FANUC Robot series

R-30*i*B CONTROLLER

Sensor Mechanical Unit/Control Unit

OPERATOR'S MANUAL

B-83434EN/01

- **Original Instructions**

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

This manual can be used with controllers labeled R-30*i*A or R-J3*i*C. If you have a controller labeled R-J3*i*C, you should read R-30*i*A as R-J3*i*C throughout this manual.

The products in this manual are controlled based on Japan's "Foreign Exchange and Foreign Trade Law". The export from Japan may be subject to an export license by the government of Japan.
Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.
Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual we have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

SAFETY PRECAUTIONS

Thank you for purchasing FANUC Robot.
This chapter describes the precautions which must be observed to ensure the safe use of the robot.
Before attempting to use the robot, be sure to read this chapter thoroughly.

Before using the functions related to robot operation, read the relevant operator's manual to become familiar with those functions.

If any description in this chapter differs from that in the other part of this manual, the description given in this chapter shall take precedence.

For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral devices installed in a work cell.
In addition, refer to the “FANUC Robot SAFETY HANDBOOK (B-80687EN)”.

1 WORKING PERSON

The personnel can be classified as follows.

Operator:
- Turns robot controller power ON/OFF
- Starts robot program from operator’s panel

Programmer or teaching operator:
- Operates the robot
- Teaches robot inside the safety fence

Maintenance engineer:
- Operates the robot
- Teaches robot inside the safety fence
- Maintenance (adjustment, replacement)

- An operator cannot work inside the safety fence.
- A programmer, teaching operator, and maintenance engineer can work inside the safety fence. The working activities inside the safety fence include lifting, setting, teaching, adjusting, maintenance, etc.
- To work inside the fence, the person must be trained on proper robot operation.

During the operation, programming, and maintenance of your robotic system, the programmer, teaching operator, and maintenance engineer should take additional care of their safety by using the following safety precautions.

- Use adequate clothing or uniforms during system operation
- Wear safety shoes
- Use helmet

2 DEFINITION OF WARNING, CAUTION AND NOTE

To ensure the safety of user 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 attempting to use the oscillator.

⚠WARNING
Applied when there is a danger of the user being injured or when there is a danger of both the user being injured and the equipment being damaged if the approved procedure is not observed.

⚠CAUTION
Applied when there is a danger of the equipment being damaged, if the approved procedure is not observed.

NOTE
Notes are used to indicate supplementary information other than Warnings and Cautions.

- Read this manual carefully, and store it in a sales place.

3 WORKING PERSON SAFETY

Working person safety is the primary safety consideration. Because it is very dangerous to enter the operating space of the robot during automatic operation, adequate safety precautions must be observed. The following lists the general safety precautions. Careful consideration must be made to ensure working person safety.

(1) Have the robot system working persons attend the training courses held by FANUC.

FANUC provides various training courses. Contact our sales office for details.

(2) Even when the robot is stationary, it is possible that the robot is still in a ready to move state, and is waiting for a signal. In this state, the robot is regarded as still in motion. To ensure working person safety, provide the system with an alarm to indicate visually or aurally that the robot is in motion.
(3) Install a safety fence with a gate so that no working person can enter the work area without passing through the gate. Install an interlocking device, a safety plug, and so forth in the safety gate so that the robot is stopped as the safety gate is opened.

The controller is designed to receive this interlocking signal of the door switch. When the gate is opened and this signal received, the controller stops the robot (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type). For connection, see Fig.3 (a) and Fig.3 (b).

(4) Provide the peripheral devices with appropriate grounding (Class A, Class B, Class C, and Class D).

(5) Try to install the peripheral devices outside the work area.
(6) Draw an outline on the floor, clearly indicating the range of the robot motion, including the tools such as a hand.
(7) Install a mat switch or photoelectric switch on the floor with an interlock to a visual or aural alarm that stops the robot when a working person enters the work area.
(8) If necessary, install a safety lock so that no one except the working person in charge can turn on the power of the robot.

The circuit breaker installed in the controller is designed to disable anyone from turning it on when it is locked with a padlock.

(9) When adjusting each peripheral device independently, be sure to turn off the power of the robot
(10) Operators should be ungloved while manipulating the operator's panel or teach pendant. Operation with gloved fingers could cause an operation error.
(11) Programs, system variables, and other information can be saved on memory card or USB memories. Be sure to save the data periodically in case the data is lost in an accident.
(12) The robot should be transported and installed by accurately following the procedures recommended by FANUC. Wrong transportation or installation may cause the robot to fall, resulting in severe injury to workers.
(13) In the first operation of the robot after installation, the operation should be restricted to low speeds. Then, the speed should be gradually increased to check the operation of the robot.
(14) Before the robot is started, it should be checked that no one is in the area of the safety fence. At the same time, a check must be made to ensure that there is no risk of hazardous situations. If detected, such a situation should be eliminated before the operation.
(15) When the robot is used, the following precautions should be taken. Otherwise, the robot and peripheral equipment can be adversely affected, or workers can be severely injured.
- Avoid using the robot in a flammable environment.
- Avoid using the robot in an explosive environment.
- Avoid using the robot in an environment full of radiation.
- Avoid using the robot under water or at high humidity.
- Avoid using the robot to carry a person or animal.
- Avoid using the robot as a stepladder. (Never climb up on or hang from the robot.)

(16) When connecting the peripheral devices related to stop(safety fence etc.) and each signal (external emergency , fence etc.) of robot. be sure to confirm the stop movement and do not take the wrong connection.
(17) When preparing trestle, please consider security for installation and maintenance work in high place according to Fig.3 (c). Please consider footstep and safety bolt mounting position.

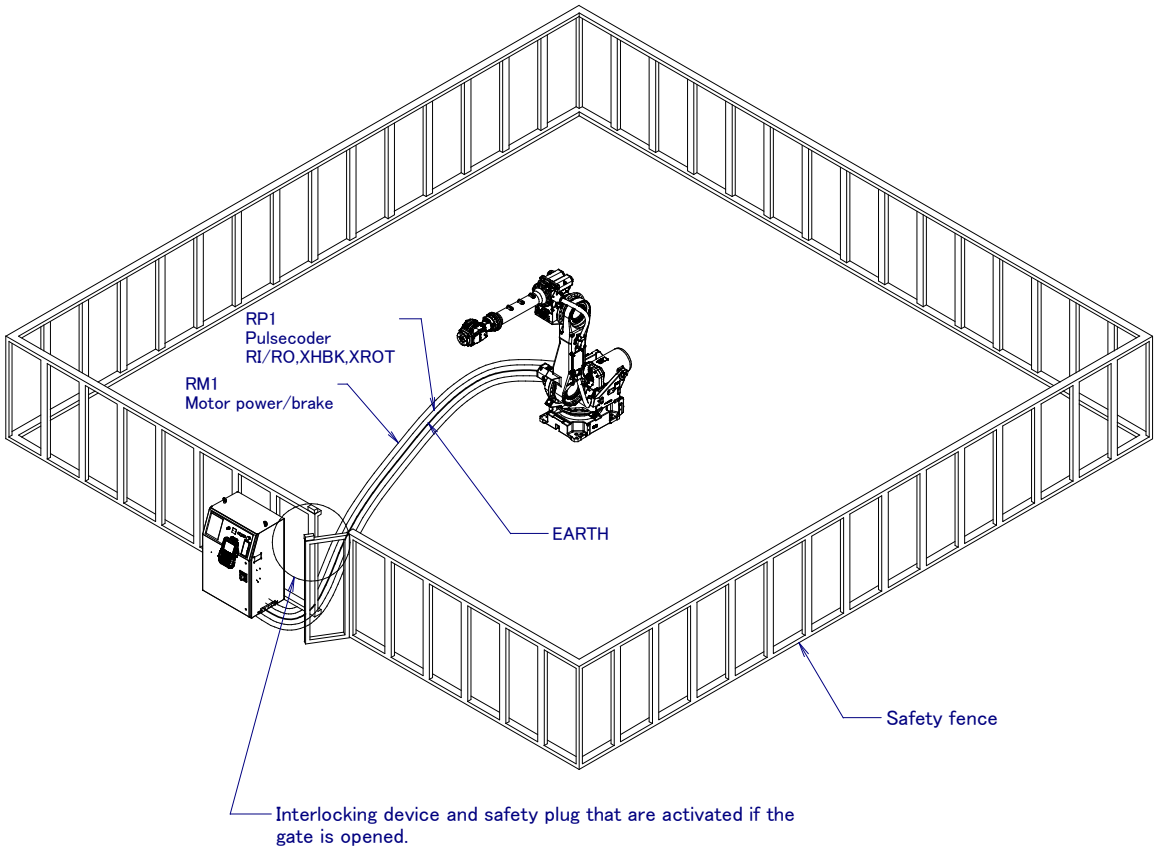


Fig. 3 (a) Safety fence and safety gate

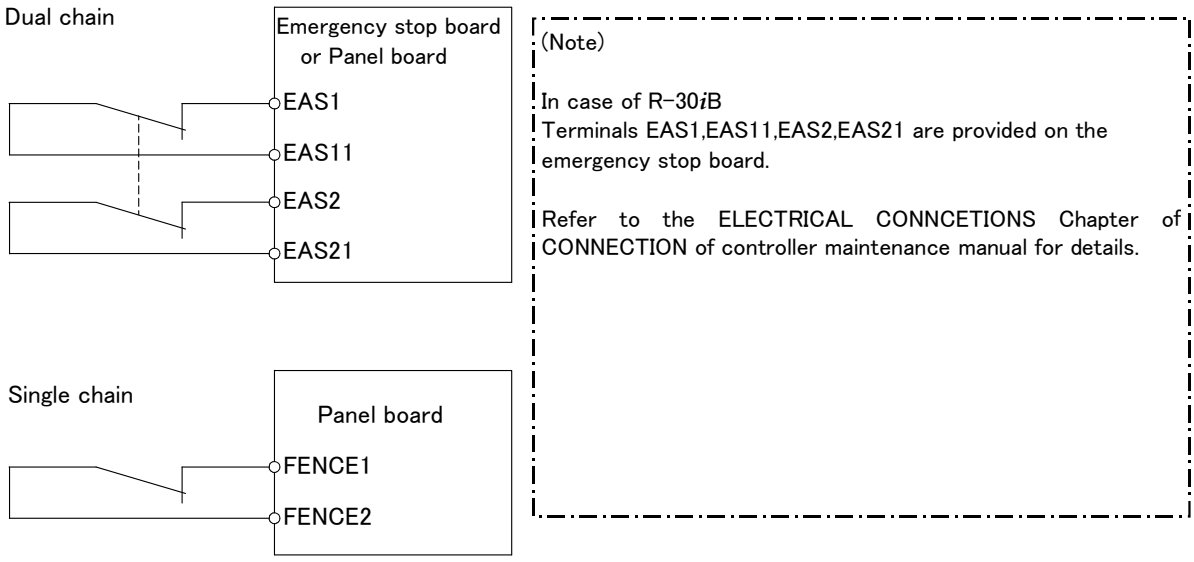


Fig. 3 (b) Limit switch circuit diagram of the safety fence

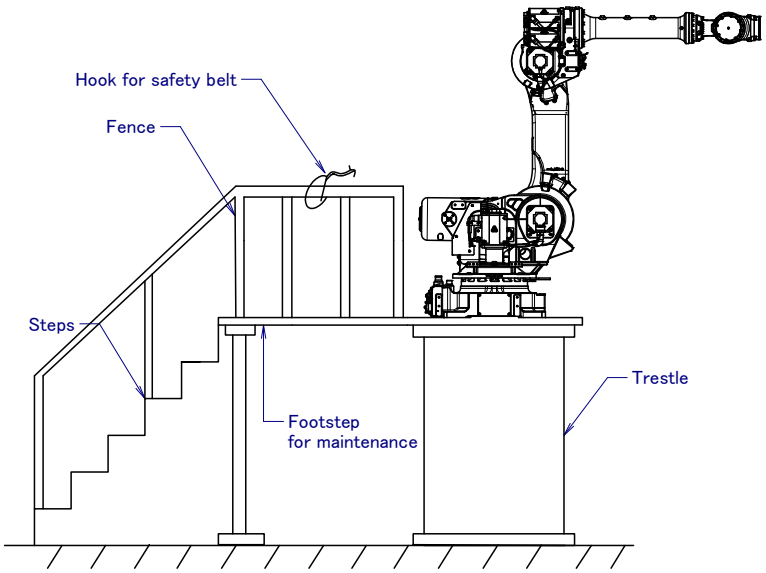


Fig.3 (c) Footstep for maintenance

3.1 OPERATOR SAFETY

The operator is a person who operates the robot system. In this sense, a worker who operates the teach pendant is also an operator. However, this section does not apply to teach pendant operators.

(1) If you do not have to operate the robot, turn off the power of the robot controller or press the EMERGENCY STOP button, and then proceed with necessary work.
(2) Operate the robot system at a location outside of the safety fence
(3) Install a safety fence with a safety gate to prevent any worker other than the operator from entering the work area unexpectedly and to prevent the worker from entering a dangerous area.
(4) Install an EMERGENCY STOP button within the operator's reach.

The robot controller is designed to be connected to an external EMERGENCY STOP button. With this connection, the controller stops the robot operation (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type), when the external EMERGENCY STOP button is pressed. See the diagram below for connection.

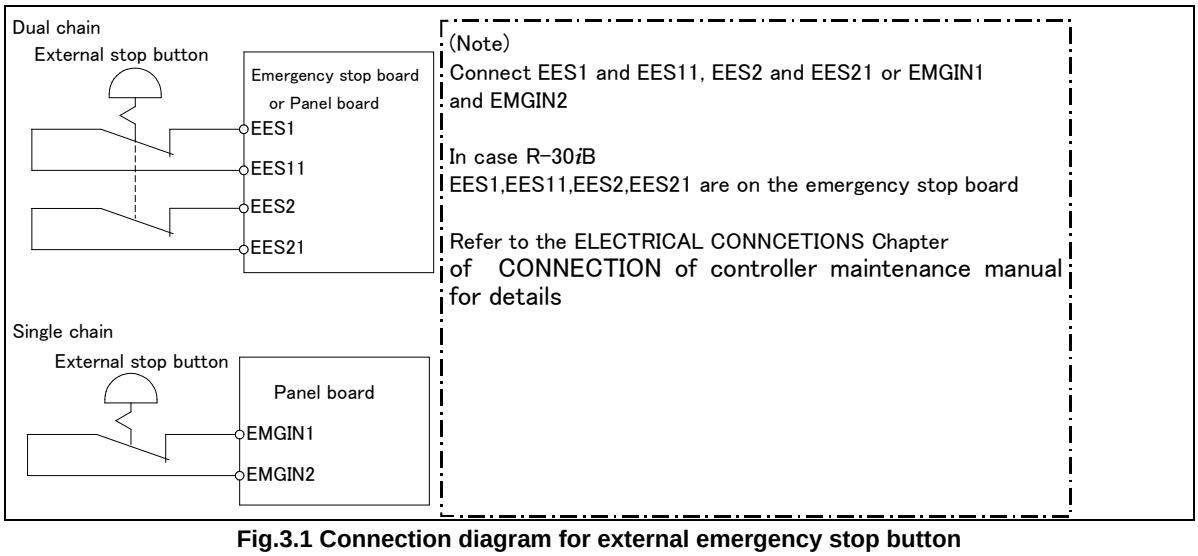


Fig.3.1 Connection diagram for external emergency stop button

3.2 SAFETY OF THE PROGRAMMER

While teaching the robot, the operator must enter the work area of the robot. The operator must ensure the safety of the teach pendant operator especially.

(1) Unless it is specifically necessary to enter the robot work area, carry out all tasks outside the area.
(2) Before teaching the robot, check that the robot and its peripheral devices are all in the normal operating condition.
(3) If it is inevitable to enter the robot work area to teach the robot, check the locations, settings, and other conditions of the safety devices (such as the EMERGENCY STOP button, the DEADMAN switch on the teach pendant) before entering the area.
(4) The programmer must be extremely careful not to let anyone else enter the robot work area.
(5) Programming should be done outside the area of the safety fence as far as possible. If programming needs to be done in the area of the safety fence, the programmer should take the following precautions:
   - Before entering the area of the safety fence, ensure that there is no risk of dangerous situations in the area.
   - Be prepared to press the emergency stop button whenever necessary.
   - Robot motions should be made at low speeds.
   - Before starting programming, check the entire system status to ensure that no remote instruction to the peripheral equipment or motion would be dangerous to the user.

Our operator panel is provided with an emergency stop button and a key switch (mode switch) for selecting the automatic operation mode (AUTO) and the teach modes (T1 and T2). Before entering the inside of the safety fence for the purpose of teaching, set the switch to a teach mode, remove the key from the mode switch to prevent other people from changing the operation mode carelessly, then open the safety gate. If the safety gate is opened with the automatic operation mode set, the robot stops (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type). After the switch is set to a teach mode, the safety gate is disabled. The programmer should understand that the safety gate is disabled and is responsible for keeping other people from entering the inside of the safety fence.

Our teach pendant is provided with a DEADMAN switch as well as an emergency stop button. These button and switch function as follows:
(1) Emergency stop button: Causes an emergency stop (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type) when pressed.
(2) DEADMAN switch: Functions differently depending on the teach pendant enable/disable switch setting status.
   (a) Disable: The DEADMAN switch is disabled.
   (b) Enable: Servo power is turned off when the operator releases the DEADMAN switch or when the operator presses the switch strongly.
   Note) The DEADMAN switch is provided to stop the robot when the operator releases the teach pendant or presses the pendant strongly in case of emergency. The R-30*i*B employs a 3-position DEADMAN switch, which allows the robot to operate when the 3-position DEADMAN switch is pressed to its intermediate point. When the operator releases the DEADMAN switch or presses the switch strongly, the robot stops immediately.

The operator's intention of starting teaching is determined by the controller through the dual operation of setting the teach pendant enable/disable switch to the enable position and pressing the DEADMAN switch. The operator should make sure that the robot could operate in such conditions and be responsible in carrying out tasks safely.

Based on the risk assessment by FANUC, number of operation of DEADMAN SW should not exceed about 10000 times per year.

The teach pendant, operator panel, and peripheral device interface send each robot start signal. However the validity of each signal changes as follows depending on the mode switch and the DEADMAN switch of the operator panel, the teach pendant enable switch and the remote condition on the software.

In case of R-30*i*B Controller

Mode	Teach pendant enable switch	Software remote condition	Teach pendant	Operator panel	Peripheral device
AUTO mode	On	Local	Not allowed	Not allowed	Not allowed
		Remote	Not allowed	Not allowed	Not allowed
	Off	Local	Not allowed	Allowed to start	Not allowed
		Remote	Not allowed	Not allowed	Allowed to start
T1, T2 mode	On	Local	Allowed to start	Not allowed	Not allowed
		Remote	Allowed to start	Not allowed	Not allowed
	Off	Local	Not allowed	Not allowed	Not allowed
		Remote	Not allowed	Not allowed	Not allowed

T1,T2 mode: DEADMAN switch is effective.

(6) To start the system using the operator's panel, make certain that nobody is the robot work area and that there are no abnormal conditions in the robot work area.
(7) When a program is completed, be sure to carry out a test operation according to the procedure below.
  (a) Run the program for at least one operation cycle in the single step mode at low speed.
  (b) Run the program for at least one operation cycle in the continuous operation mode at low speed.
  (c) Run the program for one operation cycle in the continuous operation mode at the intermediate speed and check that no abnormalities occur due to a delay in timing.
  (d) Run the program for one operation cycle in the continuous operation mode at the normal operating speed and check that the system operates automatically without trouble.
  (e) After checking the completeness of the program through the test operation above, execute it in the automatic operation mode.
(8) While operating the system in the automatic operation mode, the teach pendant operator should leave the robot work area.

3.3 SAFETY OF THE MAINTENANCE ENGINEER

For the safety of maintenance engineer personnel, pay utmost attention to the following.

(1) During operation, never enter the robot work area.
(2) A hazardous situation may arise when the robot or the system, are kept with their power-on during maintenance operations. Therefore, for any maintenance operation, the robot and the system should be put into the power-off state. If necessary, a lock should be in place in order to prevent any other person from turning on the robot and/or the system. In case maintenance needs to be executed in the power-on state, the emergency stop button must be pressed.
(3) If it becomes necessary to enter the robot operation range while the power is on, press the emergency stop button on the operator panel, or the teach pendant before entering the range. The maintenance personnel must indicate that maintenance work is in progress and be careful not to allow other people to operate the robot carelessly.
(4) When entering the area enclosed by the safety fence, the maintenance worker must check the entire system in order to make sure no dangerous situations exist. In case the worker needs to enter the safety area whilst a dangerous situation exists, extreme care must be taken, and entire system status must be carefully monitored.
(5) Before the maintenance of the pneumatic system is started, the supply pressure should be shut off and the pressure in the piping should be reduced to zero.

(6) Before the start of teaching, check that the robot and its peripheral devices are all in the normal operating condition.
(7) Do not operate the robot in the automatic mode while anybody is in the robot work area.
(8) When you maintain the robot alongside a wall or instrument, or when multiple workers are working nearby, make certain that their escape path is not obstructed.
(9) When a tool is mounted on the robot, or when any moving device other than the robot is installed, such as belt conveyor, pay careful attention to its motion.
(10) If necessary, have a worker who is familiar with the robot system stand beside the operator panel and observe the work being performed. If any danger arises, the worker should be ready to press the EMERGENCY STOP button at any time.
(11) When replacing a part, please contact FANUC service center. If a wrong procedure is followed, an accident may occur, causing damage to the robot and injury to the worker.
(12) When replacing or reinstalling components, take care to prevent foreign material from entering the system.
(13) When handling each unit or printed circuit board in the controller during inspection, turn off the circuit breaker to protect against electric shock.
If there are two cabinets, turn off the both circuit breaker.
(14) A part should be replaced with a part recommended by FANUC. If other parts are used, malfunction or damage would occur. Especially, a fuse that is not recommended by FANUC should not be used. Such a fuse may cause a fire.
(15) When restarting the robot system after completing maintenance work, make sure in advance that there is no person in the work area and that the robot and the peripheral devices are not abnormal.
(16) When a motor or brake is removed, the robot arm should be supported with a crane or other equipment beforehand so that the arm would not fall during the removal.
(17) Whenever grease is spilled on the floor, it should be removed as quickly as possible to prevent dangerous falls.
(18) The following parts are heated. If a maintenance worker needs to touch such a part in the heated state, the worker should wear heat-resistant gloves or use other protective tools.
- Servo motor
- Inside the controller
- Reducer
- Gearbox
- Wrist unit

(19) Maintenance should be done under suitable light. Care must be taken that the light would not cause any danger.
(20) When a motor, reducer, or other heavy load is handled, a crane or other equipment should be used to protect maintenance workers from excessive load. Otherwise, the maintenance workers would be severely injured.
(21) The robot should not be stepped on or climbed up during maintenance. If it is attempted, the robot would be adversely affected. In addition, a misstep can cause injury to the worker.
(22)When performing maintenance work in high place, secure a footstep and wear safety belt.
(23) After the maintenance is completed, spilled oil or water and metal chips should be removed from the floor around the robot and within the safety fence.
(24) When a part is replaced, all bolts and other related components should put back into their original places. A careful check must be given to ensure that no components are missing or left not mounted.
(25) In case robot motion is required during maintenance, the following precautions should be taken :
- Foresee an escape route. And during the maintenance motion itself, monitor continuously the whole system so that your escape route will not become blocked by the robot, or by peripheral equipment.
- Always pay attention to potentially dangerous situations, and be prepared to press the emergency stop button whenever necessary.

(26) The robot should be periodically inspected. (Refer to the robot mechanical manual and controller maintenance manual.) A failure to do the periodical inspection can adversely affect the performance or service life of the robot and may cause an accident

(27) After a part is replaced, a test operation should be given for the robot according to a predetermined method. (See TESTING section of “Controller operator’s manual”.) During the test operation, the maintenance staff should work outside the safety fence.

4 SAFETY OF THE TOOLS AND PERIPHERAL DEVICES

4.1 PRECAUTIONS IN PROGRAMMING

(1) Use a limit switch or other sensor to detect a dangerous condition and, if necessary, design the program to stop the robot when the sensor signal is received.
(2) Design the program to stop the robot when an abnormal condition occurs in any other robots or peripheral devices, even though the robot itself is normal.
(3) For a system in which the robot and its peripheral devices are in synchronous motion, particular care must be taken in programming so that they do not interfere with each other.
(4) Provide a suitable interface between the robot and its peripheral devices so that the robot can detect the states of all devices in the system and can be stopped according to the states.

4.2 PRECAUTIONS FOR MECHANISM

(1) Keep the component cells of the robot system clean, and operate the robot in an environment free of grease, water, and dust.
(2) Don’t use unconfirmed liquid for cutting fluid and cleaning fluid.
(3) Employ a limit switch or mechanical stopper to limit the robot motion so that the robot or cable does not strike against its peripheral devices or tools.
(4) Observe the following precautions about the mechanical unit cables. When theses attentions are not kept, unexpected troubles might occur.
   - Use mechanical unit cable that have required user interface.
   - Don’t add user cable or hose to inside of mechanical unit.
   - Please do not obstruct the movement of the mechanical unit cable when cables are added to outside of mechanical unit.
   - In the case of the model that a cable is exposed, Please do not perform remodeling (Adding a protective cover and fix an outside cable more) obstructing the behavior of the outcrop of the cable.
   - Please do not interfere with the other parts of mechanical unit when install equipments in the robot.
(5) The frequent power-off stop for the robot during operation causes the trouble of the robot. Please avoid the system construction that power-off stop would be operated routinely. (Refer to bad case example.) Please execute power-off stop after reducing the speed of the robot and stopping it by hold stop or cycle stop when it is not urgent. (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type.)
   (Bad case example)
   - Whenever poor product is generated, a line stops by emergency stop.
   - When alteration was necessary, safety switch is operated by opening safety fence and power-off stop is executed for the robot during operation.
   - An operator pushes the emergency stop button frequently, and a line stops.
   - An area sensor or a mat switch connected to safety signal operate routinely and power-off stop is executed for the robot.
(6) Robot stops urgently when collision detection alarm (SRVO-050) etc. occurs. The frequent urgent stop by alarm causes the trouble of the robot, too. So remove the causes of the alarm.

5 SAFETY OF THE ROBOT MECHANISM

5.1 PRECAUTIONS IN OPERATION

(1) When operating the robot in the jog mode, set it at an appropriate speed so that the operator can manage the robot in any eventuality.
(2) Before pressing the jog key, be sure you know in advance what motion the robot will perform in the jog mode.

5.2 PRECAUTIONS IN PROGRAMMING

(1) When the work areas of robots overlap, make certain that the motions of the robots do not interfere with each other.
(2) Be sure to specify the predetermined work origin in a motion program for the robot and program the motion so that it starts from the origin and terminates at the origin.
Make it possible for the operator to easily distinguish at a glance that the robot motion has terminated.

5.3 PRECAUTIONS FOR MECHANISMS

(1) Keep the work areas of the robot clean, and operate the robot in an environment free of grease, water, and dust.

5.4 PROCEDURE TO MOVE ARM WITHOUT DRIVE POWER IN EMERGENCY OR ABNORMAL SITUATIONS

For emergency or abnormal situations (e.g. persons trapped in or by the robot), brake release unit can be used to move the robot axes without drive power.
Please refer to controller maintenance manual and mechanical unit operator’s manual for using method of brake release unit and method of supporting robot.

6 SAFETY OF THE END EFFECTOR

6.1 PRECAUTIONS IN PROGRAMMING

(1) To control the pneumatic, hydraulic and electric actuators, carefully consider the necessary time delay after issuing each control command up to actual motion and ensure safe control.
(2) Provide the end effector with a limit switch, and control the robot system by monitoring the state of the end effector.

7 STOP TYPE OF ROBOT

The following three robot stop types exist:

Power-Off Stop (Category 0 following IEC 60204-1)

Servo power is turned off and the robot stops immediately. Servo power is turned off when the robot is moving, and the motion path of the deceleration is uncontrolled.
The following processing is performed at Power-Off stop.

- An alarm is generated and servo power is turned off.
- The robot operation is stopped immediately. Execution of the program is paused.

Controlled stop (Category 1 following IEC 60204-1)

The robot is decelerated until it stops, and servo power is turned off.
The following processing is performed at Controlled stop.

- The alarm "SRVO-199 Controlled stop" occurs along with a decelerated stop. Execution of the program is paused.
- An alarm is generated and servo power is turned off.

Hold (Category 2 following IEC 60204-1)

The robot is decelerated until it stops, and servo power remains on.
The following processing is performed at Hold.

- The robot operation is decelerated until it stops. Execution of the program is paused.

> ⚠ **WARNING**
> The stopping distance and stopping time of Controlled stop are longer than the stopping distance and stopping time of Power-Off stop. A risk assessment for the whole robot system, which takes into consideration the increased stopping distance and stopping time, is necessary when Controlled stop is used.

When the emergency stop button is pressed or the FENCE is open, the stop type of robot is Power-Off stop or Controlled stop. The configuration of stop type for each situation is called *stop pattern*. The stop pattern is different according to the controller type or option configuration.

There are the following 3 Stop patterns.

Stop pattern	Mode	Emergency stop button	External Emergency stop	FENCE open	SVOFF input	Servo disconnect
A	AUTO	P-Stop	P-Stop	C-Stop	C-Stop	P-Stop
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
B	AUTO	P-Stop	P-Stop	P-Stop	P-Stop	P-Stop
	T1	P-Stop	P-Stop	-	P-Stop	P-Stop
	T2	P-Stop	P-Stop	-	P-Stop	P-Stop
C	AUTO	C-Stop	C-Stop	C-Stop	C-Stop	C-Stop
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop

P-Stop: Power-Off stop
C-Stop: Controlled stop
-: Disable

The following table indicates the Stop pattern according to the controller type or option configuration.

Option	R-30*i*B
Standard	A (*)
Controlled stop by E-Stop (A05B-2600-J570)	C (*)

(*) R-30*i*B does not have servo disconnect.

The stop pattern of the controller is displayed in "Stop pattern" line in software version screen. Please refer to "Software version" in operator's manual of controller for the detail of software version screen.

"Controlled stop by E-Stop" option

When "Controlled stop by E-Stop" (A05B-2600-J570) option is specified, the stop type of the following alarms becomes
Controlled stop but only in AUTO mode. In T1 or T2 mode, the stop type is Power-Off stop which is the normal operation of the system.

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open. (R-30*i*B controller)
SRVO-218 Ext.E-stop/Servo Disconnect	External emergency stop input (EES1-EES11, EES2-EES21) is open. (R-30*i*B controller)
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.

Controlled stop is different from Power-Off stop as follows:

- In Controlled stop, the robot is stopped on the program path. This function is effective for a system where the robot can interfere with other devices if it deviates from the program path.
- In Controlled stop, physical impact is less than Power-Off stop. This function is effective for systems where the physical impact to the mechanical unit or EOAT (End Of Arm Tool) should be minimized.
- The stopping distance and stopping time of Controlled stop is longer than the stopping distance and stopping time of Power-Off stop, depending on the robot model and axis. Please refer to the operator's manual of a particular robot model for the data of stopping distance and stopping time.

When this option is loaded, this function cannot be disabled.

The stop type of DCS Position and Speed Check functions is not affected by the loading of this option.

> ⚠ **WARNING**
> The stopping distance and stopping time of Controlled stop are longer than the stopping distance and stopping time of Power-Off stop. A risk assessment for the whole robot system, which takes into consideration the increased stopping distance and stopping time, is necessary when this option is loaded.

PREFACE

1 OVERVIEW

This manual describes the maintenance and connections for the following sensors:

Mechanical section	Ordering information
Force Sensor FS-15*i*A (Rated 15kgf)	A05B-1407-B002
Force Sensor FS-40*i*A (Rated 40kgf)	A05B-1407-B101
Force Sensor FS-100*i*A (Rated 100kgf)	A05B-1407-B201
Force Sensor FS-250*i*A (Rated 255kgf)	A05B-1407-B301
3-axis force sensor FS-15***i***Ae (Rated 15kgf)	A05B-1421-B001
3D Laser Vision Sensor	A05B-1405-B131
Camera package (standard camera)	A05B-1408-B101
Camera package (double speed camera)	A05B-1408-B111
3D Area Sensor	A05B-1422- B101

Refer to the manual of the mechanical unit for each robot model.

2 SAFETY INSTRUCTIONS FOR 3D LASER VISION SENSOR

3D Laser Vision Sensor systems detect the position orientation of an object using a semiconductor laser.

Safety guidelines and measures conforming to national and regional safety standards and regulations should be established and exercised to ensure the safety of personnel using the sensor system. Ensure that changes in related safety standards and regulations are incorporated into the established guidelines and measures.

The class is using this sensor.

Semiconductor laser → class 3R laser
(IEC Pub. 60825-1/JIS C 6802)
Class IIIa laser (FDA Pub. 1040.10)

2.1 LASER LIGHT

The semiconductor laser emits visible light with a wavelength of 0.65 μm. Although the maximum output of the laser is 4.5 mWx2, care is nevertheless necessary when handling the laser sensor. Always observe the following:

(1) Never look directly at the laser light.
(2) Avoid looking at diffused laser light for extended periods.

2.2 EMISSION PATH

Laser light is generated by the semiconductor element of the laser module. It is emitted from the front of the sensor.

2.3 MAINTENANCE AND CONNECTION

Turning off the 3D Laser Vision Sensor
Semiconductor laser light, either direct or diffused, is hazardous. Over exposure to laser light can cause serious eye damage.
When performing maintenance or connection work, turn off the laser output, double-checking that it has been turned off before entering the robot operation area.

(1) Turn off the robot controller power if you are not operating the robot.
(2) To view programs and data from the teach pendant, press the EMERGENCY STOP button or turn off the ENBL signal for peripheral equipment control interface A. This disables the robot.

2.4 WARNING LABELS

Warning labels are affixed to all sections of the 3D Laser Vision Sensor system where laser light radiation can be expected. Warning labels conforming to U.S. FDA, standards are available as options.

Fig. 2.4 (a) shows the locations where warning labels are affixed. Figs. 2.4 (b) and (c) show the warning labels affixed to the laser sensor.

