VisPool" occurs while the TP program is running, it is no problem if it is completed normally.
   If that error stops the TP program, cycle controller, and run the TP program again.

11.4.10 Running the TP Program for Vision Frame Shift (after relocation)

Execute measurement after the relocation of the system.
Run the TP program for Vision Frame Shift.

Procedure 11-24   Running the TP program
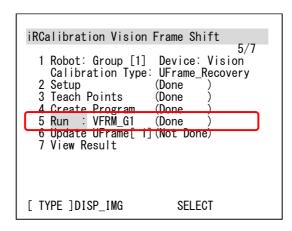
Step
1 On the vision frame set screen, move the cursor to "Run" then press the F4 (SELECT) key.
   Then, a confirmation message is displayed, which asks whether the TP program is to be run after relocation since it has already been run before relocation ("Run" is already set to Done).
   In this step, press the F2 (YES) key to run the TP program after relocation.

Then, a confirmation message is displayed. Press the SHIFT and F2 (YES) keys together to run the TP program.

```
iRCalibration Vision Frame Shift
                              5/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: UFrame_Recovery
 2 Setup              (Done     )
 3 Teach Points       (Done     )
 4 Create Program     (Done     )
 5 Run  : VFRM_G1     (Done     )
 6 Update UFrame[ 1] (Not Done)
 7 View Result



[ TYPE ]DISP_IMG         SELECT
```

> ⚠**CAUTION**
> 1 Do not run the TP program after relocation if remastering is performed. The stored remastering data is overwritten and Vision Frame Shift will fail.
> 2 During execution, the robot moves to snap images of the target from various directions.
>   Be sure there is enough clearance to avoid colliding with other fixtures in the workcell.
> 3 You must keep pressing the SHIFT key during the measurement. If the SHIFT key is released, the measurement is stopped.
> 4 If the camera image is too dark or too bright and vision detection fails and the measurement is stopped, try changing the exposure time. Refer to "3.4.4.1 Adjusting the Exposure Time" for more details.
> 5 For 7DC3/10 (V8.30P/10) or later software, when you resume the measurement after interruption, if a part of the measurement has been completed, the confirmation message to select "RESUME" or "RESTART" is displayed. Then, if "RESUME" is selected, the measurement is resumed. If "RESTART" is selected, the measurement is restarted from the beginning.

> **NOTE**
> Even if "CVIS-021 Exceed VisPool" occurs while the TP program is running, it is no problem if it is normally completed.
> If that error stops the TP program, cycle controller power, and run the TP program again.
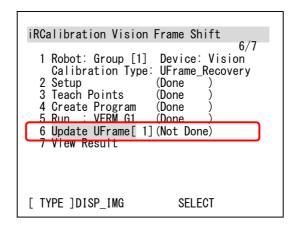
11.4.11 Updating the User Frame

Update the frame calibrated using the target marks and vision to the user frame.

Procedure 11-25   Updating the user frame

Step

1   On the vision frame shift screen, move the cursor to "Update UFrame" then press the   F4 (SELECT)
   key.

```
iRCalibration Vision Frame Shift
                                6/7
 1 Robot: Group [1]  Device: Vision
   Calibration Type: UFrame_Recovery
 2 Setup             (Done    )
 3 Teach Points      (Done    )
 4 Create Program    (Done    )
 5 Run  : VERM G1    (Done    )
 6 Update UFrame[ 1] (Not Done)
 7 View Result


[ TYPE ]DISP_IMG          SELECT
```

2   The Calibration Result confirmation screen is displayed as shown below .
   Press the F2 (UPDATE) key.   A confirmation message is displayed.   Press the F2 (YES) key to
   update the user frame settings with the calibration result.
   On the Calibration Result confirmation screen, press the PREV key to return to the vision frame
   shift screen.

```
Frame Calibration Result

 UFrame Offset[G:1, 1]
   X:  -0.485 Y:   0.009 Z:   -0.001
   W:  -0.003 P:   0.000 R:    0.007

 UFrame XYZ Change:       0.485 mm
 UFrame Angular Change:   0.008 deg
 Mean Fit Error:          0.041 mm
 Maximum Deviation:       0.527 mm




       UPDATE
```

Calibration Result confirmation screen

When the user frame is updated, the "Update UFrame" status is updated to "Done".
Now, the execution of Vision Frame Shift is completed.

NOTE
   For a Dynamic UFrame, the user frame setting is not updated directly.
   The Leader Frame setting is updated according to the calibration result.
   To update the Leader Frame to the Dynamic UFrame, turn the power to the
   controller off, then on again.

---

12   VISION SHIFT

12.1   ABOUT VISION SHIFT

Vision shift

Vision shift has two separate functions.
- The taught positions of a program can be modified if the system is moved or reinstalled.
- The positions of a robot program created with the offline programming system can be modified on the factory floor.

The positions of three reference points set on a fixture or workpiece are measured with the camera attached to a robot. The positional relationship between the robot and fixture or workpiece is calculated accurately. The TP program data is shifted.

Measurement based on Vision shift

When Vision shift is used, the camera is temporarily attached to the EOAT of a robot.   Vision shift uses the camera to measure the positions of reference points on a fixture or workpiece.

Vision shift uses robot TP programs to calculate the position of the camera. The camera is attached to the robot EOAT.

TP programs can be created beforehand by using the offline programming system of the robot. This method reduces factory downtime since the TP program creation does not required the robot controller that is running production...

For details of TP programs, see "12.5 SPECIFICATIONS OF TP PROGRAMS FOR VISION SHIFT".

Program shift

The six reference points (three points before reinstallation and three points after reinstallation) are stored in position registers. The positions are measured with Vision shift.   These reference points are used in a position shift operation. Use the program edit screen's online shift function to specify a shift.

The online shift function is divided into two types:
- three-point shift function using three reference points
- one-point shift function using the difference between the teach position on the current line and the current robot position.

Program teaching can be checked easily. Use the three-point shift operation result of the Vision shift measurement. Afterwards, check and adjust the teach position using the one-point shift operation.

12.2   OUTLINE OF VISION SHIFT

12.2.1   System Configuration

Overall configuration

Vision shift consists of a robot controller, the teach pendant (*i*Pendant), and a camera.

For the specifications of a camera, a camera cable, and a lens, see "2.1 COMPONENTS".
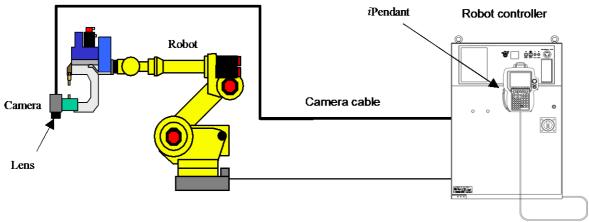
Fig. 12.2.1(a) System configuration of Vision shift

The camera must be attached to the robot's EOAT securely.   The customer must provide the necessary hardware to mount the camera to the robot's EOAT.

NOTE
1   The user is responsible for the camera, lens, camera cable, camera attachment adaptor, and other camera support equipment.
2   For multi-group with the 7DF3/10(V9.30P/10) or earlier software, Vision shift can be used only with robots in group 1.
    For multiple group systems, Vision shift only supports robots in group 1.
    With the 7DF3/11(V9.30P/11) or later software, Vision shift can be performed by specifying a group number.
3   Vision shift only supports 6-axis robots. It cannot be used for 4-axis or 5 axis robot.

Target mark
Two recommended targets are shown below. The second target is a combination of a circle and a cross.

Fig. 12.2.1 (b) Example 1 of a target mark

Fig. 12.2.1 (c) Example 2 of a target mark

A target should have the following features:
- A flat detection surface.
- A contour that makes it easy to recognize the size of the target. (See the circle in the above examples.)
- A contour that makes it easy to recognize rotation within a 45 degree range. (The cross in the above examples.)

NOTE
Glossy materials are not recommended.
If a metal target is required, use one with frosted surface, such as anodized aluminum(duralumin).
A handy way to attach a target mark is to affix an affixing sticker with that mark printed on it.

You should place the three targets such that
- The targets are as far away from each other as possible.
- The targets do not form a straight line. (All inner angles of the triangle made by the three points must be over 30 degrees.)

12.2.2　Vision Shift Procedure

Vision shift can be used two ways.
- In one method, the function performs a shift operation based on reinstallation, which compensates for any installation errors that occur before and after system reinstallation.
- In the second method, the function performs an offline shift operation, which is used when a robot program created with the offline programming system is applied to an operation on the factory floor.

This section describes the procedure for two ways.

Setting camera and target	Connect the camera then set a target and the camera.
Setting initial setting	Set position register number and so on from the initial setting screen.
Setting vision data	Move to a position where the target is measured by the camera and then teach a model for vision detection.
Creating and confirming TP program	Select the measurement method and teach three or four points where the target is measured by the camera. Confirm the created TP program. (The measurement method can be selected by the sub-program called by TP program)
Measuring Reference Points before Reinstallation	Measure reference points before reinstallation by the execution of TP program.
Reinstallation	Reinstall the system.
Measuring Reference Points after Reinstallation	Measure reference points after reinstallation by the execution of TP program.
Three-point shift	The taught positions of a program are shifted according to the measurement result of both before and after reinstallation.
One-point shift	The taught positions of a program are shifted as necessary.

Fig. 12.2.2(a) Outline of the procedure for shift operation based on reinstallation

Setting camera and target	Connect the camera then set a target and the camera.
Setting initial setting	Set position register number and so on from the initial setting screen.
Setting vision data	Move to a position where the target is measured by the camera and then teach a model for vision detection.
Creating and confirming TP program	Select the measurement method and teach three or four points where the target is measured by the camera. Confirm the created TP program. (The measurement method can be selected by the sub-program called by TP program)
Setting reference points in off-line	Input the position of reference points in off-line into position register.
Changing status of reference points	Set the status of reference points for before reinstallation DONE.
Measuring reference points	Measure reference points by the execution of TP program.
Three-point shift	The taught positions of a program are shifted according to the measurement result of both before and after reinstallation.
One-point shift	The taught positions of a program are shifted as necessary.

Fig. 12.2.2 (b) Outline of the procedure for Offline shift

12.2.3   Selection of the Measurement Method

As shown in Table 12.2.3, the available type of measurement method for Vision shift differs depending on the version of the software.

For Vision Shift on 7DC1/09(V8.10P/09), 7DD0/02(V8.13P/02) or earlier software, the Vision Shift only supports the stereo measurement method which requires a large workspace. Later versions of Vision Shift support the Visual touch-up measurement method in addition to the stereo measurement method used in later software versions.

Table 12.2.3 Selectable measurement method by version of system software

System software		Stereo measurement method	Visual touch-up method
7DC2(V8.20P) or later			
7DC1(V8.10P)	P10 or later	○	○
7DD0(V8.13P)	P03 or later		
7DC1(V8.10P)	P09 or earlier	○	
7DD0(V8.13P)	P02 or earlier		

As shown in Fig. 12.2.3, both measurement methods perform camera position calibration as its first step, and then performs reference point measurement. Camera position calibration can be performed by the target mark which is mounted at arbitrary places, but reference point measurement must be performed by the target mark which is mounted on the workpiece or fixture.
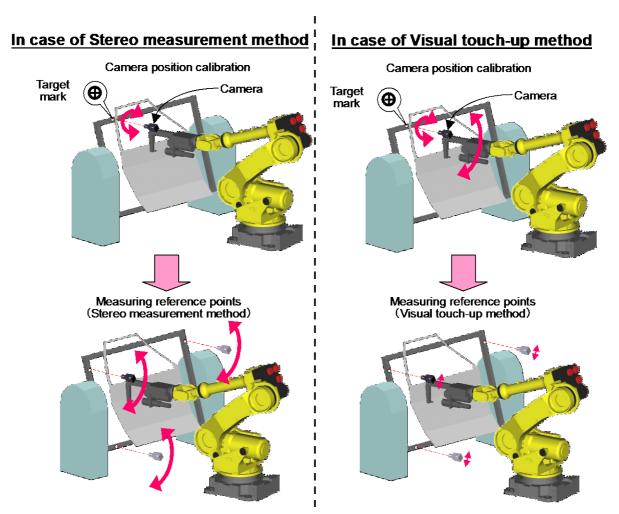
Fig. 12.2.3 Two types of measurement method for Vision shift

For the stereo measurement method, the robot does not perform the extra orientation change during camera position calibration, but adds extra orientations during the reference point measurements. For the visual touch-up method, the robot adds extra orientations during the camera position calibration, but does not have extra motion during reference point measurement. If the workspace is limited, use the visual touch-up method. Use the stereo measurement method if there is sufficient space.

12.3   MEASUREMENT BASED ON VISION SHIFT

This section describes the shift operation based on reinstallation. See Subsection 12.3.10 for the "Offline Shift Operation" details, describing its differences from shift operation based on reinstallation.

12.3.1   Preparation

1   Plug the camera cable into the robot controller or the *i*Pendant.
2   Check that the camera image can be displayed on the *i*Pendant, according to the procedure described in "3 BASIC VISION FUNCTION OPERATION".
3   Secure the camera to the tool tip of the robot.
     No precision requirement is imposed on the position of camera attachment.   However, make sure the camera is secure and does not move when measuring.

12.3.2   Starting and Ending Measurement Based on Vision Shift

Use the Vision shift screen on the robot teach pendant to perform Vision shift setting and measurement operations.
If you have two or more screens displayed on the *i*Pendant, use the left-side screen to display the Vision shift screen. It will not work from the right display pane.

Procedure 12-1   Starting Vision shift

Step
1   Press the   MENU   key on the teach pendant.
2   Select "UTILITIES".
3   Press the   F1, [TYPE]   key.
4   Select "*i*RCalibration".
     The UTILITIES *i*RCalibration screen is displayed.
5   Select "Vision Shift".
     The Vision shift screen is displayed.

You can return to the Vision shift screen anytime using steps 1 through 5 (above).

Procedure 12-2   Ending Vision shift

Step
Select "0: Exit" on the Vision shift screen.
The Vision shift screen is closed.

Upon completion of measurement based on Vision shift, close the Vision shift screen.   Measurement results are not lost.

12.3.3　Checking Initial Settings

With Vision shift two robot tool frames, one register, as many as $(1 + 6 \times)$ measurement areas, and position registers are required. They are specified on the initial setting screen of Vision shift.
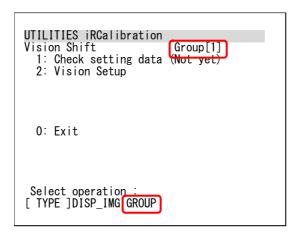
Procedure 12-3　Starting the initial setting screen

Step
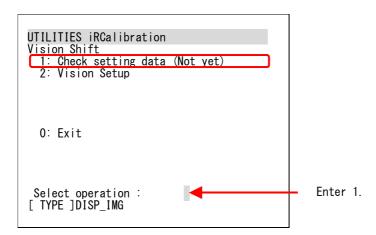
1　Start Vision shift with the robot controller.
The Vision shift screen is displayed.
For 7DF3/11(V9.30P/11) or later software, change the group number pressing the F3 (GROUP) key to execute Vision shift with robots in group 2 or later.

```
UTILITIES iRCalibration
Vision Shift              Group[1]
  1: Check setting data (Not yet)
  2: Vision Setup




   0: Exit




  Select operation :
[ TYPE ]DISP_IMG GROUP
```

2　Select "1: Check setting data" on the Vision shift screen.

```
UTILITIES iRCalibration
Vision Shift
  1: Check setting data (Not yet)
  2: Vision Setup




   0: Exit




  Select operation :                          Enter 1.
[ TYPE ]DISP_IMG
```

The initial setting screen is displayed.

3　Check the contents of the initial setting screen and make modifications if necessary.
- If no modification is required, press the PREV key.
- If a modification is required, move the cursor to the item to be modified, then change the value. Next, press the F5 (MODIFY) key.
- When using two or more areas, set each area by pressing the F2 (AREA) key to switch the area.

```
┌─────────────────────────────────────────────────────┐
│ UTILITIES iRCalibration                               │
│ Vision Shift                              1/16        │
│  Setting Data : Area  1                               │
│                                                       │
│  Tool Frame                                           │
│   1 Result of calibration                 8          │
│   2 Camera position                       9          │
│  Number of shift area                     1          │
│                                                       │
│   Camera position (TOOL)                              │
│   4 Camera position      X =     1300.000             │
│   5 Camera position      Y =      200.000             │
│   6 Camera position      Z =     -130.000             │
│   7 Camera position      W =        0.000             │
│   8 Camera position      P =        0.000             │
│   9 Camera position      R =        0.000             │
│                                                       │
│   Stereo move direction (Tool)            W           │
│                                                       │
│   Position Register (Reference points)                │
│    Before                                             │
│   11 Reference point 1          PR[  50]              │
│   12 Reference point 2          PR[  51]              │
│   13 Reference point 3          PR[  52]              │
│    After                                              │
│   14 Reference point 1          PR[  53]              │
│   15 Reference point 2          PR[  54]              │
│   16 Reference point 3          PR[  55]              │
│                                                       │
│  [ TYPE ]  AREA                        MODIFY         │
└─────────────────────────────────────────────────────┘
```

Details of settings

Tool Frame/Result of Calibration
> This item specifies the number of the tool frame used to store the found camera attachment position (found by program).   (Default: 8)

Tool Frame/Camera Position
> This item specifies the number of the tool frame used to store the initial (rough) camera attachment position (entered by user).   (Default: 9)

Number of shift area
> This item specifies the number of areas to be measured.   Up to five areas can be specified for each group.   (Default: 1)
> If there are multiple areas to be measured, pressing F2 (AREA) displays the settings of the next area.   The number of the currently displayed area is displayed on the top line of the teach pendant.

Camera position (TOOL)
> Set the initial estimated position (tool frame) of the camera with respect to the robot faceplate.   Set the camera position in X, Y, and Z.   Set the optical axis direction of the camera in W, P, and R.
> The required precision of position is within about +/-50 mm. normally this is the center of the lens exterior. The required precision of direction is within about +/-15 degrees.
> (Default for each of X, Y, Z, W, P, and R: 0)

┌───┐
│ ⚠ **CAUTION**   │
│   When setting a camera tool coordinate system, make sure the tool z axis is │
│   aligned with the camera lens center line. The positive Z axis goes into the │
│   camera.   │
│   If the Z-axis direction or the camera position is incorrect, the robot may move │
│   outside of the field of view of the target during calibration.   │
└───┘

Stereo move direction (Tool)

Specify the tilt direction of the camera. This setting is valid only for Stereo measurement method (Default: W)

W: tilts the camera about the X-axis in the tool coordinate system.

P: tilts the camera about the Y-axis in the tool coordinate system.

Position Register (Reference points)

This item specifies the position register numbers to store the reference points. Two sets (before and after) of position registers are required

Before / Reference point 1–3

This item specifies the position register numbers in which to store the positions of three reference points before reinstallation.

After/ Reference point 1- 3

This item specifies the position register numbers in which to store the positions of three reference points after reinstallation.

NOTE

"Camera position(TOOL)", "Stereo move direction (TOOL)" and "Position Register (Reference points)" needs to be set for each area.
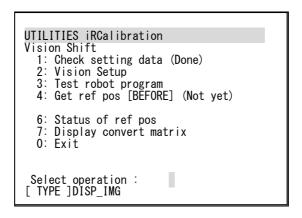
When using multiple areas, check the settings of each area by pressing the $\boxed{\text{F2}}$ $\boxed{\text{(AREA)}}$ key to switch the area.

Ending initial setting

If no modification has been made, press the $\boxed{\text{PREV}}$ key.

If a setting has been modified, press the $\boxed{\text{F5 (MODIFY)}}$ key.

Upon completion of initial setting confirmation, the processing selection screen of Vision shift displays items other than the initial setting items.

```
UTILITIES iRCalibration
Vision Shift
  1: Check setting data (Done)
  2: Vision Setup
  3: Test robot program
  4: Get ref pos [BEFORE] (Not yet)

  6: Status of ref pos
  7: Display convert matrix
  0: Exit


 Select operation :
[ TYPE ]DISP_IMG
```

Tips

The settings made on the initial setting screen are saved as comment statements in the TP programs VSMAIN and VSSUB1 through VSSUB5.

For details of TP programs, see "SPECIFICATIONS OF TP PROGRAMS FOR VISION SHIFT".

12.3.4   Setting up Vision

On the Vision Data Setup Screen, teach the model of the target.

Procedure 12-4   Testing programs

Step

1   Select "2: Vision Setup" on the Vision shift screen.

```
UTILITIES iRCalibration
Vision Shift
  1: Check setting data (Done)
  2: Vision Setup
  3: Test robot program
  4: Get ref pos [BEFORE] (Not yet)

  6: Status of ref pos
  7: Display convert matrix
  0: Exit


 Select operation :
[ TYPE ]DISP_IMG
```

2   Teach the model on the Vision Data Setup Screen. (For the procedure, please refer to "3.4.4 Model Training Screen".)

3   Press the PREV key to go back to the Vision shift screen.

12.3.5   Creating and Testing Programs for Vision Shift Measurement

Create robot TP programs to measure the of reference positions on a workpiece or fixture with the camera.

Creating measurement programs

Create TP programs VSFIND1 through VSFIND5 in the measurement areas.
With the 7DF3/11(V9.30P/11) or later software, the name of these TP programs is VSFINDm_Gn (m is the area number, n is the group number), but they are referred to with VSFIND1 to VSFIND5 in the following explanations.
These programs call the following subprograms:

Table 12.3.5 Subprogram called in TP program
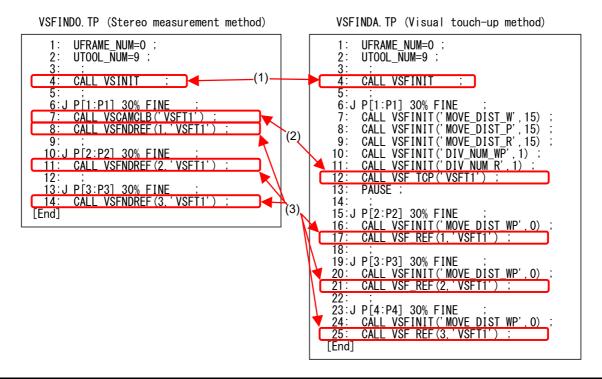
	Stereo measurement method	Visual touch-up method
(1) Subprogram for initial setting	VSINIT	VSFINIT
(2) Subprogram for camera position calibration	VSCAMCLB	VSF_TCP
(3) Subprogram for reference point measurement	VSFNDREF	VSF_REF

VSFIND0 is a sample program for Stereo measurement method and VSFINDA is a simple program for Visual touch-up method. With the 7DF3/11(V9.30P/11) or later software, there are sample files for group 2 or later that have "_Gn" appended to the file name (n is the group number). For example, VSFIND0_G2.TP, VSFINDA_G2.TP. You can use these sample programs as template in creating your own TP programs.

The contents of VSFIND0 and VSFINDA are shown below. Teach three or four points before calling the above subprograms. The taught points should meet the following criteria:

- The target must be at the central of the image.
- The distance between the camera and target is about 400 mm.

```
VSFIND0.TP (Stereo measurement method)          VSFINDA.TP (Visual touch-up method)

 1:  UFRAME_NUM=0 ;                               1:  UFRAME_NUM=0 ;
 2:  UTOOL_NUM=9 ;                                2:  UTOOL_NUM=9 ;
 3:    :                                          3:    :
 4:  CALL VSINIT      ;        ◄────(1)────►      4:  CALL VSFINIT      ;
 5:    :                                          5:    :
 6:J P[1:P1] 30% FINE     ;                       6:J P[1:P1] 30% FINE     ;
 7:  CALL VSCAMCLB('VSFT1') ;                      7:  CALL VSFINIT('MOVE_DIST_W',15) ;
 8:  CALL VSFNDREF(1,'VSFT1') ;                    8:  CALL VSFINIT('MOVE_DIST_P',15) ;
 9:    :                          (2)             9:  CALL VSFINIT('MOVE_DIST_R',15) ;
10:J P[2:P2] 30% FINE     ;                      10:  CALL VSFINIT('DIV_NUM_WP',1) ;
11:  CALL VSFNDREF(2,'VSFT1') ;                   11:  CALL VSFINIT('DIV_NUM_R',1) ;
12:    :                                          12:  CALL VSF_TCP('VSFT1') ;
13:J P[3:P3] 30% FINE     ;                       13:  PAUSE ;
14:  CALL VSFNDREF(3,'VSFT1') ;     (3)           14:    :
[End]                                             15:J P[2:P2] 30% FINE     ;
                                                  16:  CALL VSFINIT('MOVE_DIST_WP',0) ;
                                                  17:  CALL VSF_REF(1,'VSFT1') ;
                                                  18:    :
                                                  19:J P[3:P3] 30% FINE     ;
                                                  20:  CALL VSFINIT('MOVE_DIST_WP',0) ;
                                                  21:  CALL VSF_REF(2,'VSFT1') ;
                                                  22:    :
                                                  23:J P[4:P4] 30% FINE     ;
                                                  24:  CALL VSFINIT('MOVE_DIST_WP',0) ;
                                                  25:  CALL VSF_REF(3,'VSFT1') ;
                                                 [End]
```

> **NOTE**
> For 7DC3/10 (V8.30P/10) or later software, call instructions of the program
> VCRSM_CHECK, label instructions, and jump instructions are added to the TP
> program so that efficient resuming of the measurement can be done. For details,
> refer to "12.5.5 Details of TP Programs".