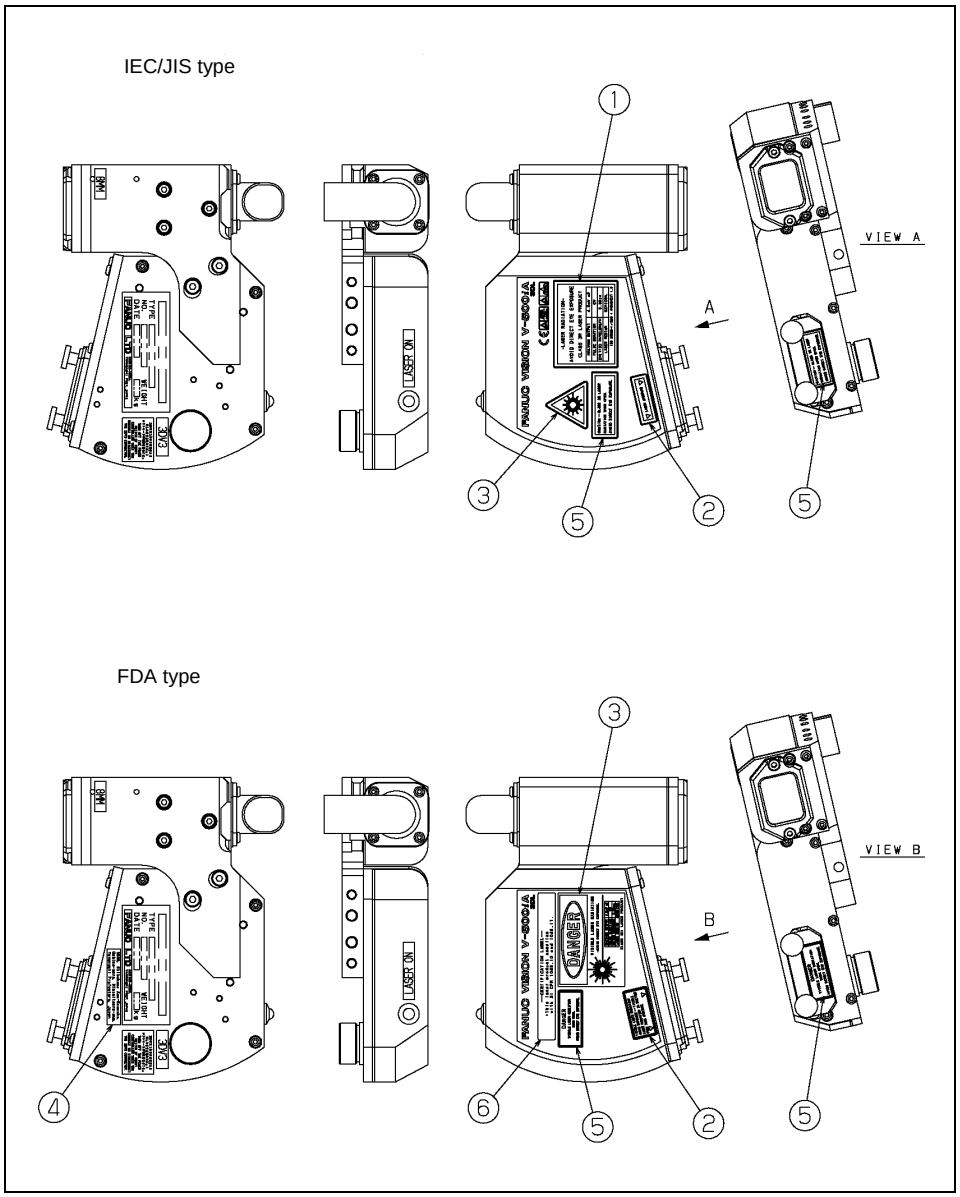


Fig. 2.4 (a) Locations of warning labels (IEC, JIS, and FDA) standard

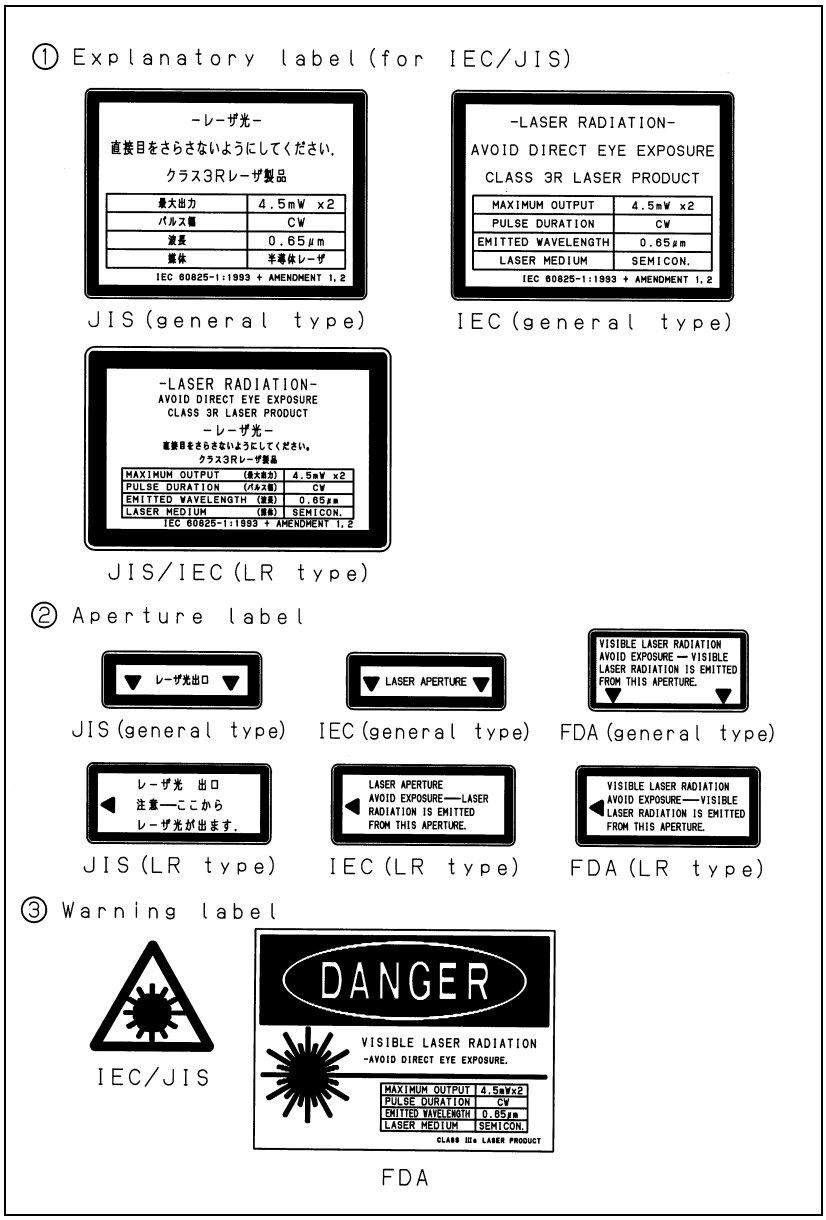


Fig. 2.4 (b) Warning label (1)

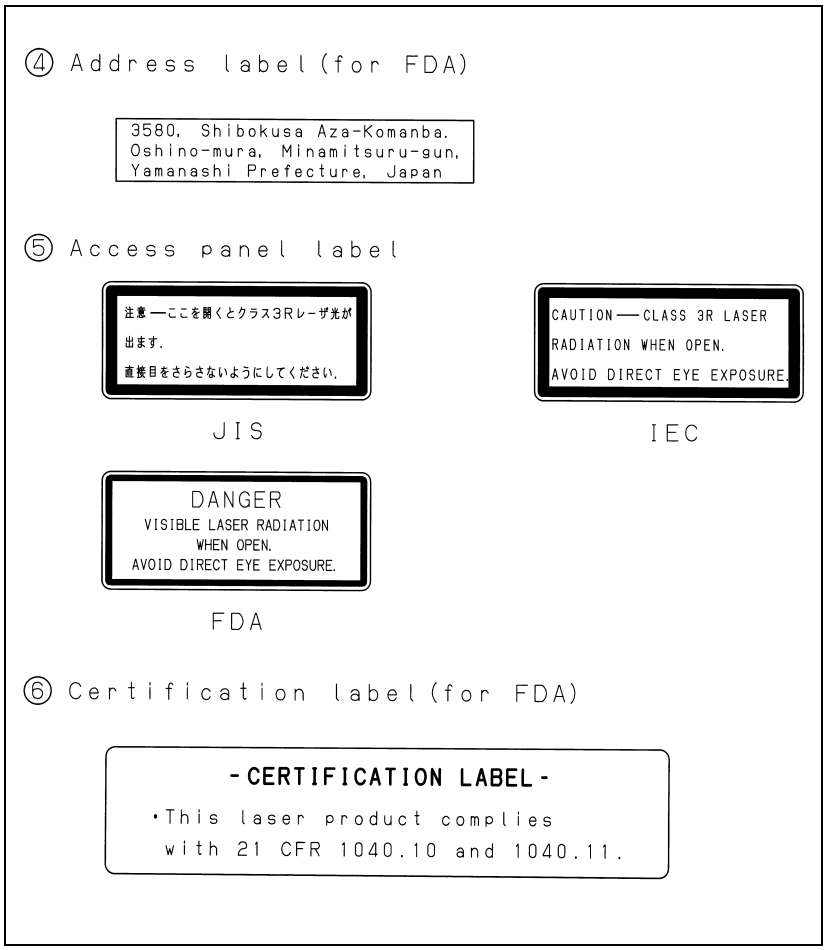


Fig. 2.4 (c) Warning label (2)

2.5 BEAM STOPS

The 3D Laser Vision Sensor has two beam stops to protect operator's eyes from laser beams.

Beam stop 1

When the target application requires no 3D Laser Vision Sensor, attach beam stop 1 to the opening of the 3D Laser Vision Sensor.
Before using the 3D Laser Vision Sensor, detach beam stop 1.

Beam stop 2

Beam stop 2 is a projector cover.
Do not detach beam stop 2 from the base plate of the 3D Laser Vision Sensor.

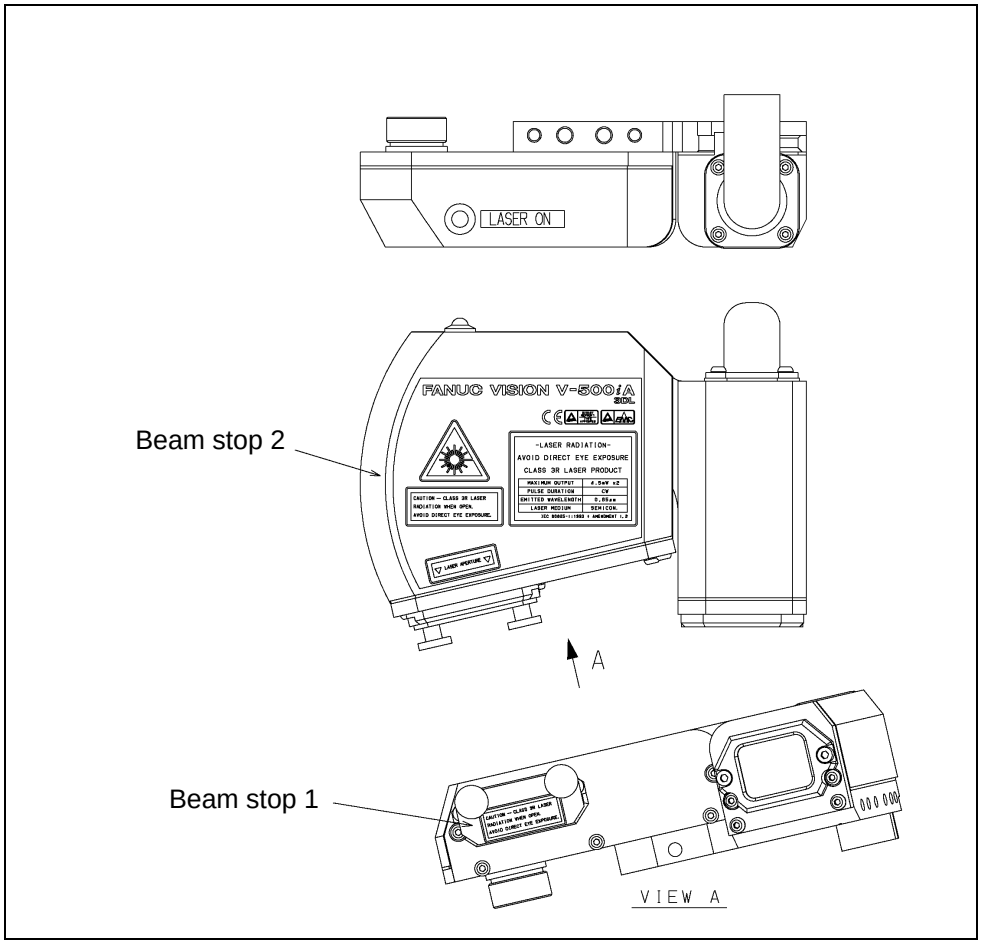


Fig. 2.5 Beam stop (Standard)

2.6 RELATED MANUALS

R-30*i*B CONTROLLER OPERATOR'S MANUAL (Basic Operation) B-83284EN

This is the main manual of R-30*i*B Controller. This manual describes the following items for manipulating workpieces with the robot:

- Setting the system for manipulating workpieces
- Operating the robot
- Creating and changing a program
- Executing a program

- Status indications
- Backup and restore robot programs.

This manual is used on an applicable design, robot installation, robot teaching.

R-30*i*B CONTROLLER MAINTENANCE MANUAL B-83195EN

This manual describes the maintenance and connection of R-30*i*B Controller.

R-30*i*B CONTROLLER OPERATOR'S MANUAL (Alarm Code List) B-83284EN-1

This manual describes the error code listings, causes, and remedies of R-30*i*B Controller.

R-30*i*B CONTROLLER OPERATOR'S MANUAL (Reference) B-83304EN

This manual is the reference manual for ***i***RVision on the R-30***i***B controller. This manual describes each functions which are provided by ***i***RVision. This manual describes the meanings (e.g. the items on ***i***RVision setup screen, the arguments of the instruction, and so on.

R-30*i*B CONTROLLER *i*RVision 2D Vision Application OPERATOR'S MANUAL B-83304EN-1

This manual is desired to first refer to when you start up systems of *i*RVision 2D Compensation and 2.5D Compensation. This manual describes startup procedures of *i*RVision 2D Compensation and 2.5D Compensation system, creating programs, caution, technical know-how, responce to several cases, and so on.

R-30*i*B CONTROLLER *i*RVision 3D Laser Vision Sensor Application OPERATOR'S MANUAL B-83304EN-2

This manual is desired to first refer to when you start up systems of *i*RVision 3D Laser Sensor Compensation. This manual describes startup procedures of *i*RVision 3D Laser Sensor Compensation, creating programs, caution, technical know-how, responce to several cases, and so on.

R-30*i*B CONTROLLER *i*RVision Inspection Application OPERATOR'S MANUAL B-83304EN-3

This manual is desired to first refer to when you start up systems of inspection which uses *i*RVision.

This manual describes startup procedures of inspection system which uses *i*RVision, creating programs, caution, technical know-how, responce to several cases, and so on.

R-30*i*B CONTROLLER *i*RVision Visual Tracking Application OPERATOR'S MANUAL B-83304EN-4

This manual is desired to first refer to when you start up systems of *i*RVision Visual Tracking. This manual describes startup procedures of *i*RVision Visual Tracking system, creating programs, caution, technical know-how, responce to several cases, and so on.

R-30*i*B CONTROLLER *i*RVision Bin Picking Application OPERATOR'S MANUAL B-83304EN-5

This manual is desired to first refer to when you start up systems of *i*RVision Bin Picking.
This manual describes startup procedures of *i*RVision Bin Picking system, creating programs, caution, technical know-how, responce to several cases, and so on.

R-30*i*B CONTROLLER FORCE SENSOR OPERATOR'S MANUAL B-83424EN

This manual is desired to first refer to when you start up systems of precise fitting, grinding and deburring with force sensor.

TABLE OF CONTENTS

1 TRANSPORTATION AND INSTALLATION REQUIREMENTS

1.1 TRANSPORTATION

For the other cautions related to transportation, refer to mechanical unit manuals for each robot.

Caution

For transport, cover the sensor head section with an air cap, or the like, to protect the sensor, as shown in Fig. 1.1.

NOTE

To transport over a long distance, avoid keeping the hand and other parts mounted on the force sensor as much as possible, as vibration that occurs during transportation might damage the force sensor.

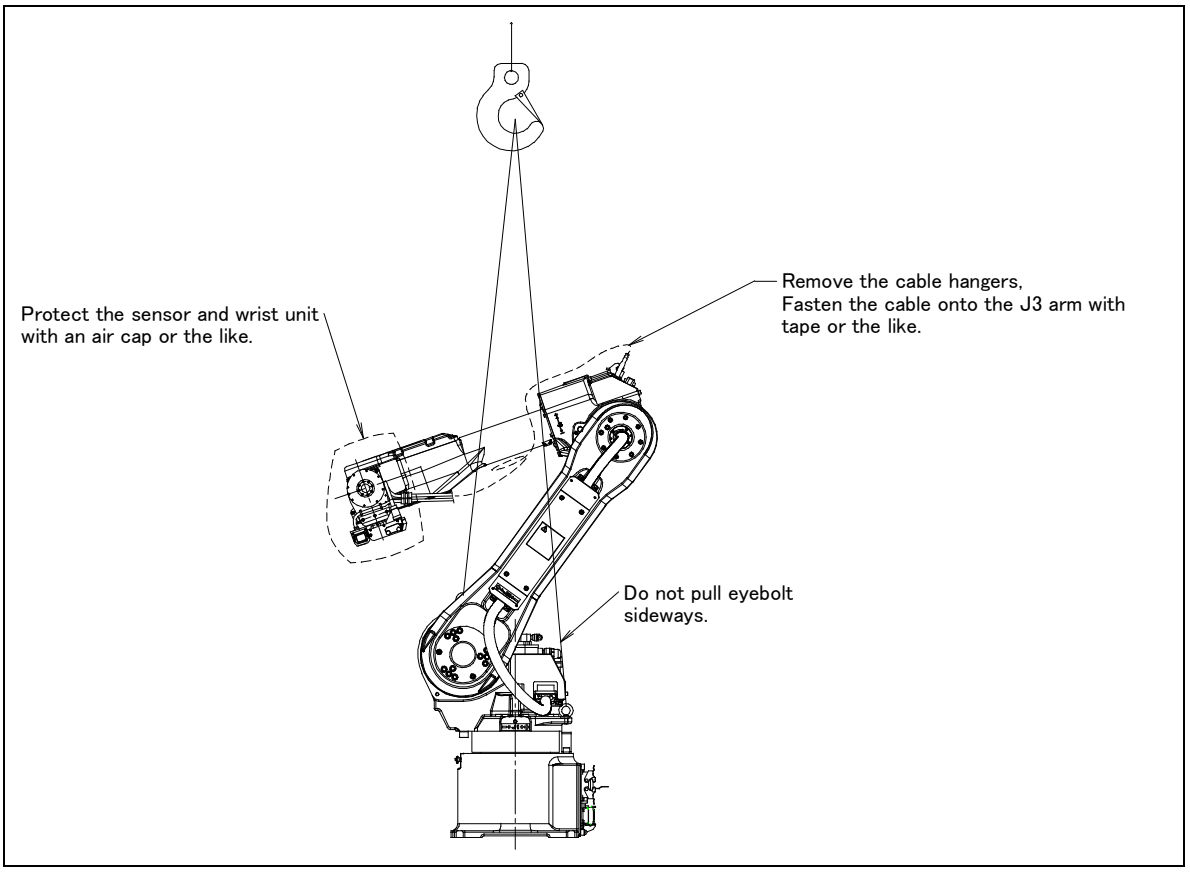


Fig. 1.1 Caution of transportation posture

1.2 INSTALLATION REQUIREMENTS

Table 1.2 lists the installation requirements of the force sensor , 3D Laser Vision sensor , camera package and 3D Area Sensor.

Table 1.2 Installation requirements

Item	Requirements
Allowable ambient temperature range	0 to 45°C
Allowable ambient humidity range	Regular use: Relative humidity of 75% or less with no condensation Short-period use (within one month): Relative humidity of 95% or less with no condensation
Atmosphere	No corrosive gas (*2)
Vibration	0.5 G or less

NOTE
Before trying to use the robot in an environment in which it might be subjected to vibration or there are lots of dust and cutting fluid mist, contact FANUC.

2 CONFIGURATION

2.1 CONFIGURATION OF THE FORCE SENSOR AND 3D LASER VISION SENSOR

When provided with a force sensor and 3D Laser Vision Sensor, the robot is usually configured by combining the sensors with the mechanical unit and controller of the robot.

The total system is then configured as a combination of the robot, a peripheral device, and an external controller.

Fig. 2.1 (a) shows the configuration of the robot loaded with the force sensor and 3D Laser Vision Sensor.
Fig. 2.1 (b) shows the configuration of the robot loaded with the camera package as hand camera.

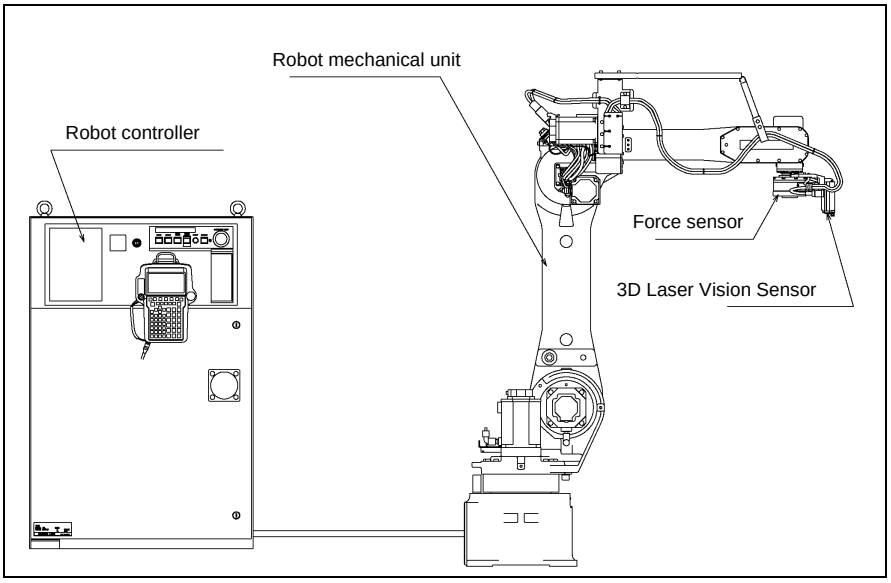


Fig. 2.1 (a) Configuration of the robot loaded with the force sensor and 3D Laser Vision Sensor

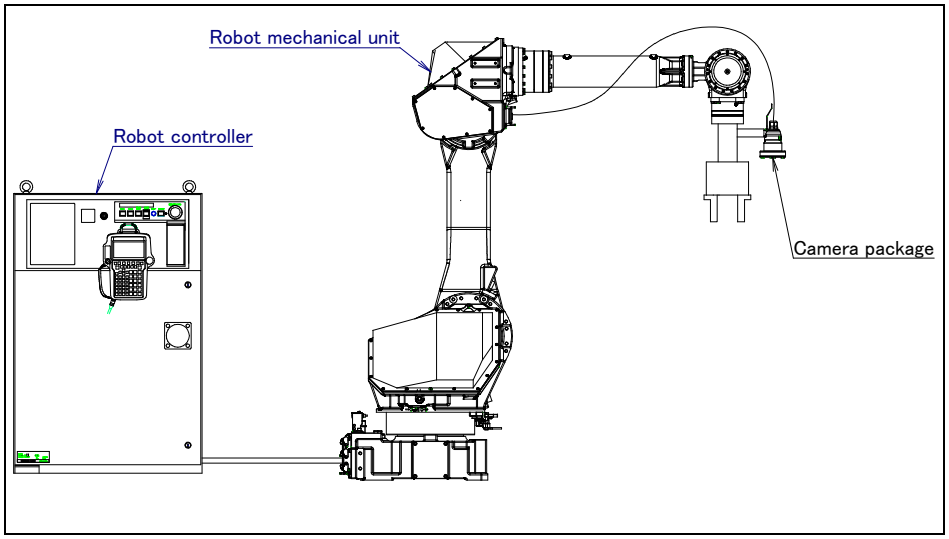


Fig. 2.1 (b) Configuration of the robot loaded with the camera package

2.2 CONFIGURATION OF THE FORCE SENSOR MECHANICAL SECTION

The force sensor consists of a sensor head, sensor adapter, and sensor cable.

The sensor head consists of a load support, fixed portion, and electronic circuit (head PCB).

The sensor adapter electrically isolates the sensor head from the robot main body to protect against noise from the robot main body.

The sensor cable is a shielded, twisted-multiple-conductor cable having a high noise resistance.

Fig. 2.2 shows the configuration of the force sensor head.

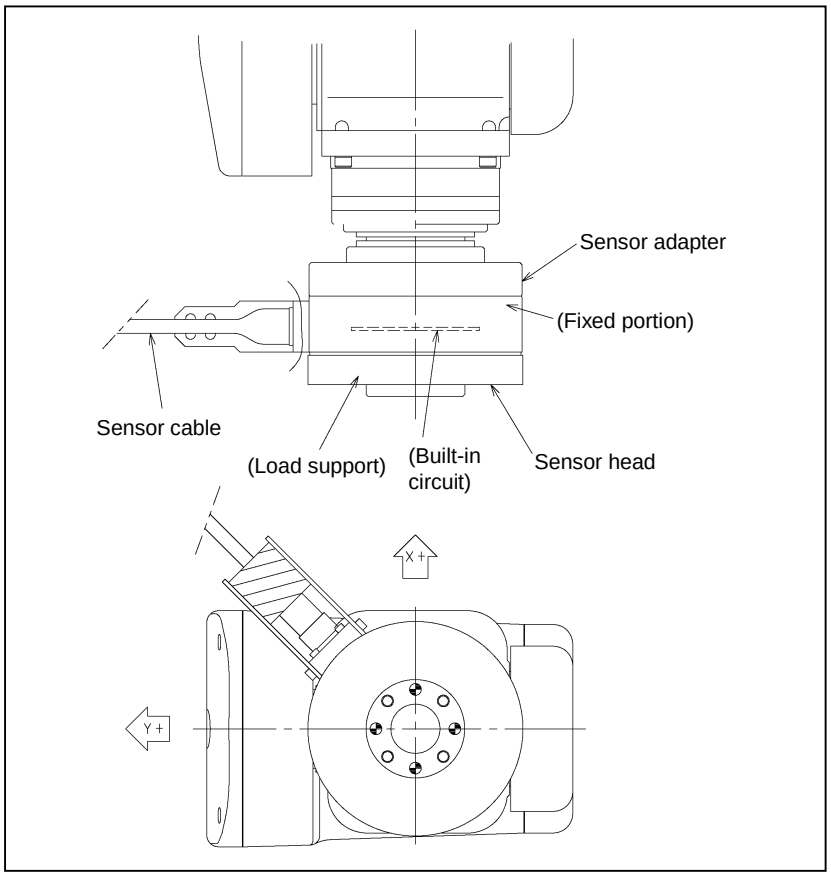


Fig. 2.2 Configuration of the force sensor head

2.3 CONFIGURATION OF THE 3D LASER VISION SENSOR MECHANICAL SECTION

The 3D Laser Vision Sensor consists of a sensor head, sensor cable and camera cable.

The sensor head and robot main body are linked with the sensor adapter, but electrically isolated from each other with an insulating member in the sensor adapter.

Fig. 2.3 shows the configuration of the 3D Laser Vision Sensor.

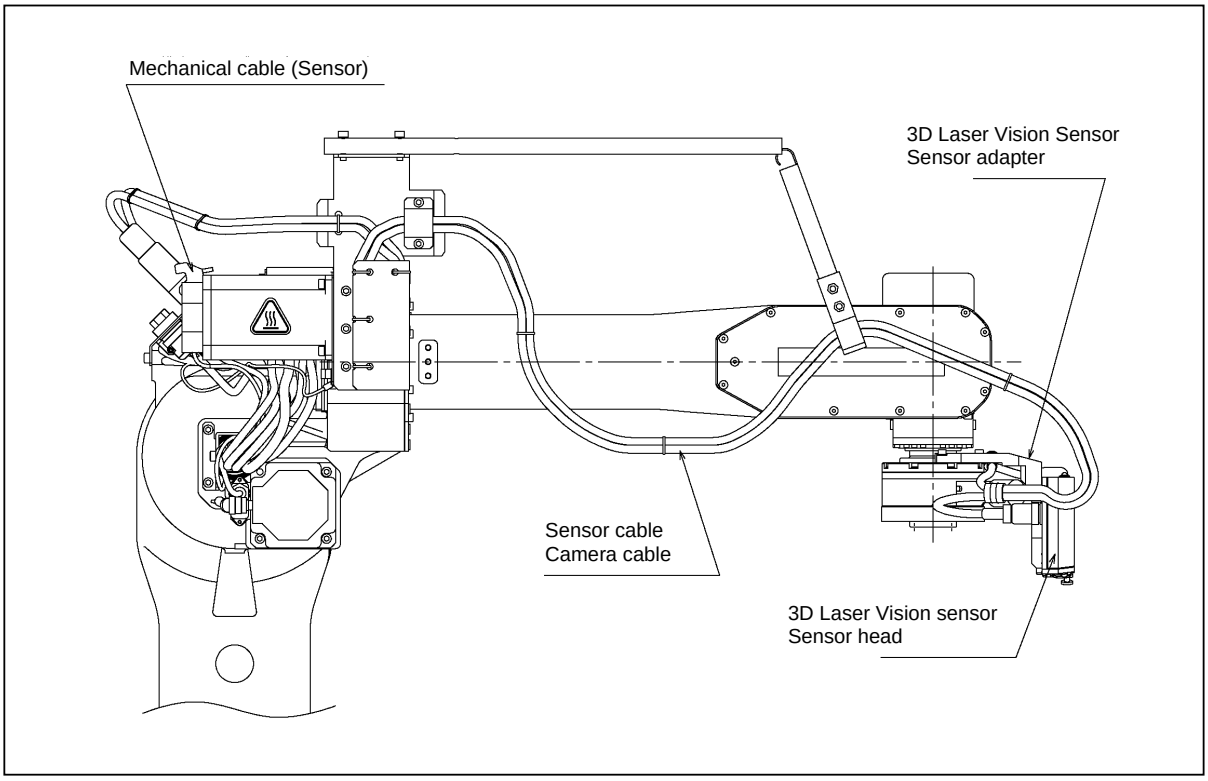


Fig. 2.3 (a) Configuration of the 3D Laser Vision Sensor

Configuration of 3D the Laser Vision Sensor head

The 3D Laser Vision Sensor head mainly consists of a laser projector, light receiving device, PCB in the sensor head, base plate and cover. It consists of the laser projector unit and the light receiving unit.

Fig. 2.3.1 shows the configuration of the 3D Laser Vision Sensor head.

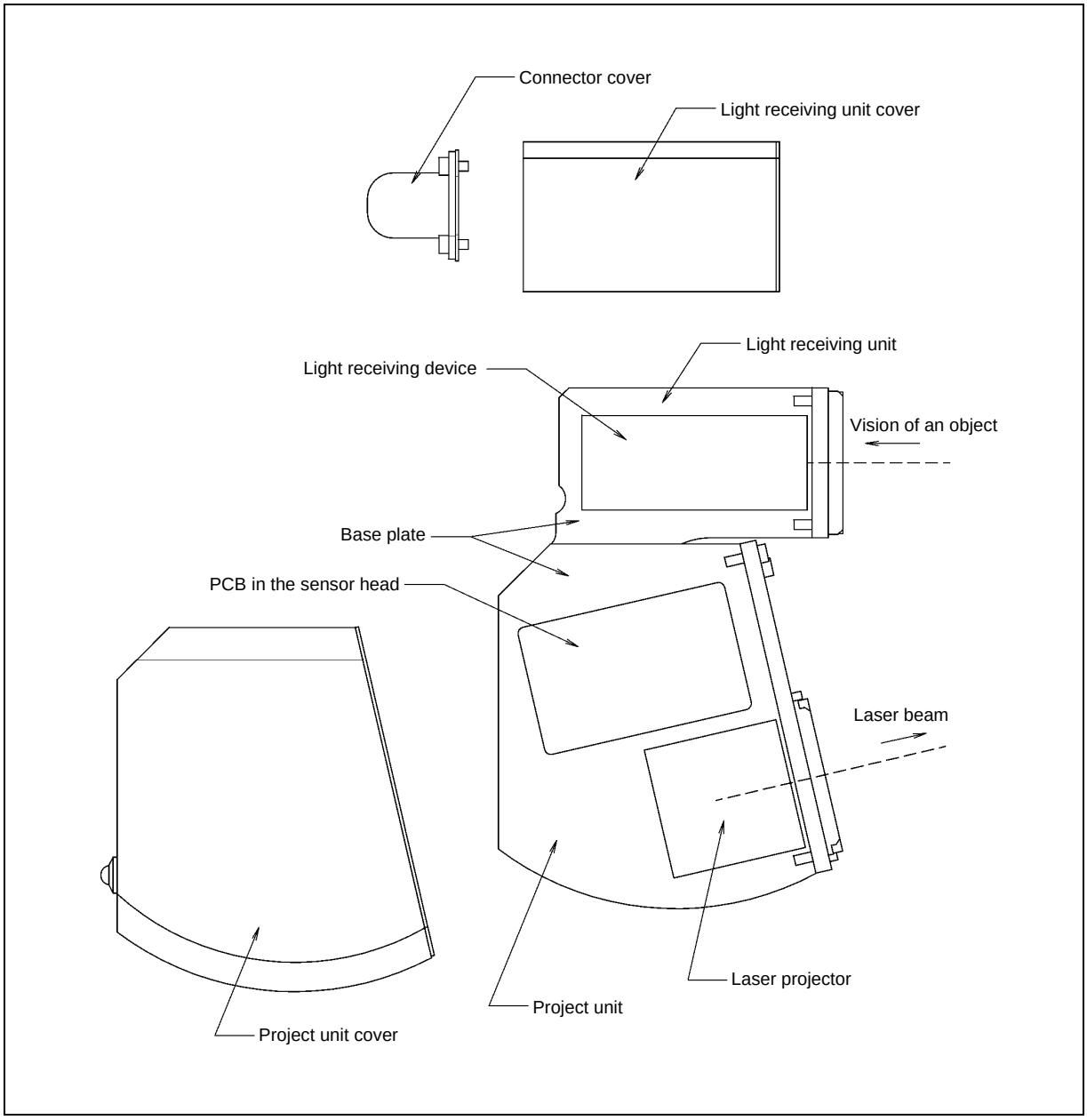


Fig. 2.3 (b) Configuration of the 3D Laser Vision Sensor Head (standard)

2.4 CONFIGURATION OF THE CAMERA PACKAGE

Camera package is composed of sensor head and camera cable.

When sensor head of camera package is set up as hand camera, install it to the hand of the robot wrist. Fig.2.4 (a) shows the configuration of camera package (hand camera).

When sensor head of camera package is set up as fixed camera, prepare trestle and install to it. Fig.2.4 (b) shows the configuration of camera package (Fixed installation).

Take measures to electrically isolate the sensor head from for the robot or the trestle. In addition, verify the sensor head is electrically isolated from the earth cable for the robot controller.

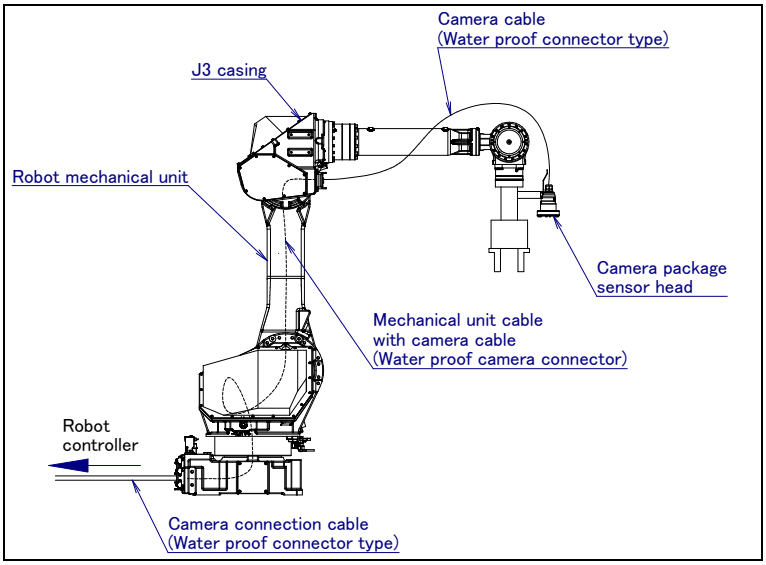


Fig.2.4 (a) Configuration of camera package (hand camera)

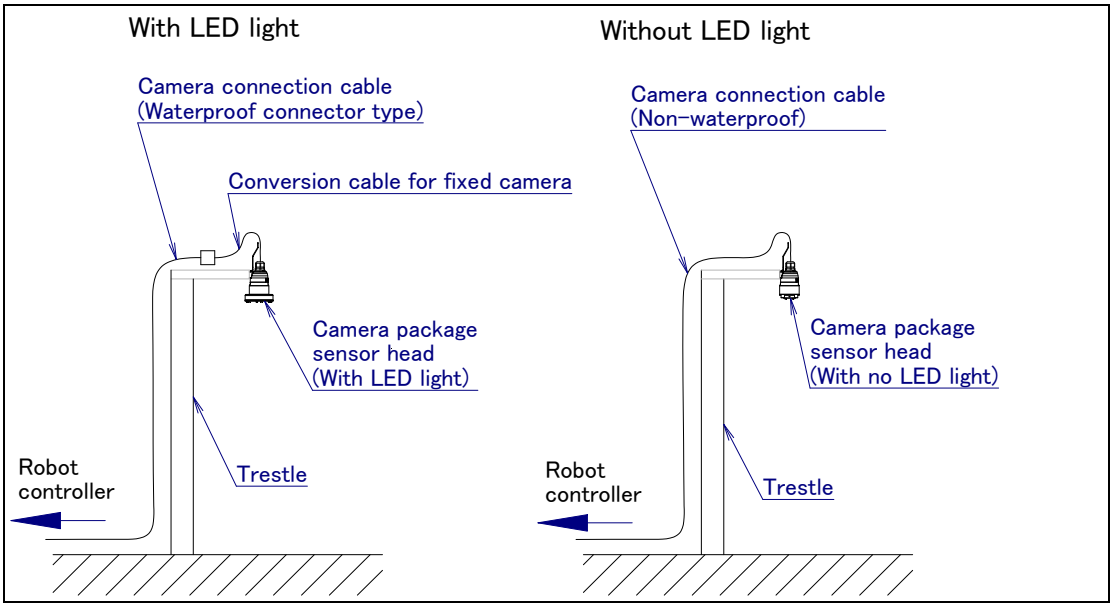


Fig.2.4 (b) Configuration of camera package (fixed camera)

Configuration of Sensor Head of camera package

The sensor head is composed of CCD camera, lens, cover and LED light.
The front adaptor is installed when there is no LED light installed.
Fig.2.4 (c) shows the configuration of camera package.

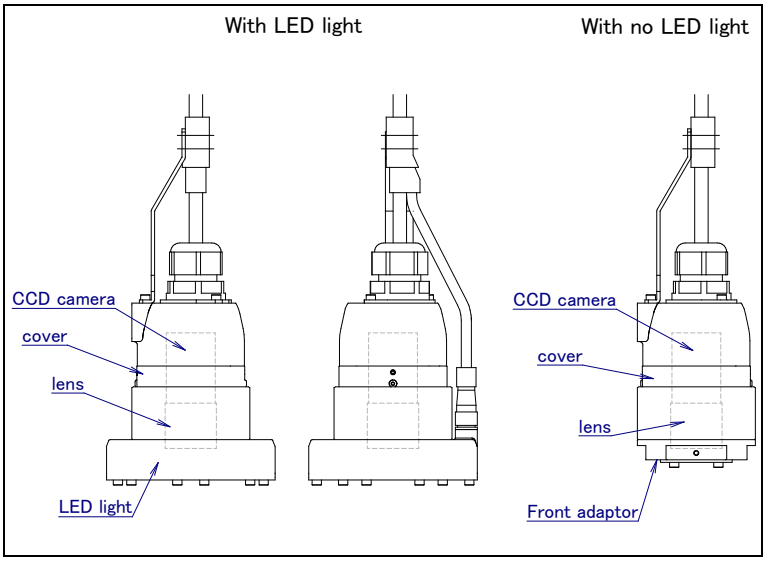


Fig.2.4 (c) Configuration of sensor head of camera package

2.5 CONFIGURATION OF 3D AREA SENSOR

3D Area Sensor is composed of projector unit and camera unit. Install projector unit and camera unit with a trestle.
Fig 2.5 (a) shows the configuration of 3D Area Sensor.

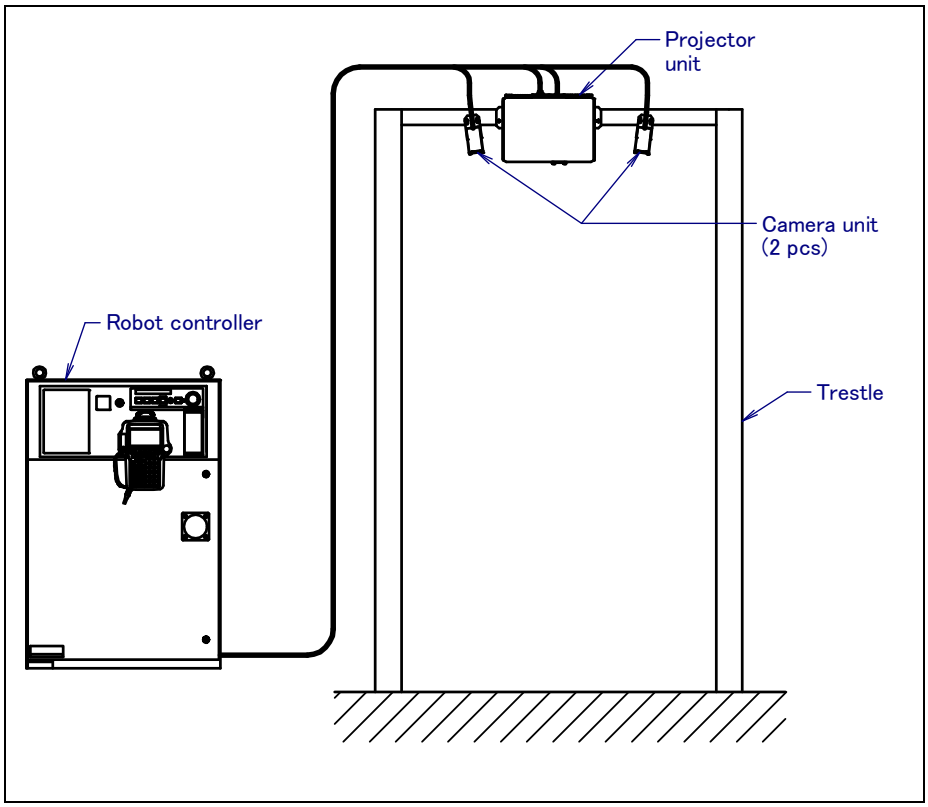


Fig.2.5 (a) Configuration of 3D area sensor

Configuration of 3D Area Sensor projector unit

Projector unit is composed of case, cover and adapter. Lower side of the projector, window is fixed by the window holder, light is thrown from here. The top surface has power connector and signal connector. In case of using projector front lens kit, substitute lens and lens holder for window holder.
Fig.2.5 (b) shows the configuration of the projector unit.

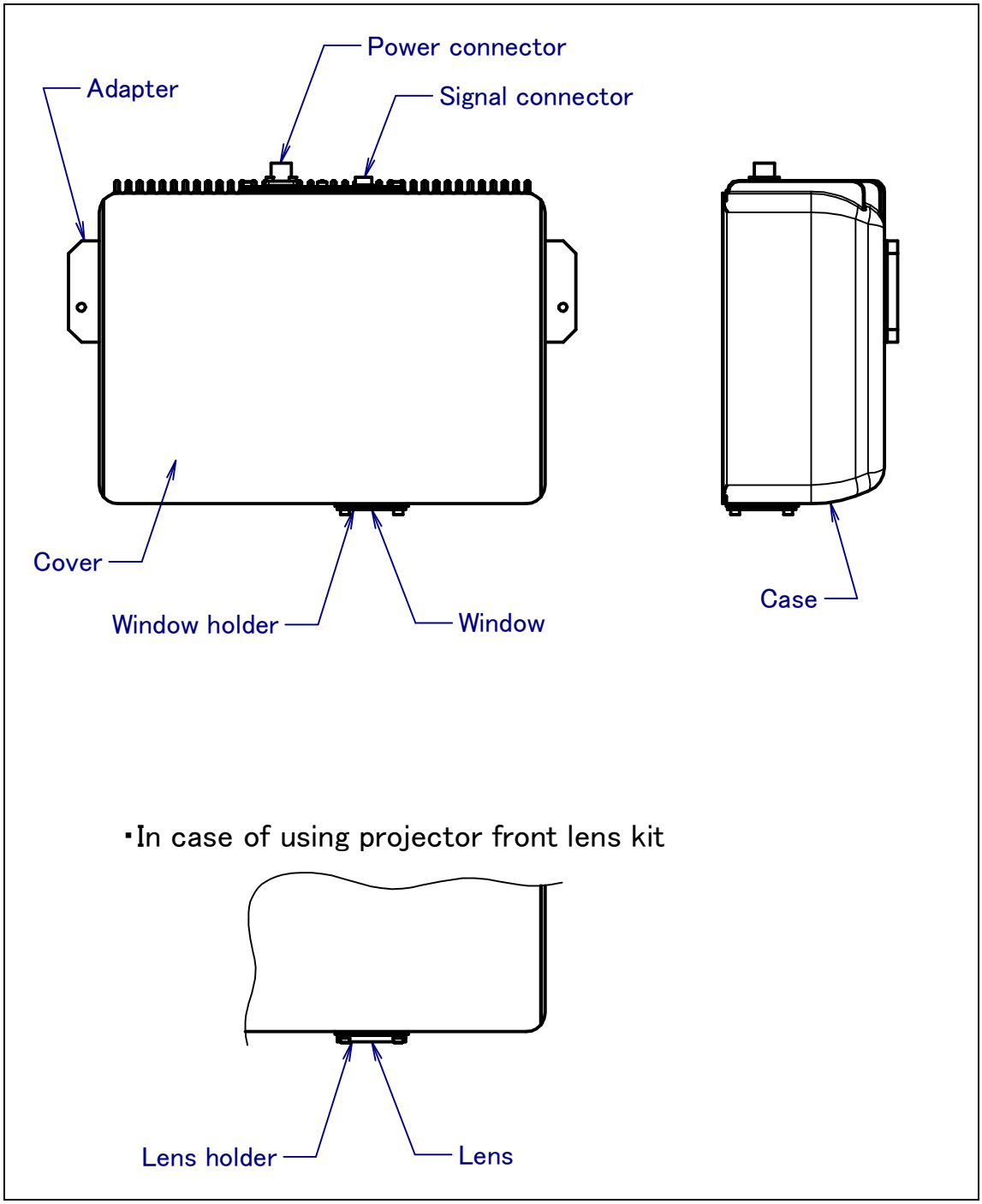


Fig.2.5 (b) Configuration of 3D area sensor projector unit

Configuration of the 3D Area Sensor camera unit

Camera unit is composed of CCD camera, lens and cover.
Fig 2.5 (c) shows the configuration of the camera unit.

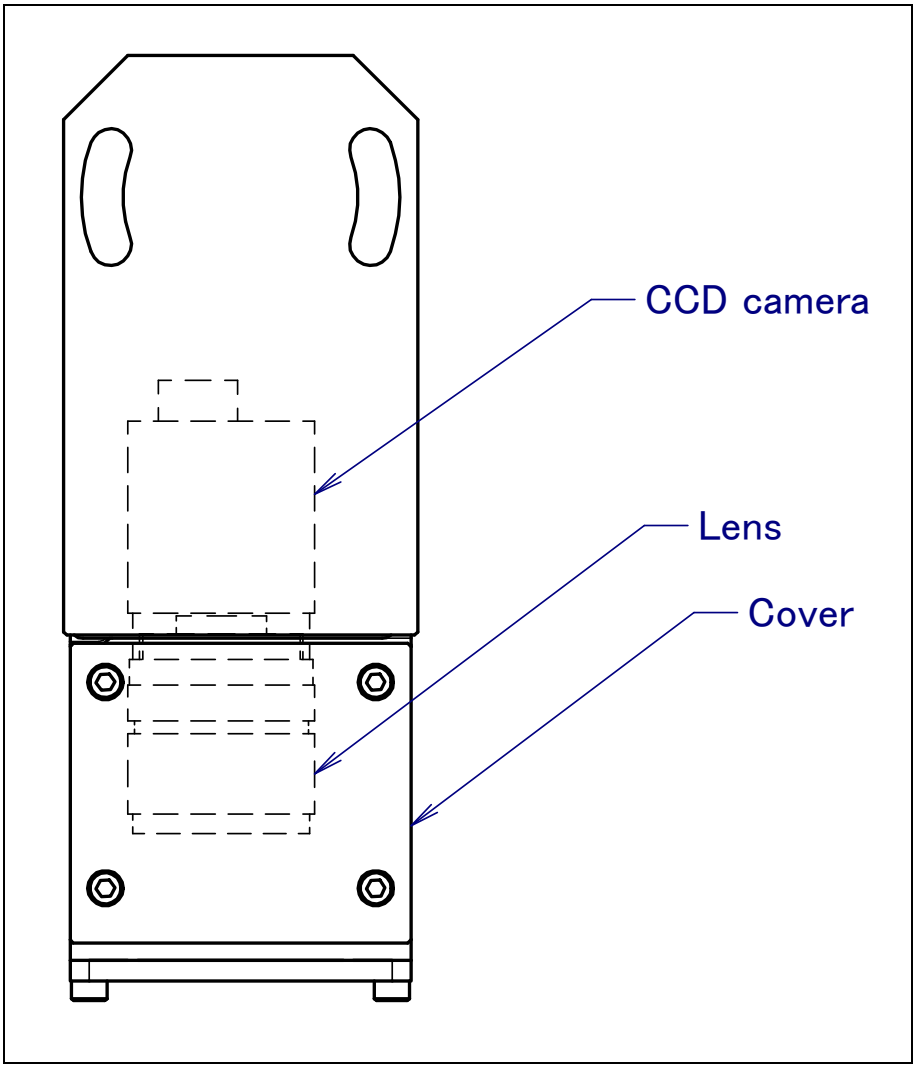


Fig.2.5 (c) Configuration of 3D area sensor camera unit

2.6 CONFIGURATION OF THE FORCE SENSOR CONTROLLER

2.6.1 Camera Connection Cable (A-cabinet)

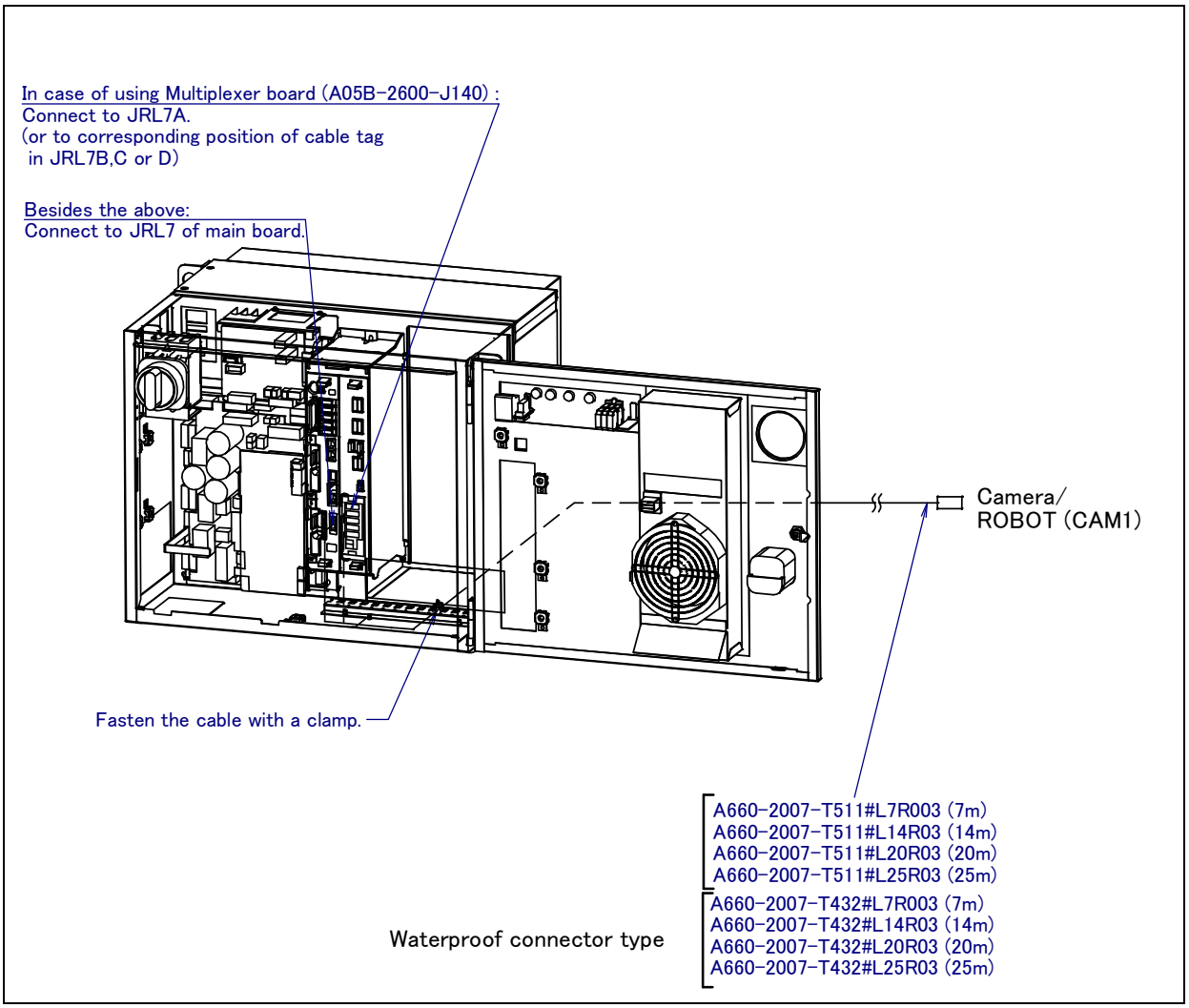


Fig. 2.6.1 (a) Camera connection cable (analog camera connection cable)

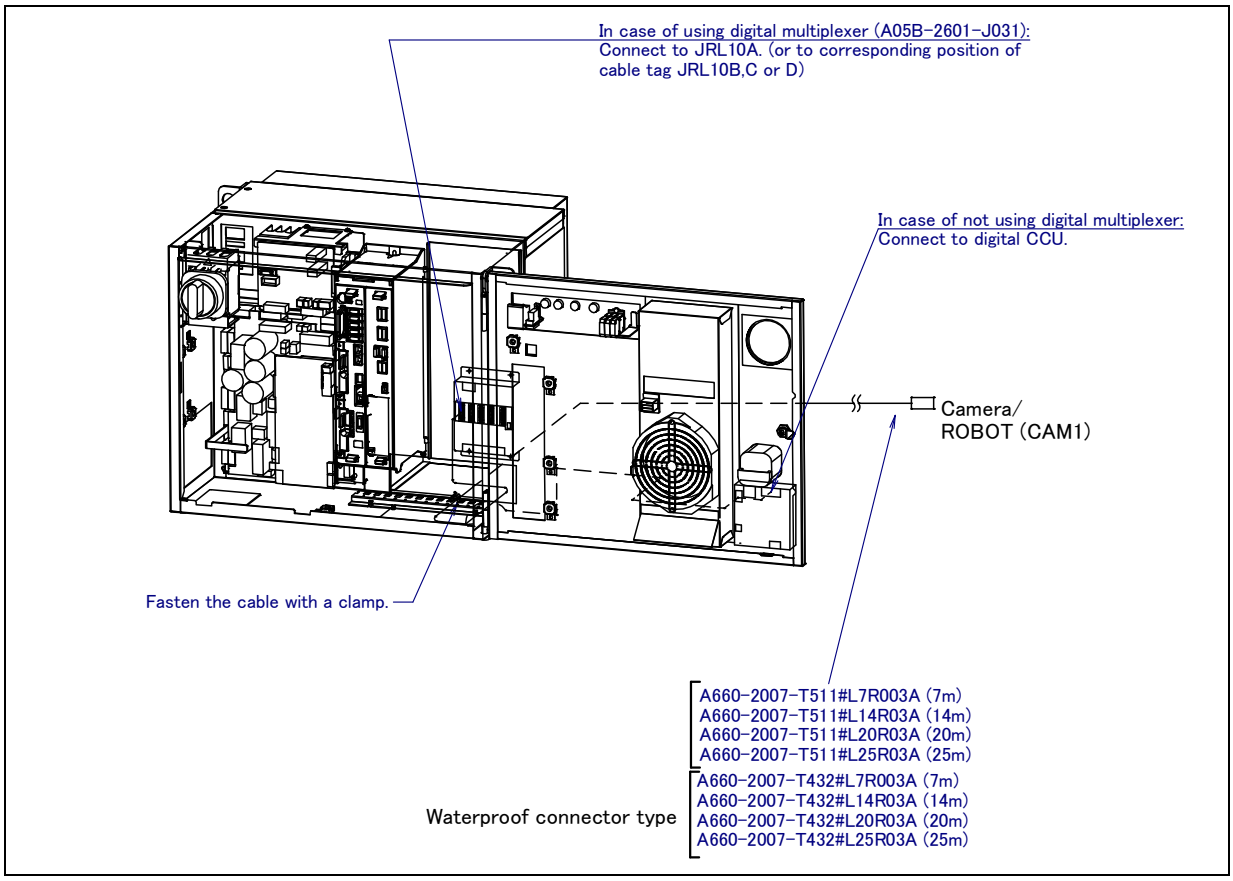


Fig. 2.6.1 (b) Camera connection cable
(digital camera connection cable, digital CCU, digital camera multiplexer in main box)

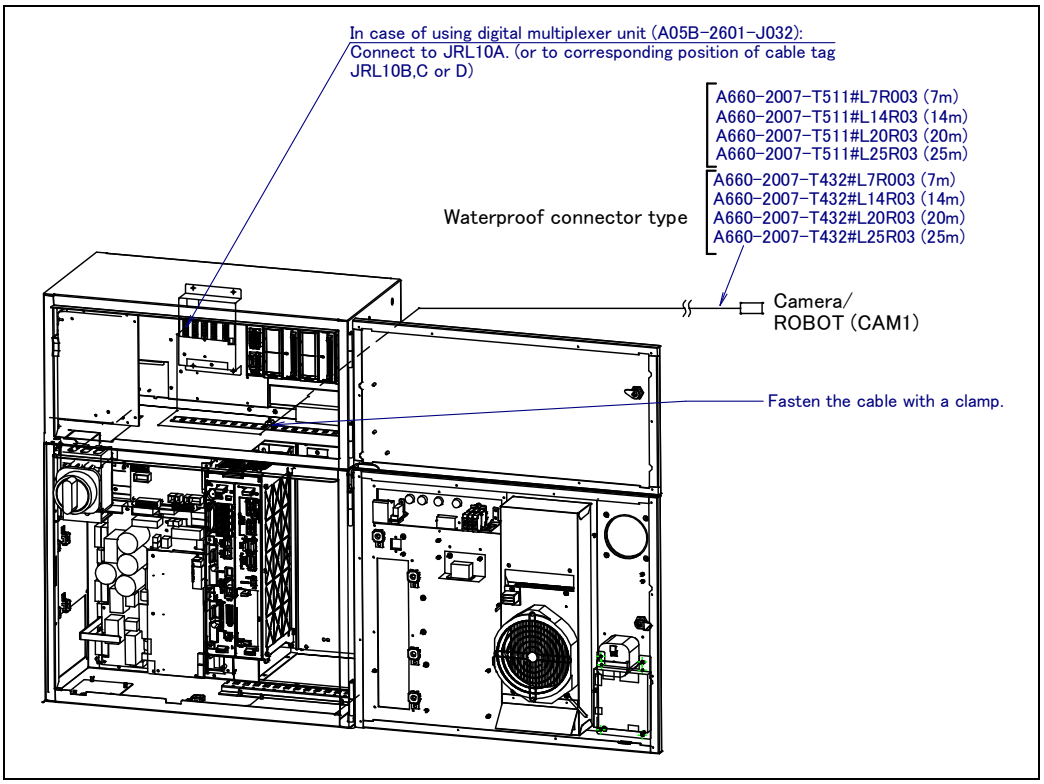


Fig. 2.6.1 (c) Camera connection cable
(digital camera connection cable, digital camera multiplexer in top process box)

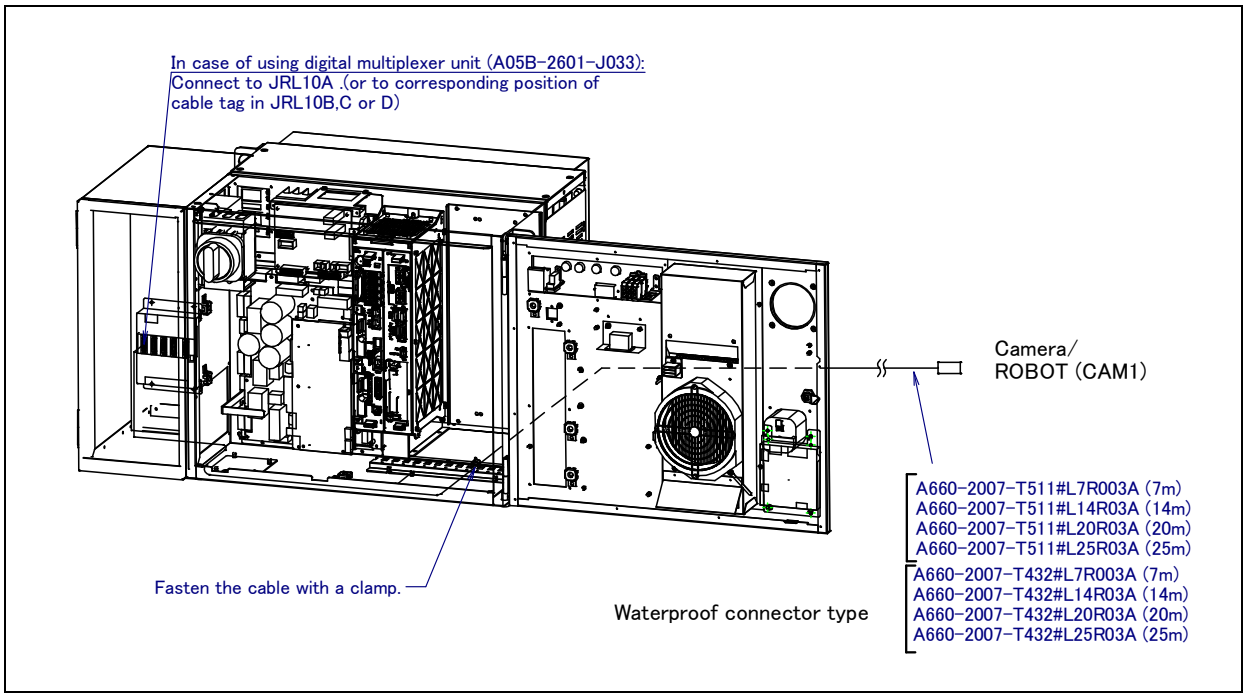


Fig. 2.6.1 (d) Camera connection cable
(digital camera connection cable, digital camera multiplexer in side process box)

2.6.2 Force Sensor Connection Cable (A-cabinet)

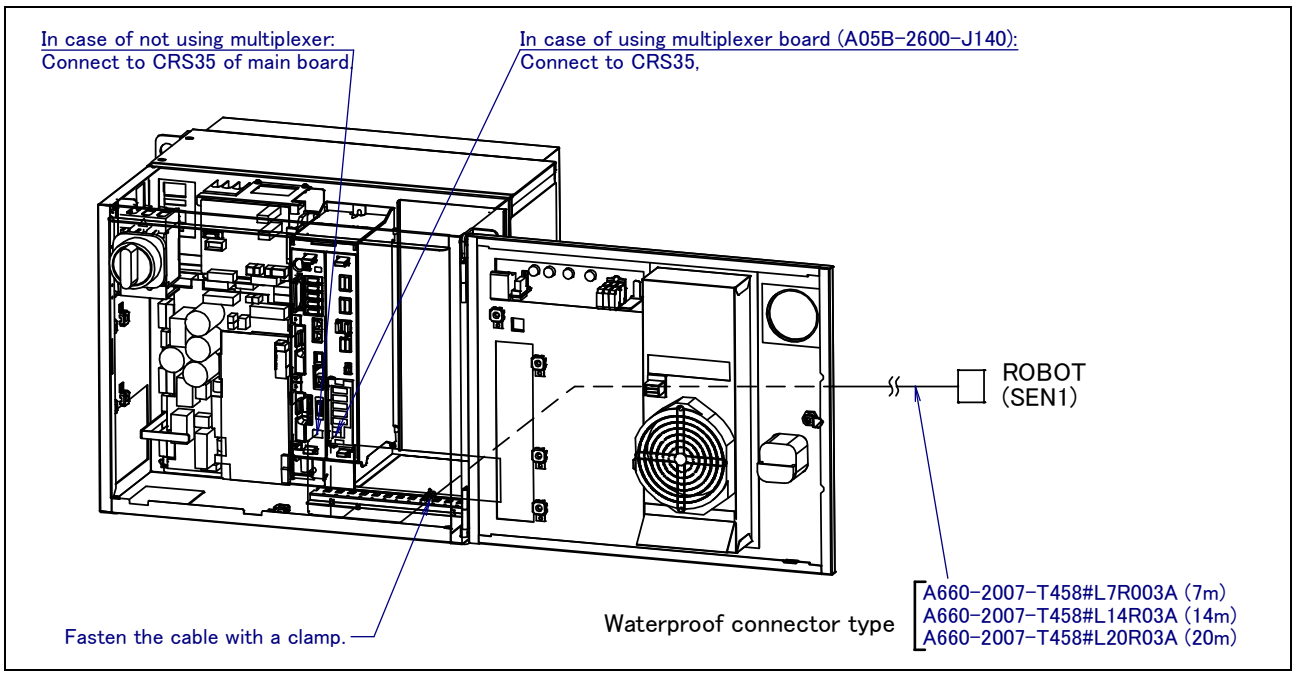


Fig. 2.6.2 Force sensor connection cable

2.6.3 3D Laser Vision Sensor + Analog Camera Connection Cable (A-cabinet)

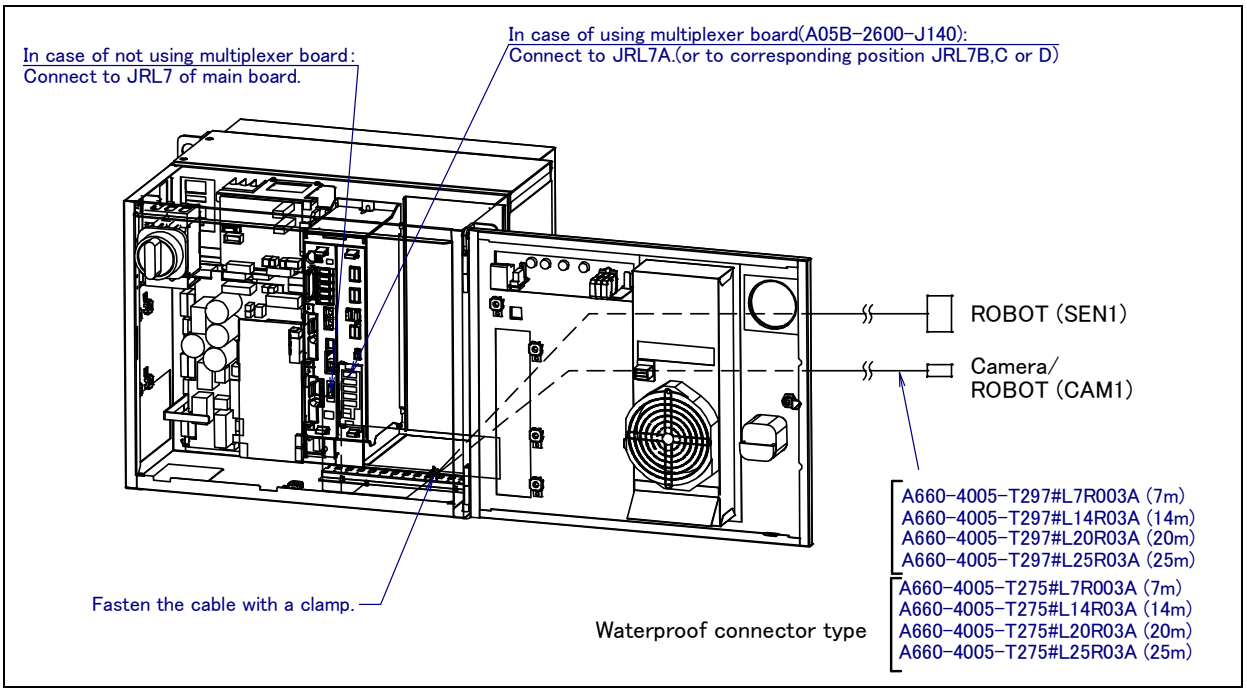


Fig. 2.6.3 3D Laser Vision Sensor + analog camera connection cable

2.6.4 Force Sensor + 3D Laser Vision Sensor + Analog Camera Connection Cable (A-cabinet)

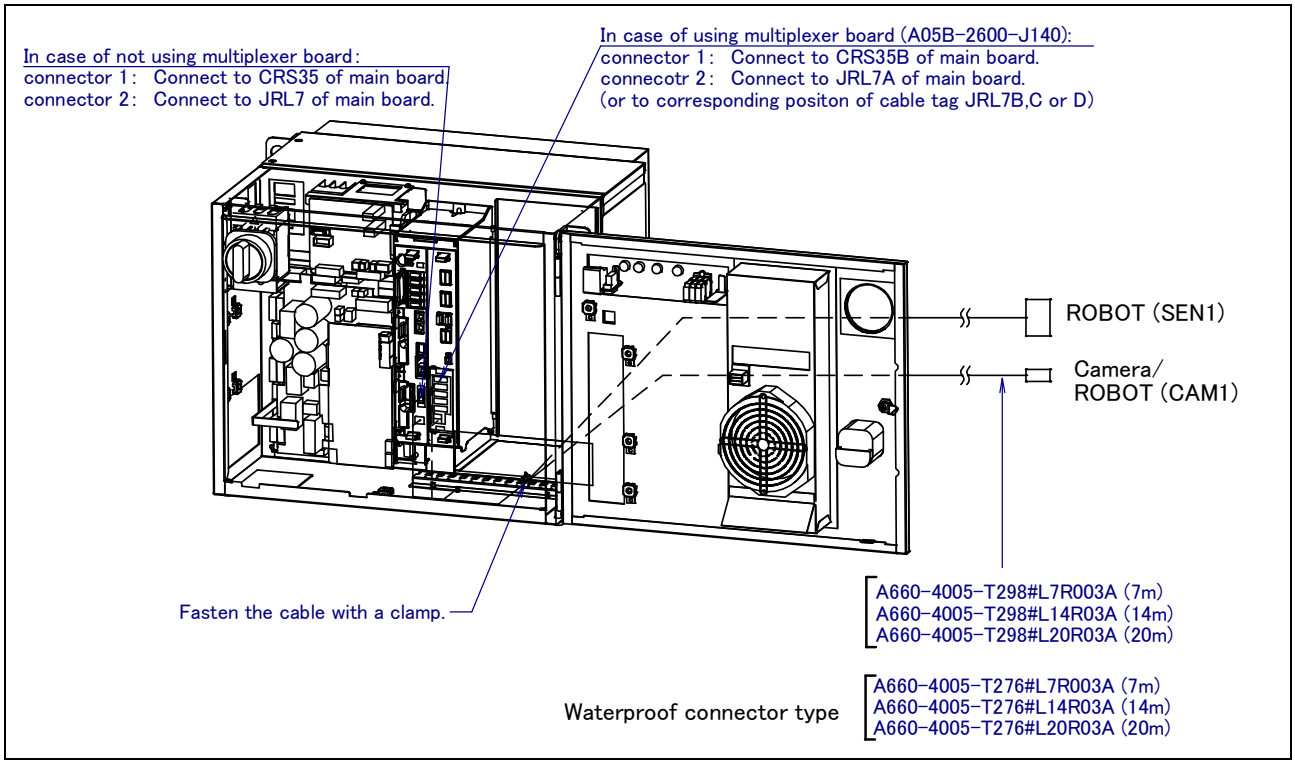


Fig. 2.6.4 Force sensor + 3D Laser Vision Sensor + analog camera connection cable

2.6.5 Projector Unit Connection Cable (A-cabinet)

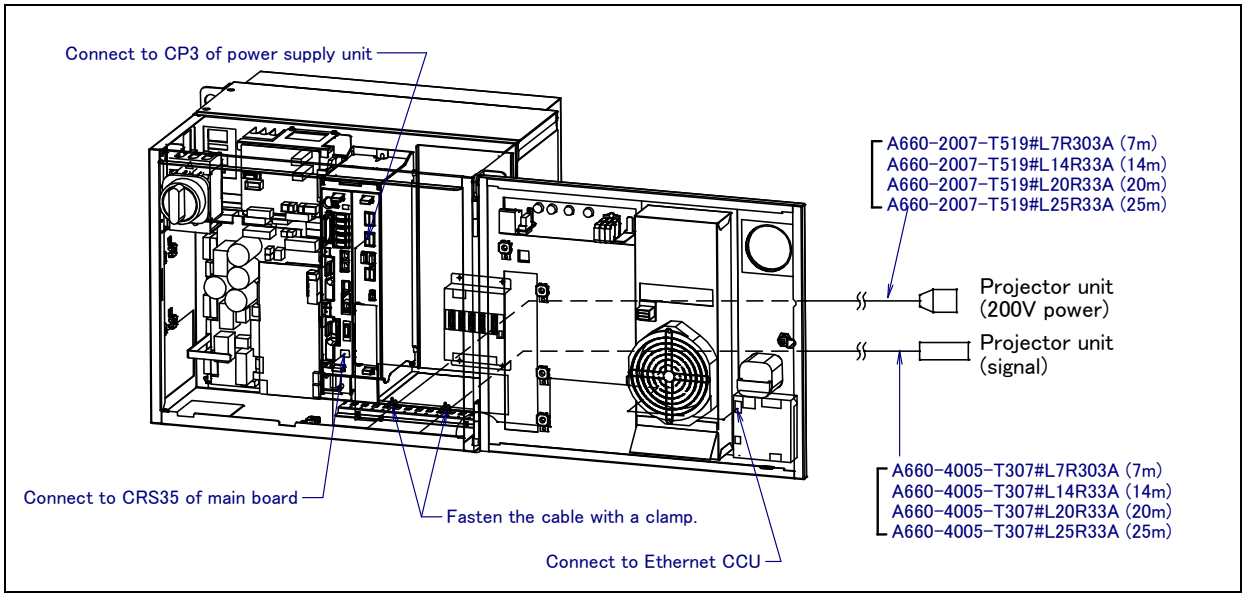


Fig. 2.6.5 Projector unit connection cable

2.6.6 Camera Connection Cable (B-cabinet)

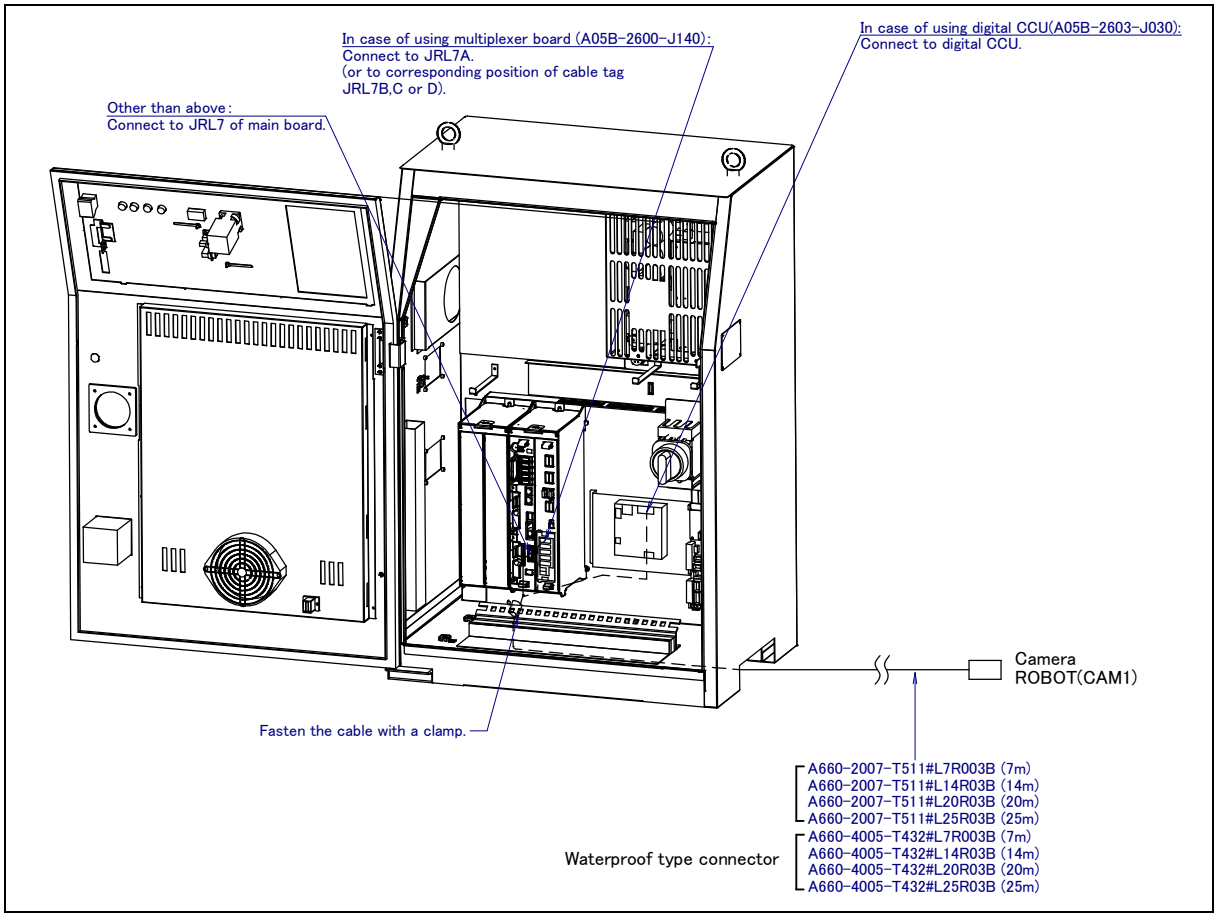


Fig. 2.6.6 (a) Camera connection cable
(Analog・digital camera connection cable, digital CCU)

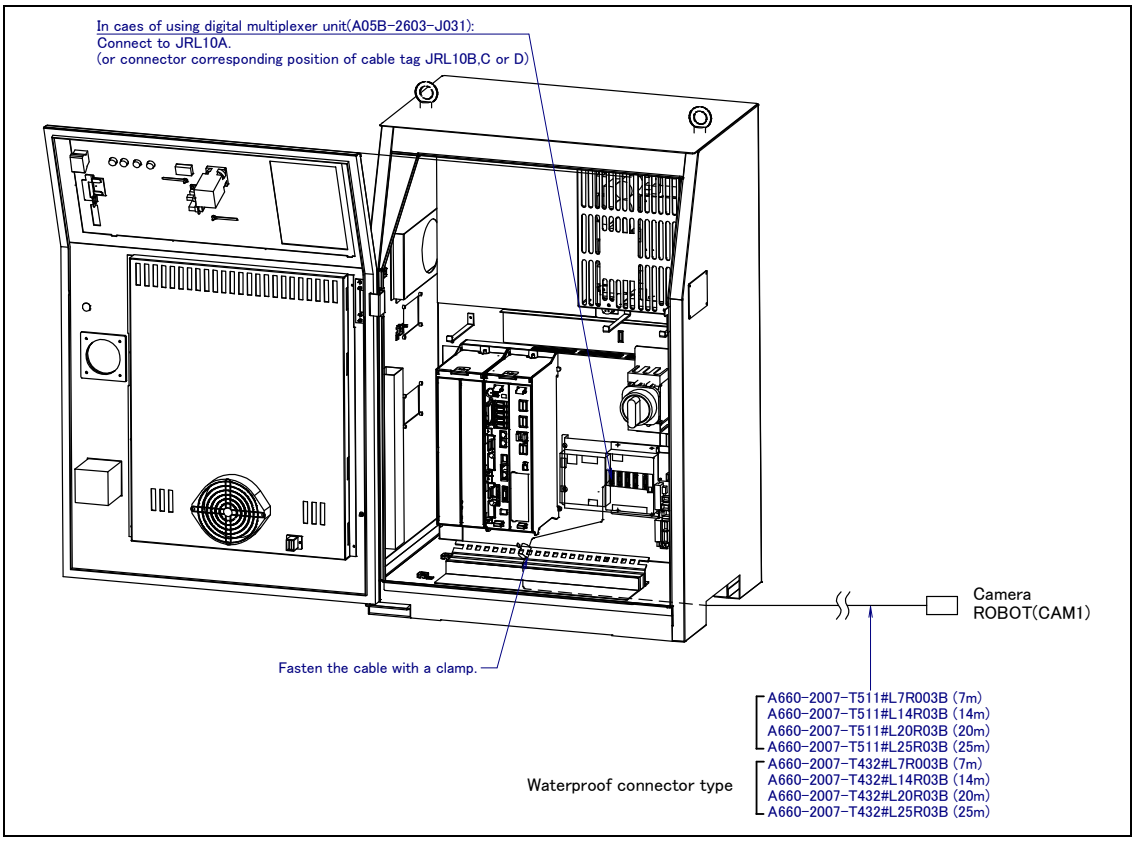


Fig. 2.6.6 (b) Camera connection cable (digital camera connection cable, digital camera multiplexer)