In the above example, in case of Stereo measurement method the reference point for camera position calibration is the same as the one for measuring one of reference points, and in case of Visual touch-up method the reference point for camera position calibration is different form the one for measuring one of reference points. For both measurement methods, the teaching point before VSCAMCLB or VSF_TCP can be the same or different as the one before VSFNDREF or VSF_REF.

> **NOTE**
> 1 Vision shift does not create VSFIND1 to VSFIND TP programs. Users have to
>   create them using VSFIND0 or VSFINDA as template.
> 2 Make sure to use either of the following program combinations: VSINIT /
>   VSCAMCLB / VSFNDREF, or VSFINIT / VSF_TCP / VSF_REF. Any other
>   combinations are not supported. In addition, do not change the sequence of
>   calling the programs.

For further details, refer to "12.5 SPECIFICATIONS OF TP PROGRAMS FOR VISION SHIFT".

Testing programs

Test the TP programs to be used for reference point measurement.
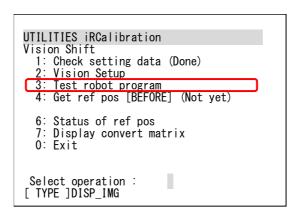
Procedure 12-5   Testing programs

Condition
- Verify "Test robot completed" appears in line 2 on the Vision shift screen.
- Verify the required measurement TP programs (VSFIND1 to VSFIND5) have been created.
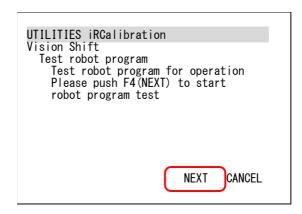
Step
1   Select "3: Test robot program" on the Vision shift screen.

```
UTILITIES iRCalibration
Vision Shift
  1: Check setting data (Done)
  2: Vision Setup
  3: Test robot program
  4: Get ref pos [BEFORE] (Not yet)

  6: Status of ref pos
  7: Display convert matrix
  0: Exit


 Select operation :
[ TYPE ]DISP_IMG
```
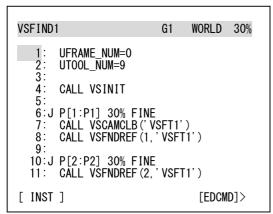
2   Press the   F4 (NEXT)   key on the screen as shown below.
     If multiple areas are measured, you enter the number of an area to be checked.

```
UTILITIES iRCalibration
Vision Shift
  Test robot program
    Test robot program for operation
    Please push F4(NEXT) to start
    robot program test




                              NEXT   CANCEL
```

3   The screen display switches to the edit screen, and the program (from VSFIND1 to VSFIND5)
     corresponding to the selected area is displayed.
     Execute the program to perform a reference point measurement test operation (Camera position
     calibration).
     Modify, add, or delete taught positions as needed.

```
          For Stereo measurement method                For Visual touch-up method

 ┌─────────────────────────────────────┐       ┌─────────────────────────────────────┐
 │ VSFIND1              G1   WORLD  30% │       │ VSFIND1              G1   WORLD  30% │
 │                                      │       │                                      │
 │    1:   UFRAME_NUM=0                 │       │    1:   UFRAME_NUM=0                 │
 │    2:   UTOOL_NUM=9                  │       │    2:   UTOOL_NUM=9                  │
 │    3:                                │       │    3:                                │
 │    4:   CALL VSINIT                  │       │    4:   CALL VSFINIT                 │
 │    5:                                │       │    5:                                │
 │    6:J P[1:P1] 30% FINE              │       │    6:J P[1:P1] 30% FINE              │
 │    7:   CALL VSCAMCLB('VSFT1')       │       │    7:   CALL VSFINIT('MOVE_DIST_W',15)│
 │    8:   CALL VSFNDREF(1,'VSFT1')     │       │    8:   CALL VSFINIT('MOVE_DIST_P',15)│
 │    9:                                │       │    9:   CALL VSFINIT('MOVE_DIST_R',15)│
 │   10:J P[2:P2] 30% FINE              │       │   10:   CALL VSFINIT('DIV_NUM_WP',1) │
 │   11:   CALL VSFNDREF(2,'VSFT1')     │       │   11:   CALL VSFINIT('DIV_NUM_R',1)  │
 │                                      │       │                                      │
 │ [ INST ]                   [EDCMD]> │       │ [ INST ]                   [EDCMD]> │
 └─────────────────────────────────────┘       └─────────────────────────────────────┘
```

> **NOTE**
> 1 Execute "CALL VSINIT" or "CALL VSFINIT" first.
> 2 Adjust each taught reference position so that the target is at the central position of the screen. Also, adjust the distance between the camera and reference points to about 400 mm (+/-50 mm).
> 3 Re-teach the measurement position if an interference occurred with peripheral or reached robot motion limit.

> **NOTE**
> For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the TP program so that efficient resuming of the measurement can be done. For details, refer to "12.5.5 Details of TP Programs".
> For 7DC3/10 (V8.30P/10) or later software, if the measurement is interrupted by the release of the SHIFT key, the occurrence of an alarm or other reasons, re-execute the TP program after moving the cursor to the first line. If a part of the measurement has been completed, a message "Press 0 (restart) or 9 (resume)" appears. Press the 0 key to restart the measurement from the beginning or the 9 key to resume the measurement.

4   Upon completion of program execution, the Vision shift operation screen is displayed. After checking the program, press the F5 (CANCEL) key   The Vision shift screen is displayed.
    To continue checking the program, press the F4 (NEXT) key.

```
 ┌─────────────────────────────────────┐
 │ UTILITIES iRCalibration             │
 │ Vision Shift                         │
 │   Test robot program                 │
 │     Test robot program for operation │
 │     Please push F4(NEXT) to start    │
 │     robot program test               │
 │                                      │
 │                                      │
 │                                      │
 │                                      │
 │               NEXT   CANCEL          │
 │                                      │
 └─────────────────────────────────────┘
```

> **NOTE**
> "Test robot program" is used to teach a measurement motion to VSFINDi and to test the motion, but does not actually measure the reference points.

12.3.6   Measuring Reference Points before Reinstallation

After checking the initial settings and robot program, measure the reference points before reinstallation.

Procedure 12-6   Measuring reference points before reinstallation

Condition

- "Check setting data" must have been completed.
  If "Check setting data" has not been completed, "Get ref pos [BEFORE]" is not displayed on the Vision shift screen.
- Measurement TP programs (VSFIND1 to VSFIND5) corresponding to areas to be measured must have been created.

Step
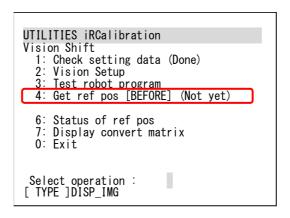
1   Adjust the lens focus, aperture setting, and shutter speed so that reference points can be clearly viewed at a measurement position.

> ⚠ **CAUTION**
> Adjust the lens focus and aperture setting before executing a reference point measurement.   Do not change the focus and aperture settings during reference point measurement.

2   Select "4: Get ref pos [BEFORE]" on the Vision shift screen.

```
UTILITIES iRCalibration
Vision Shift
  1: Check setting data (Done)
  2: Vision Setup
  3: Test robot program
  4: Get ref pos [BEFORE] (Not yet)

  6: Status of ref pos
  7: Display convert matrix
  0: Exit


 Select operation :
[ TYPE ]DISP_IMG
```

3   Press the   F4 (NEXT)   key on the screen as shown below.
    If multiple areas are measured, you enter the number of an area to be measured.

```
UTILITIES iRCalibration
Vision Shift
  Get Reference Points [BEFORE] / Area 1
    Ref pos measurement will be
    started
    Please push F4(NEXT) to start
    ref pos measurement




                              NEXT   CANCEL
```

4   The screen display switches to the edit screen, and the program (from VSFIND1 to VSFIND5) corresponding to the selected area is displayed.
Execute the program from the first line to the last to perform a reference point measurement.

```
     For Stereo measurement method                    For Visual touch-up method

  1:   UFRAME_NUM=0 ;                           1:   UFRAME_NUM=0 ;
  2:   UTOOL_NUM=9 ;                            2:   UTOOL_NUM=9 ;
  3:      ;                                     3:      ;
  4:   CALL VSINIT    ;                         4:   CALL VSFINIT    ;
  5:      ;                                     5:      ;
  6:J P[1:P1] 30% FINE      ;                   6:J P[1:P1] 30% FINE      ;
  7:   CALL VSCAMCLB('VSFT1') ;                 7:   CALL VSFINIT('MOVE_DIST_W',15) ;
  8:   CALL VSFNDREF(1,'VSFT1') ;               8:   CALL VSFINIT('MOVE_DIST_P',15) ;
  9:      ;                                     9:   CALL VSFINIT('MOVE_DIST_R',15) ;
 10:J P[2:P2] 30% FINE      ;                  10:   CALL VSFINIT('DIV_NUM_WP',1) ;
 11:   CALL VSFNDREF(2,'VSFT1') ;              11:   CALL VSFINIT('DIV_NUM_R',1) ;
 12:      ;                                    12:   CALL VSF_TCP('VSFT1') ;
 13:J P[3:P3] 30% FINE      ;                  13:   PAUSE ;
 14:   CALL VSFNDREF(3,'VSFT1') ;              14:      ;
[End]                                          15:J P[2:P2] 30% FINE      ;
                                               16:   CALL VSFINIT('MOVE_DIST_WP',0) ;
                                               17:   CALL VSF_REF(1,'VSFT1') ;
                                               18:      ;
                                               19:J P[3:P3] 30% FINE      ;
                                               20:   CALL VSFINIT('MOVE_DIST_WP',0) ;
                                               21:   CALL VSF_REF(2,'VSFT1') ;
                                               22:      ;
                                               23:J P[4:P4] 30% FINE      ;
                                               24:   CALL VSFINIT('MOVE_DIST_WP',0) ;
                                               25:   CALL VSF_REF(3,'VSFT1') ;
                                              [End]
```

NOTE
For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the TP program so that efficient resuming of the measurement can be done. For details, refer to "12.5.5 Details of TP Programs".
For 7DC3/10 (V8.30P/10) or later software, if the measurement is interrupted by the release of the SHIFT key, the occurrence of an alarm or other reasons, re-execute the TP program after moving the cursor to the first line. If a part of the measurement has been completed, a message "Press 0 (restart) or 9 (resume)" appears. Press the 0 key to restart the measurement from the beginning or the 9 key to resume the measurement.

5   Upon completion of program execution, please return to the Vision shift operation screen.
Then, the next screen is displayed.
Pressthe   F4 (NEXT)   key.   The Vision shift screen is displayed

```
UTILITIES iRCalibration
Vision Shift
  Get Reference Points [BEFORE] / Area 1
     Ref pos measurement was done




                                 ( NEXT )
```

If multiple areas are measured, the system asks you whether to measure the reference points of the next area.   Press the F4 (YES) key to continue measurement.

6   Similarly, measure the reference points of all areas.
      Upon completion of measurement of the reference points of all areas, "Done" is displayed after Item 4 ("Get ref pos [BEFORE]") on the Vision shift screen, and Item 5 ("Get ref pos [AFTER]") is displayed.

```
UTILITIES iRCalibration
Vision Shift
  1: Check setting data (Done)
  2: Vision Setup
  3: Test robot program
  4: Get ref pos [BEFORE] (Done)
  5: Get ref pos [AFTER] (Not yet)
  6: Status of ref pos
  7: Display convert matrix
  0: Exit


 Select operation :
[ TYPE ]DISP_IMG
```

When Item 5 ("Get ref pos [AFTER]") is displayed, reference point measurement before reinstallation is completed.

12.3.7   Measuring Reference Points after Reinstallation

Measure the positions of reference points after system reinstallation with the camera.
Measure the reference points by replaying the TP program VSFINDi (i representing an area number from 1 to 5) created and taught before reinstallation.

Procedure 12-7   Measuring reference points after reinstallation

Condition
- "Get ref pos [BEFORE]" must have been completed.
  When two or more areas are to be measured, complete "Get ref pos [BEFORE]" for all of the areas.
  If "Get ref pos [BEFORE]" has not been completed, "Get ref pos [AFTER]" is not displayed.

Step
1   Select "5: Get ref pos [AFTER]" on the Vision shift screen.

```
UTILITIES iRCalibration
Vision Shift
  1: Check setting data (Done)
  2: Vision Setup
  3: Test robot program
  4: Get ref pos [BEFORE] (Done)
  5: Get ref pos [AFTER] (Not yet)
  6: Status of ref pos
  7: Display convert matrix
  0: Exit


 Select operation :
[ TYPE ]DISP_IMG
```

2   Press the   F4 (NEXT)   key on the screen as shown below.
     If multiple areas are measured, you enter the number of an area to be measured.

```
UTILITIES iRCalibration
Vision Shift
  Get Reference Points [AFTER] / Area 1
    Ref pos measurement will be
    started
    Please push F4(NEXT) to start
    ref pos measurement





                          NEXT   CANCEL
```

3   The screen display switches to the edit screen, and the program (from VSFIND1 to VSFIND5)
     corresponding to the selected area is displayed.
     Execute the program from the first line to the last to perform a reference point measurement.

```
       For Stereo measurement method              For Visual touch-up method
   1:   UFRAME_NUM=0 ;                          1:   UFRAME_NUM=0 ;
   2:   UTOOL_NUM=9 ;                           2:   UTOOL_NUM=9 ;
   3:    ;                                      3:    ;
   4:   CALL VSINIT    ;                        4:   CALL VSFINIT    ;
   5:    ;                                      5:    ;
   6:J P[1:P1] 30% FINE    ;                    6:J P[1:P1] 30% FINE    ;
   7:   CALL VSCAMCLB('VSFT1') ;                7:   CALL VSFINIT('MOVE_DIST_W',15) ;
   8:   CALL VSFNDREF(1,'VSFT1') ;              8:   CALL VSFINIT('MOVE_DIST_P',15) ;
   9:    ;                                      9:   CALL VSFINIT('MOVE_DIST_R',15) ;
  10:J P[2:P2] 30% FINE    ;                   10:   CALL VSFINIT('DIV_NUM_WP',1) ;
  11:   CALL VSFNDREF(2,'VSFT1') ;             11:   CALL VSFINIT('DIV_NUM_R',1) ;
  12:    ;                                     12:   CALL VSF_TCP('VSFT1') ;
  13:J P[3:P3] 30% FINE    ;                   13:   PAUSE ;
  14:   CALL VSFNDREF(3,'VSFT1') ;             14:    ;
[End]                                          15:J P[2:P2] 30% FINE    ;
                                               16:   CALL VSFINIT('MOVE_DIST_WP',0) ;
                                               17:   CALL VSF_REF(1,'VSFT1') ;
                                               18:    ;
                                               19:J P[3:P3] 30% FINE    ;
                                               20:   CALL VSFINIT('MOVE_DIST_WP',0) ;
                                               21:   CALL VSF_REF(2,'VSFT1') ;
                                               22:    ;
                                               23:J P[4:P4] 30% FINE    ;
                                               24:   CALL VSFINIT('MOVE_DIST_WP',0) ;
                                               25:   CALL VSF_REF(3,'VSFT1') ;
                                             [End]
```

NOTE
- If a reference point is not within the field of view of the camera or at the edge of an image, modify the taught measurement position so that the reference point can be viewed in the central area of the camera image.
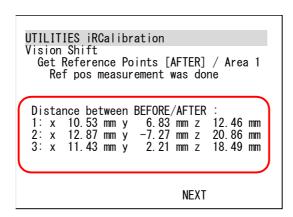

NOTE

For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the TP program so that efficient resuming of the measurement can be done. For details, refer to "12.5.5 Details of TP Programs".

For 7DC3/10 (V8.30P/10) or later software, if the measurement is interrupted by the release of the SHIFT key, the occurrence of an alarm or other reasons, re-execute the TP program after moving the cursor to the first line. If a part of the measurement has been completed, a message "Press 0 (restart) or 9 (resume)" appears. Press the 0 key to restart the measurement from the beginning or the 9 key to resume the measurement.

---

4   Upon completion of reference point measurement, return to the Vision shift operation screen.
     Then, the screen below is displayed.
     The distances between the reference points before reinstallation and the reference points measured this time are displayed.
     Press F4 (NEXT) .   The Vision Shift Processing Selection screen is displayed

```
UTILITIES iRCalibration
Vision Shift
  Get Reference Points [AFTER] / Area 1
    Ref pos measurement was done


Distance between BEFORE/AFTER :
1: x  10.53 mm y   6.83 mm z  12.46 mm
2: x  12.87 mm y  -7.27 mm z  20.86 mm
3: x  11.43 mm y   2.21 mm z  18.49 mm



                              NEXT
```

     If multiple areas are measured, the system asks you whether to measure the reference points of the next area.   Press the   F1 (YES)   key to continue measurement.

5   Measure the reference points of all areas.
     Upon completion of measurement of the reference points of all areas, "Done" is displayed in Item 5 ("Get ref pos [AFTER]").

```
UTILITIES iRCalibration
Vision Shift
  1: Check setting data (Done)
  2: Vision Setup
  3: Test robot program
  4: Get ref pos [BEFORE] (Done)
  5: Get ref pos [AFTER] (Done)
  6: Status of ref pos
  7: Display convert matrix
  0: Exit


 Select operation :
[ TYPE ]DISP_IMG
```

When "Done" is displayed in Item 5 ("Get ref pos [AFTER]"), reference point measurement after reinstallation is completed.

12.3.8 Other Operations

On the Vision shift screen, the following operations can be performed in addition to reference point measurement:
- Checking and changing reference point measurement state (completed/uncompleted)
- Displaying a conversion matrix (reference point measurement result)

Checking measurement state

The state of reference point measurement can be checked.

Procedure 12-8 Checking measurement state

Step
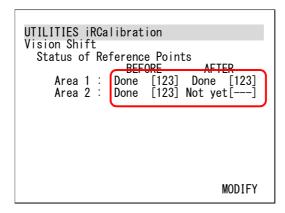
1   Select "6: Status of ref pos" on the processing selection screen of Vision shift.

```
UTILITIES iRCalibration
Vision Shift
  1: Check setting data (Done)
  2: Vision Setup
  3: Test robot program
  4: Get ref pos [BEFORE] (Done)
  5: Get ref pos [AFTER] (Done)
  6: Status of ref pos
  7: Display convert matrix
  0: Exit


 Select operation :
[ TYPE ]DISP_IMG
```

2   The screen shown below is displayed to indicate whether reference point measurements before and after reinstallation are completed or uncompleted for each measurement area.

```
┌─────────────────────────────────────────┐
│ UTILITIES iRCalibration                   │
│ Vision Shift                              │
│   Status of Reference Points              │
│                 BEFORE      AFTER         │
│       Area 1 : Done [123]  Done [123]     │
│       Area 2 : Done [123]  Not yet[---]   │
│                                           │
│                                           │
│                                           │
│                                           │
│                                  MODIFY   │
└─────────────────────────────────────────┘
```

- In the example above, two areas are measured. The screen shows that the reference points of area 2 after reinstallation are not measured yet.
- A number in [   ] indicates a reference point already measured. A hyphen in [   ] indicates a reference point not measured yet. For example, [1--] indicates that point 1 has been measured but point 2 and point 3 are not measured yet.

3   Press the PREV key.   The Vision shift screen is displayed.
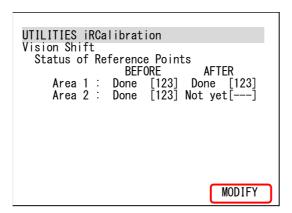
Changing measurement state

For safety, reference point measurement cannot be repeated for an area after it has been measured.   This is intended to prevent a measurement from being rewritten inadvertently by making another measurement.

To remeasure reference points, the measurement state of the reference points needs to be set to the uncompleted state by using this function.

Procedure 12-9   Changing measurement state

Step
1   Press the F5 (MODIFY) key on the reference point measurement state display screen.

```
┌─────────────────────────────────────────┐
│ UTILITIES iRCalibration                   │
│ Vision Shift                              │
│   Status of Reference Points              │
│                 BEFORE      AFTER         │
│       Area 1 : Done [123]  Done [123]     │
│       Area 2 : Done [123]  Not yet[---]   │
│                                           │
│                                           │
│                                           │
│                                           │
│                                  MODIFY   │
└─────────────────────────────────────────┘
```

2   The bottom of the screen changes as shown below.
     Enter a desired area number.

```
┌─────────────────────────────────────────┐
│   Shift area number : ▮                   │
│                             CANCEL        │
└─────────────────────────────────────────┘
```

3   Enter 1 to change the state before reinstallation.   Enter 0 to change the state after reinstallation.

```
┌─────────────────────────────────────────────────┐
│  BEFORE/AFTER (1:BEFORE,0:AFTER):                 │
│                                         CANCEL    │
└─────────────────────────────────────────────────┘
```

In the example below, the measurement state of the reference points in area 1 is changed from the completed state to the uncompleted state so that the reference points can be remeasured.

```
┌──────────────────────────────────────────────┐
│ UTILITIES iRCalibration                        │
│ Vision Shift                                   │
│   Status of Reference Points                   │
│                    BEFORE        AFTER         │
│     Area 1 :  Done  [123] Not yet[123]         │
│     Area 2 :  Done  [123] Not yet[---]         │
│                                                │
│                                                │
│                                                │
│                                                │
│                                      MODIFY    │
└──────────────────────────────────────────────┘
```

- If the measurement state is changed from "Done (completed)" to "Not yet (uncompleted)", the measurement state of each reference point is saved ([123] remains unchanged). If one point is remeasured in this state then the program is terminated, the measurement state is set to the completed state again.
- If the measurement state is changed from "Done (completed)" to "Not yet (uncompleted)", the measurement state of each reference point is set to the completed state ([123]). When setting reference point position data before reinstallation directly in position registers by performing an operation such as an offline shift operation, set the data in the position registers then change the measurement state before reinstallation from the uncompleted state to the completed state.

> ⚠ **CAUTION**
> The reference points (before reinstallation) can be modified as long as the workcell has not been reinstalled. <u>If reference points (before reinstallation) are remeasured after workcell has been reinstalled then the original data is overwritten and Vision shift is disabled. Never change the measurement state of reference points (before reinstallation) to the uncompleted state after workcell reinstallation.</u>
> If the measurement state of reference points (before reinstallation) is inadvertently changed to the uncompleted state after workcell reinstallation, change the state back to the completed state again. (Even if the state is changed to the uncompleted state with this function, the reference point measurement data is not deleted.)

Displaying a conversion matrix

The distances between reference points before reinstallation and reference points after reinstallation, and the value of a conversion matrix used with program shift operation can be checked.

Procedure 12-10   Displaying a conversion matrix

Step

1   Select "7: Display convert matrix" on the Vision shift screen.

```
UTILITIES iRCalibration
Vision Shift
  1: Check setting data (Done)
  2: Vision Setup
  3: Test robot program
  4: Get ref pos [BEFORE] (Done)
  5: Get ref pos [AFTER] (Done)
  6: Status of ref pos
  7: Display convert matrix
  0: Exit


 Select operation :
[ TYPE ]DISP_IMG
```

2   The conversion matrix of each area, and the distances between reference points before reinstallation and reference points after reinstallation are displayed.

```
USER
Vision Shift

 Display convert matrix
 Area  1
X:   150.04 Y:    20.87 Z:   110.20
W:     0.00 P:     0.00 R:     0.00

Distance between BEFORE/AFTER :
1: x  10.53 mm y   6.83 mm z  12.46 mm
2: x  12.87 mm y  −7.27 mm z  20.86 mm
3: x  11.43 mm y   2.21 mm z  18.49 mm

                                 Output
```

Outputting a conversion matrix text file

Pressing the ⎡ F5 (Output) ⎤ key outputs the conversion matrix of each area and the distances between reference points before reinstallation and reference points after reinstallation as a text file to the currently selected external device (such as a memory card).
The file name is VSFRAME.TXT.

12.3.9   Backing up Data

The initial settings of Vision shift and the robot positions for measurement are stored in the TP programs indicated below. Moreover, the result of reference point detection is stored in the position registers specified as "Position Register (Reference points)" in the initial setting screen.

VSMAIN
        Common settings used with Vision shift
VSSUB1 to VSSUB5 (as many as the number of measurement areas)
        Settings for each measurement area (tool coordinate system, position register numbers for storing reference point detection positions, and so forth)
VSFIND1 to VSFIND5 (as many as the number of measurement areas)
        Teach positions for reference point measurement

Upon completion of measurement before reinstallation, back up, for safety, the programs above and the data of position registers before reinstalling the robot.
In particular, the reference point position data stored in position registers are important.

12.3.10 Offline Shift Operation

The offline shift operation compensates for an installation error between a robot program created with the offline programming system and the actual position on the factory floor by using Vision shift.

In offline shift operation, reference points before reinstallation are not measured.   The positions of reference points are calculated using the offline programming system.   The calculated positions are set as reference point position data before reinstallation in position registers.

On the factory floor, reference points are set at the same positions as specified with the offline programming system then the reference points after reinstallation are measured with the camera attached to the robot.

The steps of "1: Check setting data", "2: Vision Setup" and "3: Test robot program" remain unchanged in offline shift operation.

Setting reference point positions

Instead of measuring reference points before reinstallation, the positions of reference points are determined with the offline programming system according to the procedure below, then the positions are set in position registers as the detected positions of reference points before reinstallation.

In offline shift operation, reference points to be measured with Vision shift are examined on the offline programming system.

1   With the offline programming system, determine at which positions those reference points to be measured are to be set.   Three reference points are needed for each area.
     Determine those positions on a workpiece or fixture to secure a workpiece that enable reference points to be set on the factory floor.

2   Calculate the positions of three reference points on the offline programming system.   Find the three-dimensional position (X,Y,Z) of each reference point when viewed from the base coordinate system of the robot.   The three-dimensional positions of three reference points are represented as P1(X1, Y1, Z1), P2(X2, Y2, Z2), and P3(X3, Y3, Z3).

3   Set the found positions of the three reference points, P1, P2, and P3, in three position registers for storing the positions of reference points before reinstallation.
     In a position register, three of the six components, X, Y, Z, W, P, and R, can be entered.   In X, Y, and Z, set the calculated values of Pi(Xi, Yi, Zi) (i = 1 to 3).   In W, P, and R, enter an arbitrary value (for example, 0).   (The values of W, P, and R of a position register have no effect on program shift operation.)

Changing measurement state

To perform an offline shift operation, set the reference point position data in the position registers, then change the measurement state of reference points before reinstallation to "Done" on the reference point measurement state screen.   Next, measure the reference points after reinstallation.

1   Set the positions of reference points in position registers then select "6: Status of ref pos" on the Vision shift screen.
2   Press the ⎣ F5 (MODIFY) ⎦ key.
3   Set a desired area number (from 1 to 5) (only when multiple areas are used).
4   Enter 1: BEFORE in "BEFORE/AFTER" prompt.
5   Check that the measurement state of reference points before reinstallation is set to "Done".
6   If multiple areas are used, set the measurement state before reinstallation for each area to "Done".
7   Press ⎣ PREV ⎦ to return to the processing selection screen.

Measuring reference point positions

Select "5: Get ref pos [AFTER]" on the Vision shift screen, and execute the program.

12.4 PROGRAM SHIFT (ONLINE SHIFT FUNCTION)

This section describes the operation of the online shift function to shift the taught positions of a robot program according to the measurement result using Vision shift.

Online shift

Two types of online shift functions are available:
- Three-point shift function
- One-point shift function

The three-point shift function shifts the taught positions of a program before reinstallation (or a program created offline) according to the actual condition on the factory floor by using the position data of three reference points measured using Vision shift.

After performing a three-point shift operation, execute the program then check the position of each taught point. Make a fine position adjustment if necessary.

At this time, a fine teach position adjustment can be made in a shorter time by using the one-point shift function.

When the position of a taught point is modified after moving the robot manually to the taught point, the one-point shift function can reflect the amount of modification at the taught point in other taught points of the program as well, thus modifying multiple taught points at a time.

By combining the three-point shift function and one-point shift function, programmed taught positions could be modified in a short time by a simple operation.

With the online three-point shift function and one-point shift function:
- A shift range can be specified on the program edit screen.
- An error that has occurred during shift operation can be checked later.
- A shift operation can be canceled.

12.4.1 Specifying a Program for Shift Operation

The online shift function shifts the currently selected program.
For either one-point shift operation or three-point shift operation, select a program to be shifted on the program list screen of the teach pendant beforehand.

> **NOTE**
> Be sure to select a program to be shifted, from the program list.
> When a subprogram is being called, the subprogram cannot be shifted with the online shift function.
> To shift a subprogram, select the subprogram from the program list beforehand.

12.4.2 Three-Point Shift Operation

Three-point shift function

The three-point shift function shifts a program by using the positions of three reference points measured with Vision shift.

This function compensates for an installation position error between before and after system reinstallation, and also compensates for an installation position error between the offline programming system and the actual positions on the factory floor.

Shift operations based on reinstallation calculates an installation position error. The position error is between the offline object (before reinstallation) and the real workcell object (after the reinstallation).
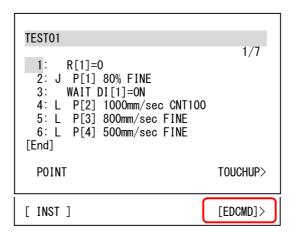
The error is used to shift the taught positions of the robot program to match the state after reinstallation.

Three-point shift operation

Procedure 12-11   Performing a three-point shift operation

Step

1   Press   F5 [EDCMD]   on the second page of the edit screen.
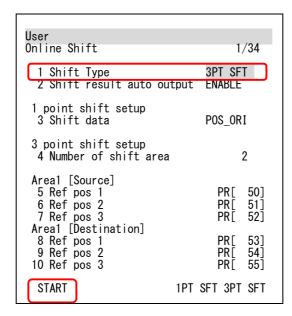   Select "Online sft" from the menu.

```
TEST01
                                                 1/7
 1:    R[1]=0
 2: J  P[1] 80% FINE
 3:    WAIT DI[1]=ON
 4: L  P[2] 1000mm/sec CNT100
 5: L  P[3] 800mm/sec FINE
 6: L  P[4] 500mm/sec FINE
[End]


   POINT                               TOUCHUP>


 [ INST ]                             [EDCMD]>
```

2   The online shift setting screen shown below is displayed.
        7DF3/10(V9.30P/10) or earlier   7DF3/11(V9.30P/11) or later

```
User              G1  WORLD  50 %      User              G1  WORLD  50 %
Online Shift                1/34       Online Shift                1/35

 1 Shift Type          3PT SFT          1 Group number                1
 2 Shift result auto output DISABLE     2 Shift type           3PT SFT
                                        3 Shift result auto output DISABLE
1 point shift setup
 3 Shift data          POS_ORI         1 point shift setup
                                        4 Shift data          POS_ORI
3 points shift setup
 4 Number of shift area       2        3 points shift setup
                                        5 Number of shift area        1
Area 1 [Source]
 5 Ref pos 1              PR[  50]      Area 1 [Source]
 6 Ref pos 2              PR[  51]       6 Ref pos 1              PR[  50]
 7 Ref pos 3              PR[  52]       7 Ref pos 2              PR[  51]
Area 1 [Destination]                    8 Ref pos 3              PR[  52]
 8 Ref pos 1              PR[  53]      Area 1 [Destination]
 9 Ref pos 2              PR[  54]       9 Ref pos 1              PR[  53]
10 Ref pos 3              PR[  55]      10 Ref pos 2              PR[  54]

  START           1PT SFT 3PT SFT        START
```

With the 7DF3/11(V9.30P/11) or later software, the robots' group number is set in "Group Number".
Select "3PT SFT" (Three point shift) in "Shift Type", then press   F1 (START) .

```
┌─────────────────────────────────────────┐
│ User                                      │
│ Online Shift                    1/34      │
│                                           │
│ ┌─────────────────────────────────────┐  │
│ │ 1 Shift Type              3PT SFT   │  │
│ └─────────────────────────────────────┘  │
│   2 Shift result auto output  ENABLE      │
│                                           │
│  1 point shift setup                      │
│   3 Shift data                POS_ORI     │
│                                           │
│  3 point shift setup                      │
│   4 Number of shift area          2       │
│                                           │
│  Area1 [Source]                           │
│   5 Ref pos 1                 PR[  50]     │
│   6 Ref pos 2                 PR[  51]     │
│   7 Ref pos 3                 PR[  52]     │
│  Area1 [Destination]                      │
│   8 Ref pos 1                 PR[  53]     │
│   9 Ref pos 2                 PR[  54]     │
│  10 Ref pos 3                 PR[  55]     │
│  ┌──────┐                                 │
│  │ START│             1PT SFT 3PT SFT     │
│  └──────┘                                 │
└─────────────────────────────────────────┘
```

- For the number of areas and position register numbers used for three-point shift operation, the settings made on the initial setting screen of Vision shift are automatically reflected. This means that no particular setting is needed.

3   The second page of the edit screen displays the F2 through F4 keys for online shift operation.
    Press F4 (3PT SFT).

```
┌─────────────────────────────────────────┐
│ TEST01                                    │
│                                           │
│  1:   R[1]=0                              │
│  2: J P[1] 80% FINE                       │
│  3:   WAIT DI[1]=ON                       │
│  4: L P[2] 1000mm/sec CNT100              │
│  5: L P[3] 800mm/sec FINE                 │
│  6: L P[4] 500mm/sec FINE                 │
│ [End]                                     │
│                             ┌────────┐    │
│ [ INST ] CANCEL   RSLT      │3PT SFT │[EDCMD]> │
│                             └────────┘    │
└─────────────────────────────────────────┘
```

The F2 through F4 keys change as shown below, and a message is displayed.

```
┌─────────────────────────────────────────┐
│ TEST01                                    │
│                                           │
│  1:   R[1]=0                              │
│  2: J P[1] 80% FINE                       │
│  3:   WAIT DI[1]=ON                       │
│  4: L P[2] 1000mm/sec CNT100              │
│  5: L P[3] 800mm/sec FINE                 │
│  6: L P[4] 500mm/sec FINE                 │
│ [End]                                     │
│                                           │
│ Specify start/end line and do convert     │
│ [ INST ] ┌STR      END     CONV┐[EDCMD]>  │
│          └─────────────────────┘          │
└─────────────────────────────────────────┘
```

4   Specify a shift start line.
    Move the cursor to a desired shift start line then press   F2 (STR) .

```
TEST01

 1:   R[1]=0
 2: J P[1] 80% FINE
 3:   WAIT DI[1]=ON
 4: L P[2] 1000mm/sec CNT100
 5: L P[3] 800mm/sec FINE
 6: L P[4] 500mm/sec FINE
[End]

Specify start/end line and do convert
[ INST ]  STR 4   END    CONV  [EDCMD]>
```

The specified shift start line is displayed after "STR" of the F2 key.

5   Next, specify a shift end line.
     Move the cursor to a desired shift end line then press F3 (END) .

```
TEST01

 1:   R[1]=0
 2: J P[1] 80% FINE
 3:   WAIT DI[1]=ON
 4: L P[2] 1000mm/sec CNT100
 5: L P[3] 800mm/sec FINE
 6: L P[4] 500mm/sec FINE
[End]

Specify start/end line and do convert
[ INST ]  STR 4   END 6  CONV  [EDCMD]>
```

The specified end line is displayed after "END" of the F3 key.

6   Press the F4 (CONV) key.   The program will be shifted.
     If multiple areas are to be shifted, the system asks you about an area to be shifted.   Enter a desired
     area number.

```
TEST01

 1:   R[1]=0
 2: J P[1] 80% FINE
 3:   WAIT DI[1]=ON
 4: L P[2] 1000mm/sec CNT100
 5: L P[3] 800mm/sec FINE
 6: L P[4] 500mm/sec FINE
[End]

Specify start/end line and do convert
[ INST ]  STR 4   END 6  CONV  [EDCMD]>
```

7   Upon completion of conversion, the F2 through F4 keys disappear, and a message indicating that
     program shift operation is completed is displayed together with the number of errors that occurred
     during conversion.
     Check whether errors occurred.

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```
┌─────────────────────────────────────────────┐
│ ▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓   │
│ TEST01                                        │
│                                               │
│ ▓1:   R[1]=0                                  │
│  2: J P[1] 80% FINE                           │
│  3:   WAIT DI[1]=ON                           │
│  4: L P[2] 1000mm/sec CNT100                  │
│  5: L P[3] 800mm/sec FINE                     │
│  6: L P[4] 500mm/sec FINE                     │
│ [End]                                         │
│                                               │
│ ┌─────────────────────────────────┐          │
│ │Program shift was done(Err   0)  │          │
│ └─────────────────────────────────┘          │
│ [ INST ]                            [EDCMD]>  │
└─────────────────────────────────────────────┘
```

- To stop using the online shift function, press the [PREV] key.   The F2 through F4 keys for online shift operation disappear.
- To check the details of errors that occurred during conversion, see Subsection 12.4.4, "Checking the Result of Shift Operation".

NOTE
If an online shift operation is performed once by pressing F4 (CONV), the F2 through F4 keys for online shift operation disappear.
To perform an online shift operation again, pressthe F5 [EDCMD] key, then select "Online sft".

12.4.3   One-Point Shift Operation

One-point shift function

An on point shift function uses the recorded position (before reinitialization) and the user-adjusted position. The user-adjusted positions obtained by jogging the robot to the correct position; the difference between the two positions is the shift amount.

This same shift amount can be applied to a range of positions, thus modifying multiple teach points at a time.

A shift range can be specified on the program edit screen.

The one-point shift function shifts the teach points in a range specified in the program by using, as a shift amount, the differential between the recorded teach position (where the cursor is placed) and the current position/posture of the robot at shift start time.

A shift amount is relative to the base coordinate system, world, of the robot.   When multiple points are shifted, each point is shifted in the same direction in the base coordinate system.

There are three options for the shift data:
- Shift in position and posture.
- Shift in position only.
- Shift in posture only.

Usually, shift in position and posture is used.

One-point shift operation

The one-point shift function shifts a program by using, as a shift amount, the differential between the teach position on the line where the cursor is placed and the current position/posture of the robot when the F4 (1PT SFT)   key is pressed to start a shift operation.

The method of specifying a shift range and the method of conversion are the same as for the three-point shift operation.
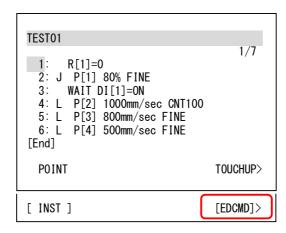
> **NOTE**
> In a one-point shift operation, a shift amount is determined from the differential between the current robot position and the teach position (on the line where the cursor is placed at shift start time).
> If a position modification is made at a teach position to be modified, the current position and the teach position match each other, so that the differential becomes 0, disabling the shift operation.
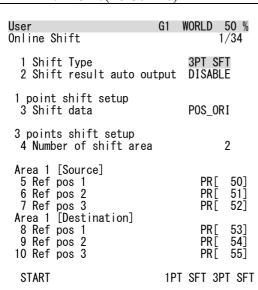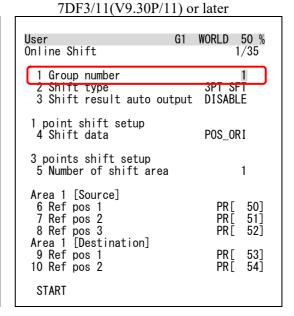
Procedure 12-12   Performing a one-point shift operation

Step

1   Press the   F5 [EDCMD]   key on the second page of the edit screen.
Select "Online sft" from the menu.
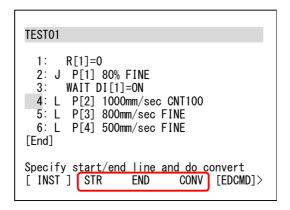
```
TEST01
                                    1/7
  1:   R[1]=0
  2: J  P[1] 80% FINE
  3:    WAIT DI[1]=ON
  4: L  P[2] 1000mm/sec CNT100
  5: L  P[3] 800mm/sec FINE
  6: L  P[4] 500mm/sec FINE
[End]

   POINT                      TOUCHUP>


[ INST ]                      [EDCMD]>
```

2   The online shift setting screen as shown below is displayed.

7DF3/10(V9.30P/10) or earlier   7DF3/11(V9.30P/11) or later

```
User            G1  WORLD  50 %
Online Shift               1/34

 1 Shift Type           3PT SFT
 2 Shift result auto output  DISABLE

1 point shift setup
 3 Shift data           POS_ORI

3 points shift setup
 4 Number of shift area        2

Area 1 [Source]
 5 Ref pos 1              PR[  50]
 6 Ref pos 2              PR[  51]
 7 Ref pos 3              PR[  52]
Area 1 [Destination]
 8 Ref pos 1              PR[  53]
 9 Ref pos 2              PR[  54]
10 Ref pos 3              PR[  55]

 START           1PT SFT 3PT SFT
```

```
User            G1  WORLD  50 %
Online Shift               1/35

 1 Group number                1
 2 Shift type           3PT SFT
 3 Shift result auto output  DISABLE

1 point shift setup
 4 Shift data           POS_ORI

3 points shift setup
 5 Number of shift area        1

Area 1 [Source]
 6 Ref pos 1              PR[  50]
 7 Ref pos 2              PR[  51]
 8 Ref pos 3              PR[  52]
Area 1 [Destination]
 9 Ref pos 1              PR[  53]
10 Ref pos 2              PR[  54]

 START
```

With the 7DF3/11(V9.30P/11) or later software, the robots' group number is set in "Group Number".
Select "1PT SFT" in "Shift Type" by pressing   F4 (1PT SFT) .
Select "POS ORI" in "Shift data".   However, select "POS" when the posture of the teach position data is not to be modified.

```
┌─────────────────────────────────────────┐
│ User                                      │
│ Online Shift                      1/34    │
│                                           │
│ ┌─────────────────────────────────────┐  │
│ │ 1 Shift Type                 1PT SFT │  │
│ └─────────────────────────────────────┘  │
│   2 Shift result auto output  ENABLE      │
│                                           │
│  1 point shift setup                      │
│ ┌─────────────────────────────────────┐  │
│ │ 3 Shift data                 POS_ORI │  │
│ └─────────────────────────────────────┘  │
│                                           │
│  3 point shift setup                      │
│   4 Number of shift area           2      │
│                                           │
│  Area1 [Source]                           │
│   5 Ref pos 1                  PR[  50]    │
│   6 Ref pos 2                  PR[  51]    │
│   7 Ref pos 3                  PR[  52]    │
│  Area1 [Destination]                      │
│   8 Ref pos 1                  PR[  53]    │
│   9 Ref pos 2                  PR[  54]    │
│  10 Ref pos 3                  PR[  55]    │
│ ┌──────┐                                  │
│ │ START│            1PT SFT 3PT SFT       │
│ └──────┘                                  │
└─────────────────────────────────────────┘
```

3   After confirming the settings above, press the ☐ F1 (START) ☐ key.
     The second page of the edit screen displays the F2 through F4 keys for the online shift operation.
     By using the F2 through F4 keys, an online shift operation can be performed.

```
┌─────────────────────────────────────────┐
│ TEST01                                    │
│                                           │
│   1:   R[1]=0                             │
│   2: J P[1] 80% FINE                      │
│   3:   WAIT DI[1]=ON                      │
│   4: L P[2] 1000mm/sec CNT100             │
│   5: L P[3] 800mm/sec FINE                │
│   6: L P[4] 500mm/sec FINE                │
│ [End]                                     │
│                                           │
│ [ INST ] CANCEL   RSLT  1PT SFT [EDCMD]>  │
└─────────────────────────────────────────┘
```

4   Move the robot in step mode to the line where a teach position is to be modified.   In this example,
     the robot is moved to the line 4 specifying the position P[2].
5   Move the current robot position manually to the position to be modified.
6   Press the ☐ F4 (1PT SFT) ☐ key
     When the F4 key is pressed, the differential between the teach position and the current robot position
     is automatically recorded as a shift amount.

┌───┐
│ **NOTE**   │
│   In a one-point shift operation, a shift amount is determined from the   │
│   difference between the current robot position and the teach position (on   │
│   the line where the cursor is placed when the F4 key (1PT SFT) is pressed).   │
│   Do not make a position modification before pressing the F4 key (1PT SFT).   │
│   Otherwise, the current position and the teach position match each other, so │
│   that the differential becomes 0, disabling the shift operation.   │
└───┘

```
TEST01

 1:    R[1]=0
 2: J  P[1] 80% FINE
 3:    WAIT DI[1]=ON
 4: L  P[2] 1000mm/sec CNT100
 5: L  P[3] 800mm/sec FINE
 6: L  P[4] 500mm/sec FINE
[End]

[ INST ] CANCEL   RSLT  1PT SFT [EDCMD]>
```

The F2 through F4 keys change as shown below, and a message is displayed.

```
TEST01

 1:    R[1]=0
 2: J  P[1] 80% FINE
 3:    WAIT DI[1]=ON
 4: L  P[2] 1000mm/sec CNT100
 5: L  P[3] 800mm/sec FINE
 6: L  P[4] 500mm/sec FINE
[End]

Specify start/end line and do convert
[ INST ] STR     END    CONV  [EDCMD]>
```

7   Specify a shift start line.   Move the cursor to a desired shift start line then press the   F2 (STR)
     key.
     The specified shift start line is displayed after the "STR" text above of the F2 key.

```
TEST01

 1:    R[1]=0
 2: J  P[1] 80% FINE
 3:    WAIT DI[1]=ON
 4: L  P[2] 1000mm/sec CNT100
 5: L  P[3] 800mm/sec FINE
 6: L  P[4] 500mm/sec FINE
[End]

Specify start/end line and do convert
[ INST ]  STR 4   END    CONV  [EDCMD]>
```

8   Next, specify a shift end line.   Move the cursor to a desired shift end line then press the F3 (END)
     key.
     The specified shift end line is displayed after the "END" text above the F3 key.

```
TEST01

 1:    R[1]=0
 2: J  P[1] 80% FINE
 3:    WAIT DI[1]=ON
 4: L  P[2] 1000mm/sec CNT100
 5: L  P[3] 800mm/sec FINE
 6: L  P[4] 500mm/sec FINE
[End]

Specify start/end line and do convert
[ INST ]   STR 4   END 6   CONV  [EDCMD]>
```

9   Press the F4 (CONV) key.   The program will be shifted.

10   Upon completion of conversion, the F2 through F4 keys disappear, and a message indicating that
     program shift operation is completed is displayed together with the number of errors that occurred
     during conversion.

```
TEST01

 1:    R[1]=0
 2: J  P[1] 80% FINE
 3:    WAIT DI[1]=ON
 4: L  P[2] 1000mm/sec CNT100
 5: L  P[3] 800mm/sec FINE
 6: L  P[4] 500mm/sec FINE
[End]

Program shift was done(Err   0)
[ INST ]                        [EDCMD]>
```

If an online shift operation is performed once, the F2 through F4 keys for online shift operation disappear.
To perform an online shift operation again, press the F5 key ([EDCMD]) then select "Online sft".

To stop using the online shift function, press the [PREV] key.   The F2 through F4 keys for online shift
operation disappear.

To check the details of errors that occurred during conversion, see Subsection 12.4.4, "Checking the
Result of Shift Operation".

12.4.4   Checking the Result of Shift Operation

Checking the detailed result of shift operation

Upon completion of conversion in either a three-point shift operation or a one-point shift operation, a
message indicating that the program shift operation is completed is displayed together with the number of
errors that occurred during conversion.
Details of errors that occurred during conversion can be checked using the procedure below.

Procedure 12-13   Checking the detailed result of shift operation

Step

1   Press the F5[EDCMD] key on the second page of the edit screen. Select "Online sft" from the menu.
2   Press the F1 (START) key.
3   Press the F3 (RSLT) key.

```
TEST01

  1:   R[1]=0
  2: J  P[1] 80% FINE
  3:    WAIT DI[1]=ON
  4: L  P[2] 1000mm/sec CNT100
  5: L  P[3] 800mm/sec FINE
  6: L  P[4] 500mm/sec FINE
[End]

[ INST ] CANCEL   RSLT  1PT SFT [EDCMD]>
```

Conversion information and details of errors that occurred during conversion are displayed.
If one page cannot display all errors that occurred during conversion, F4 displays "NextPage".
Press F4 to display details of errors that cannot be displayed on the first page.