2.6.7 Force Sensor Connection Cable (B-cabinet)

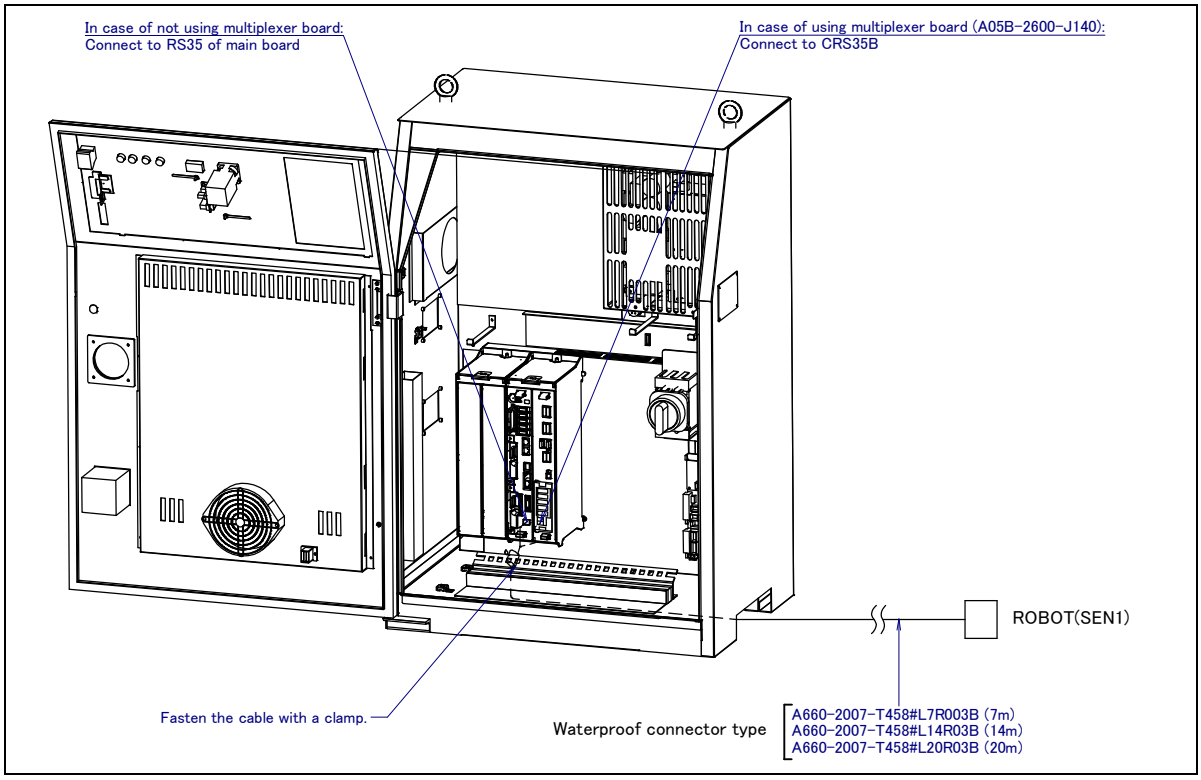


Fig. 2.6.7 Force sensor connection cable

2.6.8 3D Laser Vision Sensor + Analog Camera Connection Cable (B-cabinet)

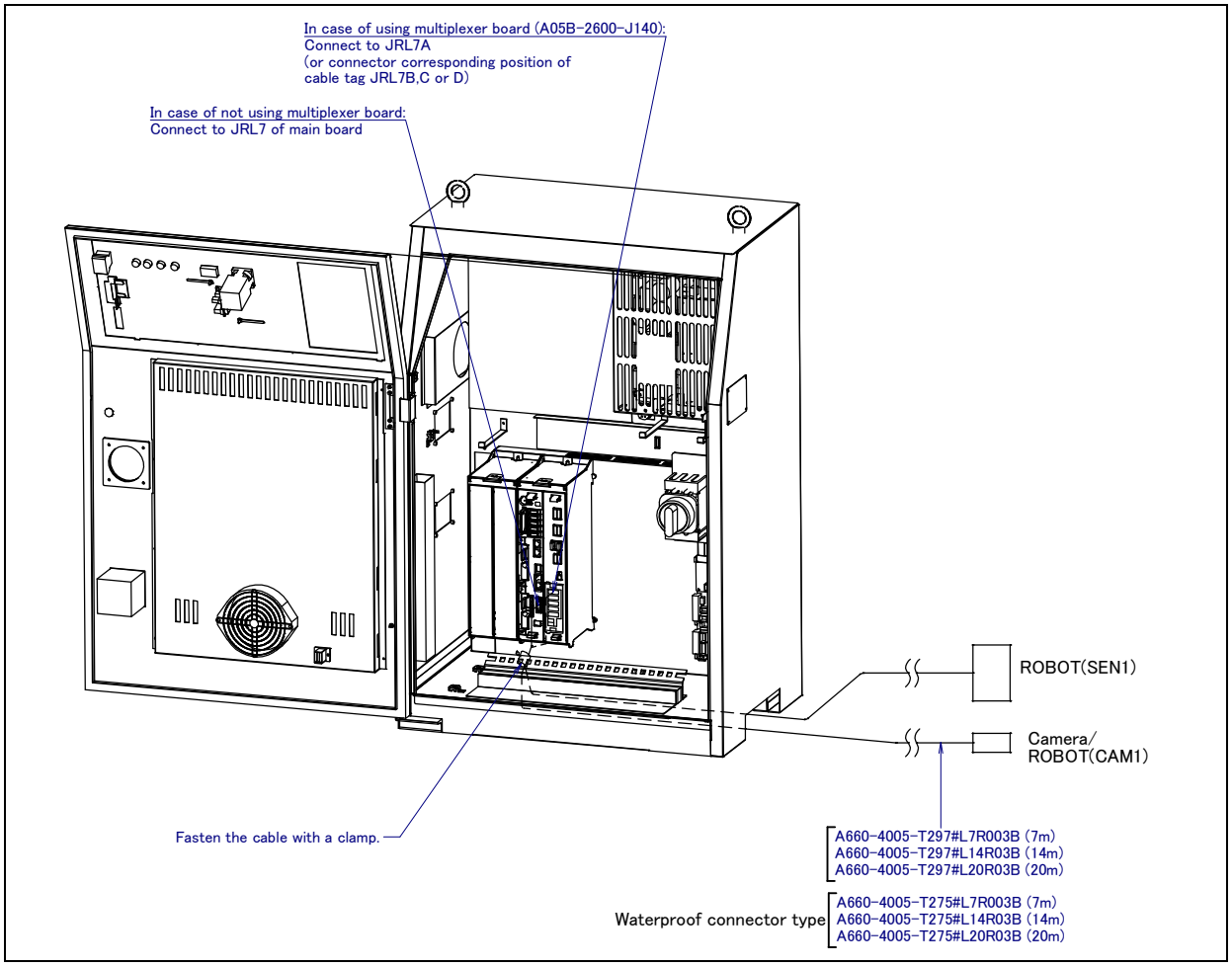


Fig. 2.6.8 3D Laser Vision Sensor + analog camera connection cable

2.6.9 Force Sensor + 3D Laser Vision Sensor + Analog Camera Cable (B-cabinet)

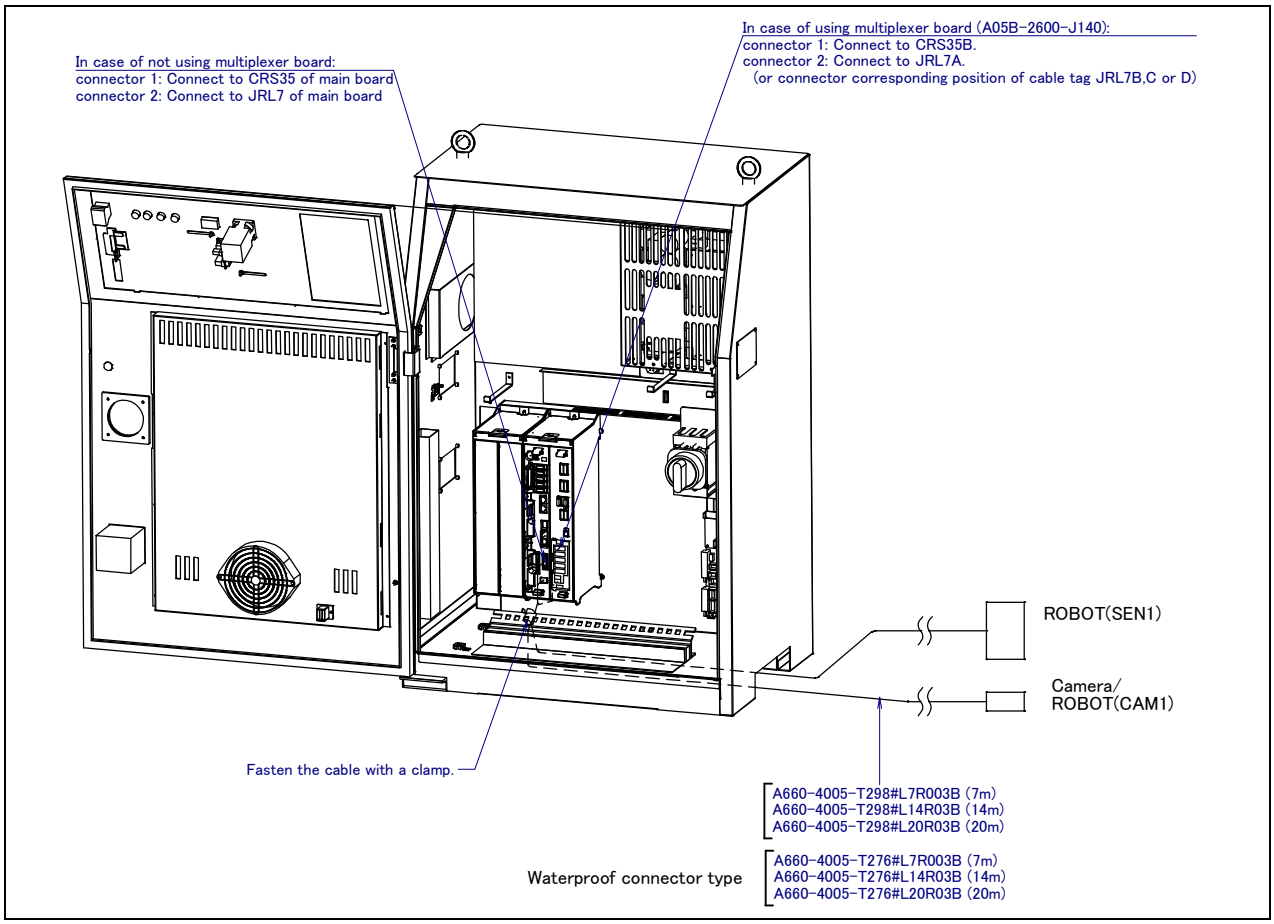


Fig. 2.6.9 Force sensor + 3D Laser Vision Sensor + analog camera connection cable

2.6.10 Projector Unit Connection Cable (B-cabinet)

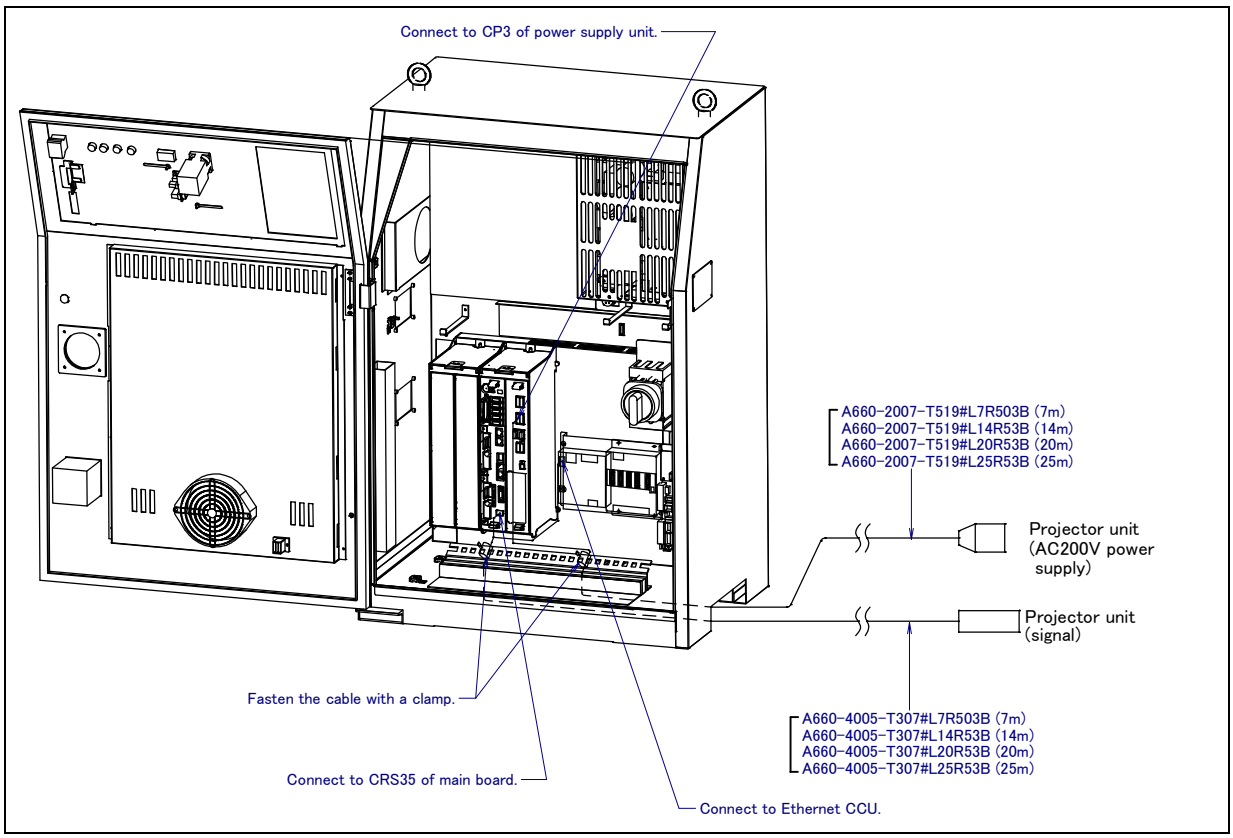


Fig. 2.6.10 Projector unit connection cable

3 MOTION RANGE AND EXTERNAL DIMENSION

3.1 MOTION RANGE

Refer to the Mechanical Unit Manual for explanations of the motion range of the each robot.
The motion range may be restricted by software to protect the sensor.

3.2 SENSOR OUTSIDE DIMENSIONS

3.2.1 Force Sensor

Fig. 3.2.1 (a) to (h) show the outside dimensions of the force sensor head.
Also, see the descriptions of the mounting face dimensions for the end effector in the next chapter.

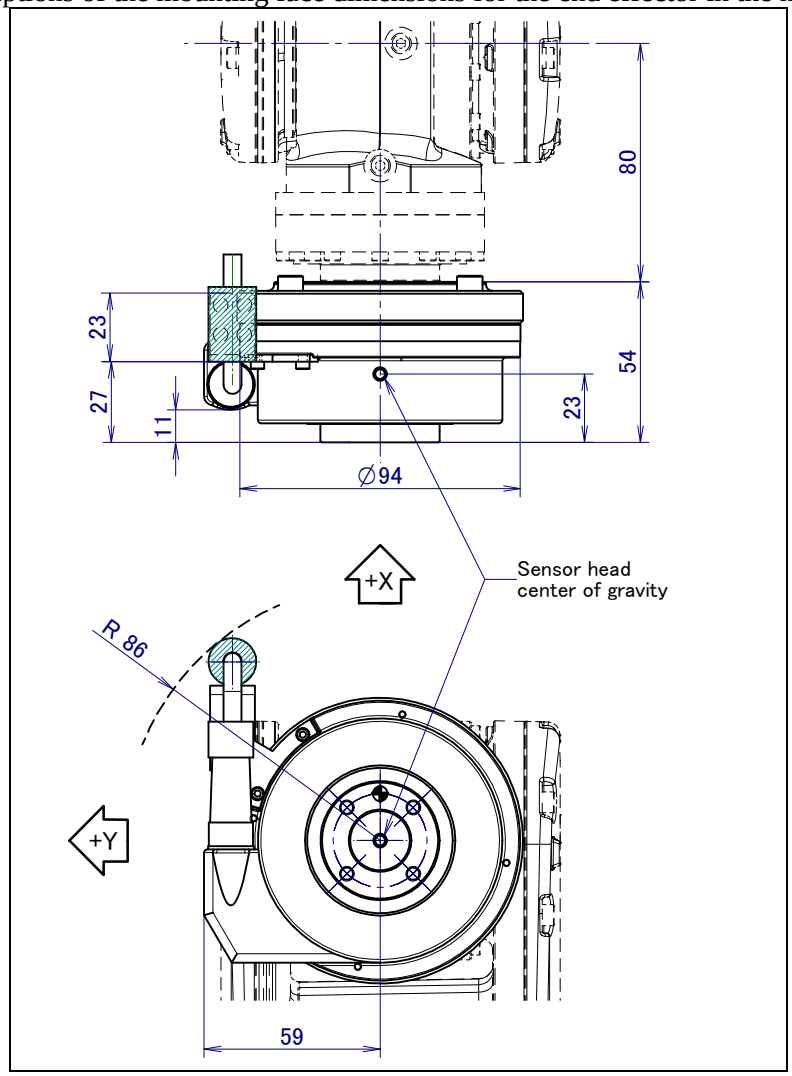


Fig. 3.2.1 (a) External dimension of the force sensor head
(Example of LR Mate 200*i*C + FS-15*i*A)

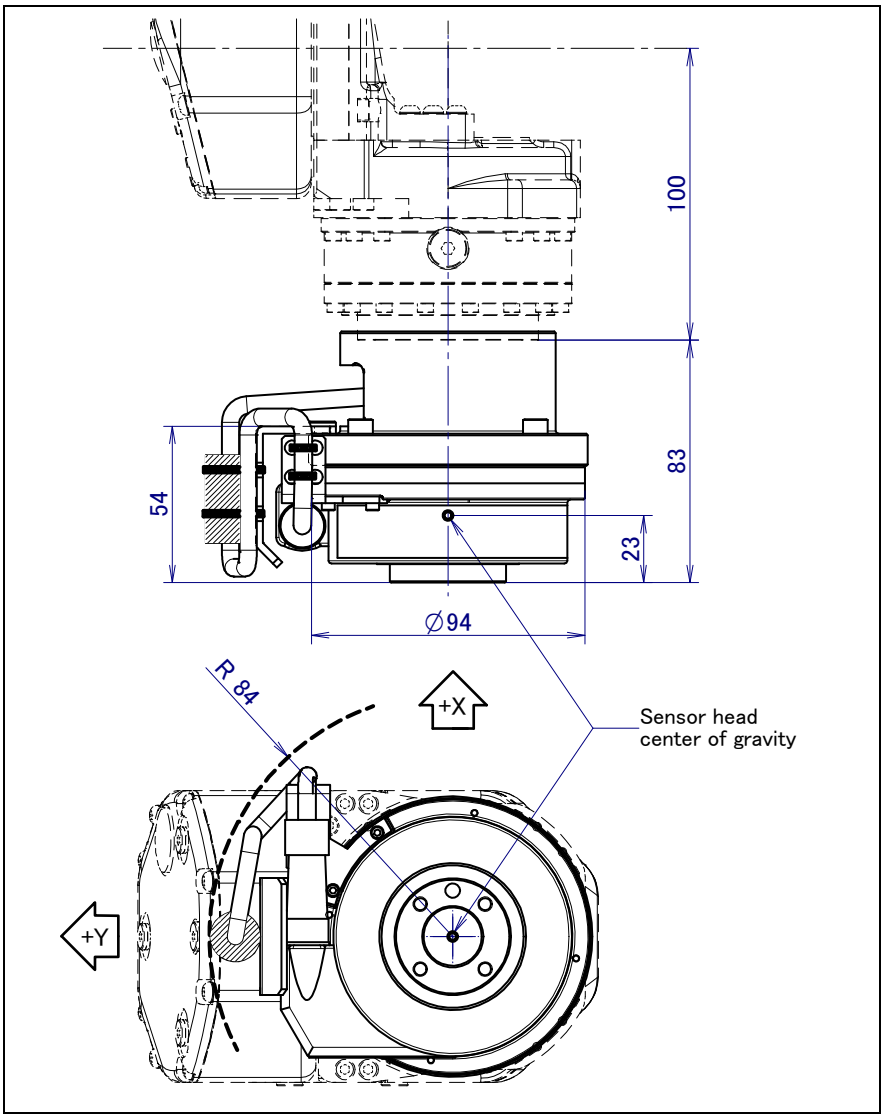


Fig. 3.2.1 (b) External dimension of the force sensor head
(Example of M-10*i*A + FS-15*i*A)

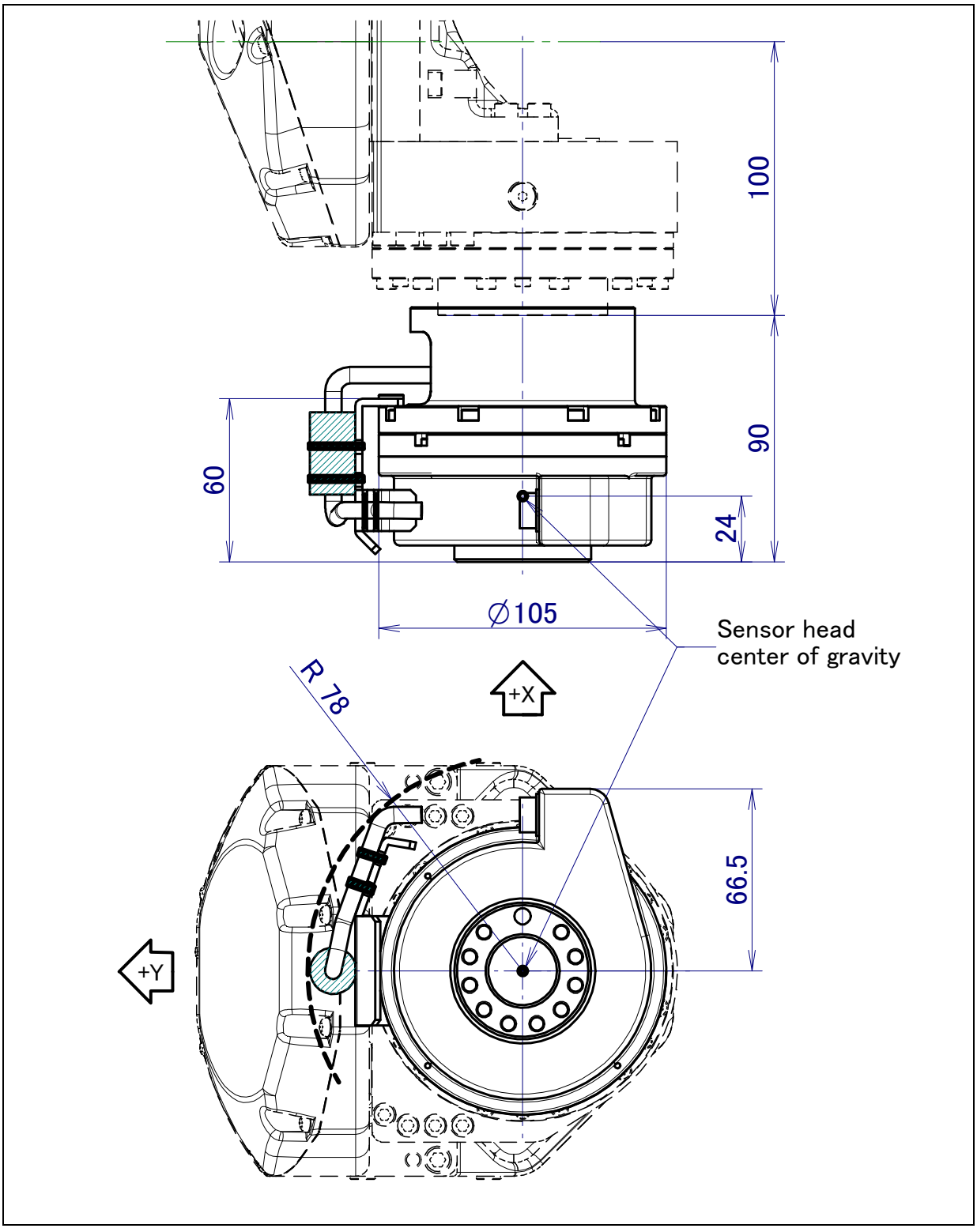


Fig. 3.2.1 (c) External dimension of the force sensor head
(Example of M-20*i*A + FS-40*i*A)

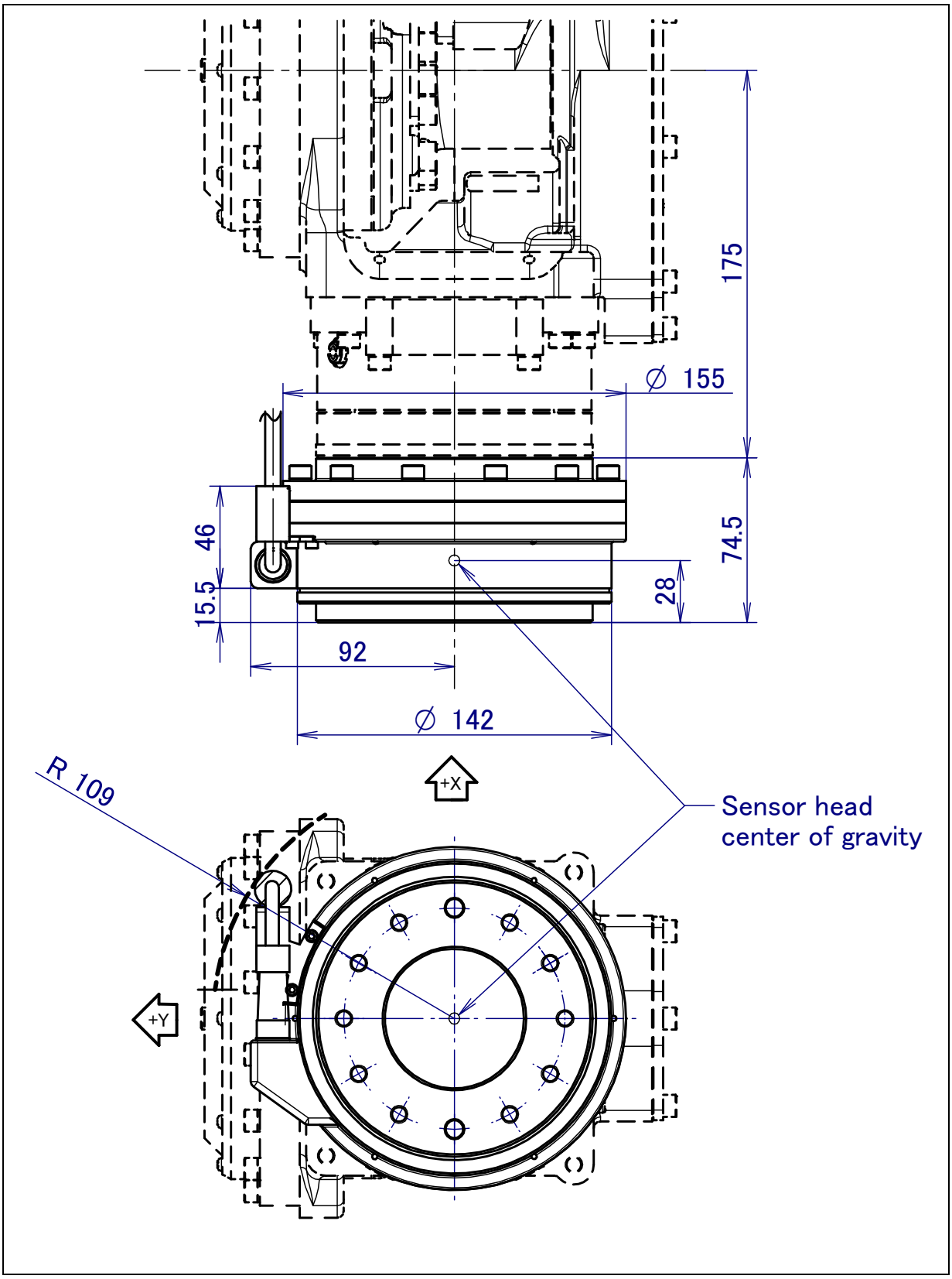


Fig. 3.2.1 (d) External dimension of the force sensor head
(Example of M-710*i*C + FS-100*i*A)

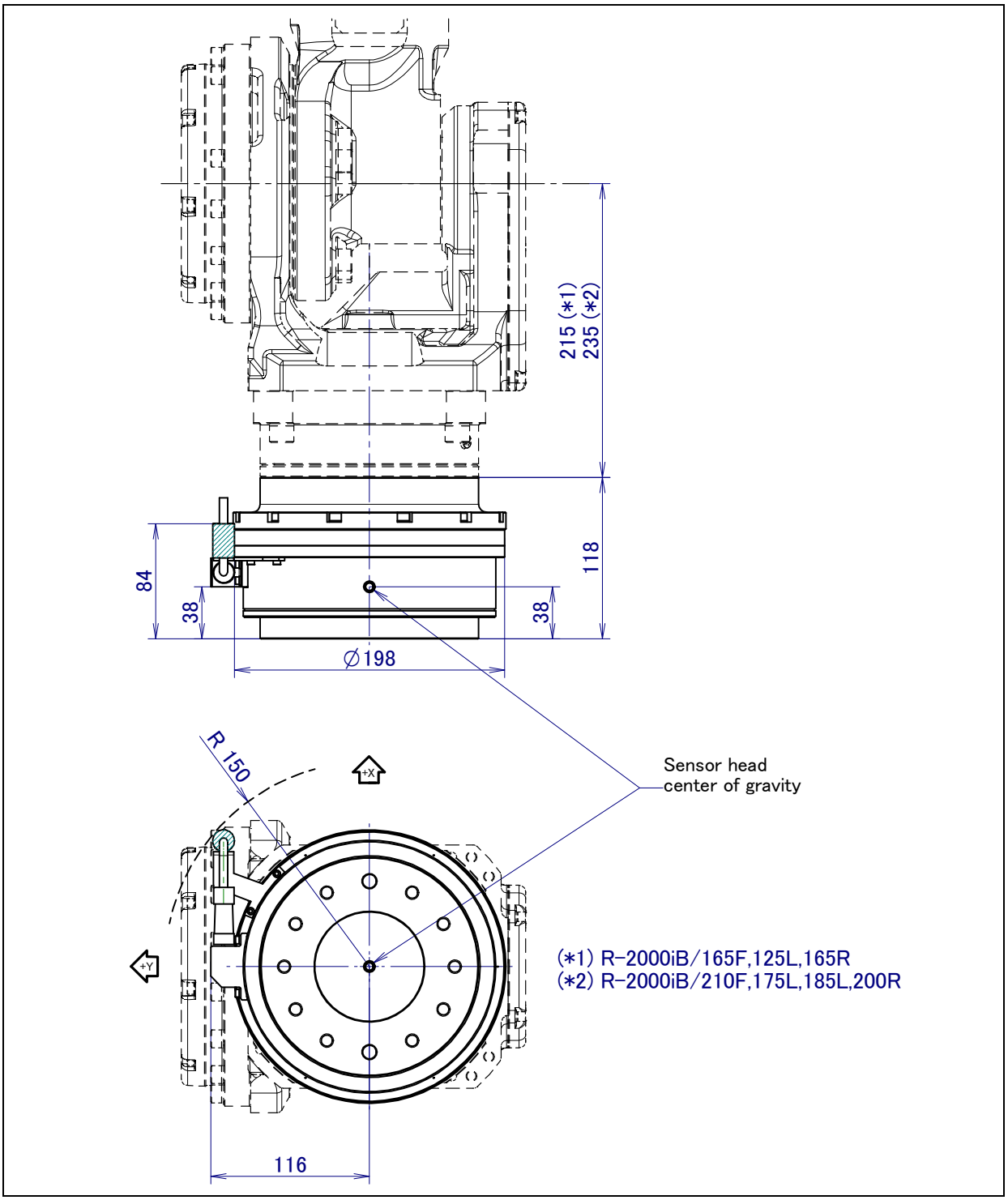


Fig. 3.2.1 (e) External dimension of the force sensor head
(Example of R-2000*i*B + FS-250*i*A with standard adapter)

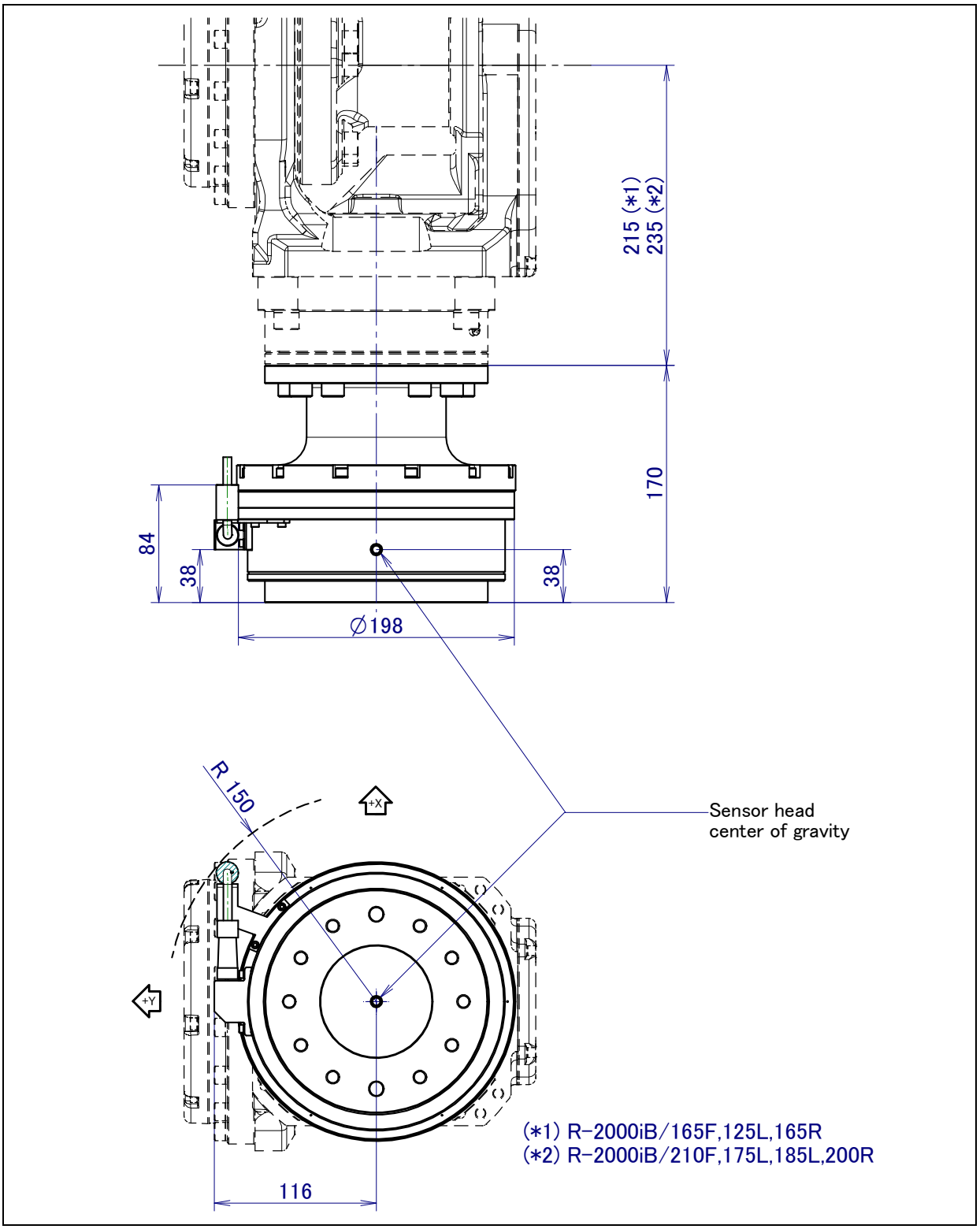


Fig. 3.2.1 (f) External dimension of the force sensor head
(Example of R-2000*i*B + FS-250*i*A with adapter which does not need torque wrench)