```
USER
Online Shift

  Shift Result
    Program : TEST01
    Lines   :   4 —    6
    Error occurred at following points
      6 P[4]  Position is not reachable
```

Outputting the result of shift operation

Press the F5 (Output) key to output the result of shift operation as a text file to an external device.   The
file name is program-name.TXT.   (In this example, the file name is PNS0001.TXT.)
If the online shift setting enables automatic output of the result of shift operation, the result of shift
operation is automatically output as a text file to an external device each time conversion is performed.

12.4.5   Canceling a Shift Operation

The last shift operation can be canceled.
The program returns to the state immediately before the last shift operation.

Procedure 12-14   Canceling the last shift operation

Step
1   Press the F5[EDCMD] key on the second page of the edit screen.
     Select "Online sft" from the menu.
2   Press the F1 (START) key.
3   Press the F2 (CANCEL) key.

```
┌─────────────────────────────────────────┐
│ TEST01                                    │
│                                           │
│  1:   R[1]=0                              │
│  2: J P[1] 80% FINE                       │
│  3:   WAIT DI[1]=ON                       │
│  4: L P[2] 1000mm/sec CNT100              │
│  5: L P[3] 800mm/sec FINE                 │
│  6: L P[4] 500mm/sec FINE                 │
│ [End]                                     │
│                                           │
│ [ INST ] CANCEL   RSLT  1PT SFT [EDCMD]>  │
└─────────────────────────────────────────┘
```

The shift cancellation confirmation screen is displayed.

4   Pressing the F1 (Yes) key returns the program to the state immediately before the last shift operation.

```
┌─────────────────────────────────────────┐
│ USER                                      │
│ Online Shift                              │
│   Cancel prev shift                       │
│     Program : TEST01                      │
│     Recover program just before           │
│     previous shift                        │
│                                           │
│     All modification will be lost         │
│     from previous shift                   │
│                                           │
│ Cancel previous shift ?                   │
│   Yes      No                             │
└─────────────────────────────────────────┘
```

> ⚠ **CAUTION**
> 1. If the last shift operation is canceled using this function, the program returns to the state immediately before the last shift operation.   Note that all modifications made after the last shift operation are lost.
> 2. This function can cancel only the last shift operation performed.

12.5   SPECIFICATIONS OF TP PROGRAMS FOR VISION SHIFT

This section describes the contents and specifications of the robot TP programs used with Vision shift.
By using the offline programming system, camera installation position and direction data and the results of examining the measurement positions and postures of reference points beforehand can be read as TP programs into the robot.

12.5.1   Outline of TP Programs Used for Vision Shift

Vision shift measures the positions of reference points by using the following TP programs:
VSMAIN: Program for setting common data
VSSUB1-5:   Program for setting area data (areas 1 to 5)
VSFIND1-5:   Program for measuring the positions of reference points (areas 1 to 5)

With the 7DF3/11(V9.30P/11) or later software, the following TP programs are used for the robots in group n.
VSMAIN_Gn   : Program for setting common data
VSSUB1_Gn to VSSUB5_Gn   : Program for setting area data (areas 1 to 5)

- 333 -

VSFIND1_Gn to VSFIND5_Gn   : Program for measuring the positions of reference points (areas 1 to 5)

VSMAIN, VSSUB

VSMAIN and VSSUB1 through VSSUB5 are used to save the settings made on the initial setting screen of Vision shift.   In VSMAIN and VSSUB1 through VSSUB5, settings are taught as comment statements.

Vision shift reads VSMAIN and VSSUB1 through VSSUB5, if present at initial setting time, and sets the data specified by VSMAIN and VSSUB1 through VSSUB5 in the controller.

If settings are modified on the initial setting screen of Vision shift, VSMAIN and VSSUB1 through VSSUB5 are updated according to the modified data.   The Vision shift settings on one controller can be set on another controller by copying VSMAIN and VSSUB1 through VSSUB5.

VSFIND

VSFIND1 through VSFIND5 are used for Camera position calibration and vision measurement of reference points.

VSFIND1 through VSFIND5 call the following subprograms:

Table 12.5.1 Subprogram called in TP program

	Stereo measurement method	Visual touch-up method
Subprogram for initial setting	VSINIT	VSFINIT
Subprogram for camera position calibration	VSCAMCLB	VSF_TCP
Subprogram for measuring reference points	VSFNDREF	VSF_REF

The KAREL subprograms above are installed on the robot controller if the Vision shift option is specified.

The TP programs and KAREL subprograms above use a tool coordinate system, register, and position registers.   A tool coordinate system number, register number, and position register numbers can be specified using all of VSMAIN and VSSUB1 through VSSUB5.   These settings can be checked or modified on the initial setting screen of Vision shift.

12.5.2   Sample TP Program
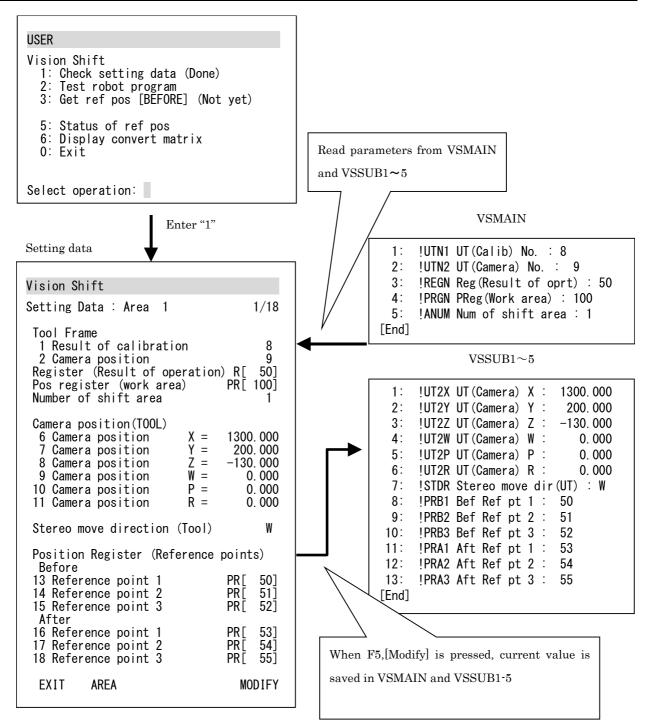
The TP program VSFIND0 and VSFINDA are sample programs for vision measurement. With the 7DF3/11(V9.30P/11) or later software, there are sample files for group 2 or later that have "_Gn" appended to the file name (n is the group number). For example, VSFIND0_G2.TP, VSFINDA_G2.TP. VSFIND0 is sample for Stereo measurement method and VSFINDA is for Visual touch-up method.

The sample program can be used as a template for TP programs.

12.5.3   Relationship between Vision Shift and TP Programs

If TP programs such as VSMAIN and VSSUB1 through VSSUB5 are available, the values specified by those TP programs are read and displayed on the initial setting screen of Vision shift as shown on the next page.

If VSMAIN and VSSUB1 through VSSUB5 are unavailable, the default values are displayed.

If modifications are made to settings on the initial setting screen, the modifications are reflected in VSMAIN and VSSUB1 through VSSUB5.

```
┌────────────────────────────────────┐
│ USER                               │
│                                    │
│ Vision Shift                       │
│   1: Check setting data (Done)     │
│   2: Test robot program            │
│   3: Get ref pos [BEFORE] (Not yet)│
│                                    │
│   5: Status of ref pos             │
│   6: Display convert matrix        │
│   0: Exit                          │
│                                    │
│                                    │
│ Select operation: ▌                │
└────────────────────────────────────┘
```

Enter "1"

Read parameters from VSMAIN
and VSSUB1～5

Setting data

VSMAIN

```
┌──────────────────────────────────────┐
│  1:  !UTN1 UT(Calib) No. : 8         │
│  2:  !UTN2 UT(Camera) No. :  9       │
│  3:  !REGN Reg(Result of oprt) : 50  │
│  4:  !PRGN PReg(Work area) : 100     │
│  5:  !ANUM Num of shift area : 1     │
│ [End]                                │
└──────────────────────────────────────┘
```

```
┌────────────────────────────────────────────┐
│ Vision Shift                               │
│                                            │
│ Setting Data : Area  1            1/18     │
│                                            │
│  Tool Frame                                │
│   1 Result of calibration          8       │
│   2 Camera position                9       │
│  Register (Result of operation) R[  50]    │
│  Pos register (work area)       PR[ 100]   │
│  Number of shift area               1       │
│                                            │
│  Camera position(TOOL)                     │
│   6 Camera position     X =    1300.000    │
│   7 Camera position     Y =     200.000    │
│   8 Camera position     Z =    -130.000    │
│   9 Camera position     W =       0.000    │
│  10 Camera position     P =       0.000    │
│  11 Camera position     R =       0.000    │
│                                            │
│  Stereo move direction (Tool)        W     │
│                                            │
│  Position Register (Reference points)      │
│   Before                                   │
│  13 Reference point 1        PR[  50]      │
│  14 Reference point 2        PR[  51]      │
│  15 Reference point 3        PR[  52]      │
│   After                                    │
│  16 Reference point 1        PR[  53]      │
│  17 Reference point 2        PR[  54]      │
│  18 Reference point 3        PR[  55]      │
│                                            │
│  EXIT    AREA                 MODIFY       │
└────────────────────────────────────────────┘
```

VSSUB1～5

```
┌────────────────────────────────────────────┐
│  1:  !UT2X UT(Camera) X :   1300.000       │
│  2:  !UT2Y UT(Camera) Y :    200.000       │
│  3:  !UT2Z UT(Camera) Z :   -130.000       │
│  4:  !UT2W UT(Camera) W :      0.000       │
│  5:  !UT2P UT(Camera) P :      0.000       │
│  6:  !UT2R UT(Camera) R :      0.000       │
│  7:  !STDR Stereo move dir(UT) : W         │
│  8:  !PRB1 Bef Ref pt 1 :  50              │
│  9:  !PRB2 Bef Ref pt 2 :  51              │
│ 10:  !PRB3 Bef Ref pt 3 :  52              │
│ 11:  !PRA1 Aft Ref pt 1 :  53              │
│ 12:  !PRA2 Aft Ref pt 2 :  54              │
│ 13:  !PRA3 Aft Ref pt 3 :  55              │
│ [End]                                      │
└────────────────────────────────────────────┘
```

When F5,[Modify] is pressed, current value is
saved in VSMAIN and VSSUB1-5

12.5.4   List of Data Used for Vision Shift

The table below indicates the tool coordinate systems, register, and position registers used with Vision shift.

Table 12.5.4 Data used with Vision shift

Data	Q'ty	Purpose			Remarks
Tool Frame	2	Stores the result of Camera position calibration.			
		Sets the position of the camera.			

Register	1	Stores vision status.			-1 Waiting for vision processing
					  0 No vision detection (number of detections = 0)
					  1 Vision detection successful (number of detection = 1)

Position register	1	Used by each operation (work register)			
Position register (storing detection positions) Position registers as many as [6 × (number of measurement areas)] are used.	6	Area 1	Before reinstal-lation	Reference point 1 detection position	
				Reference point 2 detection position	
				Reference point 3 detection position	
			After reinstal-lation	Reference point 1 detection position	
				Reference point 2 detection position	
				Reference point 3 detection position	
	6	Area 2	Before reinstal-lation	Reference point 1 detection position	
				Reference point 2 detection position	
				Reference point 3 detection position	
			After reinstal-lation	Reference point 1 detection position	
				Reference point 2 detection position	
				Reference point 3 detection position	
	6	Area 3	Before reinstal-lation	Reference point 1 detection position	
				Reference point 2 detection position	
				Reference point 3 detection position	
			After reinstal-lation	Reference point 1 detection position	
				Reference point 2 detection position	
				Reference point 3 detection position	

Data	Q'ty	Purpose			Remarks
Position register (storing detection positions) Position registers as many as [6 × (number of measurement areas)] are used.	6	Area 4	Before reinstal-lation	Reference point 1 detection position	
				Reference point 2 detection position	
				Reference point 3 detection position	
			After reinstal-lation	Reference point 1 detection position	
				Reference point 2 detection position	
				Reference point 3 detection position	
	6	Area 5	Before reinstal-lation	Reference point 1 detection position	
				Reference point 2 detection position	
				Reference point 3 detection position	
			After reinstal-lation	Reference point 1 detection position	
				Reference point 2 detection position	
				Reference point 3 detection position	

12.5.5   Details of TP Programs

VSMAIN/VSSUBi (i=1 to 5)

These programs are used to reflect the settings for Vision shift operation in the controller. These programs are also used to copy the setting for Vision shift operation on one controller to another controller.

In VSMAIN, data common to all Vision shift areas is set.

In VSSUB1 through VSSUB5, data for each measurement area is set.

All lines consist of comment statements for setting the data.   So, execution of a single program has no effect.

```
                     VSMAIN
    1:   !UTN1 UT(Calib) No. : 8
    2:   !UTN2 UT(Camera) No. :  9
    3:   !REGN Reg(Result of oprt) : 50
    4:   !PRGN PReg(Work area) : 100
    5:   !ANUM Num of shift area : 1
   [End]
```

VSSUB1 through VSSUB5

```
  1:   !UT2X UT(Camera) X :   1300.000
  2:   !UT2Y UT(Camera) Y :    200.000
  3:   !UT2Z UT(Camera) Z :   -130.000
  4:   !UT2W UT(Camera) W :      0.000
  5:   !UT2P UT(Camera) P :      0.000
  6:   !UT2R UT(Camera) R :      0.000
  7:   !STDR Stereo move dir(UT) : W
  8:   !PRB1 Bef Ref pt 1 :  50
  9:   !PRB2 Bef Ref pt 2 :  51
 10:   !PRB3 Bef Ref pt 3 :  52
 11:   !PRA1 Aft Ref pt 1 :  53
 12:   !PRA2 Aft Ref pt 2 :  54
 13:   !PRA3 Aft Ref pt 3 :  55
[End]
```

The first four characters after the "!" are used to determine the meaning of the data.
The portion from the fifth character to the ":" is ignored when Vision shift reads the data. Do not include ":" in this portion.
Do not change the order of the data.   The meaning of the data is judged by the order of teaching.
Create VSSUBi (i = 1 to 5) programs as many as the number of areas to be measured. Specify the position register numbers to store the positions of reference points for an area in the corresponding VSSUB* program. If the same position register number is specified for multiple areas, an error is indicated on the processing selection screen of Vision shift.
If a value in VSMAIN/VSSUB1 through VSSUB5 is directly modified after the initial setting using Vision shift, a mismatch occurs between the data set with Vision shift and the data set in VSMAIN/VSSUB1 through VSSUB5.
After the initial setting, do not directly modify any value in VSMAIN and VSSUB1 through VSSUB5.   When a modification is required, make the modification on the initial setting screen of Vision shift.

VSFINDi (i=1 to 5)
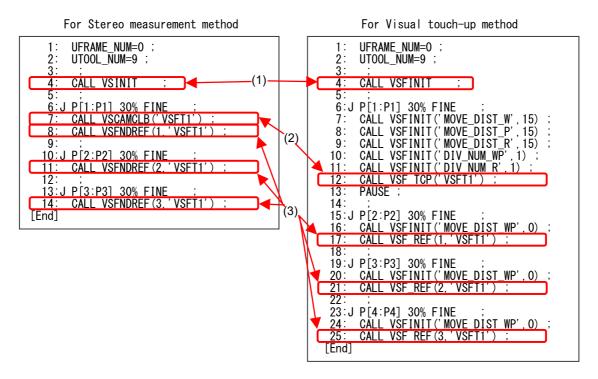
VSFIND1 through VSFIND5 are TP programs used to teach the motion positions of the robot performing camera attachment position calibration and measuring the positions of reference points.
You need to create VSFINDi.

VSFINDi format
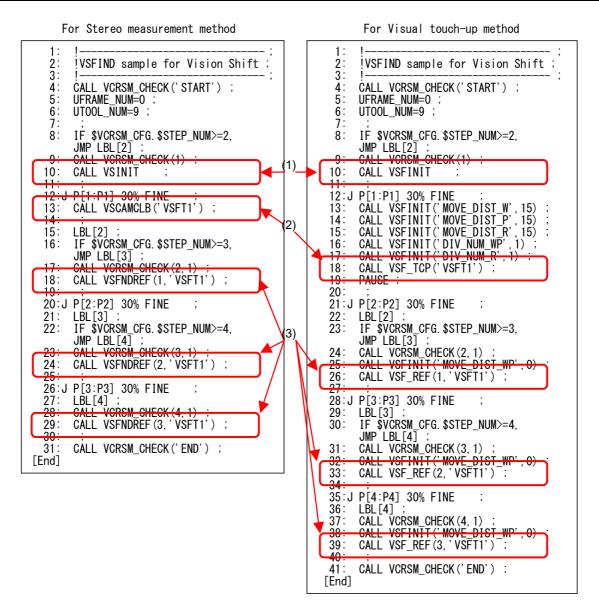
As indicated in the example below, teach three positions that enable reference points to be viewed in the central area of an image then call VSCAMCLB or VSF_TCP and VSFNDREF or VSF_REF at those positions.
Any other operation sequences can be set.   An original point and intermediate point can be added.

- For Stereo measurement method:
  (1)   Call VSINIT at the start of the program for initialization.
  (2)   Call VSCAMCLB at the first reference point.
  (3)   Call VSFNDREF at the remaining reference points.

- For Visual touch-up method:
  (1)   Call VSFINIT at the start of the program for initialization.
  (2)   Call VSF_TCP at the first reference point.
  (3)   Call VSF_REF at the remaining reference points.

```
       For Stereo measurement method                    For Visual touch-up method

     1:  UFRAME_NUM=0 ;                               1:  UFRAME_NUM=0 ;
     2:  UTOOL_NUM=9 ;                                2:  UTOOL_NUM=9 ;
     3:    :                                          3:    :
     4:  CALL VSINIT    ;          (1)                4:  CALL VSFINIT    ;
     5:    :                                          5:    :
     6:J P[1:P1] 30% FINE    ;                        6:J P[1:P1] 30% FINE    ;
     7:  CALL VSCAMCLB('VSFT1')  ;                    7:  CALL VSFINIT('MOVE_DIST_W',15) ;
     8:  CALL VSFNDREF(1,'VSFT1') ;                   8:  CALL VSFINIT('MOVE_DIST_P',15) ;
     9:    :                   (2)                    9:  CALL VSFINIT('MOVE_DIST_R',15) ;
    10:J P[2:P2] 30% FINE    ;                       10:  CALL VSFINIT('DIV_NUM_WP',1) ;
    11:  CALL VSFNDREF(2,'VSFT1') ;                   11:  CALL VSFINIT('DIV_NUM_R',1) ;
    12:    :                                         12:  CALL VSF_TCP('VSFT1')  ;
    13:J P[3:P3] 30% FINE    ;                       13:  PAUSE ;
    14:  CALL VSFNDREF(3,'VSFT1') ;  (3)             14:    :
   [End]                                             15:J P[2:P2] 30% FINE    ;
                                                     16:  CALL VSFINIT('MOVE_DIST_WP',0) ;
                                                     17:  CALL VSF_REF(1,'VSFT1') ;
                                                     18:    :
                                                     19:J P[3:P3] 30% FINE    ;
                                                     20:  CALL VSFINIT('MOVE_DIST_WP',0) ;
                                                     21:  CALL VSF_REF(2,'VSFT1') ;
                                                     22:    :
                                                     23:J P[4:P4] 30% FINE    ;
                                                     24:  CALL VSFINIT('MOVE_DIST_WP',0) ;
                                                     25:  CALL VSF_REF(3,'VSFT1') ;
                                                    [End]
```

For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the sample program in "12.3.5 Creating and Testing Programs for Vision Shift Measurement" as below so that efficient resuming of the measurement can be done.

```
           For Stereo measurement method                      For Visual touch-up method
  1:  !------------------------------ ;            1:  !------------------------------ ;
  2:  !VSFIND sample for Vision Shift ;            2:  !VSFIND sample for Vision Shift ;
  3:  !------------------------------ ;            3:  !------------------------------ ;
  4:  CALL VCRSM_CHECK('START') ;                  4:  CALL VCRSM_CHECK('START') ;
  5:  UFRAME_NUM=0 ;                               5:  UFRAME_NUM=0 ;
  6:  UTOOL_NUM=9 ;                                6:  UTOOL_NUM=9 ;
  7:     :                                         7:     :
  8:  IF $VCRSM_CFG.$STEP_NUM>=2,                  8:  IF $VCRSM_CFG.$STEP_NUM>=2,
      JMP LBL[2] ;                                     JMP LBL[2] ;
  9:  CALL VCRSM_CHECK(1) ;                        9:  CALL VCRSM_CHECK(1) ;
 10:  CALL VSINIT      ;                          10:  CALL VSFINIT      ;
 11:     :                                        11:     :
 12:J P[1:P1] 30% FINE      ;                     12:J P[1:P1] 30% FINE      ;
 13:  CALL VSCAMCLB('VSFT1') ;                    13:  CALL VSFINIT('MOVE_DIST_W',15) ;
 14:     :                                        14:  CALL VSFINIT('MOVE_DIST_P',15) ;
 15:  LBL[2] ;                                    15:  CALL VSFINIT('MOVE_DIST_R',15) ;
 16:  IF $VCRSM_CFG.$STEP_NUM>=3,                  16:  CALL VSFINIT('DIV_NUM_WP',1) ;
      JMP LBL[3] ;                                17:  CALL VSFINIT('DIV_NUM_R',1) ;
 17:  CALL VCRSM_CHECK(2,1) ;                      18:  CALL VSF_TCP('VSFT1') ;
 18:  CALL VSFNDREF(1,'VSFT1') ;                   19:  PAUSE ;
 19:     :                                        20:     :
 20:J P[2:P2] 30% FINE      ;                     21:J P[2:P2] 30% FINE      ;
 21:  LBL[3] ;                                    22:  LBL[2] ;
 22:  IF $VCRSM_CFG.$STEP_NUM>=4,                  23:  IF $VCRSM_CFG.$STEP_NUM>=3,
      JMP LBL[4] ;                                     JMP LBL[3] ;
 23:  CALL VCRSM_CHECK(3,1) ;                      24:  CALL VCRSM_CHECK(2,1) ;
 24:  CALL VSFNDREF(2,'VSFT1') ;                   25:  CALL VSFINIT('MOVE_DIST_WP',0) ;
 25:     :                                        26:  CALL VSF_REF(1,'VSFT1') ;
 26:J P[3:P3] 30% FINE      ;                     27:     :
 27:  LBL[4] ;                                    28:J P[3:P3] 30% FINE      ;
 28:  CALL VCRSM_CHECK(4,1) ;                      29:  LBL[3] ;
 29:  CALL VSFNDREF(3,'VSFT1') ;                   30:  IF $VCRSM_CFG.$STEP_NUM>=4,
 30:     :                                             JMP LBL[4] ;
 31:  CALL VCRSM_CHECK('END') ;                    31:  CALL VCRSM_CHECK(3,1) ;
[End]                                             32:  CALL VSFINIT('MOVE_DIST_WP',0) ;
                                                  33:  CALL VSF_REF(2,'VSFT1') ;
                                                  34:     :
                                                  35:J P[4:P4] 30% FINE      ;
                                                  36:  LBL[4] ;
                                                  37:  CALL VCRSM_CHECK(4,1) ;
                                                  38:  CALL VSFINIT('MOVE_DIST_WP',0) ;
                                                  39:  CALL VSF_REF(3,'VSFT1') ;
                                                  40:     :
                                                  41:  CALL VCRSM_CHECK('END') ;
                                                 [End]
```

(1) (2) (3)

Operation for VSFINDi execution

When calling VSCAMCLB or VSF_TCP, specify a vision data name (model name) in an argument. When VSCAMCLB or VSF_TCP is called, camera position calibration is performed. The result of calibration is stored (set) in the tool coordinate system specified by the initial setting.

When calling VSFNDREF or VSF_REF, specify reference point numbers and a vision data name (model name). When VSFNDREF or VSF_REF is called, the positions of reference points are measured by the Stereo measurement method or Visual touch-up method by using the result of calibration based on VSCAMCLB or VSF_TCP. The measured positions of reference points are stored in the position registers specified by the initial setting.

NOTE
Be sure to execute VSFINDi (i = 1 to 5) on the Vision shift screen. No vision measurement is taken if VSFINDi (i = 1 to 5) is executed on the program list screen.

12.5.6   Subprograms Called from VSFINDi

This section describes the following three subprograms called from VSFIND1 through VSFIND5:
- VSINIT
- VSCAMCLB
- VSFNDREF
- VSFINIT
- VSF_TCP
- VSF_REF
- VCRSM_CHECK (for 7DC3/10 (V8.30P/10) or later software)

These subprograms are KAREL programs, so that their contents cannot be viewed on the teach pendant.

VSINIT

VSINIT is the subprogram that makes settings required for Vision shift by using the data specified on the initial setting screen.

Usage

VSFINDi must always call this subprogram at the start of the program.
When this subprogram is called, no argument is used.

```
CALL VSINIT
```

Operation

VSINIT has the following settings that perform calibration and make measurements with Vision shift:
- It sets the number of the selected user coordinate system to 0.
- It sets the values specified on the initial setting screen in the tool coordinate system for camera position setting.

VSCAMCLB
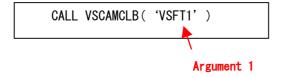
VSCAMCLB is the subprogram that performs Camera position calibration.

Usage

VSFINDi (i = 1 to 5) calls this subprogram at a position that enables the first reference point to be viewed from the camera.
When calling this subprogram, specify the following argument:

Argument 1:   Specify a vision data name (model name) by using a character string.

```
CALL VSCAMCLB( 'VSFT1' )
```
                              Argument 1

Operation

When VSCAMCLB is called, the robot moves ± 50 mm in the Z-axis direction from the current position in the tool coordinate system then rotates ±30° about the Z-axis in the tool coordinate system to perform Camera position calibration.   The result of Camera position calibration is stored (set) in "Tool Frame/Result of Calibration" specified by initial setting.

VSFNDREF

VSFNDREF is the subprogram that measures the positions of reference points.

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VSFINDi (i= 1 to 5) teaches operation statements (for three points) to enable the reference points to be viewed.   At each of the three points, call this subprogram.

Usage

When calling this subprogram, specify the following arguments:
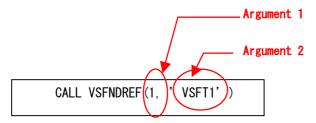
Argument 1:   Specify the number (1 to 3) of the reference point among the three reference points.
Argument 2:   Specify a vision data name (model name) by using a character string.
Argument 3:   (Optional)   Specify the direction of inclination by using a character ('W'/'P').
        If this argument is not specified, the direction specified by the initial setting is used.

Below is an example where the direction of inclination is specified in argument 3:

```
CALL VSFNDREF (1,' VSFT1' ,' P' )
```

Operation

When VSFNDREF is called, an inclination of ±15° is made in the direction specified by initial setting to measure the position of a reference point by Stereo measurement method.
The measured reference position is stored in a position register.

VSFINIT

VSFINIT initializes data setting for the Visual touch-up method.

Usage

VSFINDi should call this subprogram without an argument at the beginning of the program.

```
CALL VSFINIT
```

When calling this subprogram, specify the following arguments:

Argument 1:   Specify the name of the parameter,
Argument 2:   Specify the value of the parameter

Operation

VSFINIT without an argument does the following:
* It sets the user coordinate system to 0.
* It sets the initial values for camera position
VSFINIT with arguments is used to set parameters for camera position calibration. For camera position calibration, it is possible to improve the accuracy of the calibration by increasing tilt angle and division

number relative to the optical axis of the camera. The relevant parameters are shown below. For example, if MOVE_DIST_R is set to 90 deg and DIV_NUM_R is set to 3, vision measurements are executed with the rotation angle about the optical axis of the camera -90, -60, -30, 0, +30, +60 and +90 deg.

Table12.5.6 Parameters set by VSFINIT

Parameter	Explanation	Default value	Recommended value if there is wide work area
MOVE_DIST_R	Rotation angle about the optical axis of the camera	15 deg	60 ~ 90 deg
DIV_NUM_R	Division number for rotating about the optical axis of the camera	1	2 ~ 3
MOVE_DIST_W	Tilt angle 1 relative to the optical axis of the camera	15 deg	35 ~ 45 deg
MOVE_DIST_P	Tilt angle 2 relative to the optical axis of the camera	15 deg	35 ~ 45 deg
DIV_NUM_WP	Division number for tilting relative to the optical axis of the camera	1	2 ~ 4

VSF_TCP
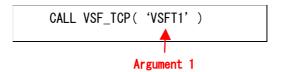
VSF_TCP performs camera position calibration for the Visual touch-up method.

Usage

VSFINDi (i = 1 to 5) calls this subprogram to find a target's position.
When calling this subprogram, specify the following argument:

Argument 1:   Specify a vision data name (model name) by using a character string.

```
CALL VSF_TCP( 'VSFT1' )
```

Argument 1

Operation

When VSF_TCP is called, the robot performs the following:
1   Moves to a position so the target is at the center of the image.
2   Moves up and down along the optical axis of the camera.
3   Rotates around the optical axis of the camera.
4   Tilts relative to the optical axis.
5   Store camera position calibration result in "Tool Frame/Result of Calibration" specified by the initial setting.

During step 2 through 4, robot moves around the target and keeps the target at the center of the camera's image.

VSF_REF
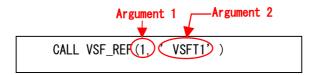
Visual touch-up method uses VSF_REF to measure the reference positions.

Usage

When calling this subprogram, specify the following arguments:

Argument 1: Specify the reference point number (1 to 3).
Argument 2 Specify the vision data name (model name)

```
                    Argument 1        Argument 2

       CALL VSF_REF(1,   VSFT1 ) )
```

Operation

VSF_REF does a small movement to take a measurement of a reference point
The measured position of a reference point is stored in a position register specified by initial setting.

VCRSM_CHECK

VCRSM_CHECK is the subprogram related to the resuming of the measurement.
This subprogram is for 7DC3/10 (V8.30P/10) or later software. For 7DC3/10 (V8.30P/10) or later software, the measurement is divided into some steps, and this subprogram controls the step number of the measurement.
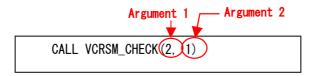
Usage

When calling this subprogram, specify the following arguments:

Argument 1: Specify 'START', 'END', or the step number.
Argument 2: (Optional) Specify the robot group number (1).

```
                  Argument 1      Argument 2

       CALL VCRSM_CHECK(2, 1) )
```

Operation

- If the argument 1 is 'START', the step number is checked, and you can choose whether to restart from the beginning or to resume when this subprogram is called after the measurement interruption.
- If the argument 1 is 'END', the step number is reset.
- If the argument 1 is the step number, the step number is updated. If the argument 2 is the robot group number, the robot with the specified group number records the position when the measurement is executed in order, and returns back to the recorded position when the measurement is resumed.

12.6 TROUBLESHOOTING

General
Symptom
The program list screen does not display the names of the KAREL subprograms (VSINIT, VSCAMCLB and VSFNDREF, or VSFINIT, VSF_TCP and VSF_REF).

Action
Set the system variable $KAREL_ENB to 1 on the system variable screen then select "All" in F1 [TYPE] on the program list screen.

Initial setting confirmation
Symptom
A warning indicating the presence of a duplicate position register is displayed as follows:
"Duplicate PReg: xx"

Action
The position register number is already used.   Change the position register number to make it unique.

Reference point measurement
Symptom
When VSINIT, VSCAMCLB, VSFNDREF, VSFINIT, VSF_TCP, or VSF_REF is called during execution of VSFINDi, the alarm "Uninitialized data" is issued.

Action
Execute VSFINDi on the processing selection screen of Vision shift.   The alarm above is issued if VSFINDi is directly selected on the TP program list screen and executed.

Symptom
"CVIS-021 Exceed VisPool" occurs.

Action
It is no problem if it is normally completed.
If that error stops the TP program, please cycle the power of the robot controller and run the TP program again.

Symptom
The alarm "Not yet calibrate Camera" occurs.

Action
This alarm occurs when VSFNDREF is called before VSCAMCLB or VSF_REF is called before VSF_TCP. Reverse the calling sequence.

Symptom
The alarm "Use previous Camera calibration data" occurs.

Action
The message is to confirm for using calibration data which was done in another measurement area or different timing (before or after reinstallation). If the position to attach a camera is the same as the camera position calibration, you can execute the program. If it is not, please execute the camera position calibration (VSCAMCLB or VSF_TCP) again.

Symptom

The alarm "Vision data name is not same as VSF_TCP" occurs.

Action

The vision data for VSF_REF must be the same as the one for VSF_TCP. Set the same vision data.

Program shift
Symptom

No program shift operation occurs.

Action

1   When the teach pendant is placed in the "Disable(OFF)" state, the program shift operation is not performed.   Perform program shift when the teach pendant is placed in the "Enable(ON)" state.
2   When the program is being edited, the program shift operation cannot be executed. Press the FCTN key and end the edit of the program.

Symptom

Pressing an F key on the teach pendant has no effect.

Action

Hold down a key on the teach pendant for a rather long time.   If a key is pressed for a very short time, it might not be recognized.

13   VISION MULTI-CAL

13.1   ABOUT VISION MULTI-CAL

13.1.1   Overview

Vision Multi-Cal is a function that defines the relationship between two robots, or between a robot and a positioner coordinated by a single controller.
Coordinated motion control requires that the relative position relationship between the leader group and follower group be set correctly for the coordinated pair. Vision Multi-Cal automatically obtains calibration data for this coordinated motion control through the use of a vision sensor.

> **NOTE**
> Vision Multi-Cal is only supported on 6-axis robot. It can not be used for 4-axis and 5-axis robots.

13.1.2   System Configuration

Overall configuration

If you are using coordinated motion with two robots, Vision Multi-Cal defines the relationship between the two robots, with a camera attached to the tool tip of one robot and a mark to be detected by the vision function (target mark) attached to the tool tip of the other robot.
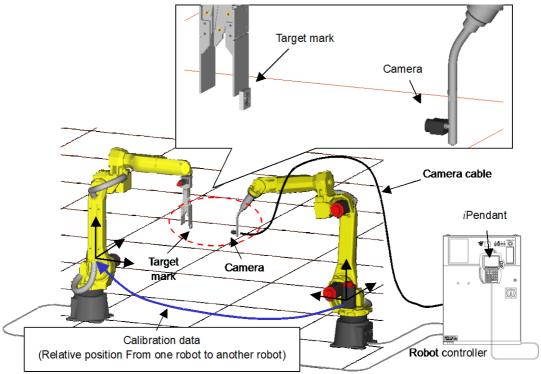
Fig. 13.1.2(a) System configuration of Vision Multi-Cal (Two robots)

If you are using coordinated motion with a robot and a positioner, Vision Multi-Cal defines the relationship between a robot and a positioner, with a camera attached to the tool tip of one robot and a mark to be detected by the vision function (target mark) attached to the tabletop axis of the positioner.

You can also execute it with the mark for vision detection (target mark) attached to the tool tip of the robot and the camera attached to the tabletop axis of the positioner.
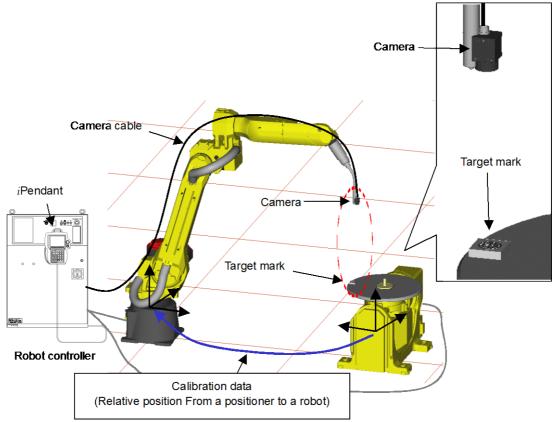
Fig. 13.1.2(b) System configuration of Vision Multi-Cal(One robot and one positioner)

> **NOTE**
> The two robots, or a robot and a positioner need to be controlled by a single robot controller.
> Vision Multi-Cal for a robot and a positioner supports unknown point calibration only.
> Configurations where multiple robots cooperate with one positioner are not supported.

Target mark

Two recommended targets are shown below. The second target is a combination of a circle and a cross.

Fig. 13.1.2(c) Example 1 of a target mark

Fig. 13.1.2(d) Example 2 of a target mark

A target should have the following features:

- A flat detection surface.
- A contour that makes it easy to recognize the size of the target. (The circle in the above examples.)
- A contour that makes it easy to recognize rotation within 45 degree range. (The cross in the above examples.)

NOTE
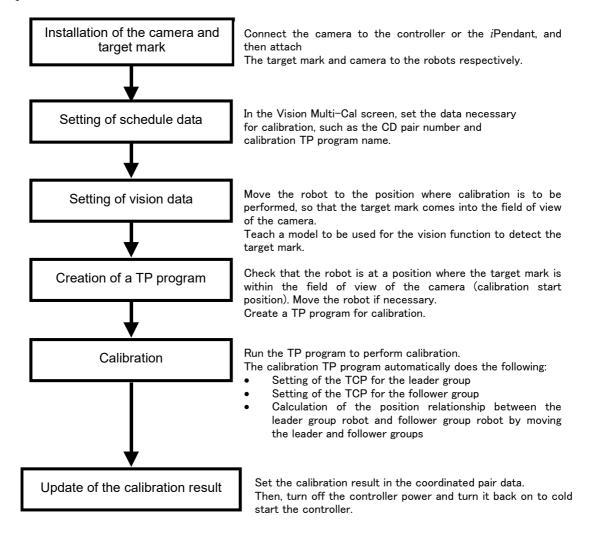
Glossy materials are not recommended.
If a metal target is required, use one with a frosted surface, such as anodized aluminum (duralumin).
A handy way to attach a target mark is to affix a sticker with that mark printed on it.
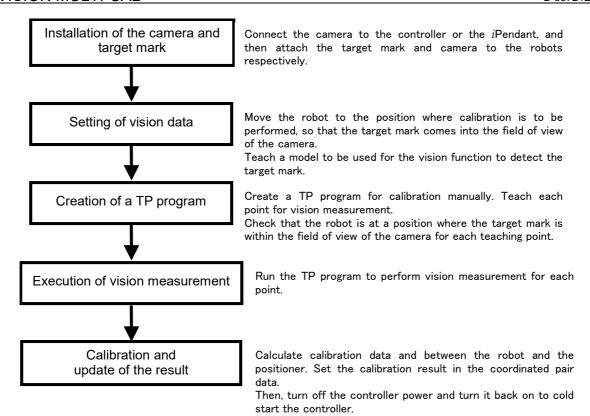
13.1.3   Outline of the Vision Multi-Cal Procedure

Vision Multi-Cal calculates the position relationship between two robots by executing a TP program for calibration.
A calibration TP program for two robots can be created automatically using the Vision Multi-Cal screen. The procedure is outlined below.

Installation of the camera and target mark	Connect the camera to the controller or the *i*Pendant, and then attach The target mark and camera to the robots respectively.
Setting of schedule data	In the Vision Multi−Cal screen, set the data necessary for calibration, such as the CD pair number and calibration TP program name.
Setting of vision data	Move the robot to the position where calibration is to be performed, so that the target mark comes into the field of view of the camera. Teach a model to be used for the vision function to detect the target mark.
Creation of a TP program	Check that the robot is at a position where the target mark is within the field of view of the camera (calibration start position). Move the robot if necessary. Create a TP program for calibration.
Calibration	Run the TP program to perform calibration. The calibration TP program automatically does the following: • Setting of the TCP for the leader group • Setting of the TCP for the follower group • Calculation of the position relationship between the leader group robot and follower group robot by moving the leader and follower groups
Update of the calibration result	Set the calibration result in the coordinated pair data. Then, turn off the controller power and turn it back on to cold start the controller.

A calibration TP program for a robot and a positioner has to be created manually. The procedure is outlined below.

```
┌─────────────────────────────────┐     Connect the camera to the controller or the iPendant, and
│   Installation of the camera and │     then attach the target mark and camera to the robots
│          target mark            │     respectively.
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐     Move the robot to the position where calibration is to be
│       Setting of vision data    │     performed, so that the target mark comes into the field of view
│                                 │     of the camera.
└─────────────────────────────────┘     Teach a model to be used for the vision function to detect the
                │                        target mark.
                ▼
┌─────────────────────────────────┐     Create a TP program for calibration manually. Teach each
│     Creation of a TP program    │     point for vision measurement.
│                                 │     Check that the robot is at a position where the target mark is
└─────────────────────────────────┘     within the field of view of the camera for each teaching point.
                │
                ▼
┌─────────────────────────────────┐     Run the TP program to perform vision measurement for each
│   Execution of vision measurement│     point.
│                                 │
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐     Calculate calibration data and between the robot and the
│        Calibration and          │     positioner. Set the calibration result in the coordinated pair
│       update of the result      │     data.
└─────────────────────────────────┘     Then, turn off the controller power and turn it back on to cold
                                         start the controller.
```

The following section describes the detail of the method for Vision Multi-Cal. To set the calibration data between two robots, refer to "13.2 PROCESS FOR VISION MULTI-CAL (TWO ROBOTS)". To set the calibration data between a robot and a positioner, refer to "0 This section describes the content of the Vision Multi-Cal TP program and how the robots move when this program is run.
The content of the Vision Multi-Cal TP program is as follows.

```
┌──────────────────────────────────────────┐
│ VMCAL_1                                    │
│                                            │
│    1:   UFRAME_NUM=0                       │
│    2:   UTOOL_NUM=9                        │
│    3:   $VSHIFT_CFG. $VISION_TYPE=0        │
│    4:J  @P[1] 30% FINE                     │
│    5:   CALL VTCPINIT                      │
│    6:   CALL VTCPSET('VSFT1',1)            │
│    7:   CALL VTCPSET('VSFT1',2)            │
│    8:   CALL VTHSCLB(1)                    │
│ [End]                                      │
│                                            │
└──────────────────────────────────────────┘
```

For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the TP program as below so that efficient resuming of the measurement can be done.

```
VMCAL_1

  1:  CALL VCRSM_CHECK('START') ;
  2:  UFRAME_NUM=0 ;
  3:  UTOOL_NUM=9 ;
  4:    ;
  5:  IF $VCRSM_CFG.$STEP_NUM>=2,
      JMP LBL[2] ;
  6:  CALL VCRSM_CHECK(1) ;
  7:J P[1] 30% FINE     ;
  8:  CALL VTCPINIT('INIT',0) ;
  9:  CALL VTCPINIT     ;
 10:  CALL VTCPSET('VSFT1',1) ;
 11:    ;
 12:  LBL[2] ;
 13:  IF $VCRSM_CFG.$STEP_NUM>=3,
      JMP LBL[3] ;
 14:  CALL VCRSM_CHECK(2,1,2) ;
 15:  CALL VTCPSET('VSFT1',2) ;
 16:    ;
 17:  LBL[3] ;
 18:  CALL VCRSM_CHECK(3,1,2) ;
 19:  CALL VTHSCLB(1) ;
 20:  CALL VCRSM_CHECK('END') ;
[End]
```

Here is the explanation for each line of the TP program. The line number for 7DC3/10 (V8.30P/10) or later software is noted in parentheses. The following is the explanation for 7DC3/09 (V8.30P/09) or earlier software, so read the line number in parentheses if the software version is 7DC3/10 (V8.30P/10) or later.

Line 1 (Line 2):   The user frame number is always 0.
Line 2 (Line 3):   The tool frame number is changed to that set in the schedule.
Line 4 (Line 7):   This is the calibration start position.   The two robots move in relation to this position.
Line 5 (Line 9):   The initialization subprogram VTCPINIT is executed.
Line 6 (Line 10):   The TCP of the leader group (group 1 in this example) is set.
Line 7 (Line 15):   The TCP of the follower group (group 2 in this example) is set.
Line 8 (Line 19):   The calibration data is calculated.   The VTHSCLB parameter indicates the schedule number.

If necessary, the intermediate point between the original point and the calibration start position may be added before line 3 and the return operation to the original point after calibration and other instructions may be added after line 7.

Calibration start position

The two robots of the leader group and follower group are placed at their respective start positions.
Install the target mark to the tool tip of one robot and the camera to the tool tip of the other robot.
Make sure that, when the robot is at the start position, the mark is seen near the center of the field of view of the camera. The distance between the camera and mark should be about 400 mm.

```
VMCAL_1

  1:   UFRAME_NUM=0
  2:   UTOOL_NUM=9
  3:   $VSHIFT_CFG.$VISION_TYPE=0
  4:J @P[1] 30% FINE
  5:   CALL VICPINIT
  6:   CALL VTCPSET('VSFT1',1)
  7:   CALL VTCPSET('VSFT1',2)
  8:   CALL VTHSCLB(1)
[End]
```


Target
mark   Camera

Leader group

                         Follower group

Fig. 13.1.3 (a) Vision Multi-Cal start position

Installation example) In arc welding coordinated motion, it is common for the leader group to hold the workpiece and for the follower group to hold the torch. In that case, the installation is easy to do if the target mark is attached to the hand of the leader group or the workpiece held by it and the camera is attached to the welding torch of the follower group.

To which robot to install the camera and to which robot to install the mark is left to the discretion of the personnel. The system may be configured so that the leader group holds the camera and the follower group holds the target mark.

Setting the leader group TCP

Set the tool frame of the leader group.

Line 6:   The TCP of the leader group (group 1 in this example) is set.

```
VMCAL_1

  1:   UFRAME_NUM=0
  2:   UTOOL_NUM=9
  3:   $VSHIFT_CFG.$VISION_TYPE=0
  4:J @P[1] 30% FINE
  5:   CALL VTCPINIT
  6:   CALL VTCPSET('VSFT1',1)
  7:   CALL VTCPSET('VSFT1',2)
  8:   CALL VTHSCLB(1)
[End]
```

The first VTCPSET parameter VSFT1 indicates the vision data name specified in the schedule.
The second parameter indicates the group number of the robot.
The robot of only the leader group moves so that the mark is seen from many different directions from the camera.   The robot of the follower group does not move.
Set the TCP of the leader group at the center of the target mark.

Leader group
(Move)

Follower group
(Hold)

Fig. 13.1.3 (b) Setting the TCP of the leader group

Setting the follower group TCP

Set the tool frame of the follower group.

Line 7:   The TCP of the follower group (group 2 in this example) is set.

```
VMCAL_1

  1:   UFRAME_NUM=0
  2:   UTOOL_NUM=9
  3:   $VSHIFT_CFG.$VISION_TYPE=0
  4:J @P[1] 30% FINE
  5:   CALL VTCPINIT
  6:   CALL VTCPSET('VSFT1',1)
  7:   CALL VTCPSET('VSFT1',2)
  8:   CALL VTHSCLB(1)
[End]
```

The robot of only the follower group moves so that the mark is seen from many different directions from the camera.   The robot of the leader group does not move.
Set the TCP of the follower group at the center of the reference mark.

Leader group
(Hold)

Follower group
(Move)
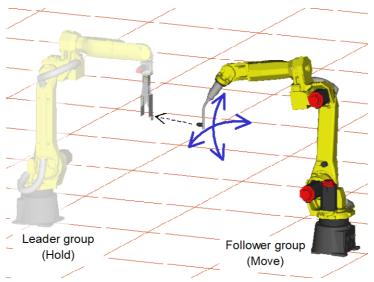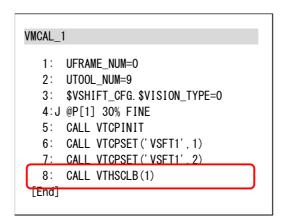
Fig. 13.1.3 (c) Setting the TCP of the follower group

Coordinated robot calibration

Calibrate the coordinated robots.

Line 8:   The calibration data is calculated. The VTHSCLB parameter indicates the schedule number.

```
VMCAL_1

  1:   UFRAME_NUM=0
  2:   UTOOL_NUM=9
  3:   $VSHIFT_CFG.$VISION_TYPE=0
  4:J  @P[1] 30% FINE
  5:   CALL VTCPINIT
  6:   CALL VTCPSET('VSFT1',1)
  7:   CALL VTCPSET('VSFT1',2)
  8:   CALL VTHSCLB(1)
[End]
```

The subprogram VTHSCLB is executed. The robots of both the leader group and follower group move.
The leader group moves in the X, Y, and Z directions (tool frame of the camera), and the follower group moves according to the leader group.
The calibration data (position and posture of the base coordinate system of the leader group relative to that of the follower group) is calculated.
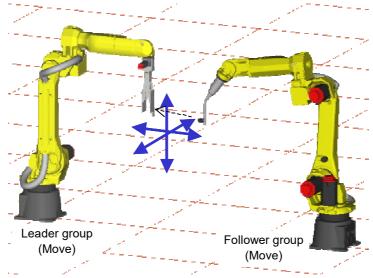
Fig. 13.1.3 (d) Coordinated robot calibration

PROCESS FOR VISION MULTI-CAL (ONE ROBOT AND ONE POSITIONER)".

13.2 PROCESS FOR VISION MULTI-CAL (TWO ROBOTS)

13.2.1 Preparation

Connecting and installing camera

Connect the camera to the robot controller or the *i*Pendant.

Check that the camera image is properly displayed, as instructed in "3 BASIC VISION FUNCTION OPERATION".

Secure the camera to the tool tip of either the leader group or follower group. Although there is no exact specification as to the position where the camera is to be installed, make sure the camera is fixed securely so that it does not move during measurement.

The camera may be installed on either the leader group robot or follower group robot.

Installing Target Mark

Install the target mark to the tool tip of the robot other than the one on which the camera has been installed. Although there is no exact specification as to the position where the target mark is to be installed, make sure the mark is fixed securely so that it does not move during measurement.

Setting coordinated pair

To calibrate a coordinated pair, set the leader group and follower group in advance using the coordinated pair setup screen.

13.2.2 Vision Multi-Cal Screen

The procedure for displaying the Vision Multi-Cal screen is as follows.

Procedure 13-2-1 Displaying the Vision Multi-Cal screen

Step

1 Press the MENU key.
2 Select "UTILITIES".
3 Press F1 [TYPE] .
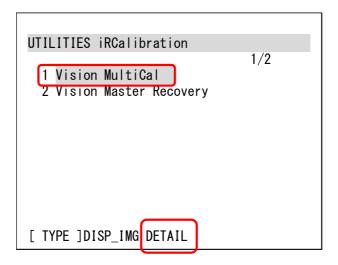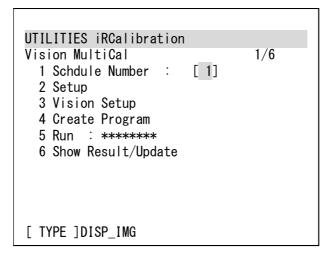
4   Select "*i*RCalibration".

If "*i*RCalibration" is selected, the teach pendant displays a screen as shown below.
This screen lists the available *i*RCalibration functions.   The items displayed on the screen differ depending on the status of the options.