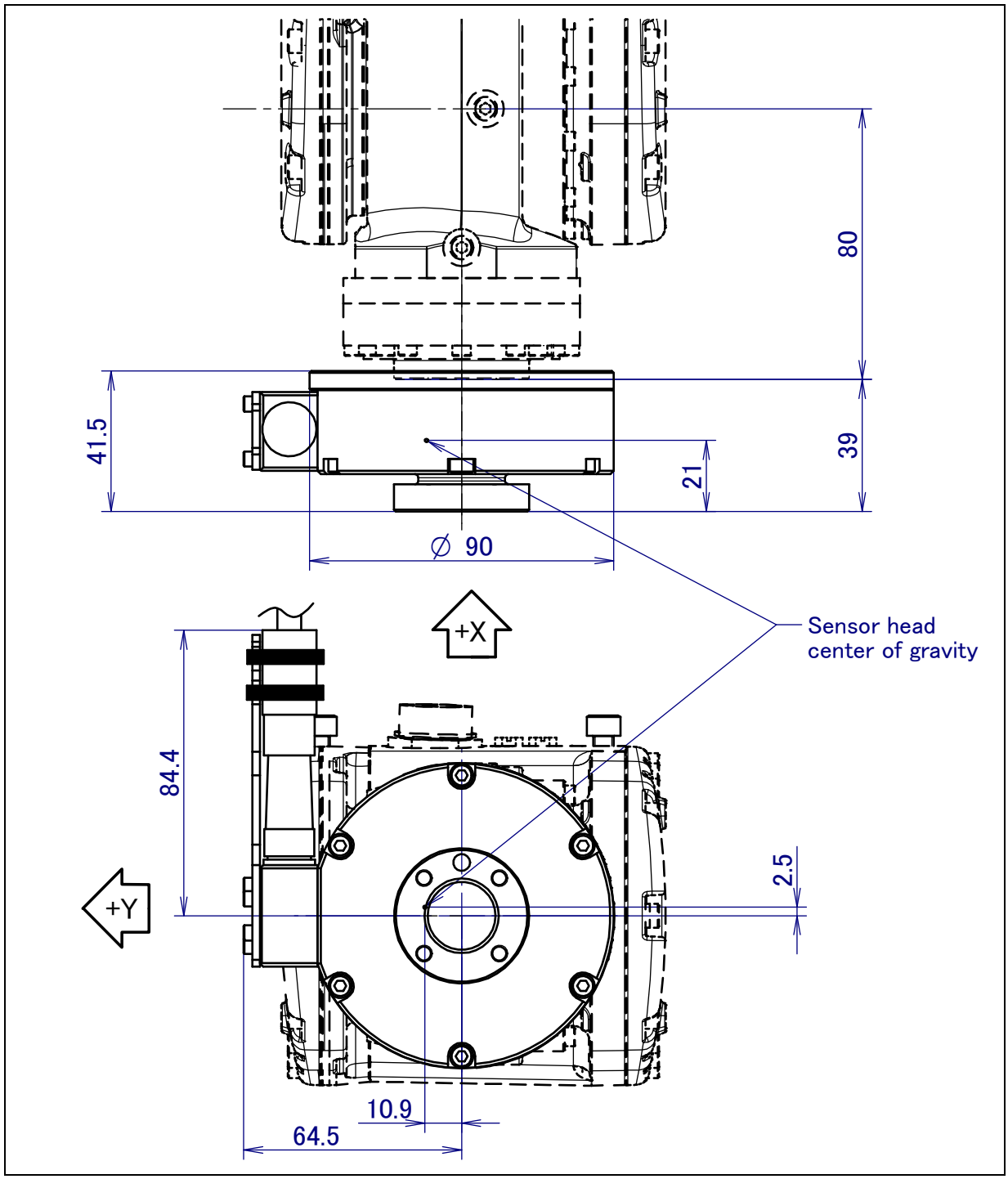


Fig. 3.2.1 (g) External dimension of the force sensor head (Example of LR Mate 200*i*C + FS-15*i*Ae)

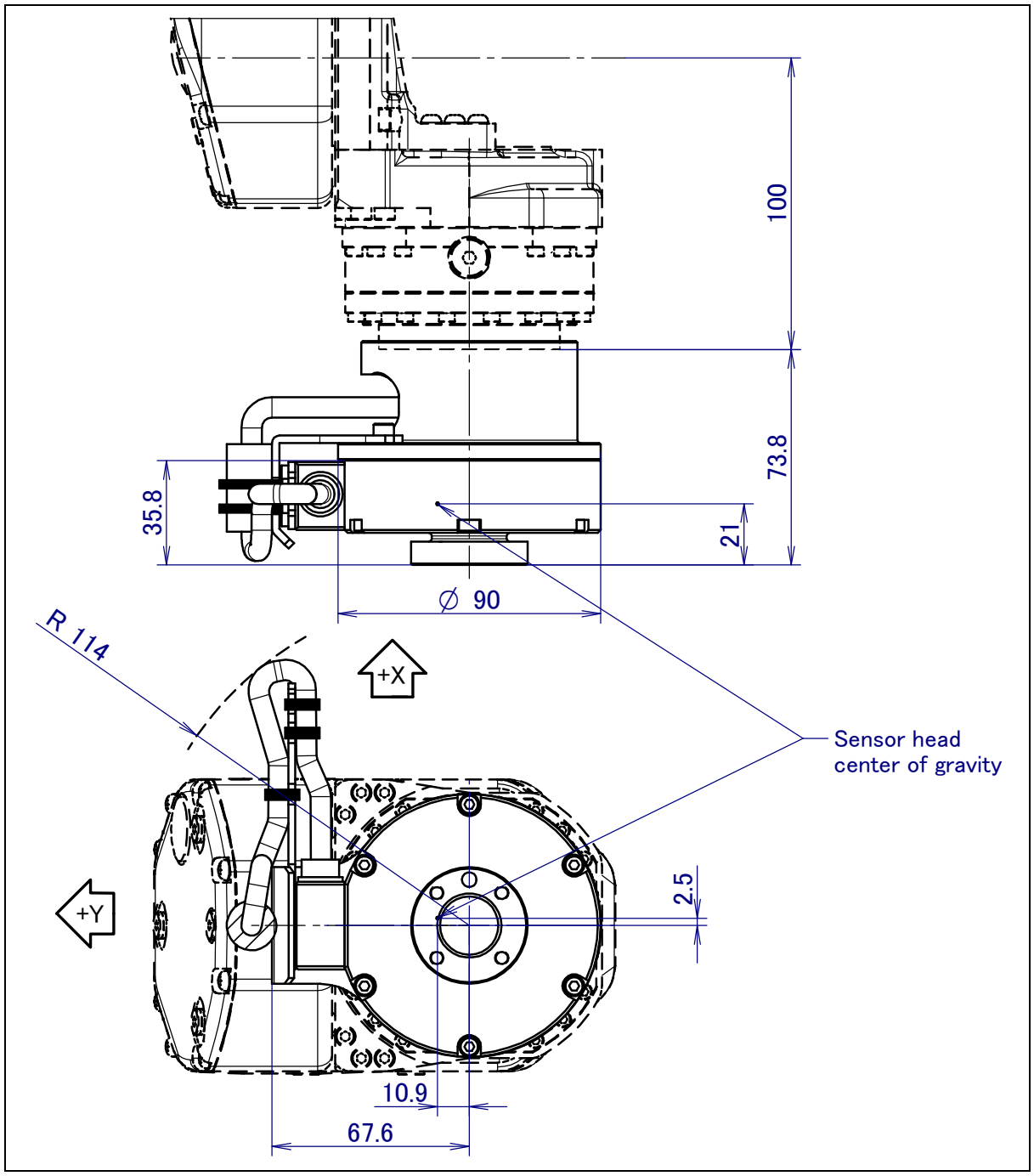


Fig. 3.2.1 (h) External dimension of the force sensor head (Example of M-10*i*A + FS-15*i*Ae)

3.2.2 3D Laser Vision Sensor

3.2.2.1 Sensor head

Fig. 3.2.2.1 (a) to (d) show the external dimension and vision range of the 3D Laser Vision sensor head.

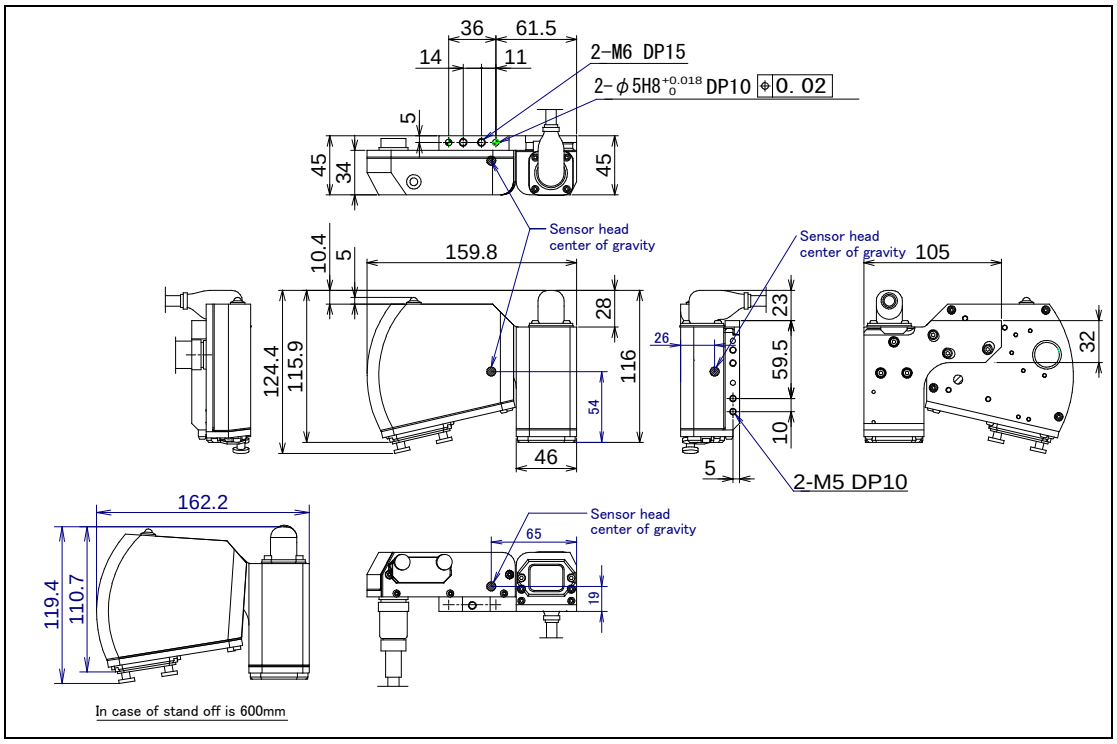


Fig. 3.2.2.1 (a) External dimension of the 3D Laser Vision Sensor Head

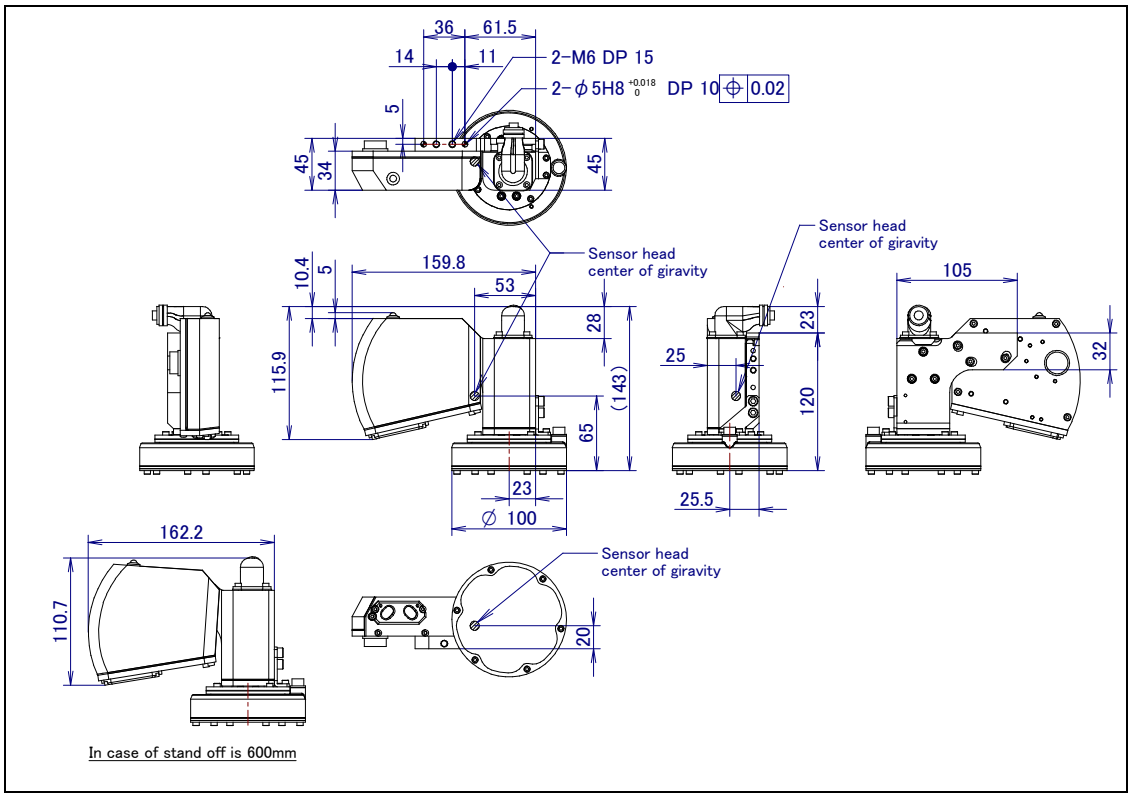


Fig. 3.2.2.1 (b) External dimension of the 3D Laser Vision Sensor Head (with LED light)

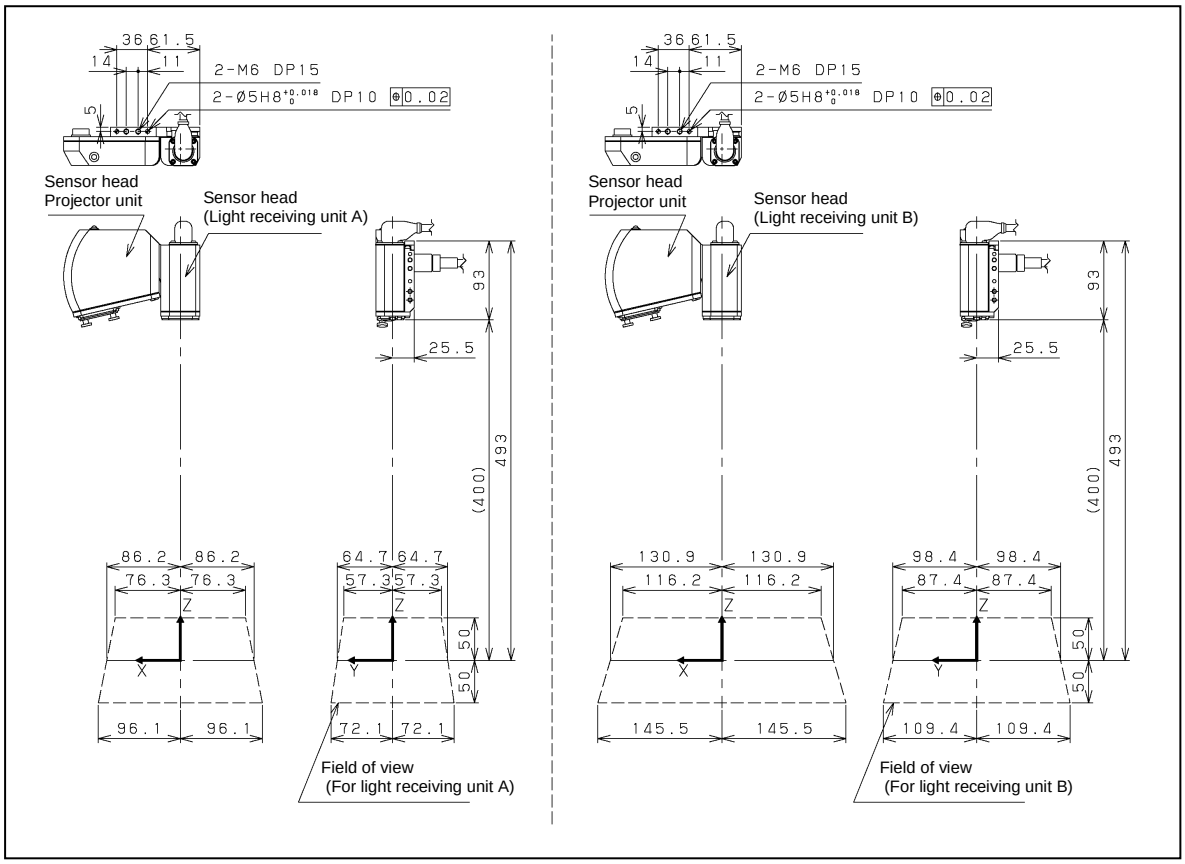


Fig. 3.2.2.1 (c) Vision range of the 3D Laser Vision Sensor (stand off 400mm/standard)

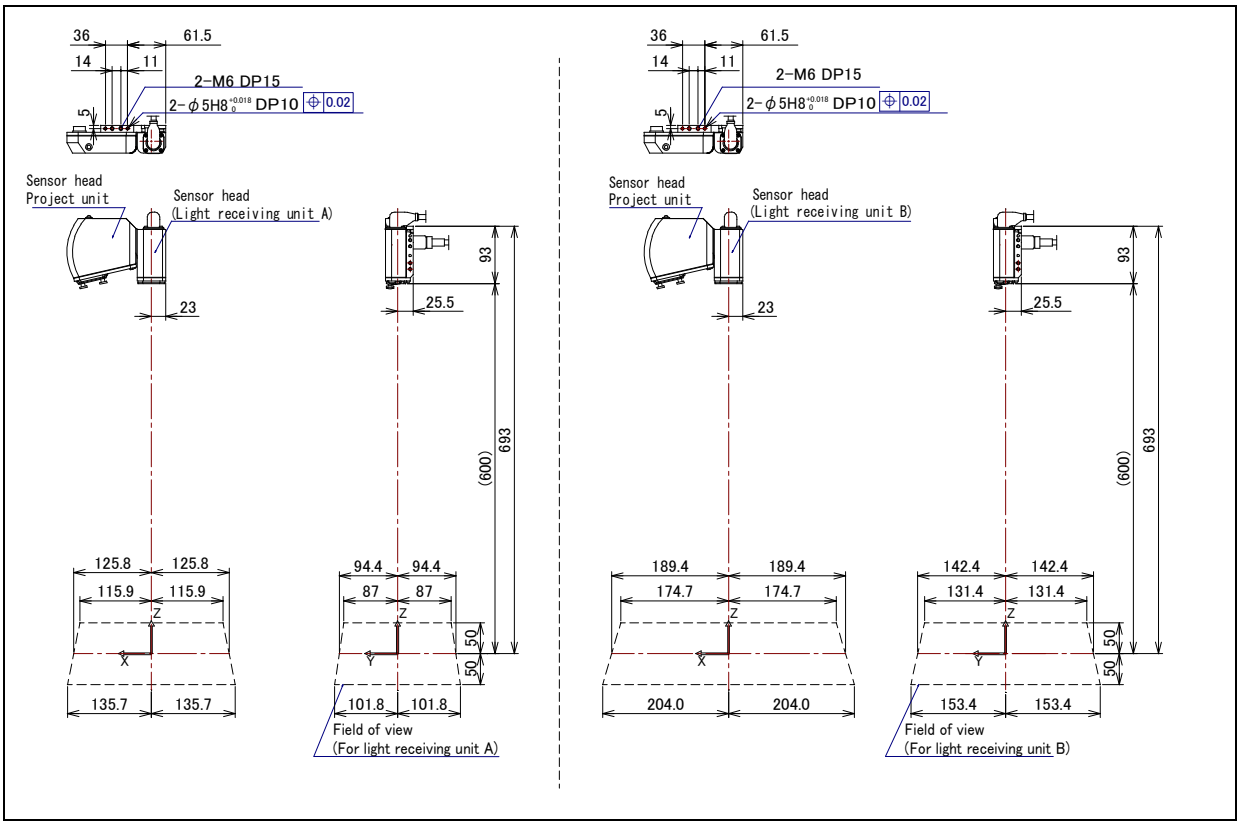


Fig. 3.2.2.1 (d) Vision range of the 3D Laser Vision Sensor (stand off 600mm)

3.2.2.2 Protector

Fig. 3.2.2.2 (a) ,(b) show the external dimension of protector for 3D Laser Vision sensor.

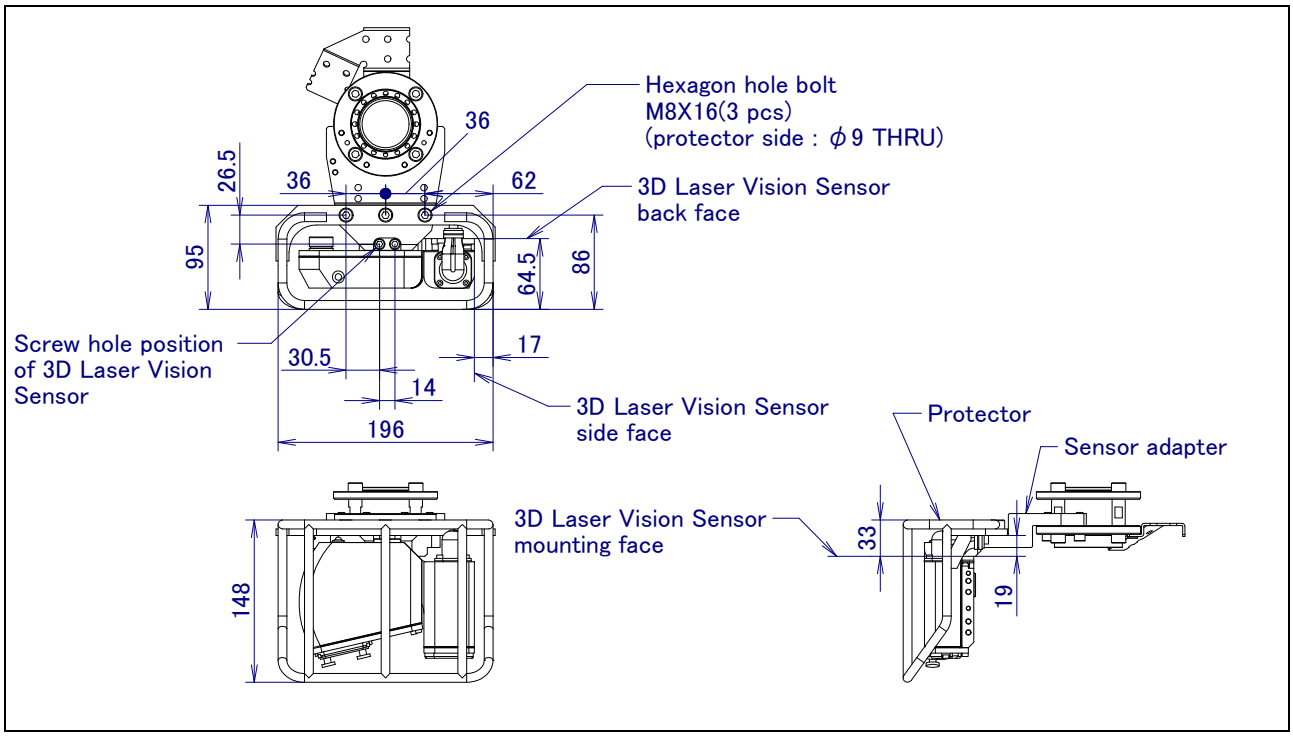


Fig.3.2.2.2 (a) External dimension of protector for 3D Laser Vision sensor (without LED light)

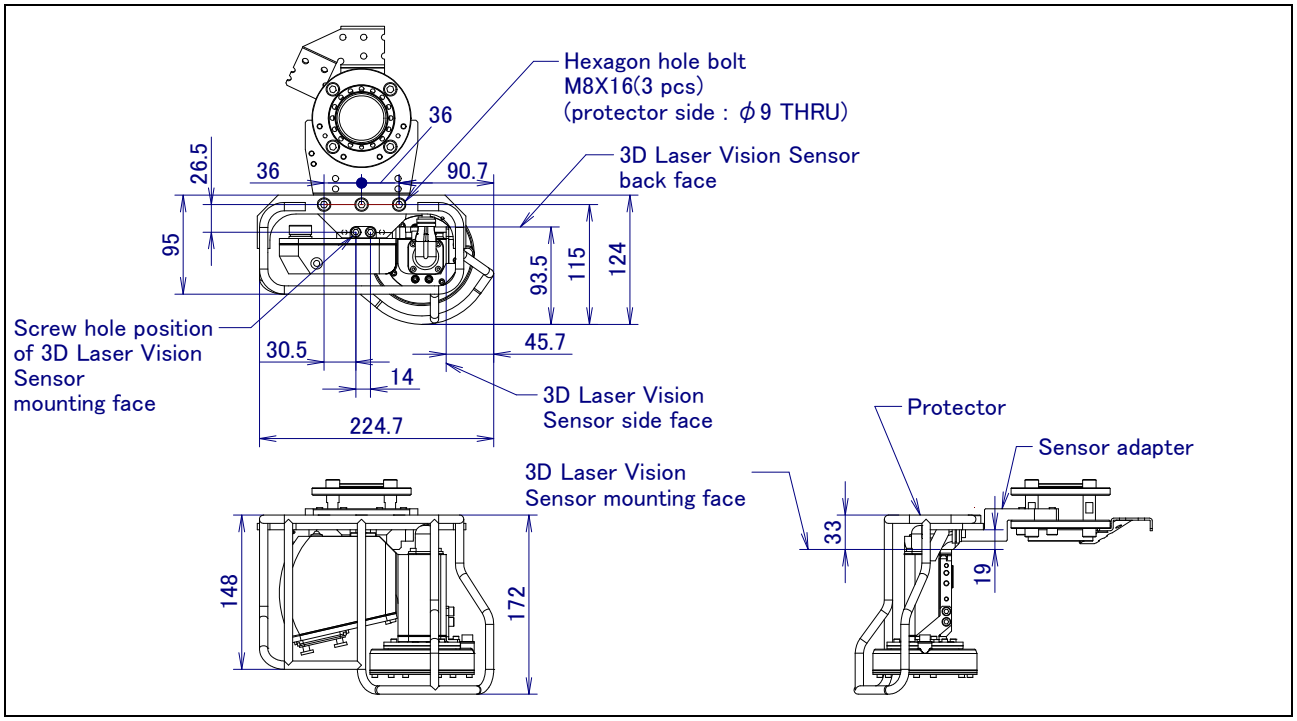


Fig.3.2.2.2 (b) External dimension of protector for 3D Laser Vision sensor (with LED light)

3.2.2.3 Camera cable clamp

Fig. 3.2.2.3 shows the external dimension drawing of camera cable clamp for 3D Laser Vision sensor.

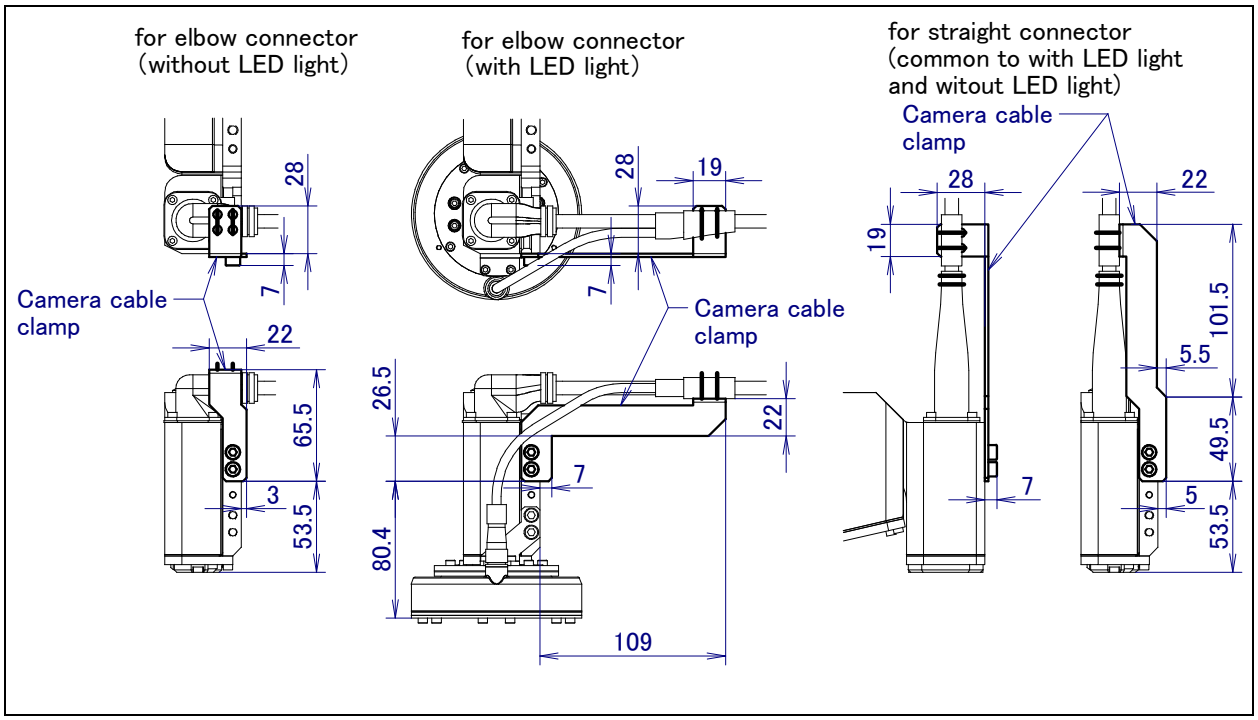


Fig.3.2.2.3 External dimension of camera cable clamp for 3D Laser Vision sensor

3.2.3 Camera Package

3.2.3.1 Sensor head

Fig. 3.2.3.1 (a) to (b) show the external dimension and vision range of the Camera package.
The vision range in figure is an example of focal distance of 8mm.
See the table below for the other case.

Table 3.2.3.1 angle of view of camera package

Focal distance of lens	horizontal × vertical
8mm	33.1°x25.0°
12mm	22.4°x16.6°
16mm	16.9°x12.7°
25mm	11.0°x8.2°

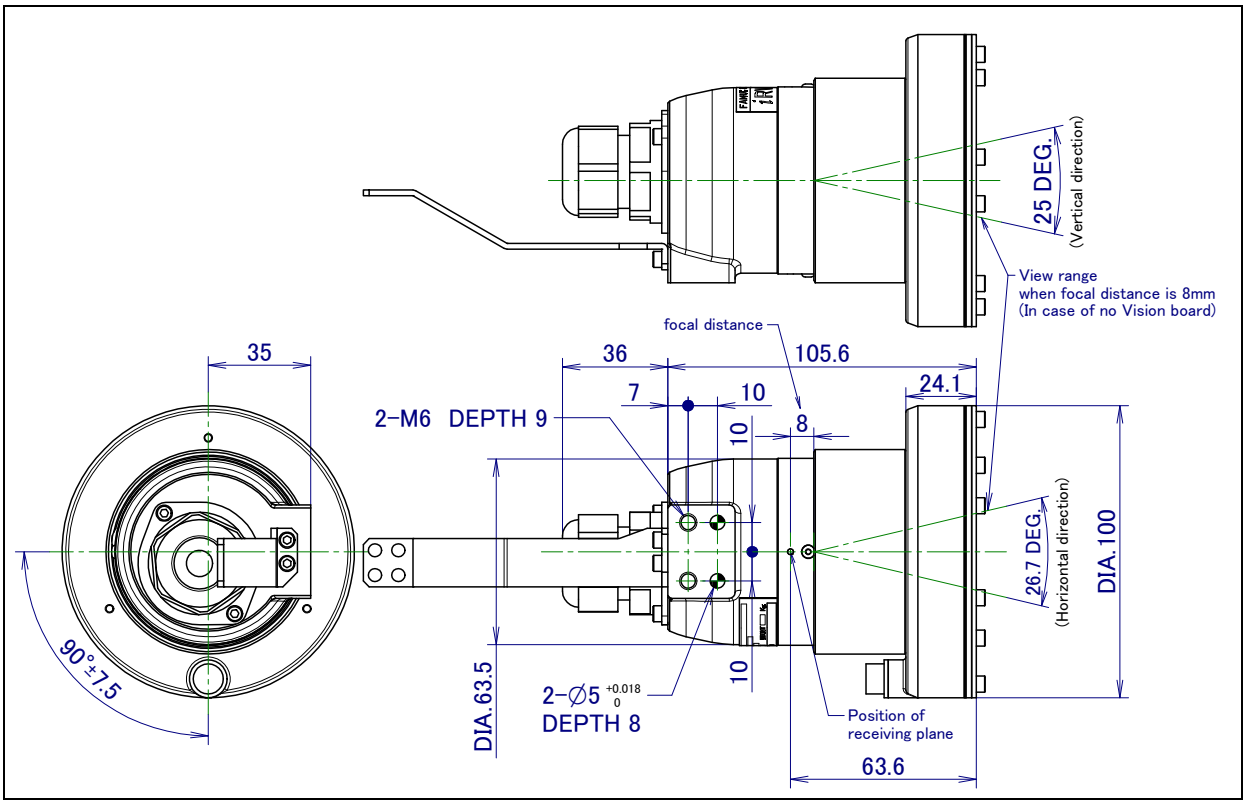


Fig. 3.2.3.1 (a) External dimension and vision range of sensor head of camera package (with LED light)

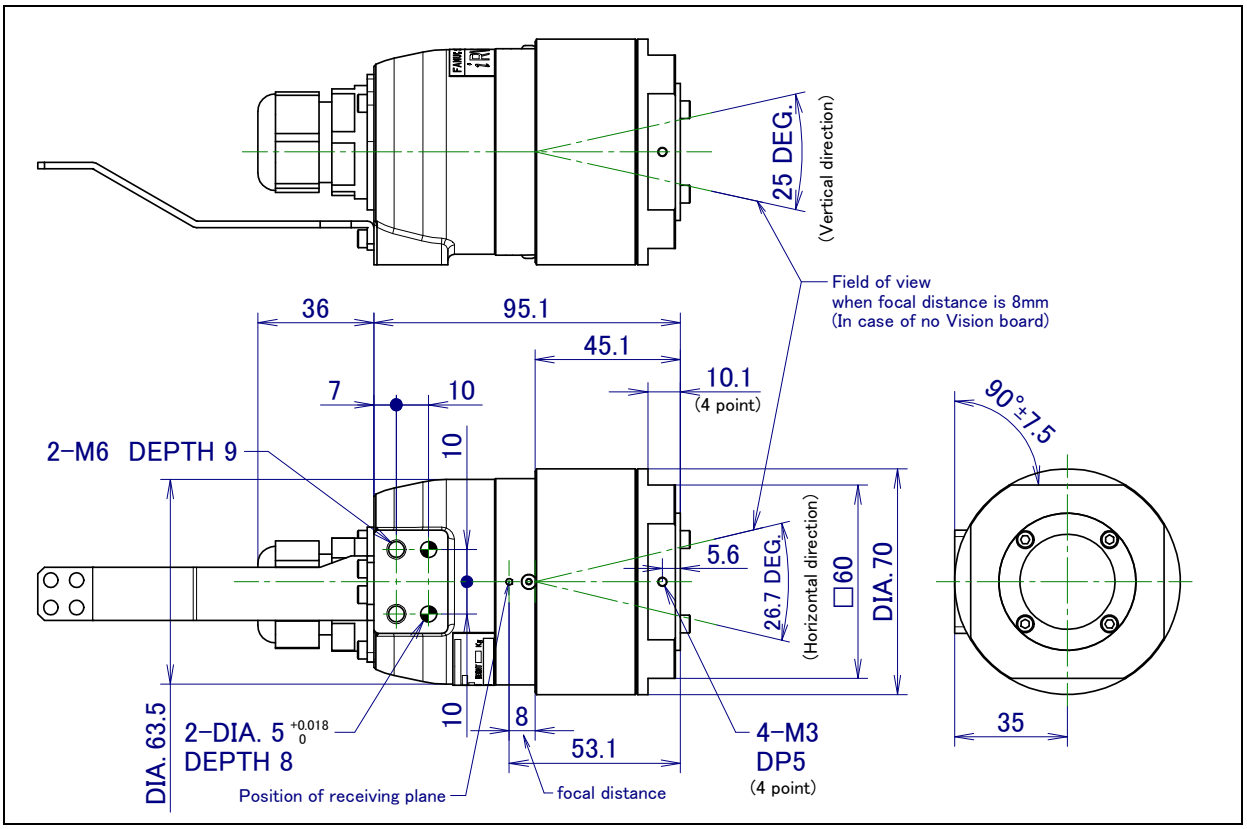


Fig. 3.2.3.1 (b) External dimension and vision range of sensor head of camera package (with LED light)

3.2.4 3D Area Sensor

Fig.3.2.4 (a) shows external dimension of 3D Area Sensor when standard placement.
Fig.3.2.4 (b) shows projection area of 3D Area Sensor projector unit.
Fig.3.2.4 (c) shows external dimension and field of view of 3D Area Sensor camera unit.