```
UTILITIES iRCalibration
                                   1/2
1 Vision MultiCal
2 Vision Master Recovery




[ TYPE ]DISP_IMG DETAIL
```

5   Move the cursor to "Vision Multi-arm Frame Set" and press the F3 (DETAIL) or ENTER key.
The teach pendant displays the Vision Multi-Cal screen as shown below.

```
UTILITIES iRCalibration
Vision MultiCal                    1/6
  1 Schdule Number  :   [ 1]
  2 Setup
  3 Vision Setup
  4 Create Program
  5 Run  : *******
  6 Show Result/Update



[ TYPE ]DISP_IMG
```

Items of the Vision Multi-Cal screen
The Vision Multi-Cal screen displays the items described below.
The relationship between the two robots can be defined by selecting and setting these onscreen items sequentially.

Schedule Number
      The settings necessary for Vision Multi-Cal calibration and the calibration result are stored in system variables called schedules.   There are 10 schedules, from 1 to 10, allowing up to 10 different sets of calibration setting and calibration result data.   Here, specify the number of the schedule to be used for calibration.
      The settings and calibration results stored in schedules are retained even after the power of the controller is turned off.

Setup
      This item sets up the schedule necessary to perform calibration.

Vision Setup
> This item teaches a model used for the vision function to detect the target, and adjust the parameters used for target detection by the vision function.

Create Program
> This item automatically creates a TP program for calibration according to the settings of the schedule.

Run
> The teach pendant displays the calibration TP program.
> If the TP program is executed from the teach pendant, Vision Multi-Cal calibration is performed to obtain the data on the relative position relationship between the robots.
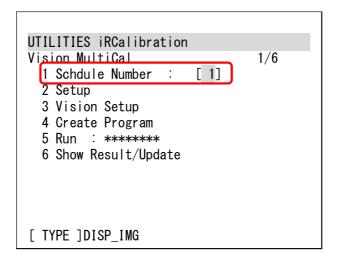
Show Result/Update
> This item displays the calibration result obtained by executing the TP program (data on the relative position relationship between the robots).
> The calibration result is set in the coordinated pair data (or in the user frame if the coordinated pair option is not available).

13.2.3   Selecting a Vision Multi-Cal Schedule

Move the cursor to "Schedule Number" on the Vision Multi-Cal screen, and enter the number of the schedule to be used for calibration.

```
UTILITIES iRCalibration
Vision MultiCal                      1/6
 1 Schdule Number  :    [ 1]
 2 Setup
 3 Vision Setup
 4 Create Program
 5 Run  : ********
 6 Show Result/Update



[ TYPE ]DISP_IMG
```

13.2.4   Setting up a Vision Multi-Cal Schedule

Set up the schedule.
Set the number of the coordinated pair or user frame in which the calibration result is to be set, the name of the calibration TP program, vision data name (model data name), etc.
The appearance of the setup screen changes depending on whether the coordinated pair option is available or not.
When the coordinated pair option is available, see 13.2.4.1, "Coordinated calibration setup".   When the coordinated pair option is not available, see 13.2.4.2, "Uncoordinated calibration setup".

13.2.4.1   Coordinated calibration setup

This subsection describes the schedule setup screen displayed when the coordinated pair option is available.

Procedure 13-2-2   Setting up a schedule for a coordinated pair

Condition
- Choose the number of the coordinated pair for which to perform calibration.
  Set the leader group and follower group in advance using the coordinated pair setup screen.

Step
1   Move the cursor to "Setup" on the Vision Multi-Cal screen, and press the ENTER key.

```
UTILITIES iRCalibration
Vision MultiCal                 2/6
  1 Schdule Number  :   [ 1]
  2 Setup
  3 Vision Setup
  4 Create Program
  5 Run  : ********
  6 Show Result/Update




[ TYPE ]DISP_IMG
```

The teach pendant displays a screen as shown below.

```
UTILITIES iRCalibration
Vision MultiCal:  Setup          1/6
  Schedule Number[ 1]
  1 CD Pair          : [1]
      Leader Group   : 0
      Follower Group : 0
  2 Program Name : ********
  3 Vision Data : VSFT1
  4 Utool Number     : 9
  5 Mean Error Register : R[  0]
  6 Max. Error Register : R[  0]


[ TYPE ]
```

2   Move the cursor to "CD Pair", and enter the number of the desired coordinated pair.
     The "Leader Group" and "Follower Group" fields respectively display the group numbers of the leader group and follower group set for the coordinated pair corresponding to the specified number.

NOTE
This screen does not allow you to change the leader group number or the follower group number. Use the coordinate pair setup screen to change the leader group and follower group.

---

3   Move the cursor to "Program Name", and enter the name of the TP program for calibration.
4   Move the cursor to "Vision Data", and press F4 (SELECT).   From the resulting list, select the name of the vision data.

5   Move the cursor to "UTool Number", and enter the number of the tool frame to be used by the calibration TP program.

```
┌─────────────────────────────────────────────────────────────┐
│ NOTE                                                          │
│   Execution of the calibration program changes the tool       │
│   frame data in the tool.                                     │
│   Make sure the Utool Number is not used by other programs.   │
└─────────────────────────────────────────────────────────────┘
```

6   Move the cursor to "Mean Error Register", enter the number of the register to which to output the mean error.   If the mean error is not to be output to any register, enter 0 as the register number.
7   Move the cursor to "Max. Error Register", enter the number of the register to which to output the maximum error.   If the maximum error is not to be output to any register, enter 0 as the register number.

The following is an example of the screen that might be displayed when the schedule setup is complete.

```
┌─────────────────────────────────────────────┐
│ UTILITIES iRCalibration                       │
│ Vision MultiCal:  Setup            1/6        │
│   Schedule Number[ 1]                         │
│   1 CD Pair           : [1]                   │
│       Leader Group    : 1                     │
│       Follower Group  : 3                     │
│   2 Program Name : VMCAL_1                     │
│   3 Vision Data : VSFT1                        │
│   4 Utool Number      : 9                     │
│   5 Mean Error Register : R[ 50]              │
│   6 Max. Error Register : R[ 51]              │
│                                               │
│                                               │
│  [ TYPE ]                                     │
└─────────────────────────────────────────────┘
```

The following table lists the items to be set on the setup screen when the coordinated pair option is available.

Table 13.2.4.1 Schedule (for a coordinated pair)

Item	Explanation
Schedule Number	(Display only) Number of the schedule To change the schedule number, return to the Vision Multi-Cal screen by pressing the PREV key.
CD Pair (Default: 1)	This item indicates the number of the coordinated pair to be calibrated The displayed numbers of the leader group and follower group are those that are set for the coordinated pair. This screen does not allow the leader group and follower group to be changed. To change the leader group and follower group, use the coordinated pair setup screen.
Leader Group	(Display only) This item indicates the leader group that is set for the selected coordinated pair number
Follower Group	(Display only) This item indicates the follower group that is set for the selected coordinated pair number
Program Name (Default: none)	This item indicates the name of the calibration TP program
Vision Data (Default: VSFT1)	This item indicates the name of the model data for detection by the vision function. Select one of the eight data names, VSFT1 to VSFT8.

Item	Explanation
UTool Number	This item indicates the number of the tool frame to be used by the calibration TP program Both the leader group and follower group use the same tool frame. Note) The data of the specified tool frame is changed when the TP program is executed.
Mean Error Register (Default: 0)	This item indicates the number of the register in which the mean calibration position error (mm) is to be set. When the register number is 1 or larger, the mean error is set in the specified register when calibration is complete. When the register number is 0, the error is not set in any register.
Max. Error Register (Default: 0)	This item indicates the number of the register in which the maximum calibration position error (mm) is to be set. When the register number is 1 or larger, the maximum error is set in the specified register when calibration is complete. When the register number is 0, the error is not set in any register.

13.2.4.2   Uncoordinated calibration setup

When the coordinated pair option is not available, the following screen is displayed.

```
UTILITIES iRCalibration
Vision MultiCal:  Setup          1/8
  Schedule Number[ 2]
  1 UFrame Number(Calib Data): [ 0]
  2   Leader Group   : 0
  3   Follower Group : 0
  4 Program Name : *******
  5 Vision Data : VSFT1
  6 UTool Number      : 9
  7 Mean Error Register : R[  0]
  8 Max. Error Register : R[  0]


 [ TYPE ]
```

The calibration result (position and direction of the base coordinate system of the leader group relative to that of the follower group) is set in the user frame of the follower group.   In this screen, specify the number of the user frame in which to set the calibration result, leader group number, and follower group number, instead of a coordinated pair number.   The other items are the same as when the schedule is set up for a coordinated pair.

By default, 0 is shown in the "UFrame Number", "Leader Group", and "Follower Group" fields.   Be sure to set 1 or a larger number in these fields.

The "Program Name" field is blank by default.   Enter a TP program name.

The following is an example of the screen that may be displayed when the schedule setup is complete.

```
┌─────────────────────────────────────────────────────┐
│ UTILITIES iRCalibration                               │
│ Vision MultiCal:  Setup              1/8              │
│   Schedule Number[ 2]                                 │
│   1 UFrame Number(Calib Data): [ 2]                   │
│   2   Leader Group   : 1                              │
│   3   Follower Group : 3                              │
│   4 Program Name : VMCAL_2                            │
│   5 Vision Data : VSFT1                               │
│   6 UTool Number       : 9                            │
│   7 Mean Error Register : R[ 50]                      │
│   8 Max. Error Register : R[ 51]                      │
│                                                       │
│                                                       │
│   [ TYPE ]                                            │
└─────────────────────────────────────────────────────┘
```

The following table lists the items to be set on the setup screen when the coordinated pair option is not available.
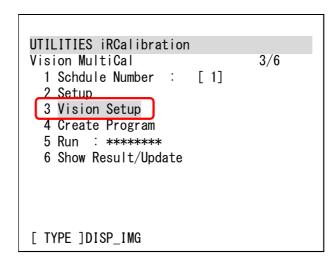
Table 13.2.4.2 Schedule (for an uncoordinated pair)

Item	Explanation
Schedule Number	(Display only) Number of the schedule To change the schedule number, return to the Vision Multi-Cal screen by pressing the PREV key.
UFrame Number (default: 0)	This item indicates the number of the user frame in which the result of coordinated calibration is to be set. The calibration result is set in the follower group's user frame corresponding to the specified number.
Leader Group (default: 0)	This item specifies the number of the leader group.
Follower Group (default: 0)	This item specifies the number of the follower group.
Program Name (default: none)	This item indicates the name of the calibration TP program
Vision Data (default: VSFT1)	This item indicates the name of the model data for detection by the vision function. Select one of the eight data names, VSFT1 to VSFT8.
UTool Number (default: 9)	This item indicates the number of the tool frame to be used by the calibration TP program Both the leader group and follower group use the same tool frame. Note) The data of the specified tool frame is changed when the TP program is executed.
Mean Error Register (default: 0)	This item indicates the number of the register in which the mean calibration position error (mm) is to be set. When the register number is 1 or larger, the mean error is set in the specified register when calibration is complete. When the register number is 0, the error is not set in any register.
Max. Error Register (default: 0)	This item indicates the number of the register in which the maximum calibration position error (mm) is to be set. When the register number is 1 or larger, the maximum error is set in the specified register when calibration is complete. When the register number is 0, the error is not set in any register.

13.2.5   Setting Up Vision

Display the Vision Data Setup Screen, teach the shape of the object to be detected by the vision function (model) and adjust the detection parameters.
Move the cursor to "Vision Setup" on the Vision Multi-Cal screen, and press the ENTER key.

```
UTILITIES iRCalibration
Vision MultiCal                    3/6
  1 Schdule Number  :   [ 1]
  2 Setup
  3 Vision Setup
  4 Create Program
  5 Run  : ********
  6 Show Result/Update




[ TYPE ]DISP_IMG
```

The teach pendant displays the Vision Data Setup Screen as shown below.

```
iRCalibration
Vision Data Setup        List     1/8

Vision Data   Status       Comment
 VSFT1     [Trained   ][            ]
 VSFT2     [Not Trained][            ]
 VSFT3     [Not Trained][            ]
 VSFT4     [Not Trained][            ]
 VSFT5     [Not Trained][            ]
 VSFT6     [Not Trained][            ]
 VSFT7     [Not Trained][            ]
 VSFT8     [Not Trained][            ]

      DISP_IMG  DETAIL     COPY    INIT
```

Teach the vision data corresponding to the data name specified on the schedule setup screen.
The Vision Data Setup Screen is the same as that displayed when "VISION SETUP" is selected from the FCTN key menu.   For details, refer to "3 BASIC VISION FUNCTION OPERATION".
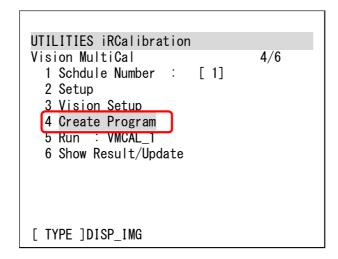
13.2.6   Program Creation
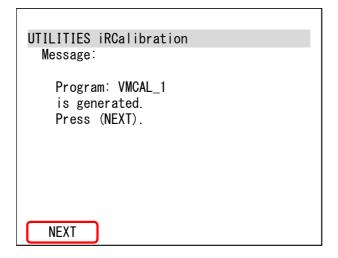
A TP program for Vision Multi-Cal calibration is automatically created.
Make sure that the target mark is within the field of view of the camera and that the distance between the camera and the mark is about 400 mm.   The current position of the leader group and follower group is taught as the start position of the calibration operation.
Move the cursor to "Create Program", and press the ENTER key.

```
┌──────────────────────────────────────────┐
│ UTILITIES iRCalibration                    │
│ Vision MultiCal                    4/6     │
│   1 Schdule Number  :   [ 1]               │
│   2 Setup                                  │
│   3 Vision Setup                           │
│ ┌─────────────────┐                        │
│ │ 4 Create Program│                        │
│ └─────────────────┘                        │
│   5 Run  : VMCAL_1                          │
│   6 Show Result/Update                      │
│                                            │
│                                            │
│                                            │
│ [ TYPE ]DISP_IMG                           │
└──────────────────────────────────────────┘
```
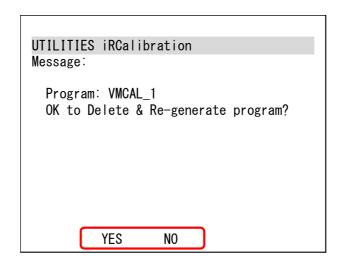
The teach pendant displays a screen as shown below.
Pressing the F1 (NEXT) key creates the program.

```
┌──────────────────────────────────────────┐
│ UTILITIES iRCalibration                    │
│   Message:                                 │
│                                            │
│     Program: VMCAL_1                       │
│     is generated.                          │
│     Press (NEXT).                          │
│                                            │
│                                            │
│                                            │
│                                            │
│                                            │
│                                            │
│ ┌──────────┐                               │
│ │  NEXT    │                               │
│ └──────────┘                               │
└──────────────────────────────────────────┘
```

If there is any existing program that has the same name as the program being created, the teach pendant displays a confirmation screen as shown below.
To create a new program by overwriting the existing program, press the F2 (YES) key.
To quit creating the program, press the F3 (NO) key.

```
┌──────────────────────────────────────────┐
│ UTILITIES iRCalibration                    │
│ Message:                                   │
│                                            │
│   Program: VMCAL_1                         │
│   OK to Delete & Re-generate program?      │
│                                            │
│                                            │
│                                            │
│                                            │
│                                            │
│                                            │
│       ┌─────────────────┐                  │
│       │  YES      NO     │                  │
│       └─────────────────┘                  │
└──────────────────────────────────────────┘
```

13.2.7   Executing Program
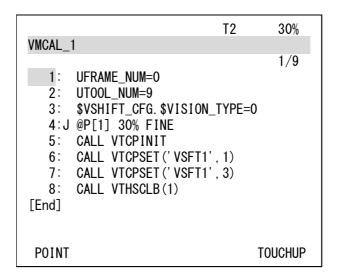
Execute the calibration TP program.
Move the cursor to "Run", and press the ENTER key.

```
UTILITIES iRCalibration
Vision MultiCal                    5/6
  1 Schdule Number  :    [ 1]
  2 Setup
  3 Vision Setup
  4 Create Program
  5 Run   : VMCAL_1
  6 Show Result/Update




[ TYPE ]DISP_IMG
```

The teach pendant displays the calibration TP program.

```
                              T2      30%
VMCAL_1
                                      1/9
   1:    UFRAME_NUM=0
   2:    UTOOL_NUM=9
   3:    $VSHIFT_CFG.$VISION_TYPE=0
   4:J  @P[1] 30% FINE
   5:    CALL VTCPINIT
   6:    CALL VTCPSET('VSFT1',1)
   7:    CALL VTCPSET('VSFT1',3)
   8:    CALL VTHSCLB(1)
[End]



  POINT                         TOUCHUP
```

> **NOTE**
> For 7DC3/10 (V8.30P/10) or later software, call instructions of the program
> VCRSM_CHECK, label instructions, and jump instructions are added to the TP
> program so that efficient resuming of the measurement can be done. For details,
> refer to "13.3 VISION MULTI-CAL TP PROGRAM (TWO ROBOTS)".
> For 7DC3/10 (V8.30P/10) or later software, if the measurement is interrupted by
> the release of the SHIFT key, the occurrence of an alarm or other reasons,
> re-execute the TP program after moving the cursor to the first line. If a part of the
> measurement has been completed, a message "Press 0 (restart) or 9 (resume)"
> appears. Press the 0 key to restart the measurement from the beginning or the 9
> key to resume the measurement.

Execute this TP program.

When the program ends, the calibration data (position and posture of the master relative to the slave) is stored in the schedule data. Also, the data is output to the specified registers if the mean error register and maximum error register numbers are specified.

To display the Vision Multi-Cal screen after completing the program execution, press the MENU key and select "UTILITIES" and then "*i*RCalibration" from the menu.
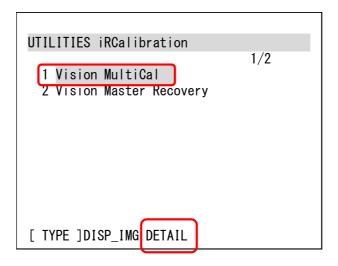
```
┌─────────────────────────────────────────────────────────────┐
│  NOTE                                                         │
│      If the TP program generates a "CVIS-021 Exceed VisPool"  │
│      error but completed its execution, the error can be      │
│      safely ignored. However, if the "CVIS-021" error         │
│      stops program execution, cycle controller power and      │
│      rerun the TP program again.                              │
└─────────────────────────────────────────────────────────────┘
```
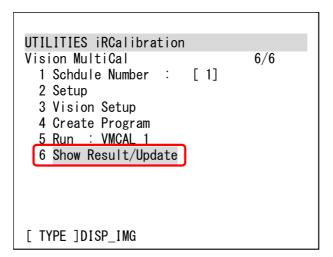
13.2.8   Displaying and Updating Calibration Result

After completing the execution of the TP program, press the MENU key and select "UTILITIES" and then "*i*RCalibration" from the menu.

Move the cursor to "Vision Multi-arm Frame Set", and press the F3 (DETAIL) key or the ENTER key.

```
┌─────────────────────────────────────────────────────┐
│  UTILITIES iRCalibration                             │
│                                          1/2         │
│   1 Vision MultiCal                                  │
│   2 Vision Master Recovery                           │
│                                                      │
│                                                      │
│                                                      │
│                                                      │
│                                                      │
│                                                      │
│                                                      │
│                                                      │
│  [ TYPE ]DISP_IMG DETAIL                             │
└─────────────────────────────────────────────────────┘
```

Move the cursor to "Show Result/Update" on the Vision Multi-Cal screen, and press the ENTER key.

```
┌─────────────────────────────────────────────────────┐
│  UTILITIES iRCalibration                             │
│  Vision MultiCal                        6/6          │
│     1 Schdule Number  :   [ 1]                       │
│     2 Setup                                          │
│     3 Vision Setup                                   │
│     4 Create Program                                 │
│     5 Run  : VMCAL 1                                 │
│     6 Show Result/Update                             │
│                                                      │
│                                                      │
│  [ TYPE ]DISP_IMG                                    │
└─────────────────────────────────────────────────────┘
```
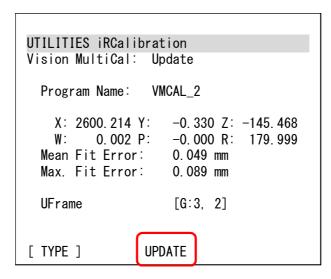
The calibration result display/update screen shown below will be displayed.   The screen to be displayed differs depending on whether the coordinated pair option is available or not.

When the coordinated pair option is available

```
┌─────────────────────────────────────────┐
│                                           │
│  UTILITIES iRCalibration                  │
│  Vision MultiCal:  Update                 │
│                                           │
│    Program Name:   VMCAL_1                 │
│                                           │
│     X: 2600.214 Y:   −0.330 Z: −145.468    │
│     W:    0.002 P:   −0.000 R:  179.999    │
│   Mean Fit Error:    0.049 mm              │
│   Max. Fit Error:    0.089 mm              │
│                                           │
│    CD Pair           [1]                   │
│                                           │
│                                           │
│   [ TYPE ]          UPDATE                 │
│                                           │
└─────────────────────────────────────────┘
```

The screen displays the calibration result and the coordinated pair number for which the result is to be set.

When the coordinated pair option is unavailable

```
┌─────────────────────────────────────────┐
│                                           │
│  UTILITIES iRCalibration                  │
│  Vision MultiCal:  Update                 │
│                                           │
│    Program Name:   VMCAL_2                 │
│                                           │
│     X: 2600.214 Y:   −0.330 Z: −145.468    │
│     W:    0.002 P:   −0.000 R:  179.999    │
│   Mean Fit Error:    0.049 mm              │
│   Max. Fit Error:    0.089 mm              │
│                                           │
│    UFrame            [G:3, 2]              │
│                                           │
│                                           │
│   [ TYPE ]          UPDATE                 │
│                                           │
└─────────────────────────────────────────┘
```

The screen displays the calibration result, the group number, and the user frame number for which the result is to be set.

Updating the calibration result

To set the calibration result in the coordinated pair data or the follower group's user frame, press the F3 (UPDATE) key while holding down the SHIFT key.   After that, turn off the power of the controller and then turn it back on.
When not updating the calibration result, press the PREV key.
The calibration data is stored in the schedule having the specified number.   The data is retained even after the power of the robot controller is turned off, until the calibration program is executed again.

13.3   VISION MULTI-CAL TP PROGRAM (TWO ROBOTS)

This section describes the content of the Vision Multi-Cal TP program and how the robots move when this program is run.
The content of the Vision Multi-Cal TP program is as follows.

```
VMCAL_1

   1:   UFRAME_NUM=0
   2:   UTOOL_NUM=9
   3:   $VSHIFT_CFG.$VISION_TYPE=0
   4:J  @P[1] 30% FINE
   5:   CALL VTCPINIT
   6:   CALL VTCPSET('VSFT1',1)
   7:   CALL VTCPSET('VSFT1',2)
   8:   CALL VTHSCLB(1)
[End]
```

For 7DC3/10 (V8.30P/10) or later software, call instructions of the program VCRSM_CHECK, label instructions, and jump instructions are added to the TP program as below so that efficient resuming of the measurement can be done.