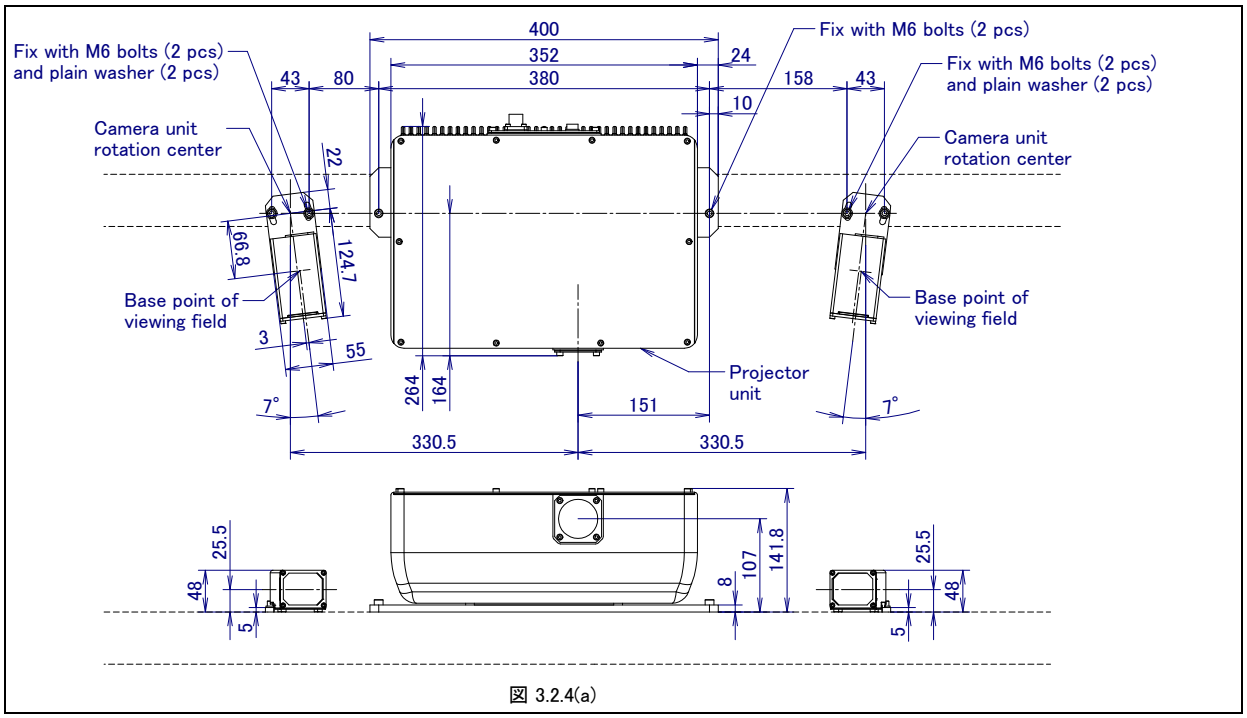


Fig.3.2.4 (a) External dimension of 3D Area Sensor

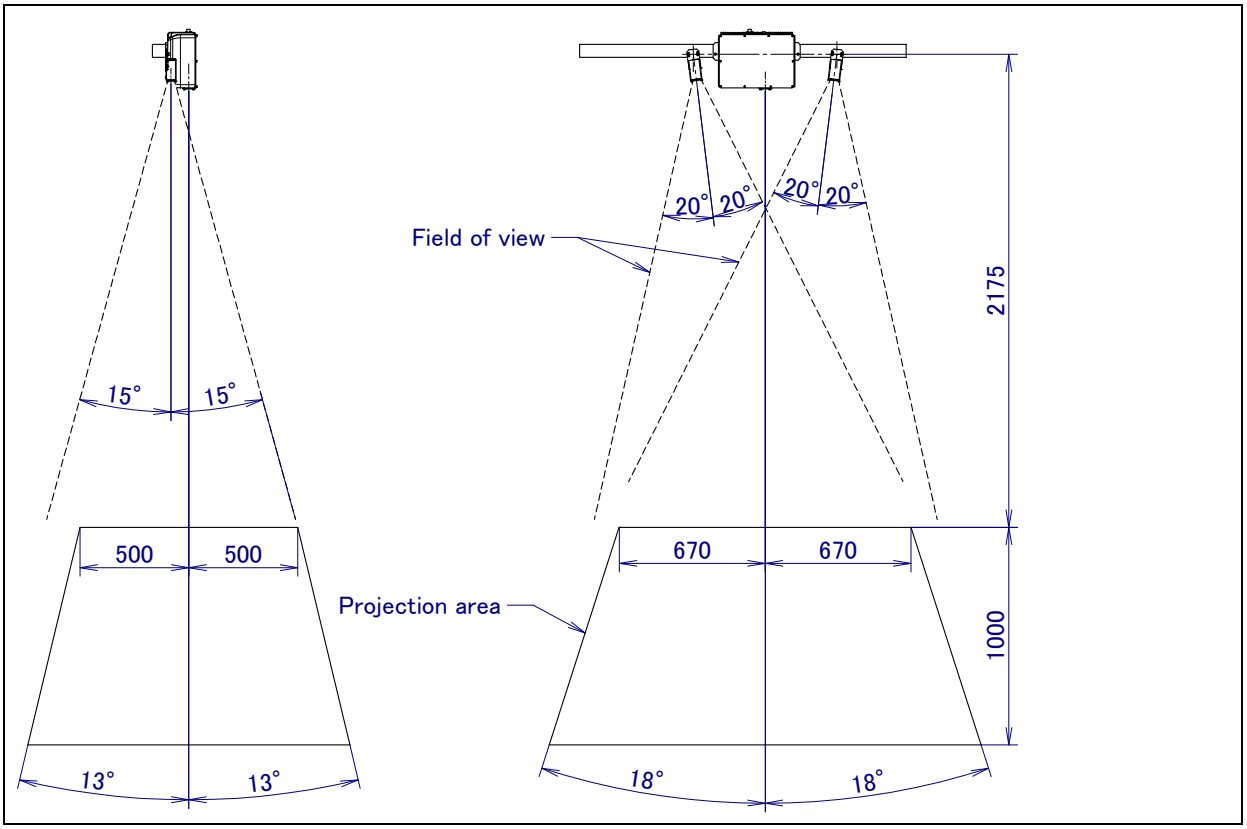


Fig.3.2.4 (b) Projection area of 3D Area Sensor projector unit

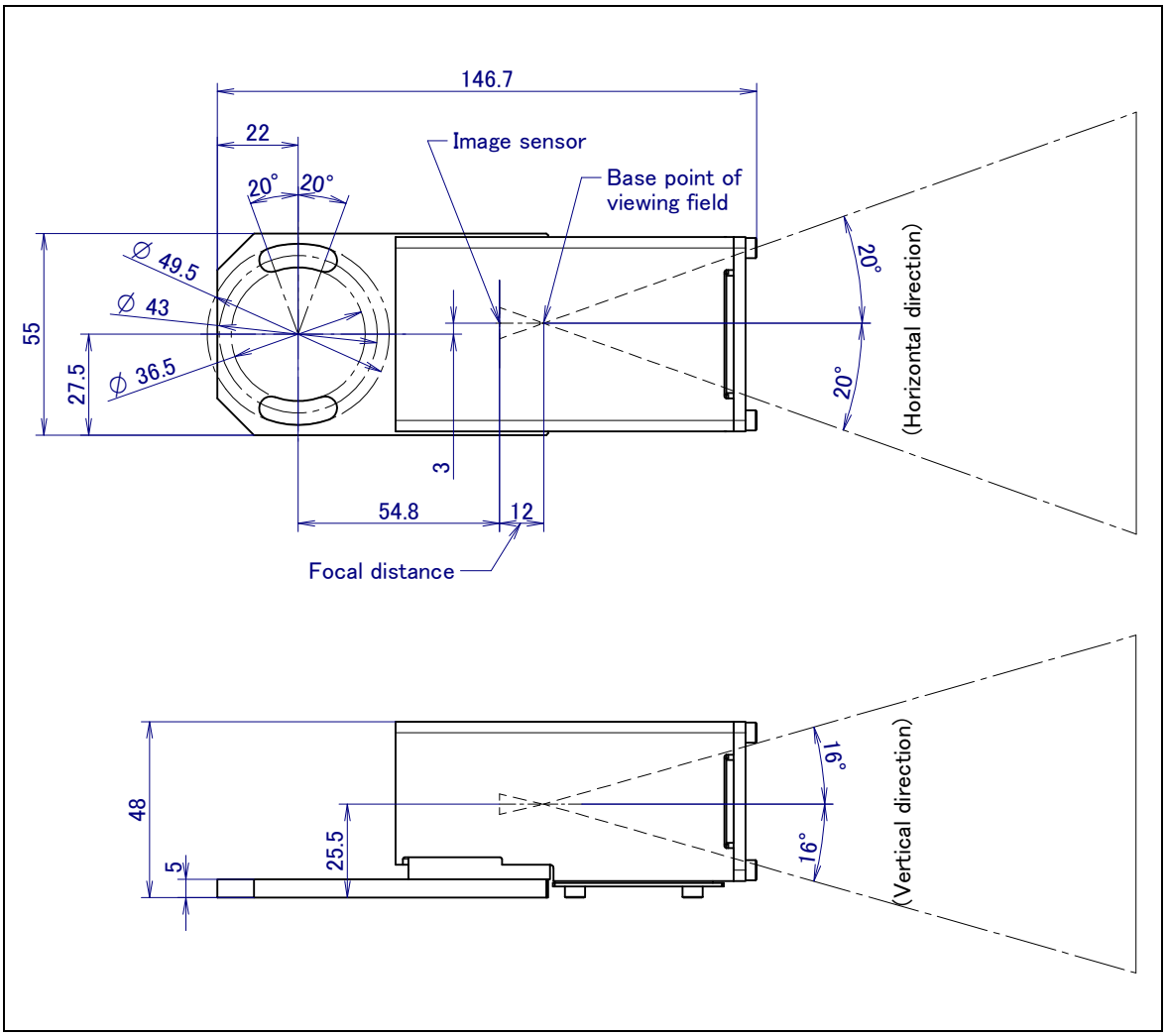


Fig.3.2.4 (c) External dimension and field of view of 3D Area Sensor camera unit

4 EQUIPMENT INSTALLATION

4.1 WRIST SECTION END EFFECTOR MOUNTING SURFACE

4.1.1 With a Force Sensor

Figs. 4.1.1 (a) to (f) show the mounting face for the wrist section end effector when a force sensor is used. The end effector should be designed in such a way that it satisfies the load requirements for the wrist section. Use caution to avoid interference with the robot main body.

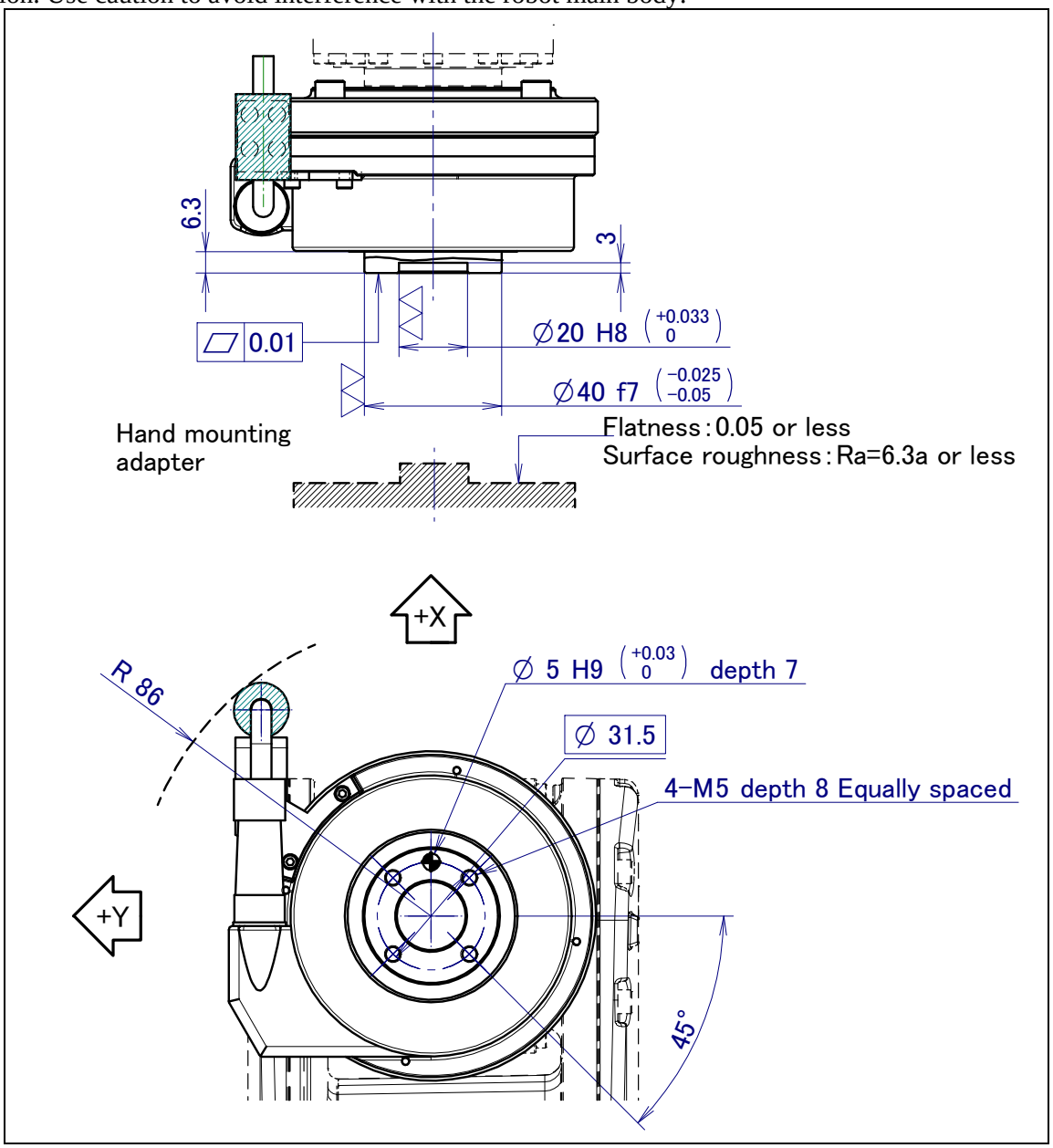


Fig. 4.1.1 (a) Wrist section end effector mounting surface (FS-15*i*A)

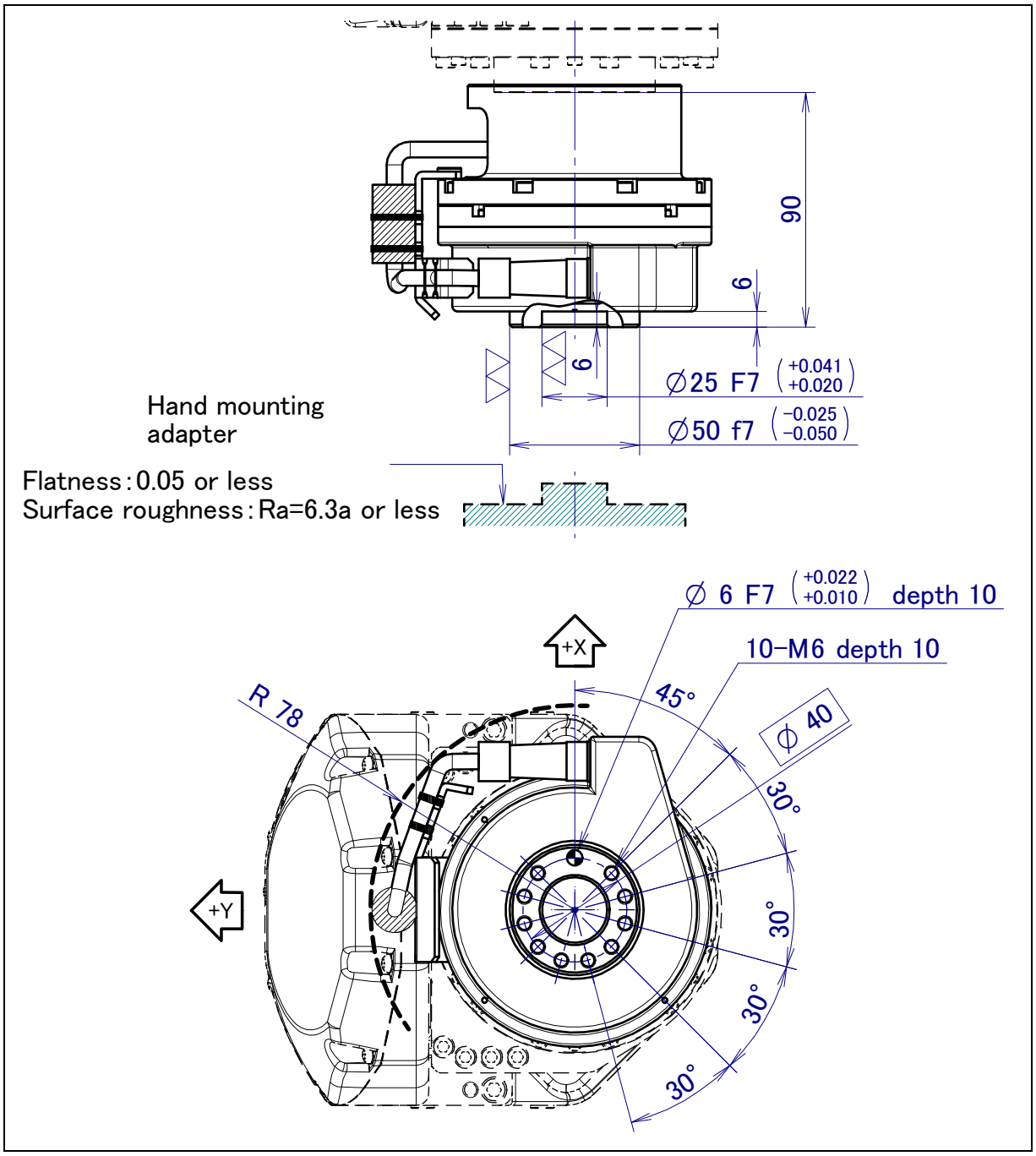


Fig. 4.1.1 (b) Wrist section end effector mounting surface (FS-40*i*A)

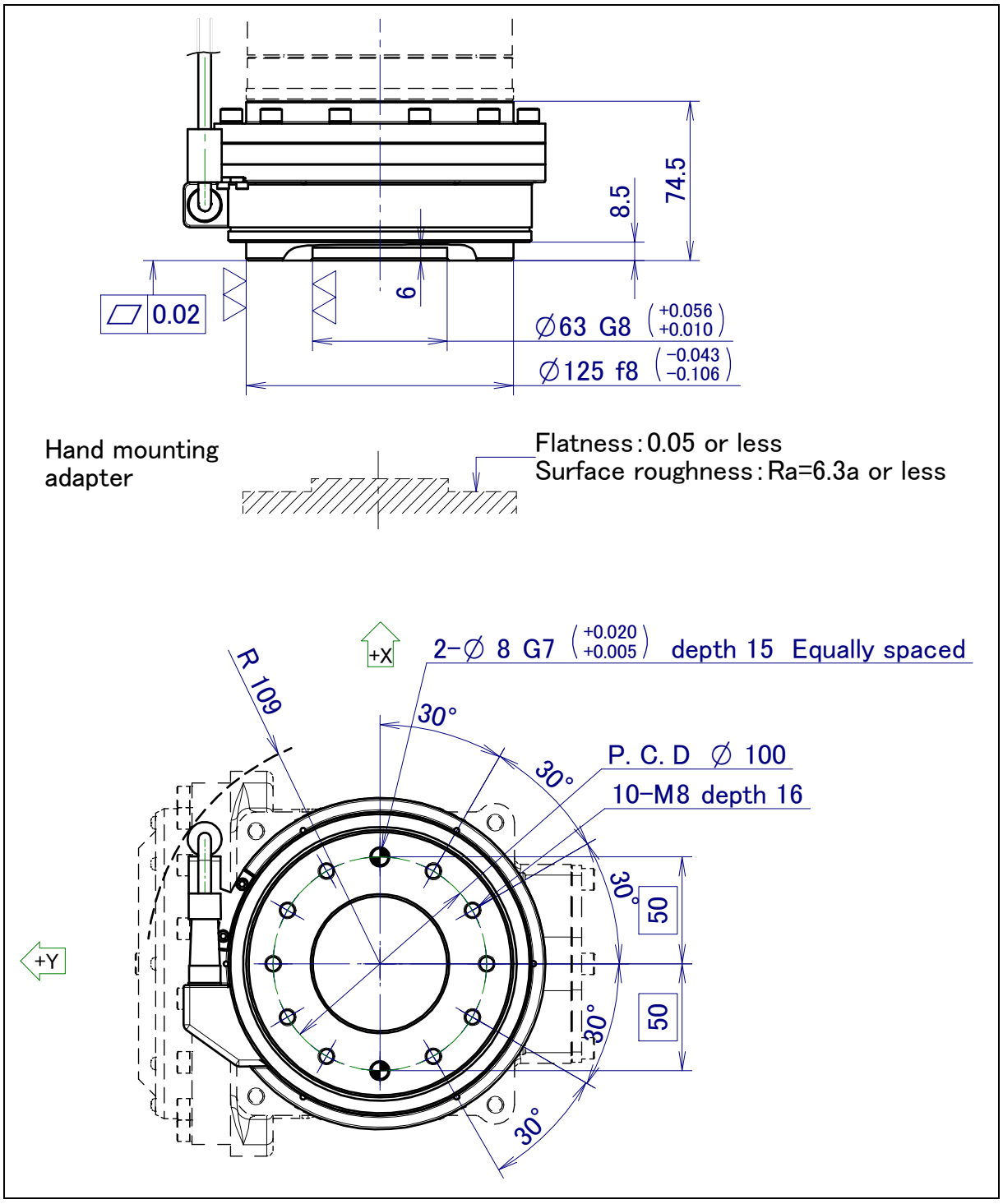


Fig. 4.1.1 (c) Wrist section end effector mounting surface (FS-100*i*A)

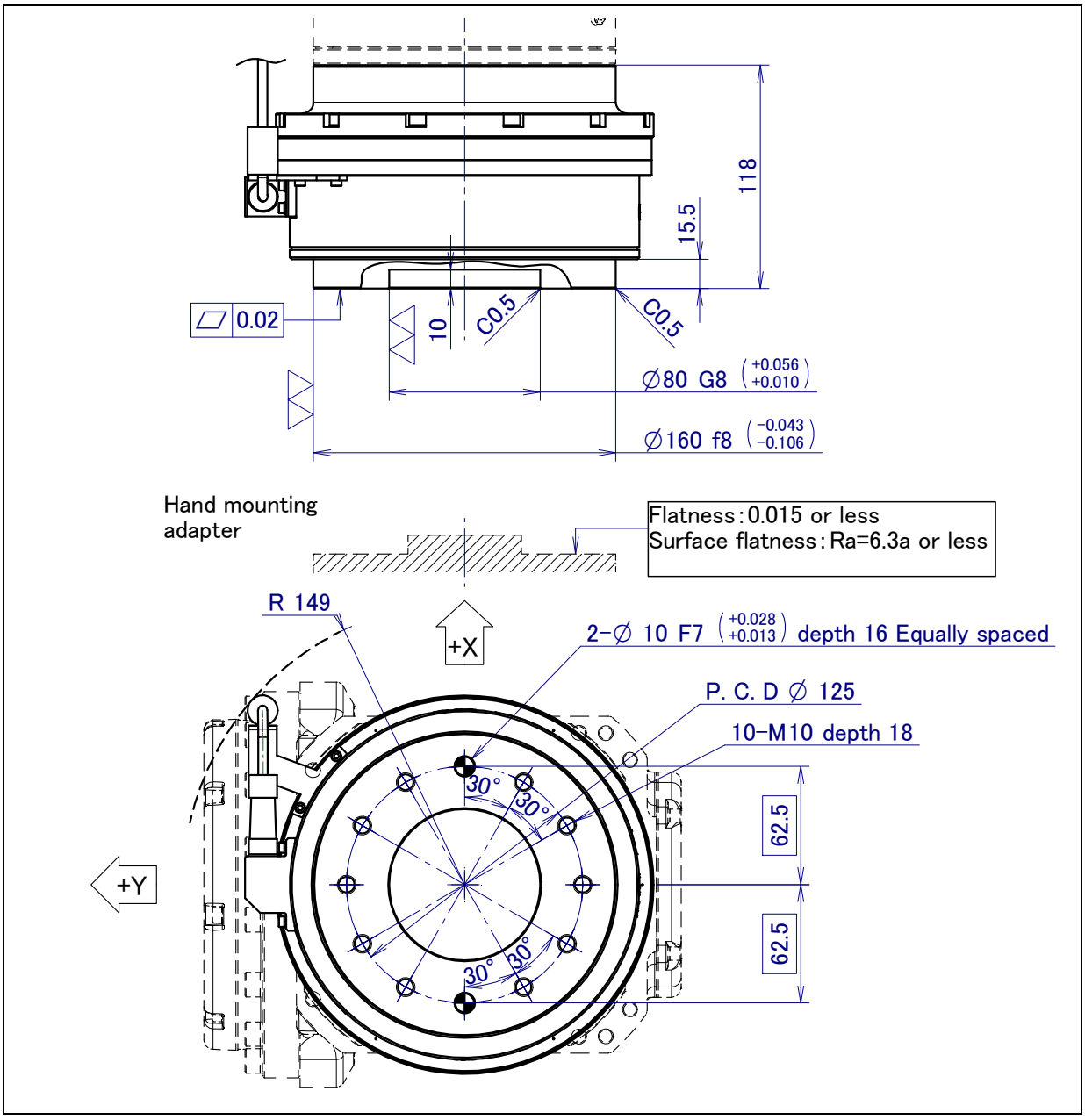


Fig. 4.1.1 (d) Wrist section end effector mounting surface (FS-250*i*A standard adapter)

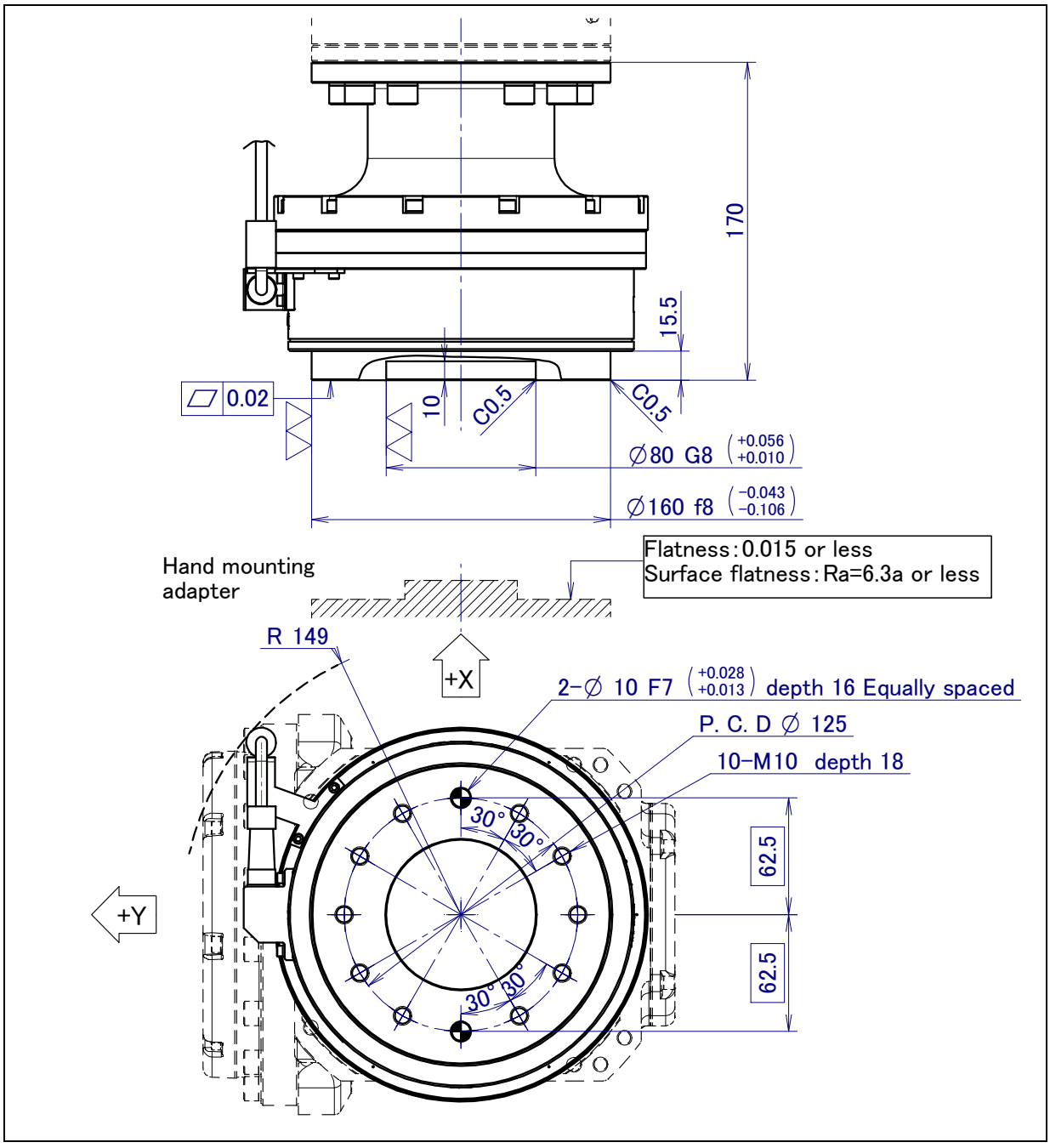


Fig. 4.1.1 (e) Wrist section end effector mounting surface (FS-250*i*A adapter which does not need torque wrench)

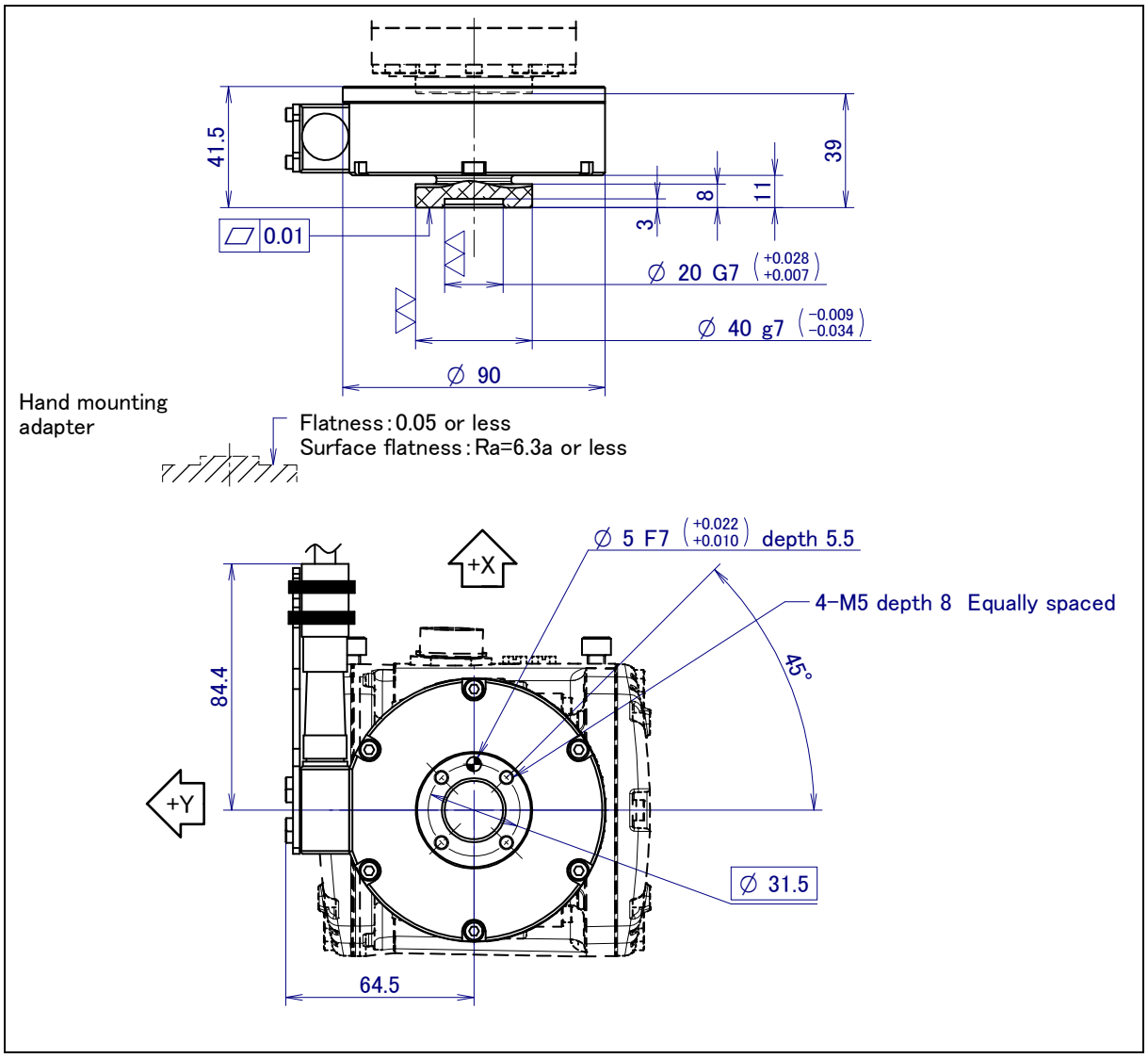


Fig. 4.1.1 (f) Wrist section end effector mounting surface (FS-15*i*Ae)

4.1.2 Example of Designing the Hand Mounting Adapter

When designing a member (hereafter called a hand mounting adapter) used to mount an end effector such as a hand on the force sensor, observe the following:

(1) The surface that meets the force sensor shall satisfy:
  Flatness: 0.05 or less (In case of FS-250*i*A : 0.015 or less)
  Surface roughness: Ra = 6.3a or less
  (See Fig. 4.1.2 (a) to (d).)
(2) The flatness of the mounting face on the hand side must also satisfy the above requirements.
(3) A parallel pin shall be used as a positioning pin for the hand mounting adapter. Do not use a spring pin.

NOTE
If the hand mounting adapter used does not satisfy the specified flatness and surface roughness requirements, the force sensor might be deformed, resulting in a heavy load being detected even when there is no load.
If this is the case, it is impossible to provide a sufficient measurement range.

NOTE

If the force sensor is subject to a sudden temperature change (for example caused by direct contact with a hot, or a cold work piece), some time is necessary in order to stabilize its output. For these cases, please consider applying an external countermeasure (such as adding a material which low thermal conductivity, between hand adapter and hand).

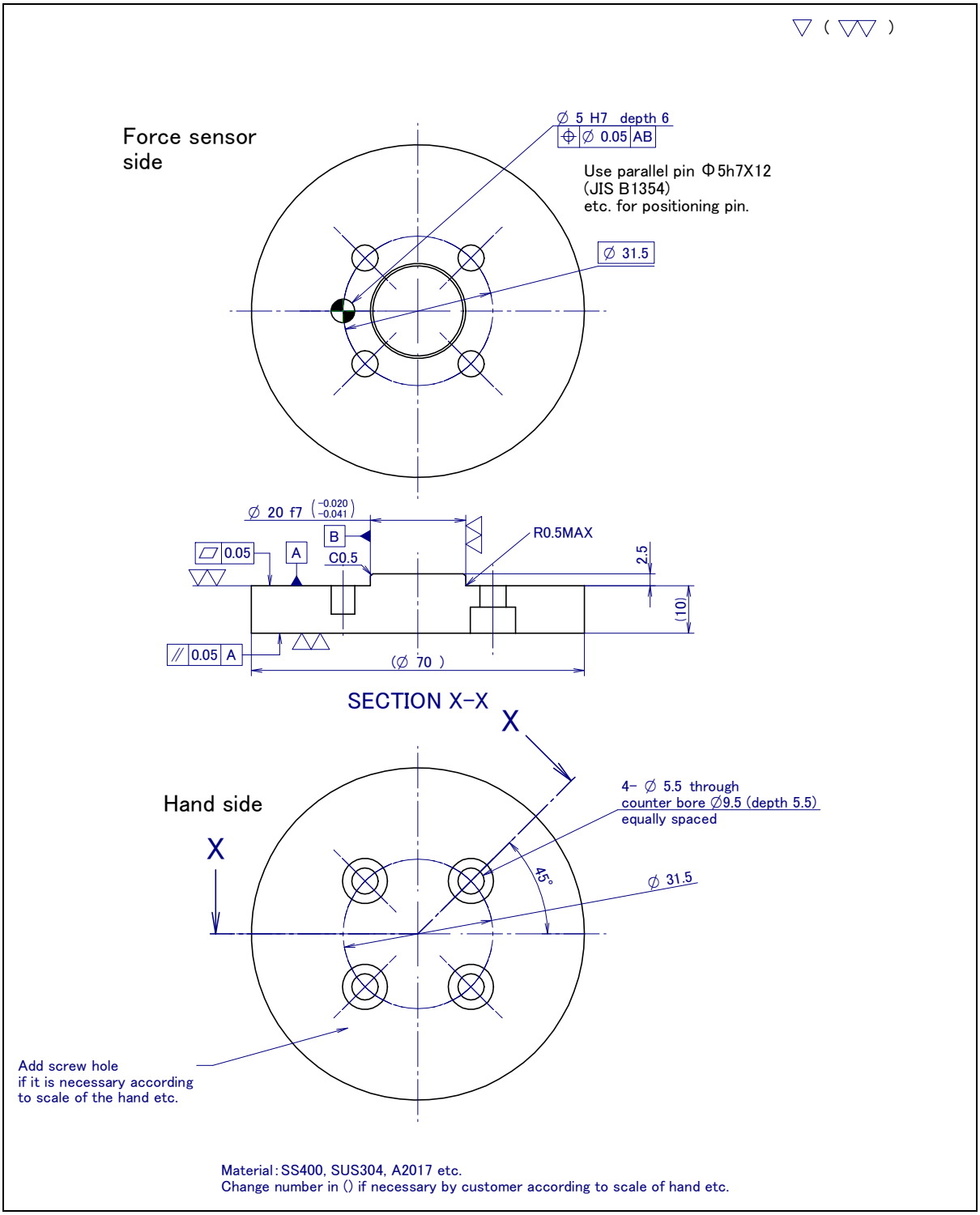


Fig. 4.1.2 (a) Example of designing the hand mounting adapter (FS-15*i*A, FS-15*i*Ae)

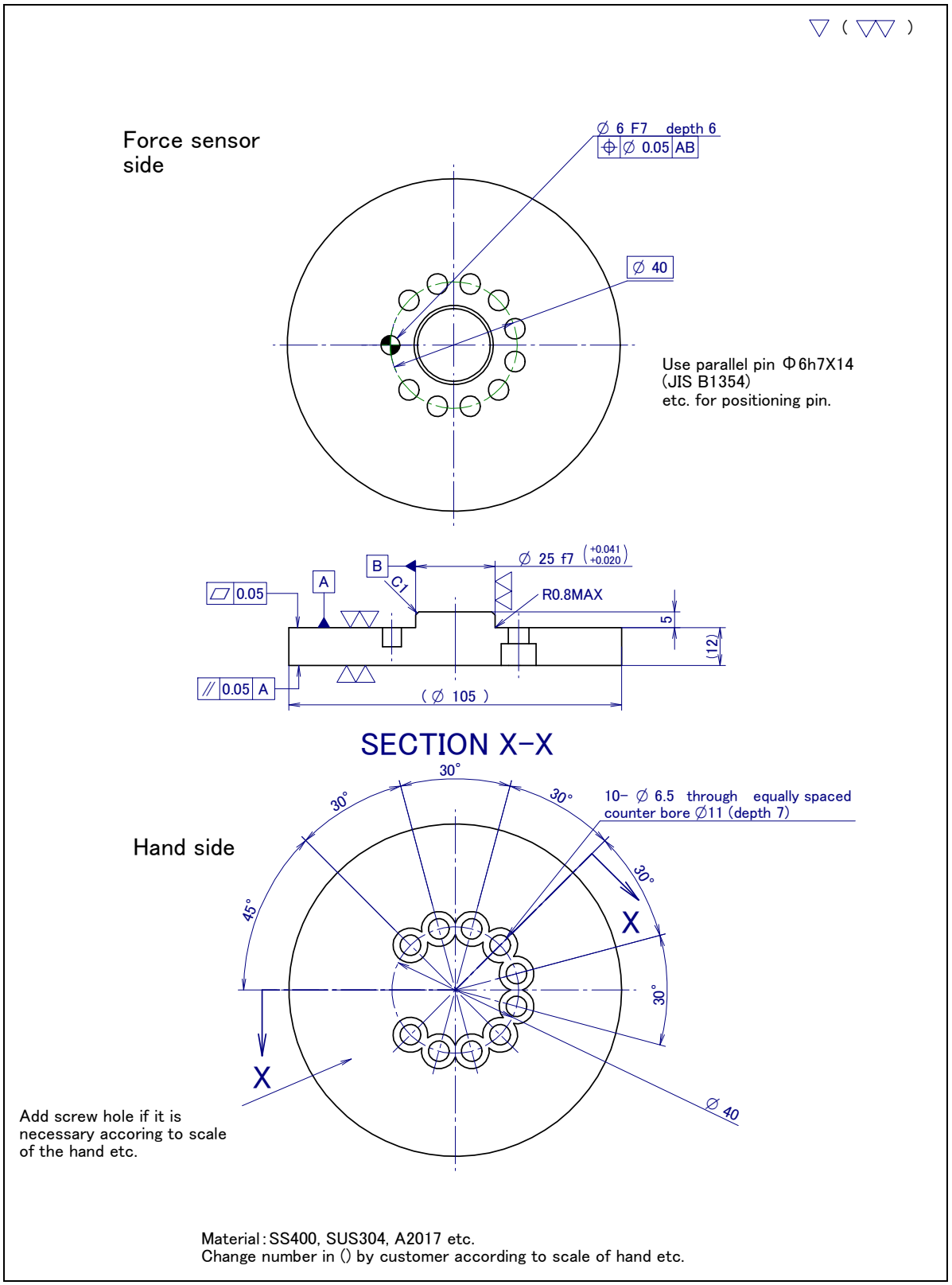


Fig. 4.1.2 (b) Example of designing the hand mounting adapter (FS-40*i*A)

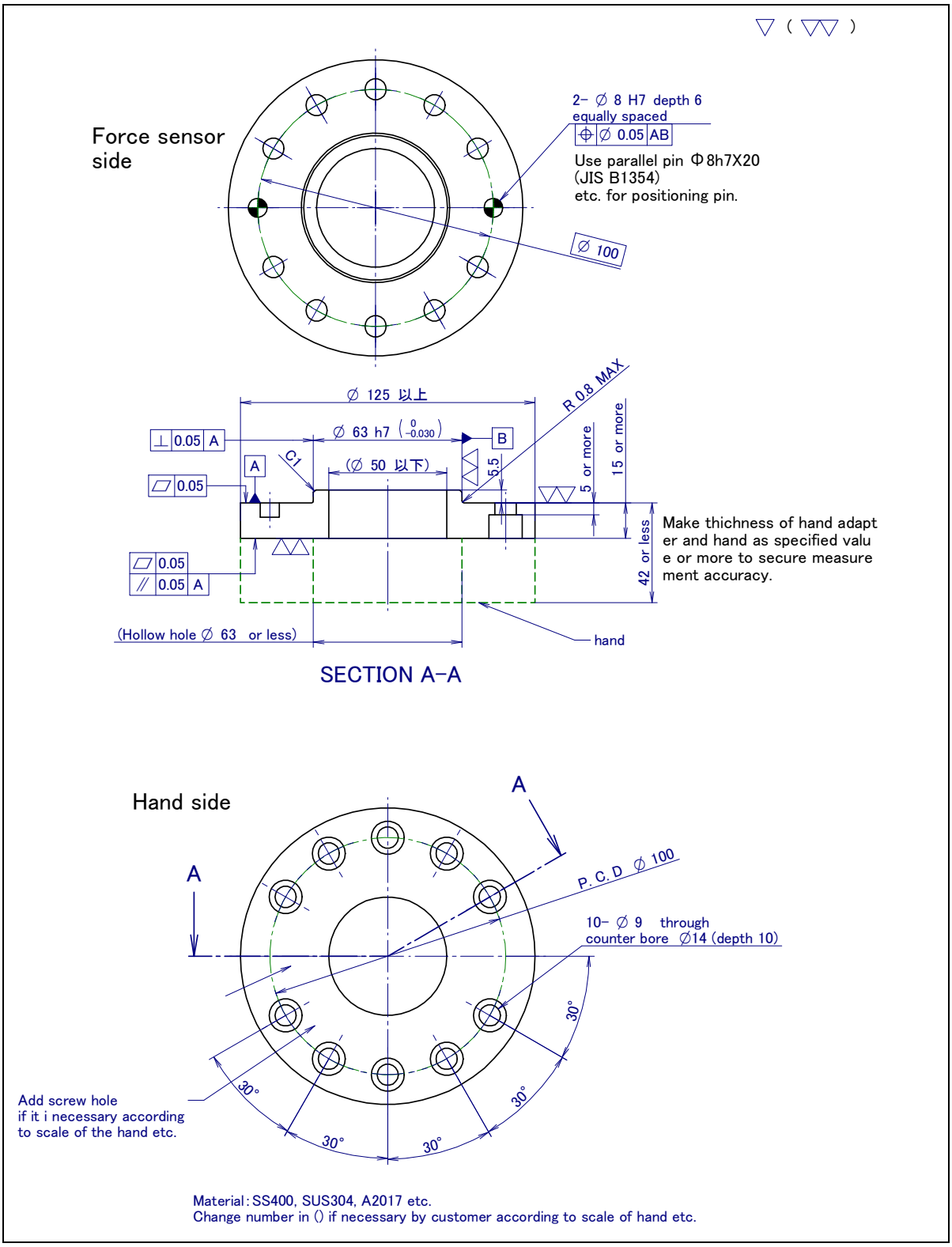


Fig. 4.1.2 (c) Example of designing the hand mounting adapter (FS-100*i*A)

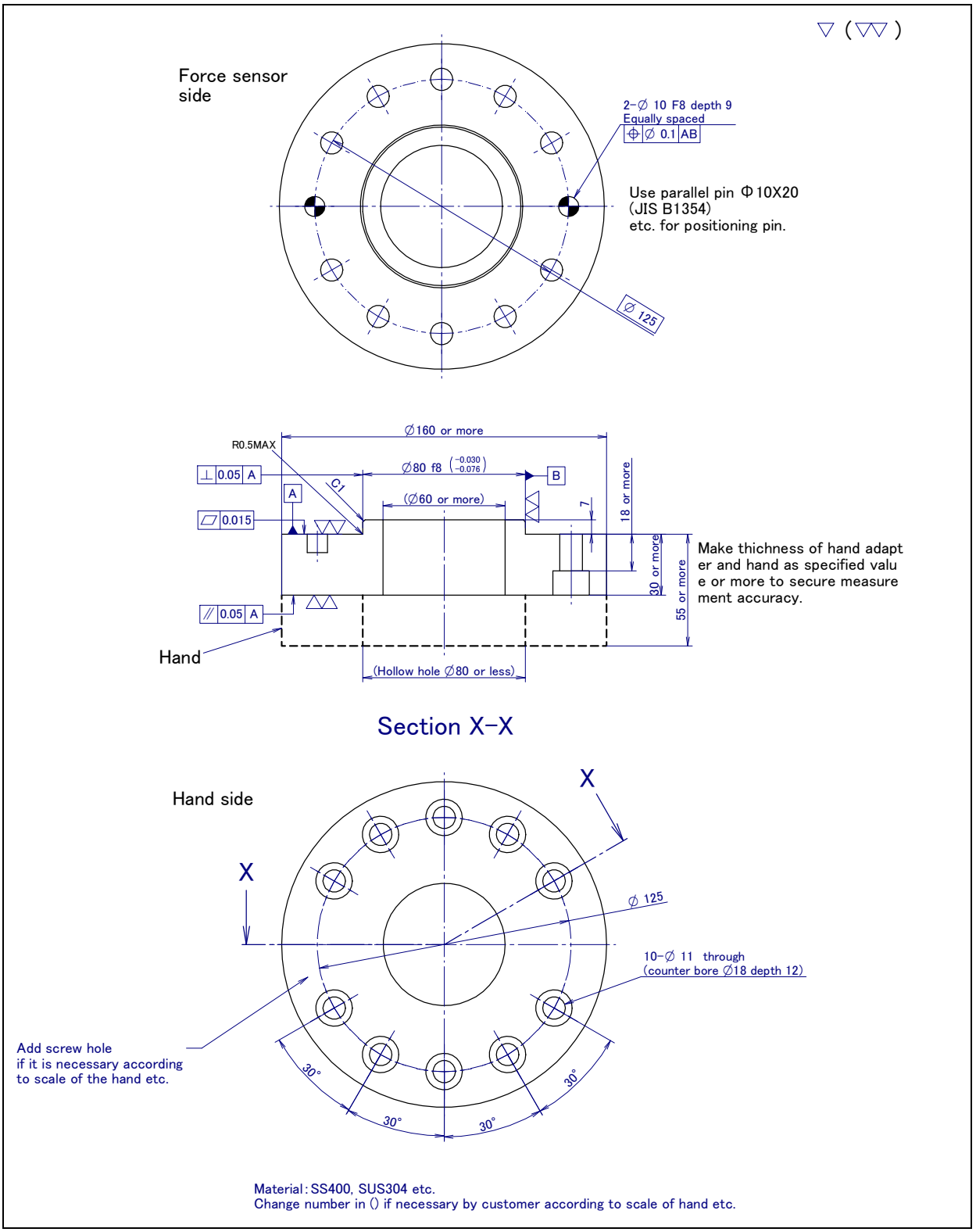


Fig. 4.1.2 (d) Example of designing the hand mounting adapter (FS-250*i*A)

4.2 3D LASER VISION SENSOR INTERFERENCE AREAS

Fig. 4.2 (a) and (b) show the interference areas of the 3D Laser Vision sensor.

When the 3D Laser Vision sensor is to be used, design an end effector in consideration of a vision interference area, a laser light interference area.

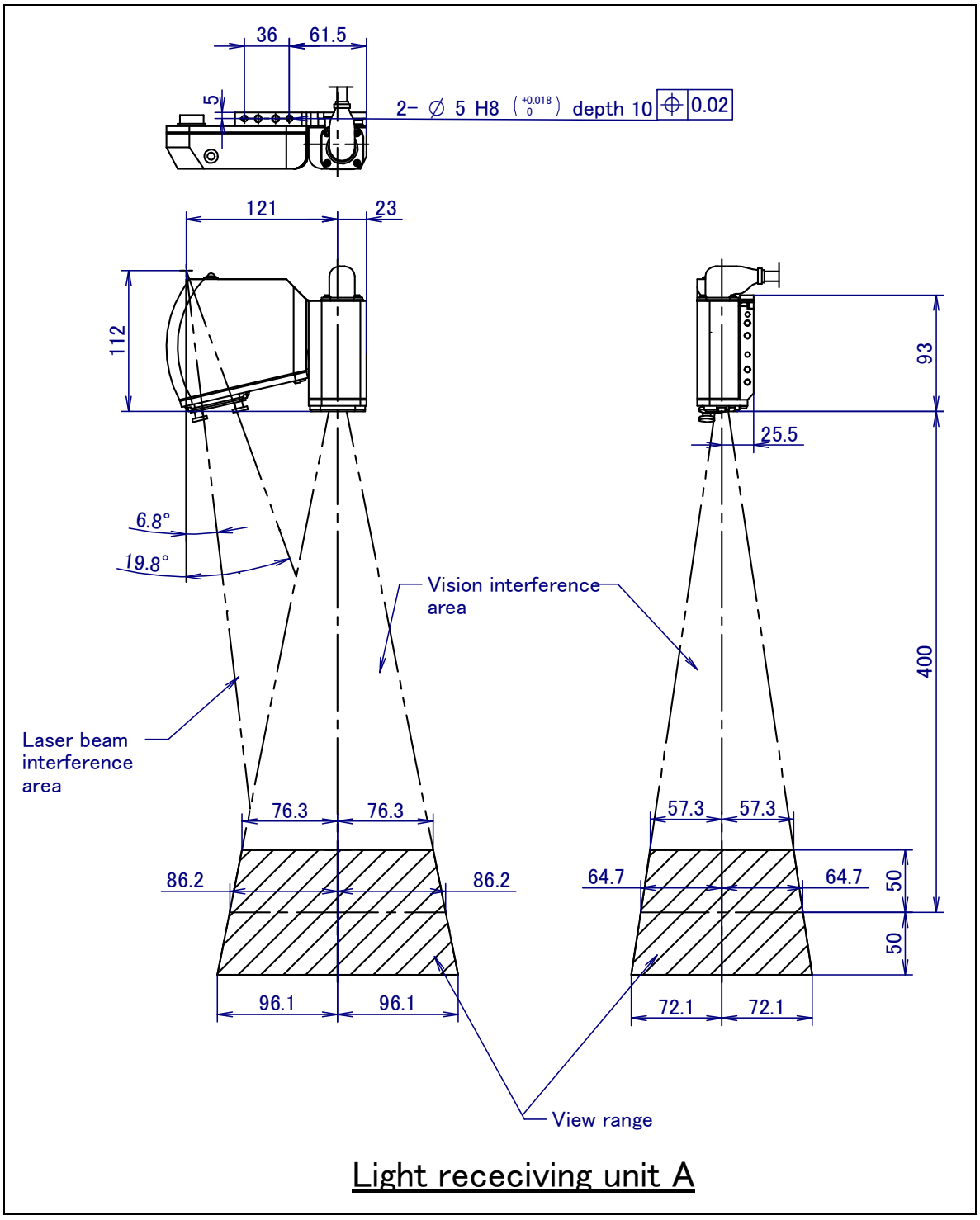


Fig. 4.2 (a) 3D laser vision sensor interference area (Light receiving unit A for Standard)

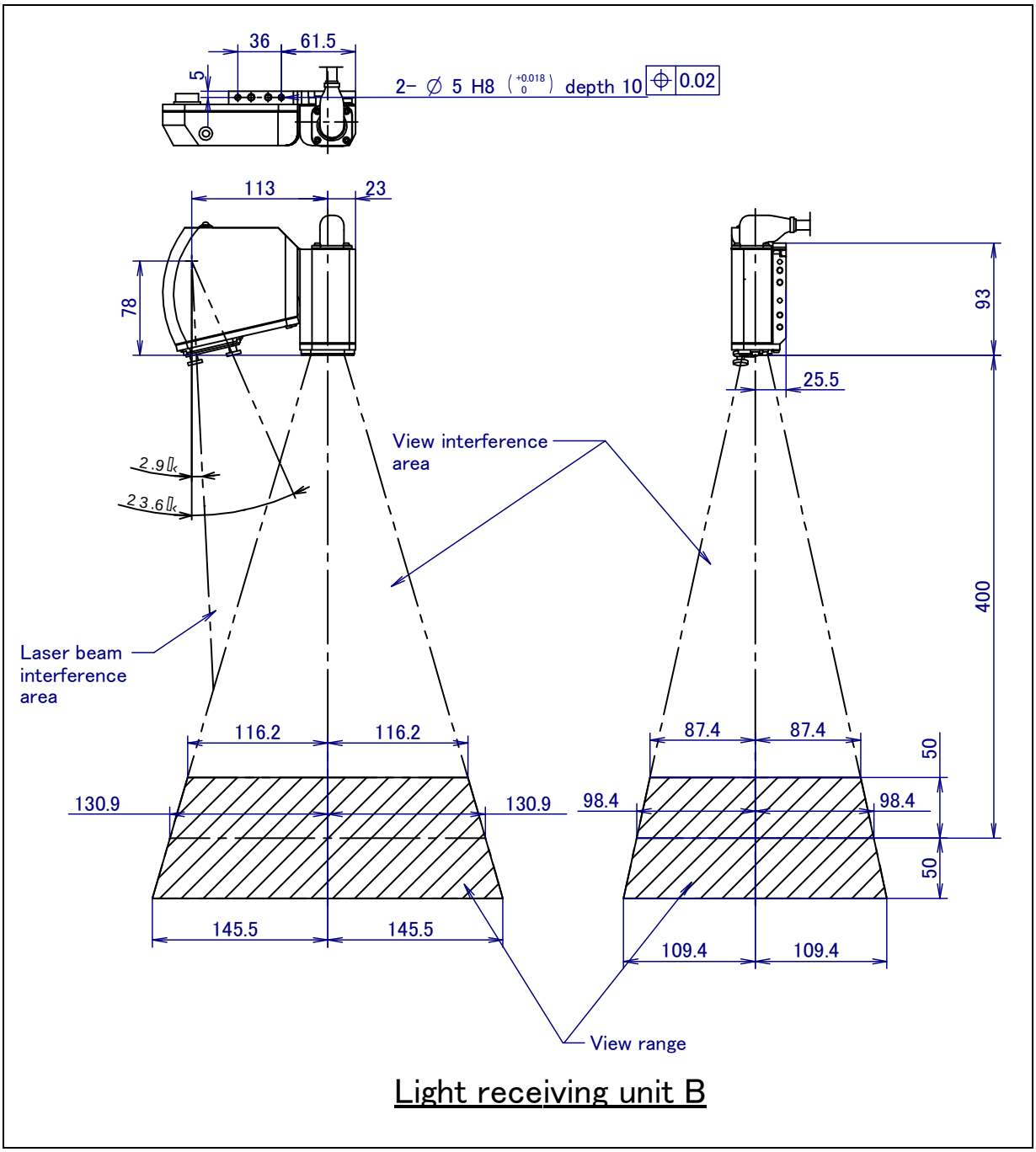


Fig. 4.2 (b) 3D laser vision sensor interference area (Light receiving B for Standard)

5 PIPING AND WIRING

5.1 PIPING

The piping in a robot loaded with the force sensor and 3D Laser Vision sensor is the same as that of the mechanical unit of the robot's mechanical main body. Refer to the specific mechanical unit manual for that robot model.

5.2 WIRING

5.2.1 Robot Which Equipped Force Sensor and 3D Laser Vision Sensor

Fig. 5.2.1 shows the schematic drawings of the robot loaded with the Force Sensor and 3D Laser Vision sensor. Refer to the Maintenance Manual for explanations of the wiring of the robot each mechanical unit.

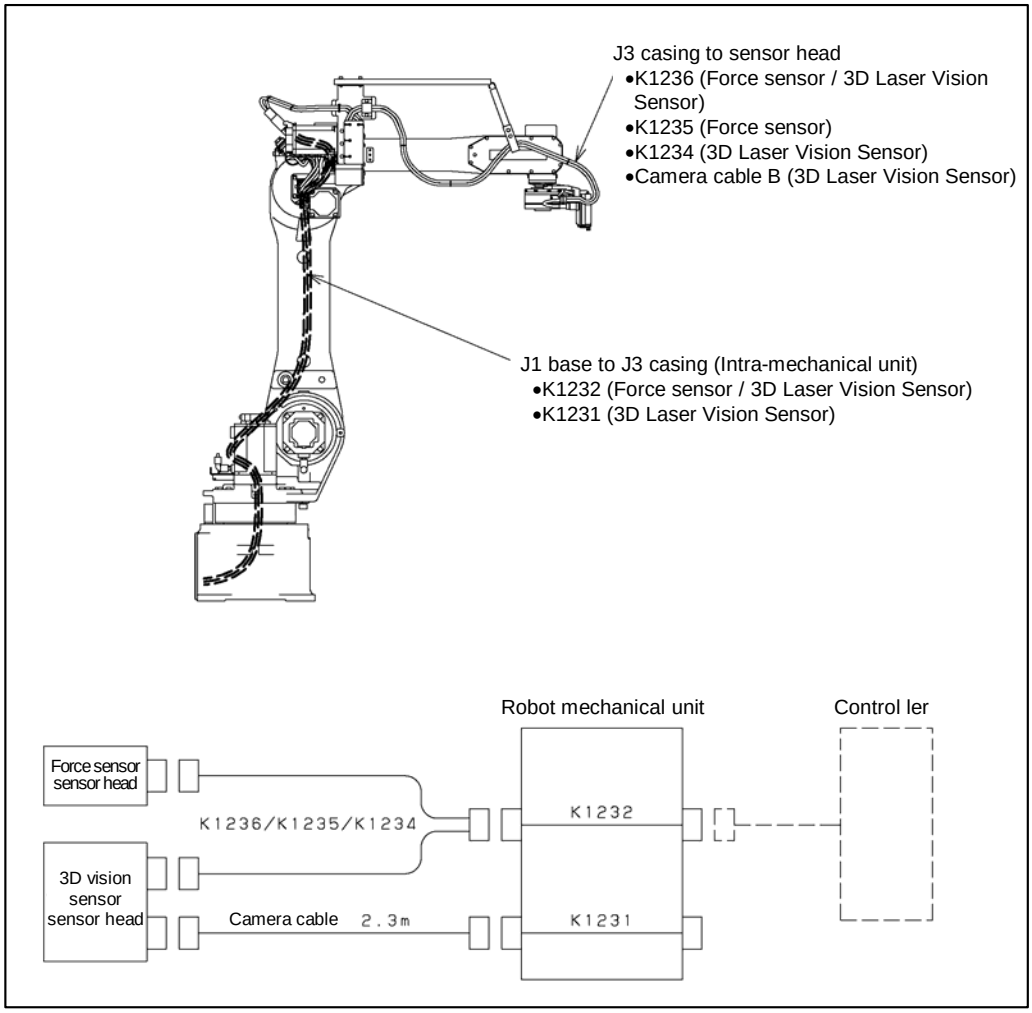


Fig. 5.2.1 Robot with sensor

5.2.2 3D Area Sensor

Fig 5.2.2 shows wiring of 3D Area Sensor.

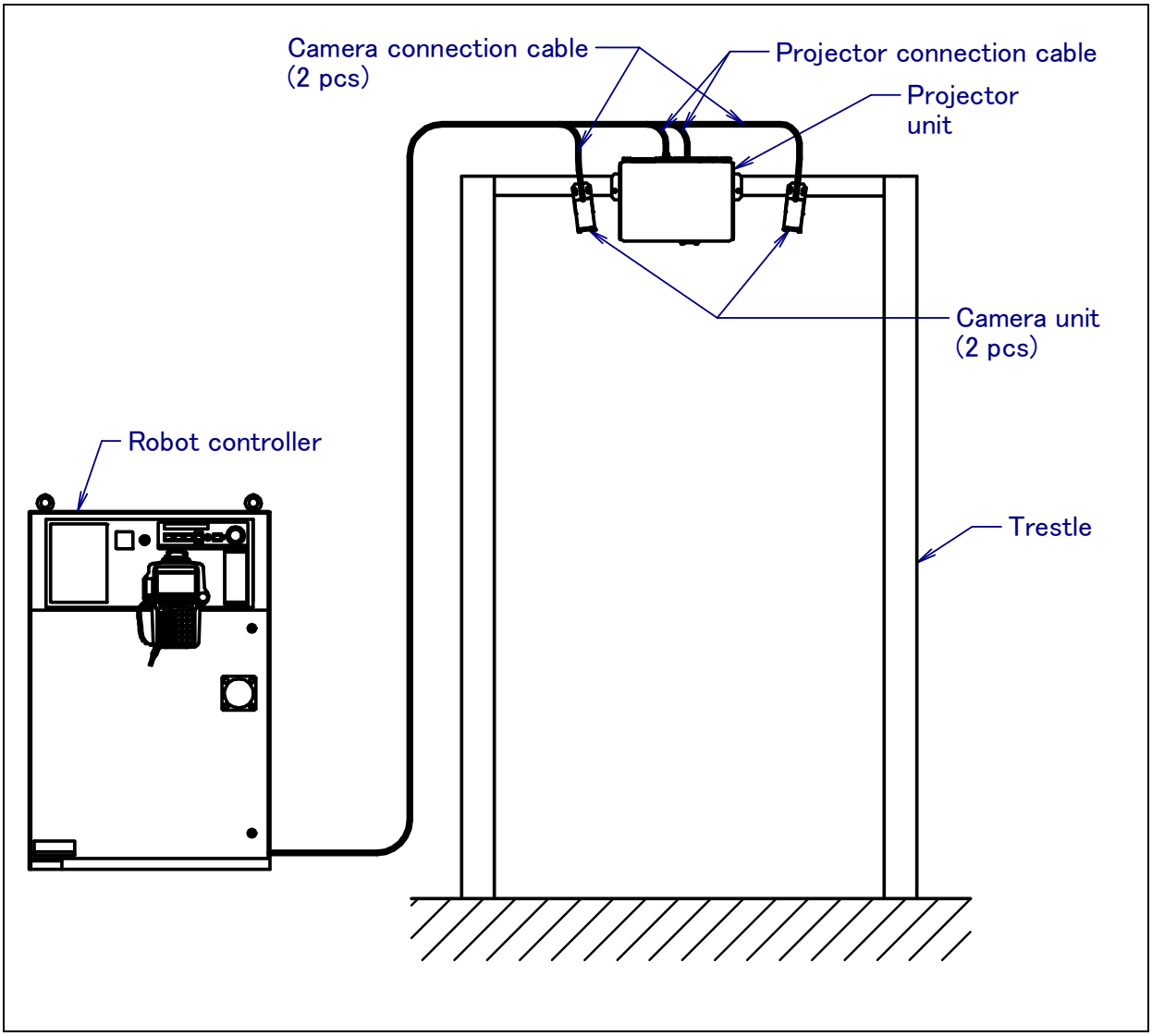


Fig.5.2.2 Wiring of 3D area sensor

6 SETUP

This chapter explains the setup operation that is required before *i*RVision can be used.

6.1 BASIC CONFIGURATION

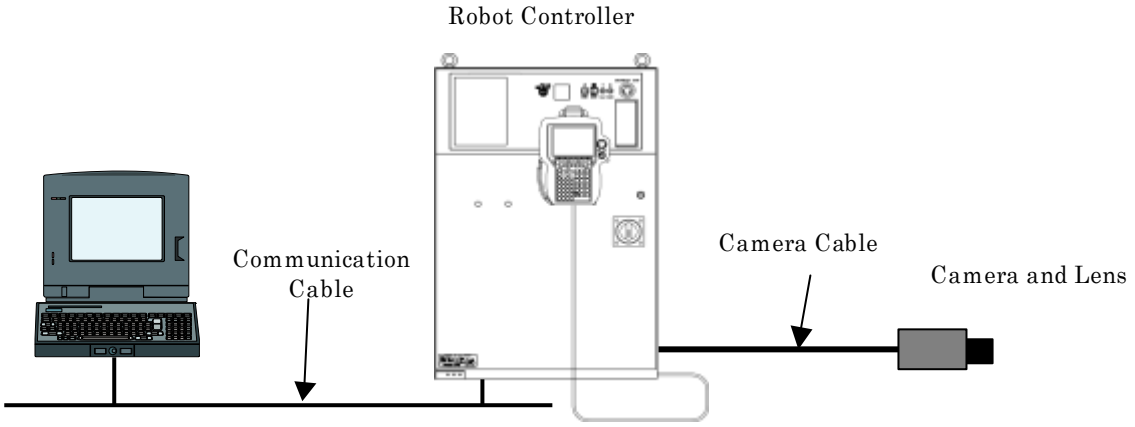
This section describes the basic configuration of the *i*RVision system.

This manual describes the standard *i*RVision configuration. Some applications might require special components. Refer to the application-specific *i*RVision Start-up Guide for more information.

*i*RVision consists of the following components:

- Camera and lens, or three-dimensional laser sensor
- Camera cable
- Optional multiplexer (contained in the robot controller)
- Setup PC ... *
- Communication cable ... *

> ⚠ **CAUTION**
> The components marked with an asterisk (*) are necessary only for setting up *i*RVision and can be removed during production operation. These components are not provided by FANUC and need to be purchased by the user.



6.2 CONNECTIN A CAMERA

Connect a camera to the robot controller.

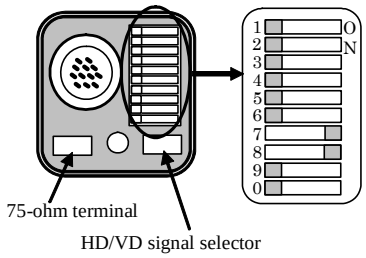
6.2.1 Configuring The Camera

Configure the camera for *i*RVision.

6.2.1.1 Progressive camera

Set the switches on the rear panel of the camera as shown in the table below in case of 1/3 CCD progressive camera (A05B-1405-K501:SONY XC-56).

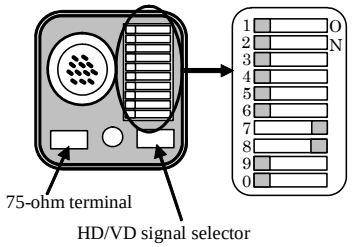
Switch	Factory-set default	Setting for using *i*RVision
DIP switches	All set to OFF	Set switches 7 and 8 to ON.
75-ohm terminal	ON	ON
HD/VD signal selector	EXT	EXT



6.2.1.2 Double speed progressive camera

Set the switches on the rear panel of the camera as shown in the table below in case of 1/3 CCD double speed progressive camera (A05B-1405-K502:SONY XC-HR50).
It is common to 1/2 CCD XC-HR57.

Switch	Factory-set default	Setting for using *i*RVision
DIP switches	All set to OFF	Set switches 7 and 8 to ON.
75-ohm terminal	ON	ON
HD/VD signal selector	EXT	EXT



6.2.2 Connecting a Camera

Refer to Section 2.6 about connection method of camera to robot controller.

6.3 CONNECTING A SETUP PC

Connect a PC to the robot controller and prepare to set up the *i*RVision system. The PC is used only for teaching *i*RVision and can be disconnected during production operation.

6.3.1 Setup PC

A PC is used to set up *i*RVision. After the setup operation for *i*RVision is completed, the PC can be removed. Make sure that the setup PC meets the specifications shown below.

Operating Systems

	V7.20P	V7.30P	V7.40P	V7.50P	V7.70P
Microsoft® Windows XP Professional Edition	•	•	•	•	•
Microsoft® Windows XP Home Edition		•			
Microsoft® Windows Vista™ Business 32-bit			•	•	•
Microsoft® Windows 7 Professional 32-bit	•	•	•	•	•
Microsoft® Windows 7 Professional 64-bit	•	•	•	•	•

Web Browsers

	V7.20P	V7.30P	V7.40P	V7.50P	V7.70P
Microsoft® Internet Explorer 6	•	•	•	•	•
Microsoft® Internet Explorer 7		•	•	•	•
Microsoft® Internet Explorer 8				•	•
Microsoft® Internet Explorer 9	•	•	•	•	•

⚠ CAUTION

1 *i*RVision supports only Japanese version and US version of Windows.
2 Operating systems and browsers not in the above tables are not supported.
3 *i*RVision setup will NOT work with 64-bit Internet Explorer. If the PC is running the 64-bit version of Windows 7, *i*RVision setup must be operated using the 32-bit version of Internet Explorer.
4 All Windows versions assume that the latest Service Pack is installed.
5 When you log in to your PC as a user without the Administrator password, the PC might not normally communicate with the robot. Log in to your PC as a user with the Administrator password.

6.3.2 Communication Cable

A cable is used to connect the robot controller and the PC to set up *i*RVision. Choose a 10BASE-T or 100BASE-T cable that meets the specifications shown below.

Cable	Twisted pair
Shield	Shielded
Cable connection	Cross cable (when connecting the PC directly to the robot controller) Straight cable (when connecting the PC to the robot controller via a hub unit)

6.3.3 Connecting a Communication Cable

Connect the robot controller and the PC using an Ethernet cable. On the robot controller side, plug the cable into the Ethernet connector on the front of the MAIN board. On the PC side, plug the cable into the network connector, usually marked 品.

6.3.4 Determining the IP Addresses

Set the IP addresses to be assigned to the robot controller and the setup PC. Typically, these IP addresses are determined by the network administrator. To find out what addresses to assign, contact the network administrator of your organization.

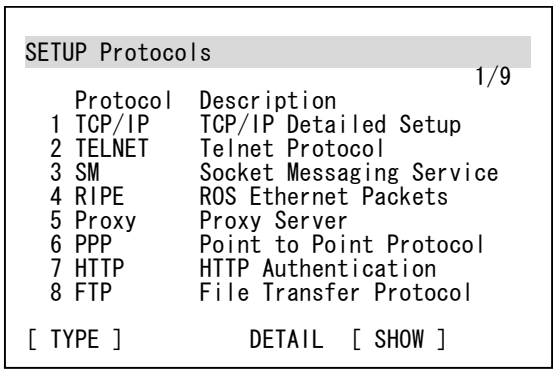
When the robot controller and the PC are connected on a one-on-one basis and not connected to any other network device, the IP addresses can be set as shown below.

Robot controller	192.168.0.1
PC	192.168.0.2
Gateway	192.168.0.3
Subnet mask	255.255.0.0

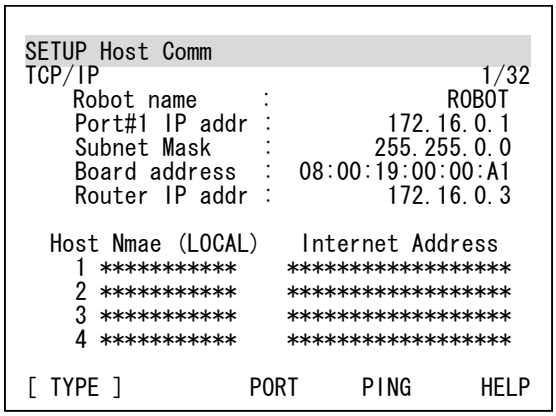
6.3.5 Setting the IP Address of the Robot Controller

Set the IP address of the robot controller.

1 Press MENUS on the teach pendant of the robot controller.
2 From the pull-down menu, select [6 SETUP].
3 Press F1, [TYPE].
4 Select [Host Comm] from the list.



5 Move the cursor to "TCP/IP" and press ENTER.



6 Enter the name of the robot controller in [Robot name].
7 Enter the IP address of the robot controller in [Port#1 IP addr].
8 Enter the subnet mask in [Subnet mask].
9 Enter the IP address of the default gateway in [Router IP addr].
10 Turn off the power of the robot controller, and then turn it back on.

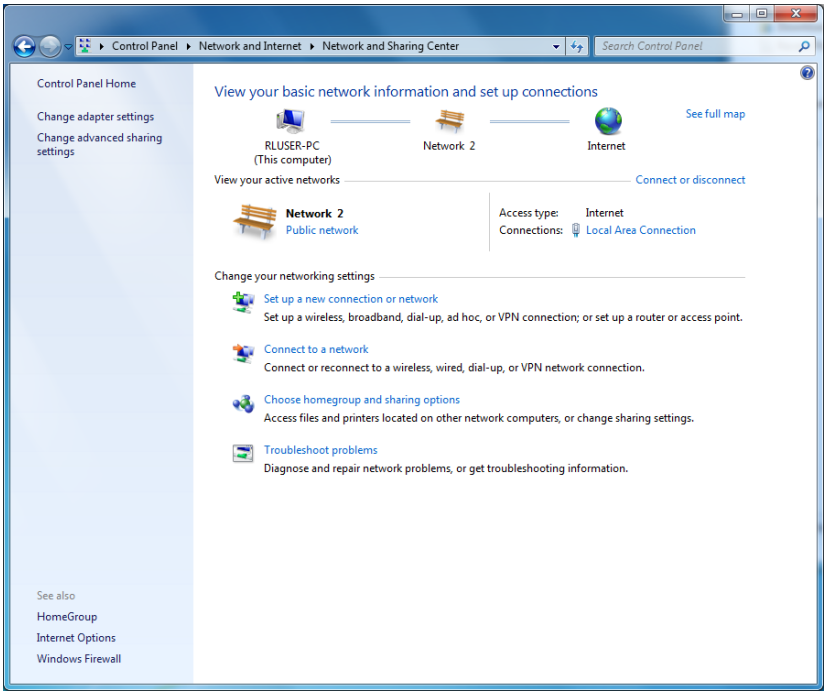
⚠ CAUTION
1 When setting the IP address, do not insert any unnecessary spaces or "0". If an unnecessary space or "0" is inserted, communication cannot be performed normally.
2 When setting the Robot Name, do not insert any spaces in the name.

6.3.6 Setting the IP Address of the PC

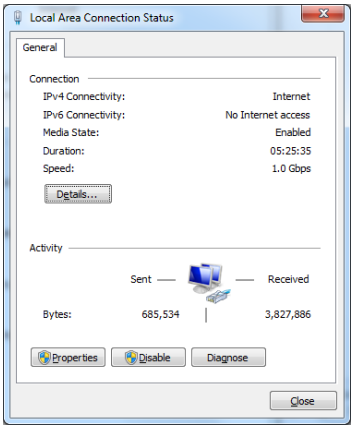
Set the IP address of the PC.

Windows 7

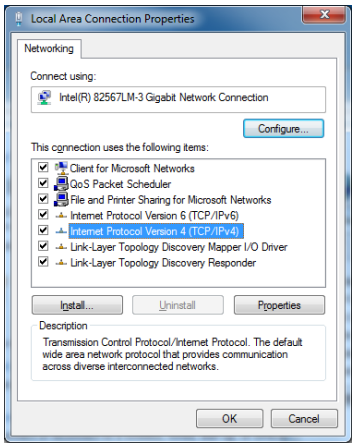
1 In the Control Panel window, open [Network and Sharing Center].



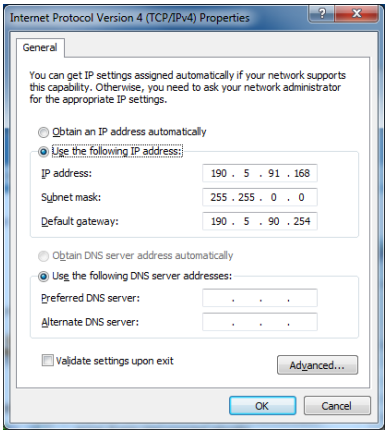
2 Click [Local Area Connections] in [View your active networks].