```
VMCAL_1

   1:   CALL VCRSM_CHECK('START') ;
   2:   UFRAME_NUM=0 ;
   3:   UTOOL_NUM=9 ;
   4:      ;
   5:   IF $VCRSM_CFG.$STEP_NUM>=2,
        JMP LBL[2] ;
   6:   CALL VCRSM_CHECK(1) ;
   7:J  P[1] 30% FINE      ;
   8:   CALL VTCPINIT('INIT',0) ;
   9:   CALL VTCPINIT      ;
  10:   CALL VTCPSET('VSFT1',1) ;
  11:      ;
  12:   LBL[2] ;
  13:   IF $VCRSM_CFG.$STEP_NUM>=3,
        JMP LBL[3] ;
  14:   CALL VCRSM_CHECK(2,1,2) ;
  15:   CALL VTCPSET('VSFT1',2) ;
  16:      ;
  17:   LBL[3] ;
  18:   CALL VCRSM_CHECK(3,1,2) ;
  19:   CALL VTHSCLB(1) ;
  20:   CALL VCRSM_CHECK('END') ;
[End]
```

Here is the explanation for each line of the TP program. The line number for 7DC3/10 (V8.30P/10) or later software is noted in parentheses. The following is the explanation for 7DC3/09 (V8.30P/09) or earlier software, so read the line number in parentheses if the software version is 7DC3/10 (V8.30P/10) or later.
Line 1 (Line 2):   The user frame number is always 0.
Line 2 (Line 3):   The tool frame number is changed to that set in the schedule.

Line 4 (Line 7):   This is the calibration start position.   The two robots move in relation to this position.
Line 5 (Line 9):   The initialization subprogram VTCPINIT is executed.
Line 6 (Line 10):   The TCP of the leader group (group 1 in this example) is set.
Line 7 (Line 15):   The TCP of the follower group (group 2 in this example) is set.
Line 8 (Line 19):   The calibration data is calculated.   The VTHSCLB parameter indicates the schedule number.

If necessary, the intermediate point between the original point and the calibration start position may be added before line 3 and the return operation to the original point after calibration and other instructions may be added after line 7.

Calibration start position

The two robots of the leader group and follower group are placed at their respective start positions.
Install the target mark to the tool tip of one robot and the camera to the tool tip of the other robot.
Make sure that, when the robot is at the start position, the mark is seen near the center of the field of view of the camera. The distance between the camera and mark should be about 400 mm.

```
VMCAL_1

   1:   UFRAME_NUM=0
   2:   UTOOL_NUM=9
   3:   $VSHIFT_CFG.$VISION_TYPE=0
   4:J  @P[1] 30% FINE
   5:   CALL VTCPINIT
   6:   CALL VTCPSET('VSFT1',1)
   7:   CALL VTCPSET('VSFT1',2)
   8:   CALL VTHSCLB(1)
[End]
```


Target
mark

Camera

Leader group

Follower group

Fig. 13.3 (a) Vision Multi-Cal start position

Installation example) In arc welding coordinated motion, it is common for the leader group to hold the workpiece and for the follower group to hold the torch. In that case, the installation is easy to do if the target mark is attached to the hand of the leader group or the workpiece held by it and the camera is attached to the welding torch of the follower group.
To which robot to install the camera and to which robot to install the mark is left to the discretion of the personnel.   The system may be configured so that the leader group holds the camera and the follower group holds the target mark.

Setting the leader group TCP

Set the tool frame of the leader group.

Line 6:   The TCP of the leader group (group 1 in this example) is set.

```
VMCAL_1

  1:   UFRAME_NUM=0
  2:   UTOOL_NUM=9
  3:   $VSHIFT_CFG.$VISION_TYPE=0
  4:J  @P[1] 30% FINE
  5:   CALL VTCPINIT
  6:   CALL VTCPSET('VSFT1',1)
  7:   CALL VTCPSET('VSFT1',2)
  8:   CALL VTHSCLB(1)
[End]
```

The first VTCPSET parameter VSFT1 indicates the vision data name specified in the schedule.
The second parameter indicates the group number of the robot.
The robot of only the leader group moves so that the mark is seen from many different directions from the camera.   The robot of the follower group does not move.
Set the TCP of the leader group at the center of the target mark.

Leader group
(Move)

Follower group
(Hold)

Fig. 13.3 (b) Setting the TCP of the leader group

Setting the follower group TCP

Set the tool frame of the follower group.

Line 7:   The TCP of the follower group (group 2 in this example) is set.

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```
VMCAL_1

   1:   UFRAME_NUM=0
   2:   UTOOL_NUM=9
   3:   $VSHIFT_CFG.$VISION_TYPE=0
   4:J  @P[1] 30% FINE
   5:   CALL VTCPINIT
   6:   CALL VTCPSET('VSFT1',1)
   7:   CALL VTCPSET('VSFT1',2)
   8:   CALL VTHSCLB(1)
[End]
```

The robot of only the follower group moves so that the mark is seen from many different directions from the camera.   The robot of the leader group does not move.
Set the TCP of the follower group at the center of the reference mark.

Leader group
(Hold)

Follower group
(Move)

Fig. 13.3 (c) Setting the TCP of the follower group

Coordinated robot calibration

Calibrate the coordinated robots.

Line 8:   The calibration data is calculated. The VTHSCLB parameter indicates the schedule number.

```
VMCAL_1

   1:   UFRAME_NUM=0
   2:   UTOOL_NUM=9
   3:   $VSHIFT_CFG.$VISION_TYPE=0
   4:J  @P[1] 30% FINE
   5:   CALL VTCPINIT
   6:   CALL VTCPSET('VSFT1',1)
   7:   CALL VTCPSET('VSFT1',2)
   8:   CALL VTHSCLB(1)
[End]
```

The subprogram VTHSCLB is executed. The robots of both the leader group and follower group move.
The leader group moves in the X, Y, and Z directions (tool frame of the camera), and the follower group moves according to the leader group.

The calibration data (position and posture of the base coordinate system of the leader group relative to that of the follower group) is calculated.

Fig. 13.3 (d) Coordinated robot calibration

13.4   PROCESS FOR VISION MULTI-CAL (ONE ROBOT AND ONE POSITIONER)

13.4.1   Preparation

Connecting and installing a camera

Connect the camera to the robot controller or the *i*Pendant.

Check that the camera image is properly displayed, as instructed in "3 BASIC VISION FUNCTION OPERATION".

Secure the camera to the tool tip of the robot. Although there is no exact specification as to the position where the camera is to be installed, make sure the camera is fixed securely so that it does not move during measurement.

Installing Target Mark

Install the target mark to the last axis of the positioner. Although there is no exact specification as to the position where the target mark is to be installed, make sure the mark is fixed securely so that it does not move during measurement.

Setting coordinated pair

To calibrate a coordinated pair, set the leader group number, follower group number, Axis type and Axis direction for the positioner in advance using the coordinated pair setup screen.

Set the calibration type to "Unknown type calibration".

13.4.2   Setting of Vision Data

Display the Vision Data Setup Screen, teach the shape of the object to be detected by the vision function (model), and adjust the detection parameters. For details, refer to "3 BASIC VISION FUNCTION OPERATION".

```
┌────────────────────────────────────────────┐
│ iRCalibration                                │
│ Vision Data Setup         List      1/8      │
│                                              │
│ Vision Data   Status        Comment          │
│  VSFT1       [Trained   ][            ]       │
│  VSFT2       [Not Trained][            ]       │
│  VSFT3       [Not Trained][            ]       │
│  VSFT4       [Not Trained][            ]       │
│  VSFT5       [Not Trained][            ]       │
│  VSFT6       [Not Trained][            ]       │
│  VSFT7       [Not Trained][            ]       │
│  VSFT8       [Not Trained][            ]       │
│                                              │
│        DISP_IMG  DETAIL    COPY   INIT        │
└────────────────────────────────────────────┘
```

13.4.3   Creation of TP Program

Create a TP program for vision measurement in Vision Multi-Cal.
For 7DC3/10 (V8.30P/10) or later software, in the case of one-axis or two-axis rotary table, you can use the sample program VCMGCAL1.TP or VCMGCAL2.TP as a template for TP program. When the sample program is not available, refer to the example of TP program for a two-axis rotary table described later, and create the TP program.

When the sample program is available

For 7DC3/10 (V8.30P/10) or later software, in the case of one-axis or two-axis rotary table, the sample program VCMGCAL1.TP or VCMGCAL2.TP is available. VCMGCAL1.TP is the sample program for one-axis rotary table, and VCMGCAL2.TP is the sample program for two-axis rotary table. The contents of VCMGCAL1.TP and VCMGCAL2.TP are shown below.

```
VCMGCAL1
  1:   CALL VCRSM_CHECK('START') ;
  2:   UFRAME_NUM=0 ;
  3:   UTOOL_NUM=1 ;
  4:     ;
  5:   IF $VCRSM_CFG.$STEP_NUM>=2,JMP LBL[2] ;
  6:   CALL VCRSM_CHECK(1) ;
  7:J P[1] 100% FINE      ;
  8:   CALL VTCPINIT('INIT',0) ;
  9:   CALL VTCPINIT      ;
 10:   CALL VTCPSET('VSFT1',1) ;
 11:   PAUSE ;
 12:     ;
 13:   LBL[2] ;
 14:   IF $VCRSM_CFG.$STEP_NUM>=3,JMP LBL[3] ;
 15:   CALL VCRSM_CHECK(2,1,2) ;
 16:   CALL VTOUCH(1,'VSFT1',3) ;
 17:     ;
 18:   !J1 Axis ;
 19:   LBL[3] ;
 20:   IF $VCRSM_CFG.$STEP_NUM>=4,JMP LBL[4] ;
 21:J P[1] 100% FINE      ;
 22:   CALL VCRSM_CHECK(3) ;
 23:   CALL VTOUCH(1,'VSFT1',0) ;
 24:   CALL VTRECP(1,1,1) ;
 25:     ;
 26:   LBL[4] ;
 27:   IF $VCRSM_CFG.$STEP_NUM>=5,JMP LBL[5] ;
 28:J P[2] 100% FINE      ;
 29:   CALL VCRSM_CHECK(4) ;
 30:   CALL VTOUCH(1,'VSFT1',0) ;
 31:   CALL VTRECP(1,1,2) ;
 32:     ;
 33:   LBL[5] ;
 34:J P[3] 100% FINE      ;
 35:   CALL VCRSM_CHECK(5) ;
 36:   CALL VTOUCH(1,'VSFT1',0) ;
 37:   CALL VTRECP(1,1,3) ;
 38:     ;
 39:   CALL VCRSM_CHECK('END') ;
[End]
```

```
VCMGCAL2
  1:   CALL VCRSM_CHECK('START') ;
  2:   UFRAME_NUM=0 ;
  3:   UTOOL_NUM=1 ;
  4:     ;
  5:   IF $VCRSM_CFG.$STEP_NUM>=2,JMP LBL[2] ;
  6:   CALL VCRSM_CHECK(1) ;
  7:J P[1] 100% FINE      ;
  8:   CALL VTCPINIT('INIT',0) ;
  9:   CALL VTCPINIT      ;
 10:   CALL VTCPSET('VSFT1',1) ;
 11:   PAUSE ;
 12:     ;
 13:   LBL[2] ;
 14:   IF $VCRSM_CFG.$STEP_NUM>=3,JMP LBL[3] ;
 15:   CALL VCRSM_CHECK(2,1,2) ;
 16:   CALL VTOUCH(1,'VSFT1',3) ;
 17:     ;
 18:   !J1 Axis ;
 19:   LBL[3] ;
 20:   IF $VCRSM_CFG.$STEP_NUM>=4,JMP LBL[4] ;
 21:J P[1] 100% FINE      ;
 22:   CALL VCRSM_CHECK(3) ;
 23:   CALL VTOUCH(1,'VSFT1',0) ;
 24:   CALL VTRECP(1,1,1) ;
 25:     ;
 26:   LBL[4] ;
 27:   IF $VCRSM_CFG.$STEP_NUM>=5,JMP LBL[5] ;
 28:J P[2] 100% FINE      ;
 29:   CALL VCRSM_CHECK(4) ;
 30:   CALL VTOUCH(1,'VSFT1',0) ;
 31:   CALL VTRECP(1,1,2) ;
 32:     ;
 33:   LBL[5] ;
 34:   IF $VCRSM_CFG.$STEP_NUM>=6,JMP LBL[6] ;
 35:J P[3] 100% FINE      ;
 36:   CALL VCRSM_CHECK(5) ;
 37:   CALL VTOUCH(1,'VSFT1',0) ;
 38:   CALL VTRECP(1,1,3) ;
 39:     ;
 40:   !J2 Axis ;
 41:   LBL[6] ;
 42:   IF $VCRSM_CFG.$STEP_NUM>=7,JMP LBL[7] ;
 43:J P[4] 100% FINE      ;
 44:   CALL VCRSM_CHECK(6) ;
 45:   CALL VTOUCH(1,'VSFT1',0) ;
 46:   CALL VTRECP(1,2,1) ;
 47:     ;
 48:   LBL[7] ;
 49:   IF $VCRSM_CFG.$STEP_NUM>=8,JMP LBL[8] ;
 50:J P[5] 100% FINE      ;
 51:   CALL VCRSM_CHECK(7) ;
 52:   CALL VTOUCH(1,'VSFT1',0) ;
 53:   CALL VTRECP(1,2,2) ;
 54:     ;
 55:   LBL[8] ;
 56:J P[6] 100% FINE      ;
 57:   CALL VCRSM_CHECK(8) ;
 58:   CALL VTOUCH(1,'VSFT1',0) ;
 59:   CALL VTRECP(1,2,3) ;
 60:     ;
 61:   CALL VCRSM_CHECK('END') ;
[End]
```

The motion group in each sample program is [1, 1, *, *, *, *, *, *].
If the configuration of the motion group is the same as that of the sample program, copy the sample program, and perform the following operations.
- Set the first argument of VTCPSET to the vision data name in "13.4.2 Setting of Vision Data", and the second argument of VTCPSET to the robot group number in line 10.
- Refer to the example of TP program for a two-axis rotary table described later, teach the positions and set the arguments of VTOUCH and VTRECP.

If the configuration of the motion group is not the same as that of the sample program, create a new TP program, paste the copied contents of the sample program, and perform the following operations.
- Set the first argument of VTCPSET to the vision data name in "13.4.2 Setting of Vision Data", and the second argument of VTCPSET to the robot group number in line 10.
- Set the second argument of VCRSM_CHECK to the robot group number and the third argument of VCRSM_CHECK to the positioner group number in line 15.
- Refer to the example of TP program for a two-axis rotary table described later, teach the positions and set the arguments of VTOUCH and VTRECP.

When the sample program is not available

When you create a TP program for vision measurement in Vision Multi-Cal, it is necessary to teach reference points for measurement. The following number of the reference points is necessary.
- If the axis type of the positioner is rotary, 3 points per one axis are necessary.
- If the axis type of the positioner is linear, 2 points per one axis are necessary.

The above reference points are necessary for each axis.
For example, in the case of two-axis rotary table, the needed number of reference points is 3 * 2 = 6. The following explains an example of TP program for a two-axis rotary table.

> **NOTE**
> For 7DC3/10 (V8.30P/10) or later software, VSETTCP can not be used. Replace the VSETTCP program in line 4 with the following 3 lines.
> CALL VTCPINIT('INIT',0) ;
> CALL VTCPINIT   ;
> CALL VTCPSET('VSFT1',1) ;

Here is the explanation for each line of the above TP program.

1   Teach the initial position for measurement. This position is recommended to satisfy the following conditions.
- The target is viewed near the center of a camera image.
- The target plane is almost parallel to the lens of the camera.
- The distance between the camera and the target is about 400 mm.
- A sufficient space is available to prevent peripheral interference during execution of the TP program.

```
1:  UFRAME_NUM=0 ;
2:  UTOOL_NUM=2 ;
3:J P[1:J1-1] 100% FINE    ;
4:  CALL VSETTCP( VSFT1 ,50,100,1) ;
5:  CALL VTOUCH(1,'VSFT1',3) ;
```

2   Call the program VSETTCP. During execution of this program, the robot automatically changes the position and posture of the tool to show the target in different orientations to the camera. For details of the arguments and the movement of VSETTCP, refer to "10.4.1 Vision TCP Set Program (7DC3/09 (V8.30P/09) or earlier)". For 7DC3/10 (V8.30P/10) or later software, VSETTCP is not

available, so replace VSETTCP with VTCPINIT and VTCPSET as the above note. For details of the arguments and the operation by VTCPSET, refer to "10.4.2 Vision TCP Set Program (7DC3/10 (V8.30P/10) or later)".

```
1:   UFRAME_NUM=0 ;
2:   UTOOL_NUM=2 ;
3:J P[1:J1-1] 100% FINE       ;
4:   CALL VSETTCP('VSFT1',50,100,1) ;
5:   CALL VTOUCH(1,'VSFT1',3) ;
```

3   Call the program VTOUCH. This program performs the initial setting for measurement of the reference points later. Specify the arguments below.
     Argument 1: Specifies the group number of a robot used for VTOUCH.
     Argument 2: Specify a vision data name (model name) by using a character string.
     Argument 3: Specify the mode for VTOUCH.
                     In this case, Set 3 to execute initial setting and vision measurement.

```
1:   UFRAME_NUM=0 ;
2:   UTOOL_NUM=2 ;
3:J P[1:J1-1] 100% FINE       ;
4:   CALL VSETTCP('VSFT1',50,100,1) ;
5:   CALL VTOUCH(1,'VSFT1',3) ;
```

4   Teach the target measurement positions.
     In case of two-axis rotary table, for example, teach 6 positions as follows. Each point should be as far as possible. All axes, except the one being calibrated, must be at their zero positions.
     •   1st point for setting J1: (J1, J2) = (0.0, 0.0) [deg]
     •   2nd point for setting J1: (J1, J2) = (30.0, 0.0) [deg]
     •   3rd point for setting J1: (J1, J2) = (60.0, 0.0) [deg]
     •   1st point for setting J2: (J1, J2) = (0.0, 0.0) [deg]
     •   2nd point for setting J2: (J1, J2) = (0.0, 120.0) [deg]
     •   3rd point for setting J2: (J1, J2) = (0.0, 240.0) [deg]

NOTE
1   When calibrating axes, you must start from the J1 axis and follow the axis order.
2   To set the relative position accurately, make the position of each axis of the positioners for measurement as far away from each other as possible.
3   When recording the calibration points for positioners, move the axes of positioners under calibration only.
4   The angle for the second point must be larger than that for the first point, and the angle for the third point must be larger than that for the second point.

After deciding the teaching points for the positioner, decide the teaching points for the robot. Set target measurement positions as follows:
•   The target is viewed near the center of a camera image.
•   The distance between the camera and the target is about 400 mm.
•   A sufficient space is available to prevent peripheral interference during execution of the TP program.

5   Change the storage form of the position data to Joint, if the position data is represented by Cartesian coordinates.

```
 8:   !J1 Axis ;
 9:J P[1:J1-1] 100% FINE      ;
10:   CALL VTOUCH(1, VSFT1 ,0) ;
11:   CALL VTRECP(1,1,1) ;
12:        ;
13:J P[2:J1-2] 100% FINE      ;
14:   CALL VTOUCH(1, VSFT1 ,0) ;
15:   CALL VTRECP(1,1,2) ;
16:        ;
17:J P[3:J1-3] 100% FINE      ;
18:   CALL VTOUCH(1, VSFT1 ,0) ;
19:   CALL VTRECP(1,1,3) ;
20:        ;
21:   !J2 Axis ;
22:J P[4:J2-1] 100% FINE      ;
23:   CALL VTOUCH(1, VSFT1 ,0) ;
24:   CALL VTRECP(1,2,1) ;
25:        ;
26:J P[5:J2-2] 100% FINE      ;
27:   CALL VTOUCH(1, VSFT1 ,0) ;
28:   CALL VTRECP(1,2,2) ;
29:        ;
30:J P[6:J2-3] 100% FINE      ;
31:   CALL VTOUCH(1, VSFT1 ,0) ;
32:   CALL VTRECP(1,2,3) ;
```

6   Call the program VTOUCH and perform vision measurement at the reference points. Specify the arguments below.

Argument 1: Specifies the group number of a robot used for VTOUCH.

Argument 2: Specifies a vision data name (model name) by using a character string.

Argument 3: Specifies the mode for VTOUCH.

In this case, Set 0 to execute vision measurement.

```
 8:   !J1 Axis ;
 9:J P[1:J1-1] 100% FINE      ;
10:   CALL VTOUCH(1,'VSFT1',0) ;
11:   CALL VTRECP(1,1,1) ;
12:        ;
13:J P[2:J1-2] 100% FINE      ;
14:   CALL VTOUCH(1,'VSFT1',0) ;
15:   CALL VTRECP(1,1,2) ;
16:        ;
17:J P[3:J1-3] 100% FINE      ;
18:   CALL VTOUCH(1,'VSFT1',0) ;
19:   CALL VTRECP(1,1,3) ;
20:        ;
21:   !J2 Axis ;
22:J P[4:J2-1] 100% FINE      ;
23:   CALL VTOUCH(1,'VSFT1',0) ;
24:   CALL VTRECP(1,2,1) ;
25:        ;
26:J P[5:J2-2] 100% FINE      ;
27:   CALL VTOUCH(1,'VSFT1',0) ;
28:   CALL VTRECP(1,2,2) ;
29:        ;
30:J P[6:J2-3] 100% FINE      ;
31:   CALL VTOUCH(1,'VSFT1',0) ;
32:   CALL VTRECP(1,2,3) ;
```

NOTE
   Before the execution of VTOUCH whose third argument is 0, execute VTOUCH whose third argument is 3, the line 6 in the above example.

7   Call the program VTRECP and record the position of reference points. Specify the arguments below.

Argument 1: Specifies the group number for the coordinated pair.

Argument 2: Specifies the axis number of the positioner to set.

Argument 3: Specifies the reference number corresponding to the number of positioner to set.

```
   8:   !J1 Axis ;
   9:J P[1:J1-1] 100% FINE        ;
  10:   CALL VTOUCH(1,'VSET1',0)  ;
  11:   CALL VTRECP(1,1,1) ;
  12:   ;
  13:J P[2:J1-2] 100% FINE        ;
  14:   CALL VTOUCH(1,'VSET1',0)  ;
  15:   CALL VTRECP(1,1,2) ;
  16:   ;
  17:J P[3:J1-3] 100% FINE        ;
  18:   CALL VTOUCH(1,'VSET1',0)  ;
  19:   CALL VTRECP(1,1,3) ;
  20:   ;
  21:   !J2 Axis  ;
  22:J P[4:J2-1] 100% FINE        ;
  23:   CALL VTOUCH(1,'VSET1',0)  ;
  24:   CALL VTRECP(1,2,1) ;
  25:   ;
  26:J P[5:J2-2] 100% FINE        ;
  27:   CALL VTOUCH(1,'VSET1',0)  ;
  28:   CALL VTRECP(1,2,2) ;
  29:   ;
  30:J P[6:J2-3] 100% FINE        ;
  31:   CALL VTOUCH(1,'VSET1',0)  ;
  32:   CALL VTRECP(1,2,3) ;
```

Tips
  The sample program above has points to start measurement only, but the user
  may add intermediate points before going to the measurement position.

13.4.4   Execution of TP Program

Execute the created TP program in order to measure by vision.B.

NOTE
  If the TP program generates a "CVIS-021 Exceed VisPool" error but completed
  its execution, the error can be safely ignored. However, if the "CVIS-021" error
  stops the program execution, cycle controller power and rerun the TP program
  again.

NOTE
  If the TP program is created by copying the sample program, call instructions of
  the program VCRSM_CHECK, label instructions, and jump instructions are
  added to the TP program so that efficient resuming of the measurement can be
  done. If the measurement is interrupted by the release of the SHIFT key, the
  occurrence of an alarm or other reasons, re-execute the TP program after
  moving the cursor to the first line. If a part of the measurement has been
  completed, a message "Press 0 (restart) or 9 (resume)" appears. Press the 0
  key to restart the measurement from the beginning or the 9 key to resume the
  measurement.

13.4.5   Update of the Calibration Result

After execution of the TP program, press the $\boxed{\text{MENU}}$ key and select "SETUP" and then "Coord" from the menu.

If the screen for the unknown point calibration is not displayed, press the $\boxed{\text{F2 [C\_TYP]}}$ key and select "Unknown Pt".
After displaying the screen for unknown type calibration, confirm if all reference points for the positioners are marked as RECORDED. If there is any reference point whose status is UNINIT, re-try the vision measurement.
After confirming all reference points are marked as RECORDED, press the $\boxed{\text{SHIFT}}$ key and $\boxed{\text{F3 [EXEC]}}$ key together.

```
SETUP Coord

                                 1/6
Unknown type calibration Coord Pair: 1
Group Number  Leader: 2 Follower: 1
    X: ********  Y: ********  Z: ********
    W: ********  P: ********  R: ********
Axis Number:           1  (Total:   2)
Axis Type:            ROTARY
Axis Direction:      +Y
Point 1 :             RECORDED
Point 2 :             RECORDED
Point 3 :             RECORDED

[ TYPE ][C_TYP ]  EXEC   MOVE_TO  RECORD
```

By the calculation of calibration data, the following message is displayed. The data is retained even after robot controller power is turned off, until the calibration program is executed again.

```
SETUP Coord

                                 1/6
Unknown type calibration Coord Pair: 1
Group Number  Leader: 2 Follower: 1
    X: 1435.026  Y:    0.001  Z: -181.155
    W:  180.000  P:    0.302  R:    0.000
Axis Number:           1  (Total:   2)
Axis Type:            ROTARY
Axis Direction:      +Y
Point 1 :             USED
Point 2 :             USED
Point 3 :             USED

Pair calibrated. Please cold start.

[ TYPE ][C_TYP ]  EXEC   MOVE_TO  RECORD
```

In order for the updated calibration data of the coordinated pair to take effect, the controller needs to be cold started by turning its power off and then turning it back on.

13.5   TROUBLESHOOTING

13.5.1   MOTN-021 No kinematics error" during TP Program Execution

This message is issued when the TP program for calibration between the robot and positioner is created from the operation screen for Vision Multi-Cal and executed. For calibration between a robot and a positioner, the TP program cannot be automatically created from the operation screen for Vision Multi-Cal. See "13.4.3 Creation of TP Program" to create the program manually.

13.5.2   "Cannot find a Ref pos (irv_find)" during TP Program Execution

This message is issued when the target mark that was taught cannot be detected in the image. Make sure the target mark is visible in the camera's field of view, and if necessary, see "3.4.5 Parameter Setting Screen" to adjust the parameters that specify the vision detection range.

13.5.3   "CVIS-010 The matrix is singular" during TP Program Execution

This message is issued when the tool frame number of the virtual camera and the tool frame number that is selected in the teach pendant are different in ROBOGUIDE. Match the numbers and execute the TP program again.

13.5.4   "MOTN-017 Limit error", "MOTN-018 Position not reachable", or "MOTN-023 In singularity" during VTCPSET Execution

An alarm such as 'MOTN-017 Limit error', 'MOTN-018   Position not reachable', or 'MOTN-023 In singularity' may occur during executing 'CALL VTCPSET('vision program name', 'group number')'. In such a case, try creating the program again after changing initial position of the camera and the target or initial pose of the robot so that the alarm doesn't occur.
In case that the alarm still occurs even if the above countermeasure has been taken, add some instructions in order to narrow the robot-moving range during executing the TP program so that the alarm doesn't occur.

The instructions to be added into the TP program are as follows.
- Add 5 lines of the instructions before all 'CALL VTCPSET('vision program name', 'group number')' as the figure below.
- Set 'MOVE_DIST_W', 'MOVE_DIST_P', 'MOVE_DIST_R', 'MOVE_DIST_FW', or 'MOVE_DIST_FP' as the first argument of each added instruction respectively. And set a value between 5 and 15 to the second argument of each instruction. Note that the smaller these values are, the less the setting accuracy of the TCP could be, so these values should not be reduced too much.
- Each default value of 'MOVE_DIST_W', 'MOVE_DIST_P', 'MOVE_DIST_R', 'MOVE_DIST_FW', and 'MOVE_DIST_FP' is 15.

```
        CALL VTCPINIT('MOVE_DIST_W',    15)
        CALL VTCPINIT('MOVE_DIST_P',    15)
        CALL VTCPINIT('MOVE_DIST_R',    15)
        CALL VTCPINIT('MOVE_DIST_FW',   15)
        CALL VTCPINIT('MOVE_DIST_FP',   15)
        CALL VTCPSET('VSFT1', 1)
        CALL VTCPINIT('MOVE_DIST_W',    15)
        CALL VTCPINIT('MOVE_DIST_P',    15)
        CALL VTCPINIT('MOVE_DIST_R',    15)
        CALL VTCPINIT('MOVE_DIST_FW',   15)
        CALL VTCPINIT('MOVE_DIST_FP',   15)
        CALL VTCPSET('VSFT1', 2)
```

13.5.5   "Recorded points are on one line" when Applying the Calibration Results

This message is issued when the all the teaching points of the TP program are arranged in a straight line. Modify the TP program so that the teaching points are not all in a straight line, and then execute it again.

14 GRID FRAME SETTING

14.1 GRID FRAME SETTING

The grid frame setting function sets the robot frame by using a camera. Compared with the manual touch-up setting method, the function offers a number of merits, including accurate setting of the frame without requiring user skills, no need for touch-up pointers or to set the TCP for touch-up setting, and semi-automatic easy-to-do operation.

In grid frame setting, the calibration grid is measured from multiple directions by using a camera and the measured calibration grid frame is set in the user frame area or tool frame area of the robot controller.

⚠ **CAUTION**
The grid frame setting function can be used with 7DF3 series (V9.30P) software of version 04 or later.
The grid frame setting function is usable with 6-axis robots only. Also, it is usable with 6-axis robots with an additional axis.
The function cannot be used with 4-axis robots and 5-axis robots.

✎**Memo**
If you choose to prepare another camera for grid frame measurement, you can also use a USB camera (BASLER acA640-750umFNC or BASLER acA640-20um) by connecting it to the teach pendant, instead of a normal *i*RVision camera. To use a USB camera, you need to change the system variable $VISION_CFG.$BASLERUSBCA according to the camera type before executing measurement. Set 1 for BASLER acA640-750umFNC or 0 for BASLER acA640-20um. The default is 1.

The below explains the grid frame setting.

Frame to set in the grid frame setting

The measurement methods in the grid frame setting vary like below in the case of setting a user frame and the case of setting a tool frame.

Setting a user frame

When the calibration grid is secured to fixed surface, the camera mounted on the robot end of arm tooling is used to set the user frame to the position of calibration grid.

When applying the grid frame setting, the function identifies the position of the calibration grid on the robot world frame and writes the results in the user defined user frame.
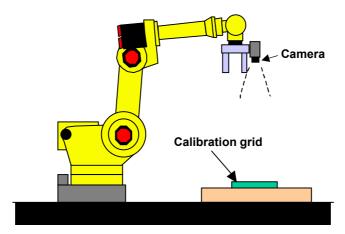
Fig. 14.1(a) Measure a fixed calibration grid with a robot-held camera

Setting a tool frame

A tool frame is set on the position of the robot-held calibration grid, by measuring the calibration grid with a camera fixed on a mount and so on.

When a fixed camera is available, that camera may perform the grid frame setting. When there is not enough space for the robot to move around the fixed camera field of view, or when a fixed camera is not available, prepare a different camera that is fixed on the temporary position, and perform the grid frame setting function.
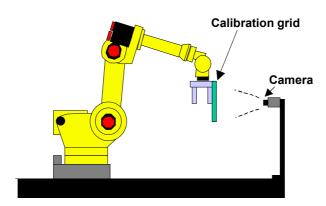
Fig. 14.1(b) Measure a robot-held calibration grid with a fixed camera

Process of grid frame setting

The process of grid frame setting is as follows.

1   Install a calibration grid.
When setting a user frame, fix the calibration grid on a table and so on.
When setting a tool frame, attach the calibration grid to the robot end of arm tooling.
In either case, make sure that the calibration grid is fixed securely so that it does not move during measurement.

> ✎**Memo**
> To prevent unnecessary circles from being found, check that the calibration grid is free of dirt and flaws. Spreading a plain sheet in the background is effective. Also, make sure to cover the printed text on the calibration grid.

2   Display the [Automatic Grid Frame Set] screen of the utilities screen on the teach pendant.

3   Set the parameter and teach the start position.
For the procedure to set procedures, refer to "Setup: 7.2.1 Setting the Parameters".
4   Run the measurement.
For executing measurement, refer to "Setup: 7.2.3 Run Measurement".
5   Check the measurement result. For details on how to check the measurement result, refer to "Setup: 7.2.4 Checking the Measurement Result".

The robot holding the camera or the robot holding calibration grid automatically moves to change relative position and orientation between the camera and the calibration grid, and find the grid pattern repeatedly.
Finally, identify the position of the grid frame on the robot world frame or the position of the grid frame on the robot mechanical interface frame (robot face plate)
When the grid frame setting function is executed, a frame is set on the calibration grid, as shown in the following figure.
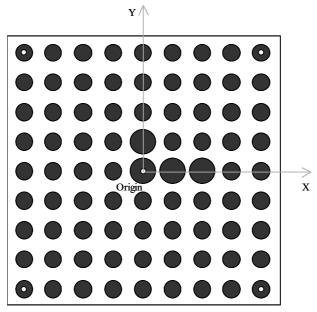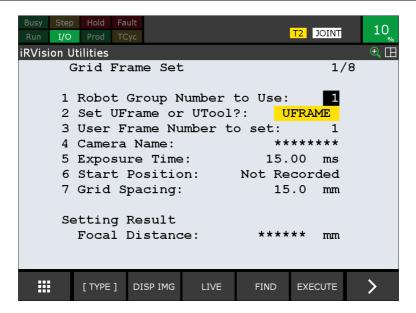
Fig. 14.1(c) Example of a frame using a calibration grid

14.1.1   Setting the Parameters

Place the cursor over [Automatic Frame Grid Set] on [iRVision Utilities] of the teach pendant and press the [ENTER] key, the [Grid Frame Set] screen like below will appear.

```
┌─────────────────────────────────────────────────────────────┐
│ Busy  Step  Hold  Fault                                   10  │
│ Run   I/O   Prod  TCyc              T2  JOINT               %  │
├─────────────────────────────────────────────────────────────┤
│ iRVision Utilities                                    ⊕  ⊞    │
│           Grid Frame Set                          1/8         │
│                                                               │
│                                                               │
│      1 Robot Group Number to Use:          1                  │
│      2 Set UFrame or UTool?:          UFRAME                  │
│      3 User Frame Number to set:           1                  │
│      4 Camera Name:                  ********                 │
│      5 Exposure Time:                 15.00  ms               │
│      6 Start Position:           Not Recorded                 │
│      7 Grid Spacing:                  15.0   mm               │
│                                                               │
│      Setting Result                                           │
│        Focal Distance:              ******   mm               │
│                                                               │
├─────────────────────────────────────────────────────────────┤
│  ▦     [ TYPE ]  DISP IMG   LIVE    FIND    EXECUTE    ⟩       │
└─────────────────────────────────────────────────────────────┘
```

> ✎ **Memo**
> The [Grid Frame Set] screen cannot be opened in more than one window at a
> time.

The following items are displayed on the [Grid Frame Set] screen.

[Robot Group Number to Use]

Specify the group number of the robot to be used for measurement.

[Set UFrame or UTool?]

Select the frame to be set with the grid frame setting function - user frame or user tool.   To set the user tool with the calibration grid mounted on the robot, select F4 [UTOOL].   To set the user frame with the calibration grid secured to a table or other fixed surface, select F5 [UFRAME].

[User Frame Number to set]

This parameter is used only when [UFRAME] is selected for [Set UFrame or UTool?].   Specify the number of the user frame to be set.

[Tool Frame Number to set]

This parameter is used only when [UTOOL] is selected for [Set UFrame or UTool?].   Specify the number of the user tool to be set.

[Camera Name]

Specify the name of the camera to be used for measurement.   Place the cursor on the line of [Camera Name], press F4 [CHOICE] to display camera list.   Specify the camera to be used for measurement by selecting from the list.

[Exposure Time]

Specify the exposure time, or shutter speed, for the camera to capture an image.   If you increase this value, the snapped image will be brighter.
Adjust the exposure time so that the black circles of the calibration grid are clearly visible.

[Start Position]

Teach the position where measurement is to be started.   If the position has been taught already, [Recorded] will be displayed.   If it hasn't been, [Not Recorded] will be displayed.

In the case of [Not Recorded], measurement cannot be executed.   Be sure you always teach the start position before measurement.
For the procedure to teach the start position, refer to "Setup: 7.2.2 Teach the Start position".

[Grid Spacing]
Set the grid spacing of the calibration grid in use.

[Setting Result]
This item is displayed when measurement is completed.   For details, refer to "Setup: 7.2.4 Checking the Measurement Result".

[Check Tool/User Frame Setup]
This item is configurable after measurement.   If measurement is not completed, this item cannot be set.
For details, refer to "Setup: 7.2.4 Checking the Measurement Result".
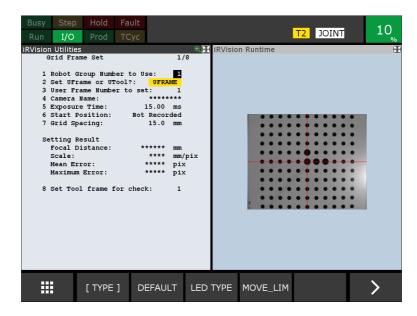
Function key
The following function keys will be displayed on the [Grid Frame Set] screen as common functions.
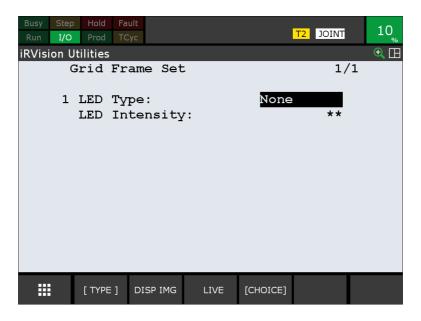
Key number	Item Name	Function
F2	DISP IMG	The grid frame screen and the vision runtime display are displayed.
F3	LIVE	The live image of the selected camera is displayed on the vision runtime display. The F3 label changes to [STOPLIVE] during the display of the live image and if you press F3 [STOPLIVE], the display of the live image is stopped.
F4	FIND	Pressing F4 [FIND] detect the calibration grid for a trial. The found result is displayed on the vision runtime display.
F7	DEFAULT	If you press F7 [DEFAULT], the set values are initialized. [Camera Name] and [Start Position] will be changed to their initial statuses, so please set them again.
F8	LED TYPE	The LED light setup screen is displayed.
F9	MOVE LIM	The move amount limit setup screen is displayed.

Pressing F2 [DISP IMG] displays the grid frame screen and the vision runtime display, as shown below.

14.1.1.1   Setting the LED light

When you press F8 [LED TYPE] on the grid frame screen, the following LED light setup screen appears.
To return to the original screen, press the [RESET] key.

[LED Type]
Press F4 [CHOICE] to select the LED light used to snap camera images.

[None]
> The LED light is not used.

[Integral]
> The integrated LED light is used for a camera package or 3D Vision Sensor.   This option allows you to select the [LED Intensity] setting item.   When [Integral] is selected, the LED light always flashes a strobe light.

[LED Intensity]
This setting item is available when [Integral] is selected in [LED Type].   The specifiable range is 1 to 16. The larger the value is, the brighter the light is.   The default is 8.

14.1.1.2   Setting the move amount limit

When you press F9 [MOVE LIM] on the grid frame screen, the following move amount limit setup screen appears.
To return to the original screen, press the [RESET] key.

```
┌──────────────────────────────────────────────────────────────┐
│ Busy  Step  Hold  Fault                                        │
│ Run   I/O   Prod  TCyc                      T2  JOINT    10  % │
├──────────────────────────────────────────────────────────────┤
│ iRVision Utilities                                        🔍 ⊞ │
│        Grid  Frame  Set                          1/9           │
│                                                                │
│        Move Amount Limit:                                      │
│        1                        X  :      30.0    %            │
│        2                        Y  :      30.0    %            │
│        3                        Z  :      50.0    mm           │
│        4                        W1 :     -30.0    deg          │
│        5                        W2 :      30.0    deg          │
│        6                        P1 :     -30.0    deg          │
│        7                        P2 :      30.0    deg          │
│        8                        R1 :     -45.0    deg          │
│        9                        R2 :      45.0    deg          │
│                                                                │
│                                                                │
│     ▦        [ TYPE ]                                          │
└──────────────────────────────────────────────────────────────┘
```

[Move Amount Limit] ([X], [Y], [Z], [W1], [W2], [P1], [P2], [R1], [R2])

Set the operation space for the robot when executing measurement.

During measurement, the robot automatically moves within the space specified here.   To prevent the robot from interfering with peripheral equipment, make sure that there is a sufficient operation space around the measurement area.   When the default settings are used, the robot makes the following motions:

- Move by 30 % of the field of view horizontally in the direction (XY) perpendicular to the camera's optical axis
- Move by 50mm horizontally in the direction (Z) toward the camera's optical axis
- Rotate at ±30-degree inclination (WP) relative to the camera's optical axis at the robot start position
- Rotate by ±45 degrees around the camera's optical axis (R)

If the move amount defined by the default settings cannot be secured, you can make the move amount smaller by changing the parameters.   Note, however, that the precision of grid frame setting depends on the amount of operation at the time of measurement.   A smaller move amount can lead to lower measurement precision. It is therefore recommended that measurements be made using a range as close to the default operation range as possible.

If there is an enough operation range, you can set a larger move amount.   For the [Z] value, in particular, setting a value larger than the default 50 mm may improve the measurement accuracy.

✎ **Memo**

There are two types of grid frame measurement: trial measurement and main measurement.   Changing the [Move Amount Limit] parameters affects the robot operation range during main measurement.   You cannot change the robot operation range during trial measurement.

Both the number of steps in main measurement and the number of [Move Amount Limit] parameters are nine, which means that they correspond to each other one-to-one.   For example, the move amount of step 4 in main measurement is determined by the fourth parameter [W1].

14.1.2   Teaching the Measurement Start Position

To teach the start position, take the following steps:

1   If Vision Runtime is not displayed, press F2 [DISP IMG].
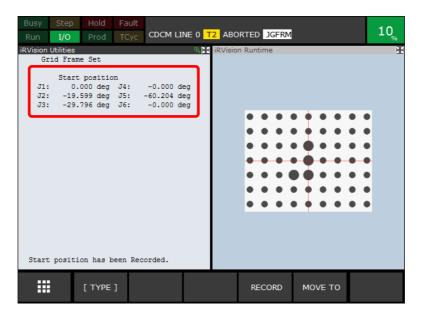
✎Memo
   Grid Frame Setting measures the calibration grid with moving the robot on which
   the camera or the calibration grid is mounted.   To increase the measurement
   accuracy, it is recommended that the calibration grid should be as large as
   possible in the camera field of view.

---

2   Pressing the [SHIFT] key on the teach pendant and F4 [RECORD] at the same time will record the
     start position, and [Start Position] will change to [Recorded].

To check the trained start position, press [F3 POSITION].   The value of each axis of the start position is
displayed, as shown below.
To return to the previous menu, press [PREV].
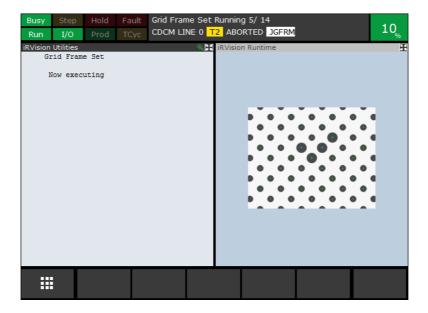
To move the robot to the start position, press [SHIFT] and F5 [MOVE TO] at the same time.

14.1.3   Run Measurement

Perform measurement as follows, using the taught start position as a reference.

1   If Vision Runtime is not displayed, press F2 [DISP IMG].
2   Check the parameter setup on the [Grid Frame Set] screen.
3   Check that the robot is at the start position.
4   Pressing the [SHIFT] key and F5 [EXECUTE] at the same time starts measurement, causing the
     robot to start moving. While the robot is operating, a message "Now executing" is displayed.
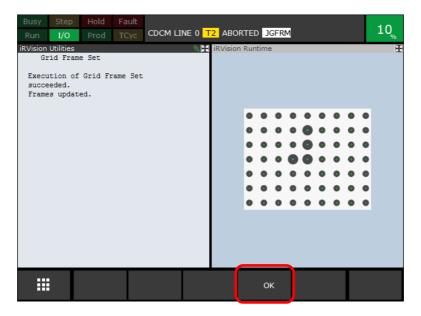
Perform trial measurement and main measurement in that order.   In trial measurement, the robot makes a
small movement to measure the approximate positions of the camera and calibration grid.   In main
measurement, the robot makes a large movement based on the trial measurement result.

> ⚠ **CAUTION**
> 1 Releasing [SHIFT] while measurement is in progress stops the measurement.
>   In that case, perform the measurement again.
> 2 During measurement, if you perform any operation intended to move to another
>   menu, such as pressing [SELECT], the measurement is stopped.   In that case,
>   visit the [Grid Frame Set] menu again and perform the measurement again.
> 3 The robot usually performs operations within an expected range according to the
>   parameter setting.   However, the robot can make a motion beyond an expected
>   range, depending on the parameter setting.   When doing the measurement,
>   check that the related parameters are set correctly and decrease the override to
>   30% or less to ensure that the robot does not interfere with peripheral
>   equipments.
> 4 If another program is paused, the Grid Frame Set may not be able to move the
>   robot.   In that case, abort all the programs using the [FUNC] menu.
> 5 If the measurement is stopped during main measurement, you can resume it
>   from where it stopped.
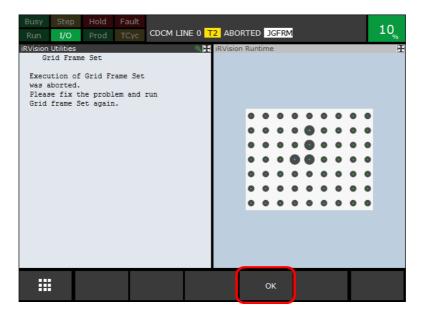
When the measurement is successfully completed, a menu like the one shown below appears.
The robot stops with the origin of the calibration grid coming to the center of the image.

5   If F4 [OK] is pressed, the screen will return to the setup screen.

In the event of failure to measure

If the measurement fails, a menu like the one shown below appears.

Press F4 [OK] to return to the previous menu.

14.1.4   Checking the Measurement Result

When measurement is completed, the values calculated by the measurement are displayed in [Check Result] on the grid frame screen.

[Focal Distance]

The calculated focal distance of the lens is displayed.
Check if the value is appropriate for the lens in use.

[Scale]

The size of a pixel (pix) in millimeters (mm) on the start position posture is displayed.
The value indicates how many millimeters are equivalent to a pixel.
The scale value is approximate since the scale is not even throughout the entire image.

[Mean error value], [Maximum error value]

The average and maximum errors of all the calibration points detected in this measurement are displayed. The smaller the value is, the more accurate the calculated frame is.   If this error value is large, the lens may be out of focus, or a non-calibration point may have been detected.   If [Maximum error value] is greater than 10 pixels, it is recommended that you should check if there are any problems with the settings or measurement conditions.

Checking the measurement result by jogging and displaying a live image

By jogging and using a live image, you can check the set frame as follows.

1   Set the confirmation tool/user frame on the grid frame screen.
     The confirmation frame is set on the optical axis of the camera.
2   Change the user frame number and tool frame number to use so that the set grid frame and confirmation frame can be selected as a user frame and a tool frame, respectively.
3   Move the robot as necessary so that X, Y, and Z of the current value are set to 0 on the selected user frame.
     After measurement is completed, the X, Y, and Z values are set to 0.
4   Change the manual-feed coordinate system to the tool frame or user frame.
5   By pressing F3 [LIVE], start the live image display and jog the robot around the X-, Y- and Z- axes.
     If the frame is set accurately, the center grid of the gird pattern will keep appearing at the center of the image.

14.2   AVAILABLE TARGET

The available target is the calibration grid for Grid Frame Set.

14.2.1   Calibration Grid

The available calibration grid for Grid Frame Set should satisfy the specification shown as below.
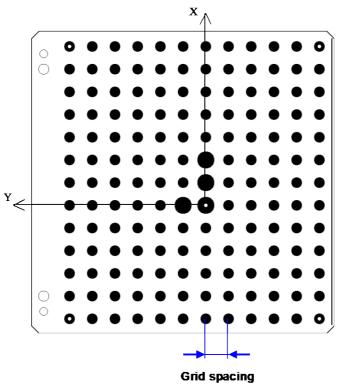
Fig. 14.2.1 Calibration grid

All the black circles are arranged in a square lattice. Four larger circles near the center indicate the origin and orientation of the frame as shown in the figure. The radius of the larger circles is about 1.5 times longer than other circles'.

You can also use the calibration grids for *i*RVision shown below.

Table 14.2.1 Calibration grid (for *i*RVision)

Type	Size (mm)	Grid spacing (mm)
Camera Calibration Plate A	□100	7.5
Camera Calibration Plate B	□200	15
Camera Calibration Plate C	□400	30

INDEX

REVISION RECORD

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