3 Click the [Properties] button.



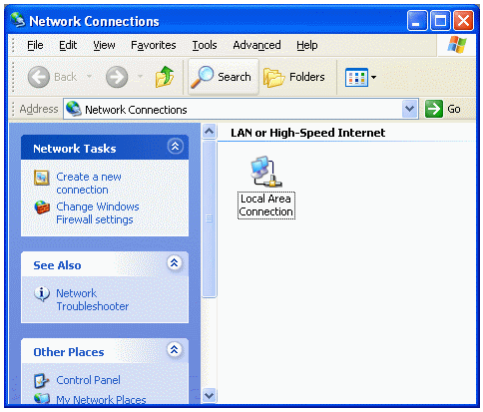
4 Select [Internet Protocol Version 4 (TCP/IPv4)], and click the [Properties] button.



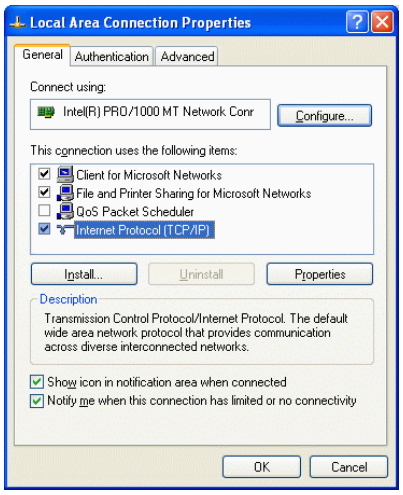
5 Check the [Use the following IP address] box, and enter values in [IP address], [Subnet mask], and [Default gateway].
6 Click the [OK] button to close the window.

Windows XP and Windows Vista

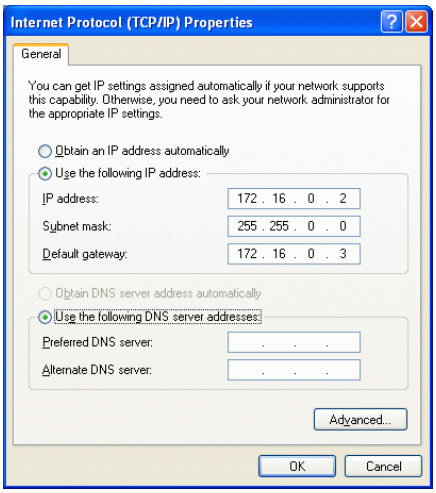
1 In the Control Panel window, double-click [Network connection].



2 Right-click [Local area connection], and then select [Properties].



3 Select [Internet protocol(TCP/IP)], and then click [Properties].

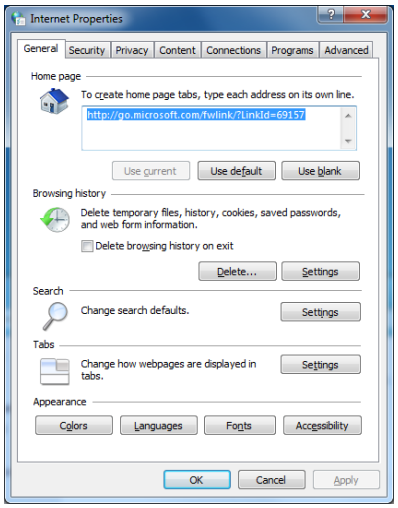


4 Check the [Use the following IP address] box, and enter values in [IP address], [Sub-net mask], and [Default gate way].
5 Click the [OK] button to close the window.

6.3.7 Modifying Settings of Internet Explorer

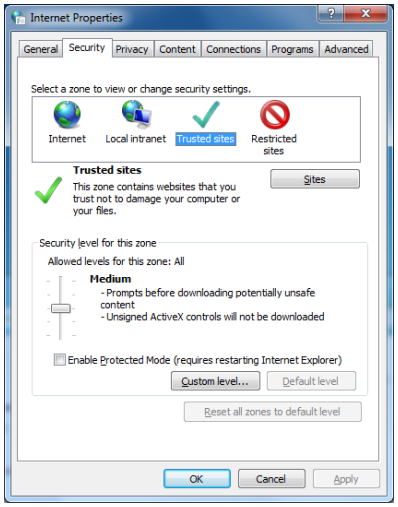
Set Internet Explorer to prevent Windows from blocking communication with the robot controller. The procedures are almost the same for Window 7, Windows Vista and Windows XP, so screenshots of Windows 7 are used in the explanation below.

1 In the Control Panel window, open [Internet Options].

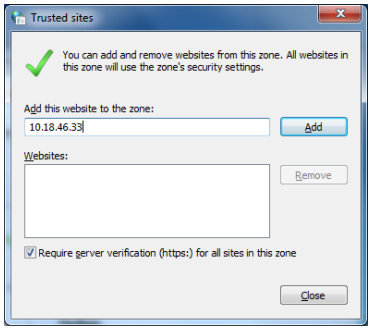


Trusted Sites

1 Select the [Security] tab.



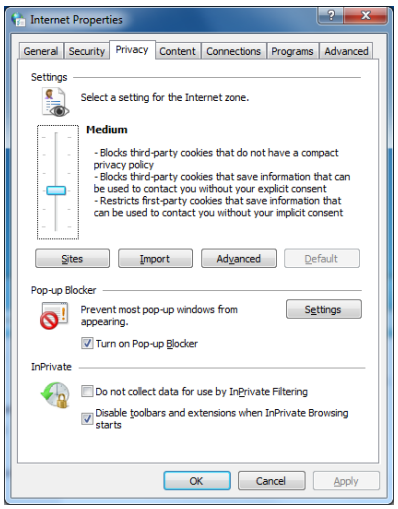
2 Select [Trusted Site], and then click the [Sites] button.



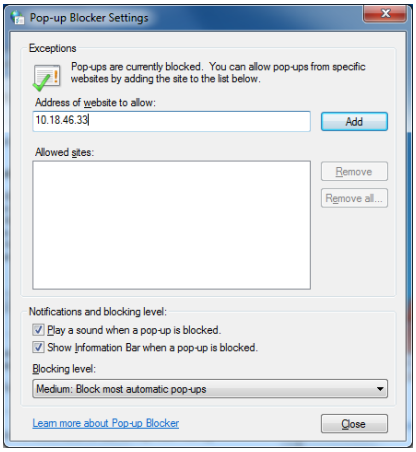
3 Uncheck the [Require server verification (https:) for all the sites in this zone] box.
4 In the [Add this Web site to the zone] textbox, enter the IP address of the robot controller (or the last digit of the IP address can be replaced by *). Then, click the [Add] button.
5 Click the [Close] button to close the dialog box.

Popup Blockers

1 Select the [Privacy] tab.



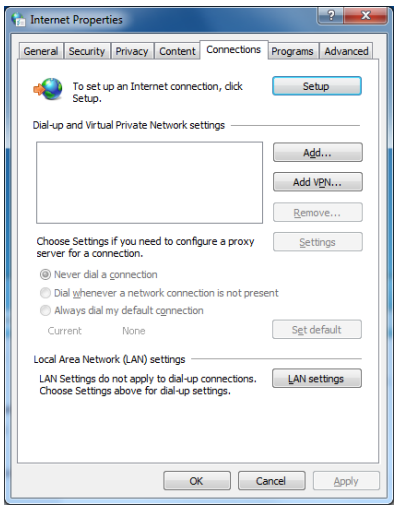
2 Click the [Settings] button of [Pop-up Blocker].



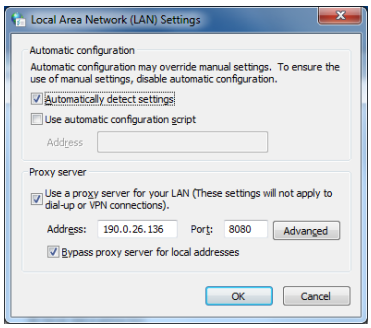
3 Enter the IP address of the robot controller in the [Address of Web site to allow] textbox, and click the [Add] button.
4 Click the [Close] button to close the dialog box.

Proxy Setting

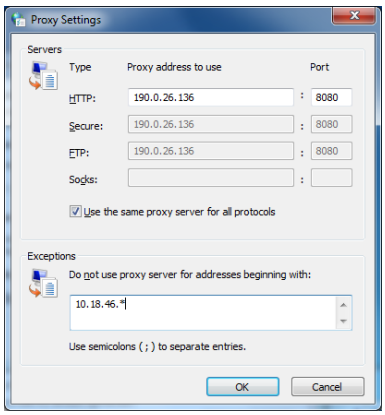
1 Select the [Connections] tab.



2 Click the [LAN Settings] button.



3 When the [Use a proxy server for your LAN] check box is not checked, proceed to the step 7. When it is checked, perform the steps 4 to 6.
4 Click the [Advanced…] button of [Proxy server].



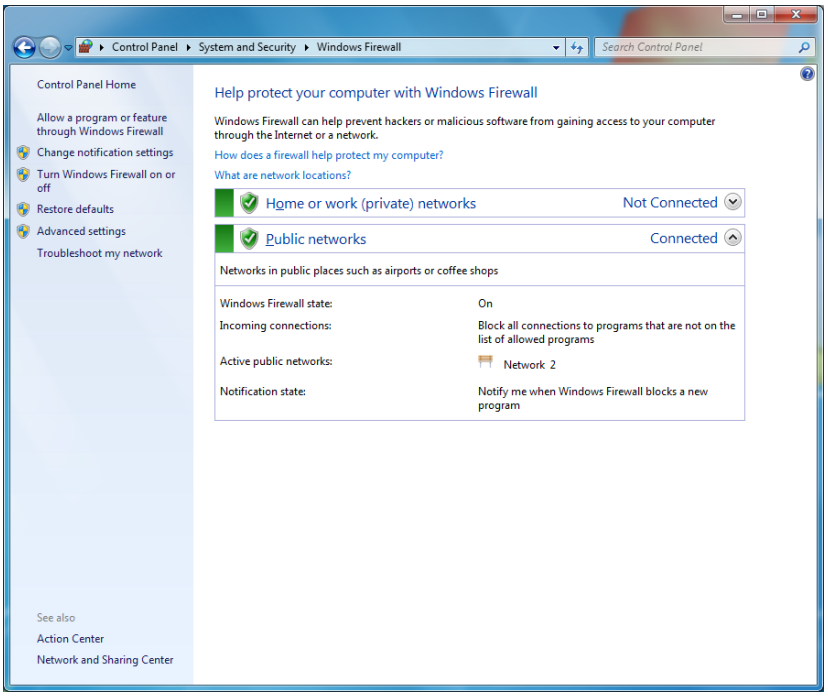
5 Enter the IP address of the robot controller in the text box under [Exceptions].
6 Click the [Close] button to close the dialog box.
7 Click the [OK] button to close the Internet property page.

6.3.8 Modifying Setting of Windows Firewall

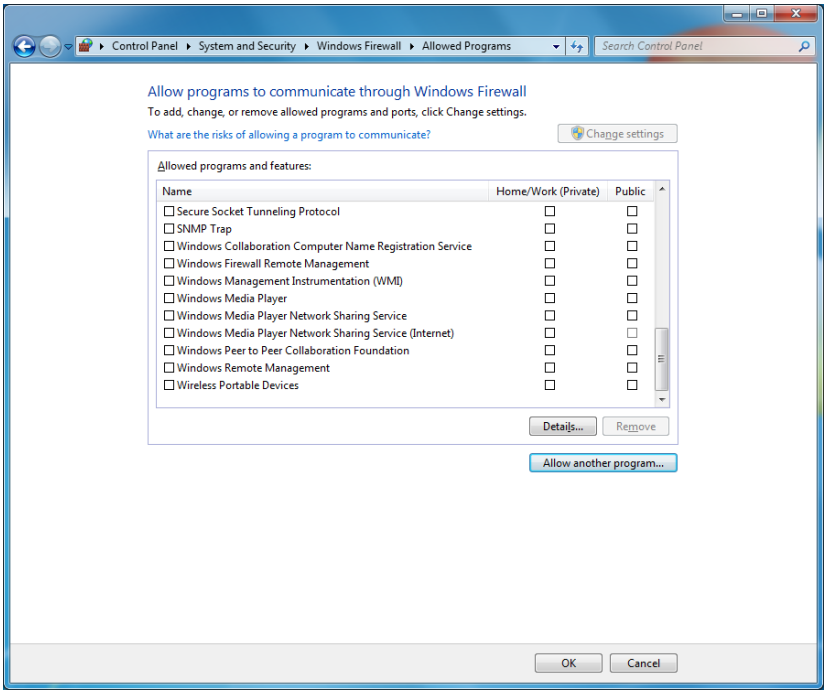
Modify the settings of Windows Firewall to prevent Windows Firewall from blocking communication with the robot controller.

Windows 7

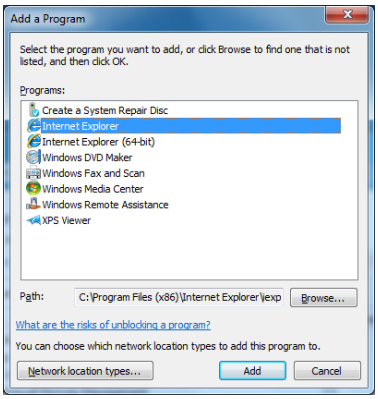
1 In the Control Panel window, open [Windows Firewall].



2 Click [Allow a program or feature through Windows Firewall].



3 Click the [Change settings] button.



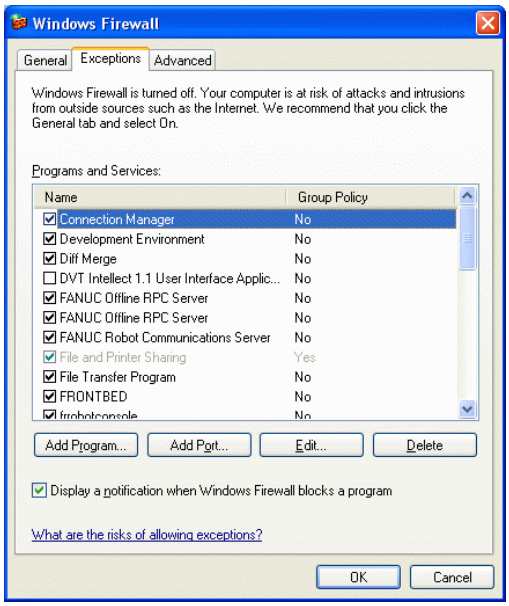
3 Select [Internet Explorer] in the list, and click the [Add] button.
4 Click the [OK] button to close the window.

TIP

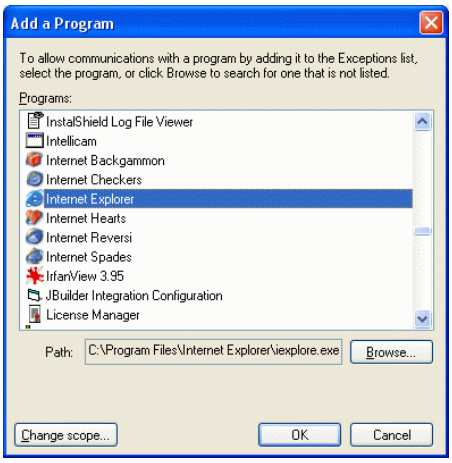
Communication with the robot controller might be prevented due to a cause other than the above, which is, for example, a Microsoft® Internet Explorer add-on or security software installed in your PC. If an error occurs during teaching of *i*RVision, see Subsection A.4.1, "PC UIF Troubles" of R-30*i*B controller *i*RVision OPERATOR'S MANUAL (Reference) (B-83034EN) first.

Windows XP, Windows Vista

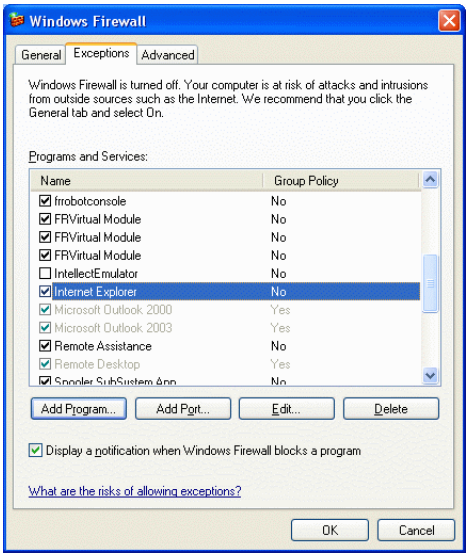
1 In the Control Panel window, open [Windows Firewall].
2 Click the [Exceptions] tab.



3 Click the [Add Program] button.



4 Select [Internet Explorer] from the list, then click the [OK] button.



5 Click the [OK] button.

TIP

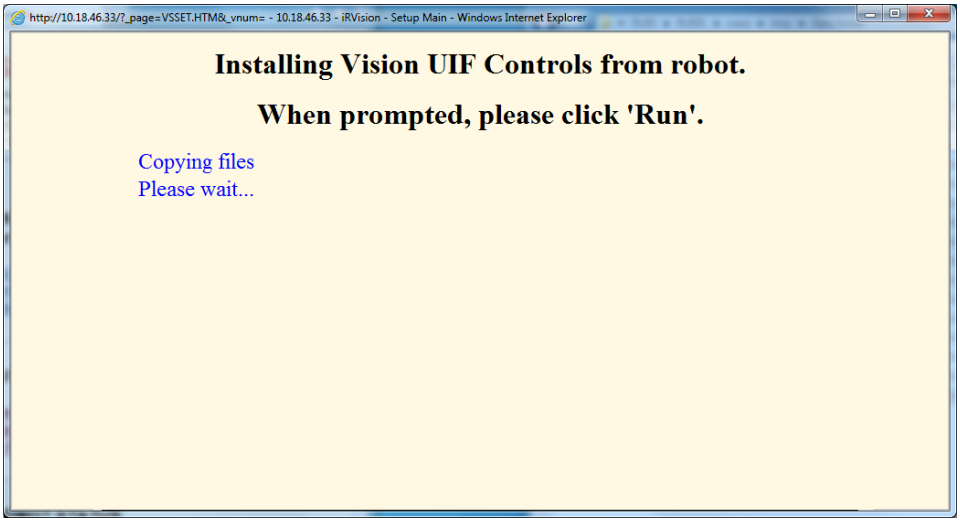
Communication with the robot controller might be prevented due to a cause other than the above, which is, for example, a Microsoft® Internet Explorer add-on or security software installed in your PC. If an error occurs during teaching of *i*RVision, see Subsection A.4.1, "PC UIF Troubles" of R-30*i*B controller *i*RVision OPERATOR'S MANUAL (Reference) (B-83304EN) first.

6.3.9 Installing Vision UIF Controls

You must install Vision UIF Controls on your PC in order to display the *i*RVision user interface. You can install Vision UIF Controls from the robot controller. Procedures are almost the same for various Internet Explorer versions, screenshots of Internet Explorer 9 are used in the explanation below.

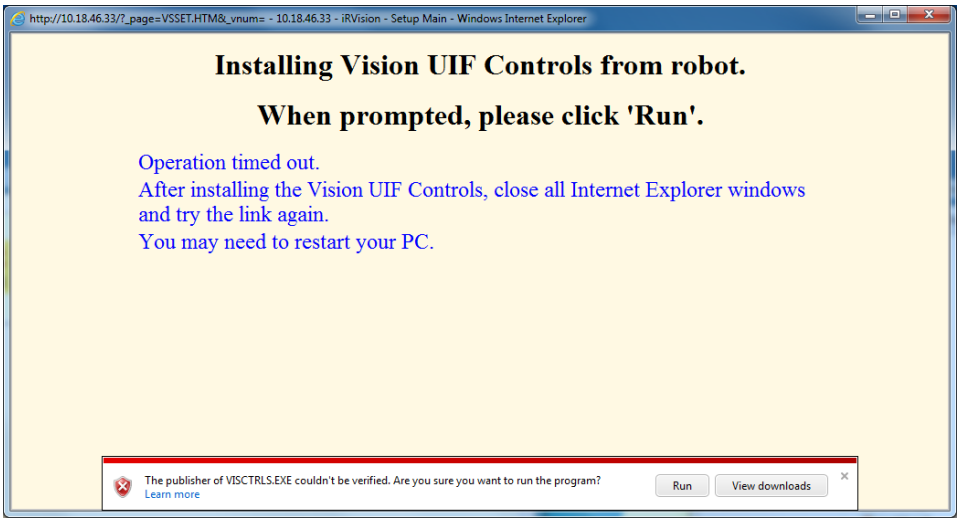
1 Start Internet Explorer, and enter the IP address or host name of the robot controller in [Address] to display the homepage of the robot.

2 Click [Vision Setup] in the *i*RVision section.
If Vision UIF Controls are already installed in the PC used, the Vision Setup Page opens.
If Vision UIF Controls are not installed in the PC, the following screen appears:

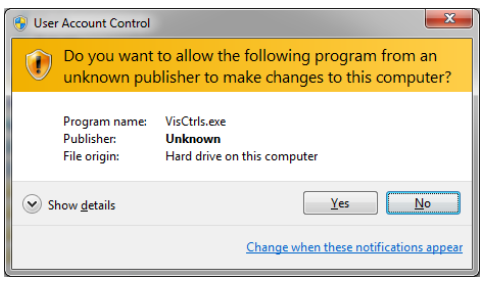


3 After a while, the following dialog appears.

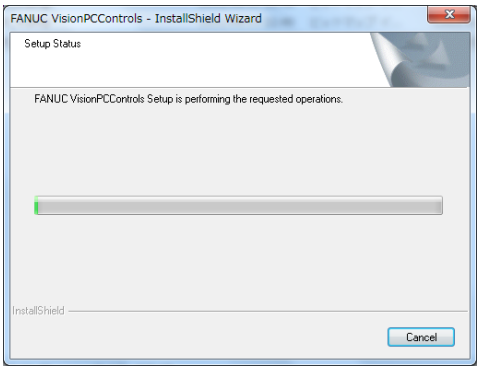
4 Clicking the [Run] button.
5 After a while, the following dialog appears.



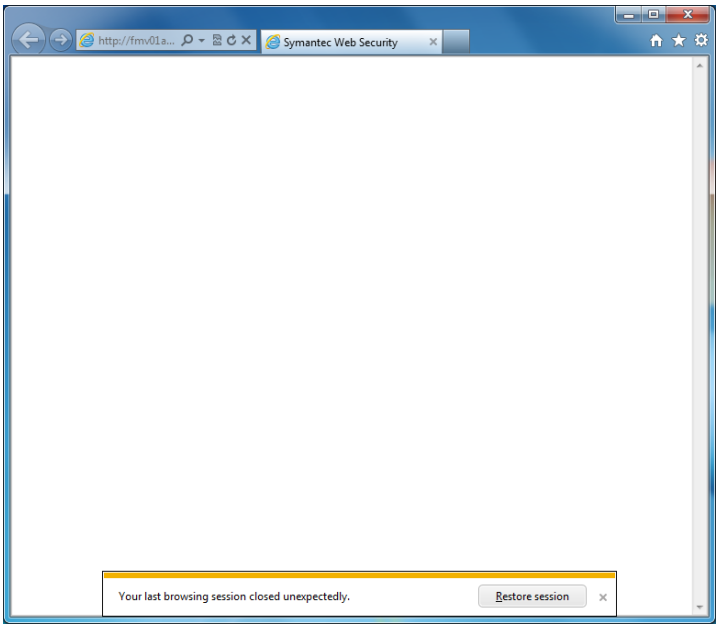
6 Click the [Run] button.
7 In the case of Windows Vista and Windows 7, the following dialog box appears.



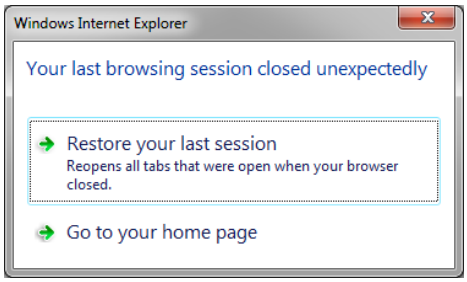
8 Click the [Yes] button.
9 Installation of Vision UIF Controls starts.



10 When the installation is completed, all Internet Explorer windows are closed.
11 Start Internet Explorer again, and open the homepage of the robot.
12 In the case of Internet Explorer 9, the following message will appear when you start Internet Explorer. Close the message by clicking the [X] button.



13 In the case of Internet Explorer 8, the following dialog box will appear when you start Internet Explorer. Click the [Go to your home page].



7 ADJUSTMENT

Each portion of the sensor has been factory-adjusted to the best condition. The customer does not need to adjust the sensor when the machine is installed.

If you kept the robot unused for prolonged time, or have replaced components, make adjustments as stated in this chapter.

In the case of the camera package, when starting system, adjust focus and aperture of lens and perform a calibration according to this chapter.

7.1 FORCE SENSOR

There are no parts to be adjusted in the force sensor.

In addition, refer to R-30*i*B CONTROLLER Force Sensor OPERATOR'S MANUAL (B-83424EN) about force control function of force sensor.

7.2 3D LASER VISION SENSOR

7.2.1 Calibration

When using the 3D sensor, calibration is necessary.
Refer to camera calibration Chapter of R-30*i*B CONTROLLER *i*RVision OPERATOR'S MANUAL (Reference) (B-83304EN).

7.3 CAMERA PACKAGE

7.3.1 Adjustment of Focus and Aperture

It is necessary to adjust the focus and aperture of the lens prior to acquiring the images using the camera package.
Use the following procedure to adjust the camera. (See Fig.7.3.1)

1 Set the distance between the camera and work, as well as the object to be detected.
2 Rotate the sensor head lens cover of camera package and match the phase of the cutting parts of the lens cover and button for omission prevention.
3 Slide the lens cover to axial direction and loosen the screw of the focus ring and aperture ring.
4 Display the image of camera on *i*Pendant or the setup PC and adjust the focus and diaphragm of the lens while confirming the image.
5 Loosen the rock screw and slide the lens cover to default position.
6 Rotate the lens cover and shift the phase of the cutting part of the lens cover and button bolt for omission prevention about 10 degree (5 to 6 mm).

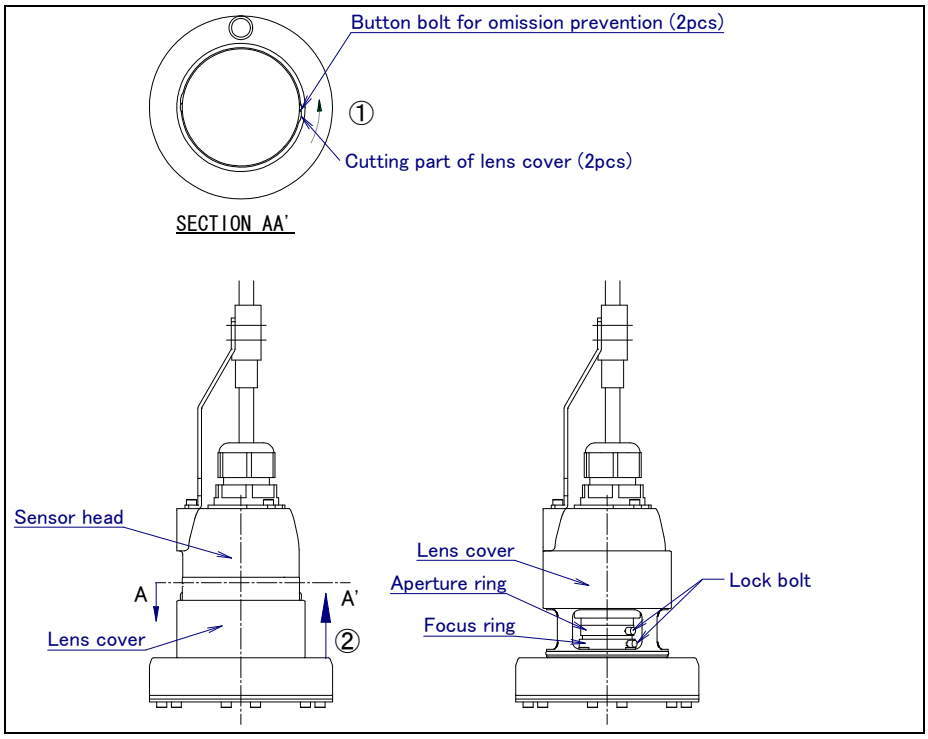


Fig. 7.3.1 Adjustment of focus and aperture

7.3.2 Calibration

Calibration is necessary for normal operation of the sensor.
Refer to R-30*i*B controller *i*RVision OPERATOR'S MANUAL (Reference) (B-83304EN).

7.3.3 Replacing the Lens

Replacing the lens allows a different focal distance that changes the vision range of camera package.
The procedure is shown below (See Fig.7.3.3.)

1 When LED light is attached, remove connector of LED light side of camera package.
2 Remove the set screw of cover A.
3 Remove cover A while turning it.
4 Remove the set screw of lens holder.
5 Remove the lens.
6 Install the new lens with lens holder attached to tip of camera.
7 Fasten the lens holder with the set screw in the state that you pushed lens holder to lens.
Apply LOCTITE 243 to thread of the set screw and tighten to the torque shown in fig.4.3.3.
8 Install cover A. Turn it well until the gap between cover A and cover B disappears.
9 Install the set screw of cover A. Apply LOCTITE 243 to the thread of the set screw and tighten it to the torque shown in fig.7.3.3.
10 If the LED light was attached, connect the LED light to the camera cable.

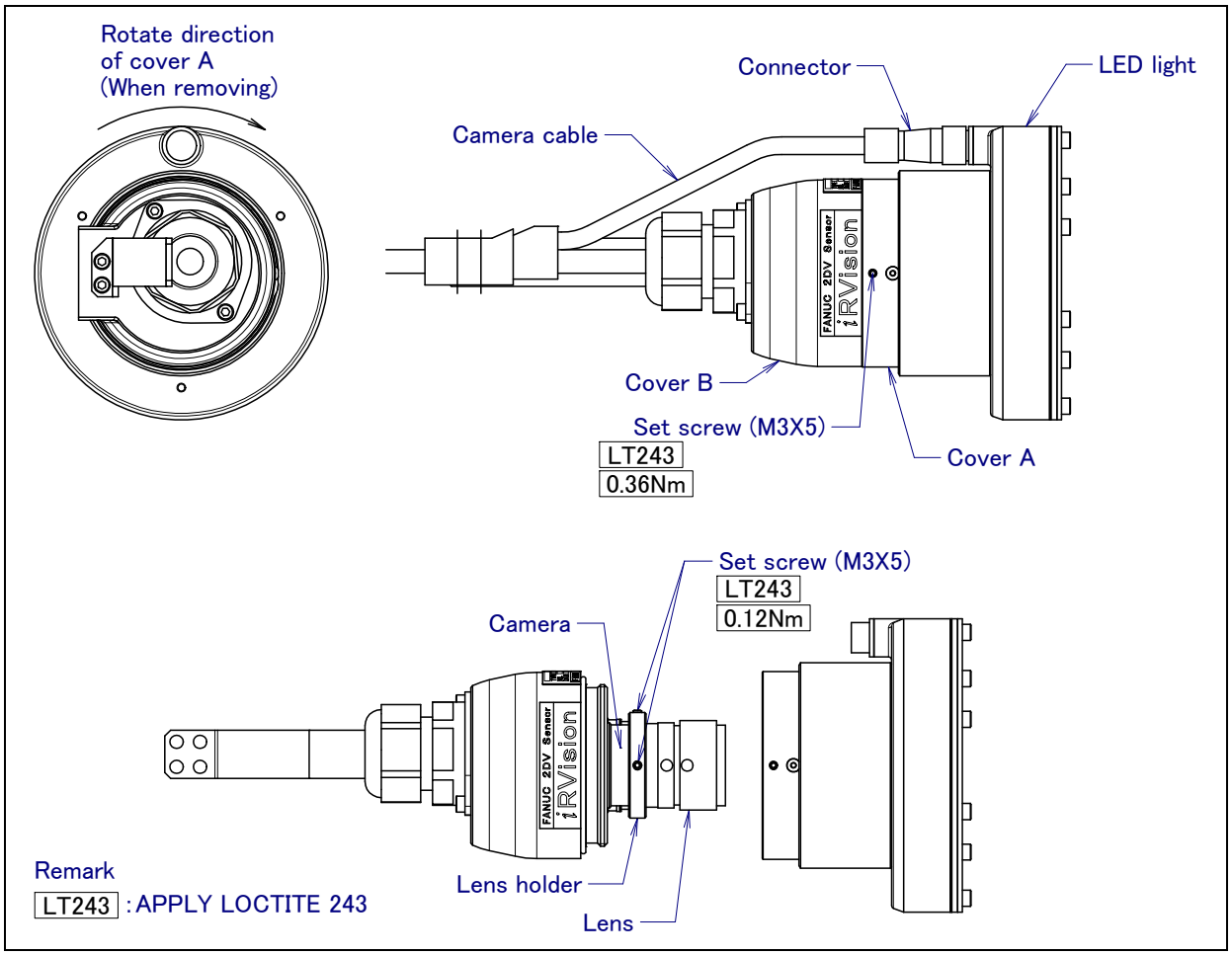


Fig.7.3.3 Replacing the lens

7.3.4 Addition of Diffusion Sheet

If a diffusion sheet is added to the LED light of camera package, it diffuses the beam of light and provides a wider range. When the diffusion sheet is used, follow the additional procedure as shown below. (See Fig.7.3.4.)

1 Stop the robot at the position where the light cover of the sensor head looks up.
2 Blow off dust of surface of holder and window with clean dry air.
3 Remove bolt, holder and light cover.
4 Blow off dust of the inside of holder, window and LED light with clean dry air.
5 Remove the protective film of diffusion sheet, and put it on lamp of LED light while adjusting it to inside shape of case. At this point, put the diffusion surface (rough surface) toward the light cover side.
6 Clean the window of the lens with cleaning paper which has alcohol applied. Clean it until any dirt disappears. If you can not remove the dirt, replace light cover with a new one.
7 Fix the light cover and holder with bolts and reinstall it.
8 Confirm there is no dust or dirt on the surface of light cover and window. If dust or dirt is seen, remove light cover and blow off it with clean dry air. If dirt is stuck to the inside, remove light cover and perform procedure 6. If dust or dirt is attached to the outside, clean it according to sub-section 9.3.1.

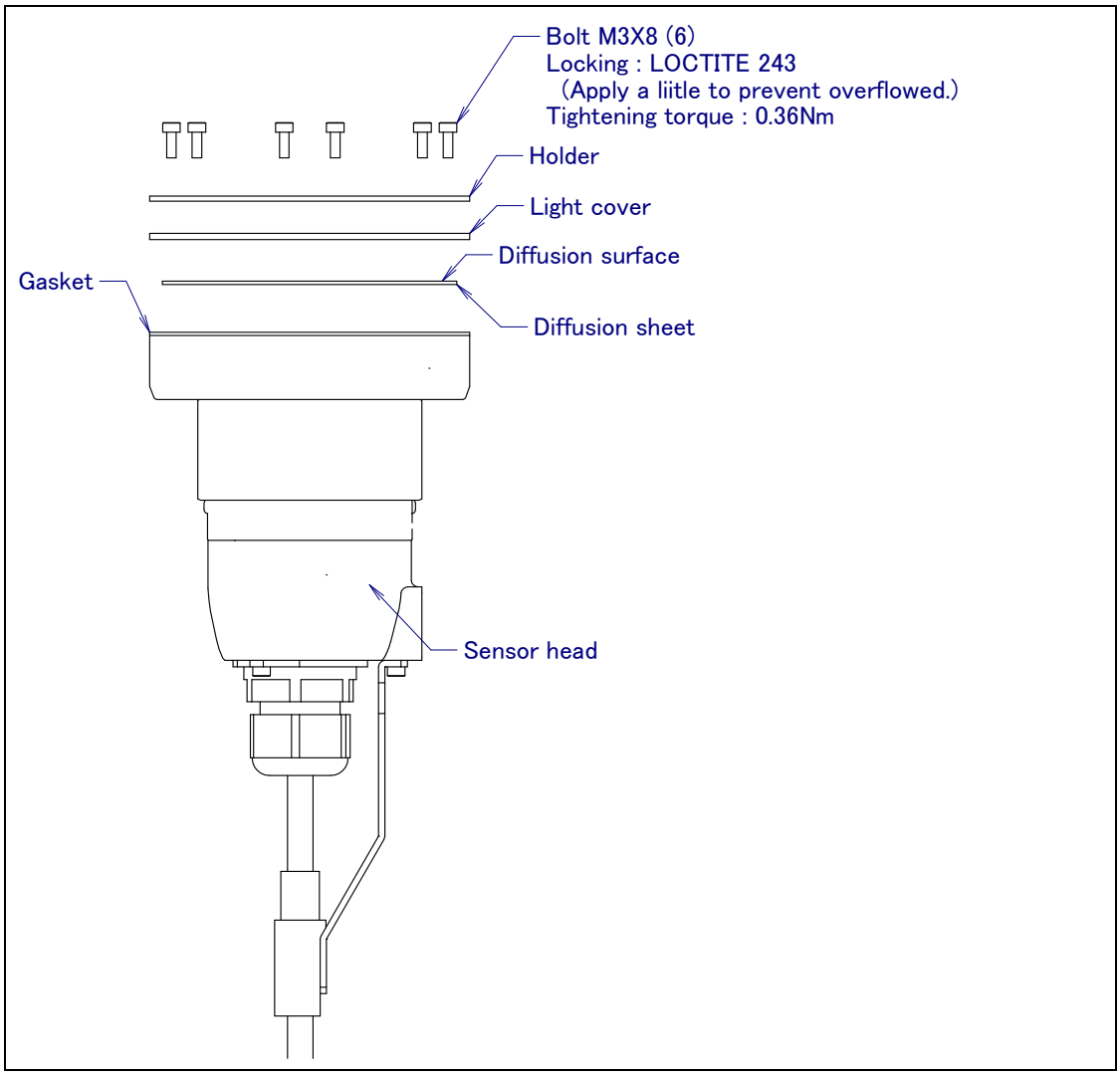


Fig.7.3.4 Addition of diffusion sheet

7.4 3D AREA SENSOR

7.4.1 Change of Field of View Area of Projector

To detect with high precision by using projector, it is necessary to change the projection area according to the required detection area. In case of using narrower area than standard projection area, shorten the distance between projector and center of projection area. Add projector front lens according to the distance , and change focus position of projection area.
Addition procedure of front lens kit is below.

1 Turn off the robot controller power.
2 Wipe the surface of the window holder and dust of the window with clean waste.
3 Remove the window holder mounting bolts, and remove window holder, gasket and window plate.
4 Blow the dust and dirt of gasket and surface of the window plate with clean dried air or wipe it off with lens cleaning paper or clean waste and remove it.
5 Attach window plate, gasket, lens and lens holder, and fix them with M3x6 bolts (4pcs).
6 Confirm there is no dirt on the lens surface. When there is dirt, clean it by the procedure of Subsection 9.4.1.

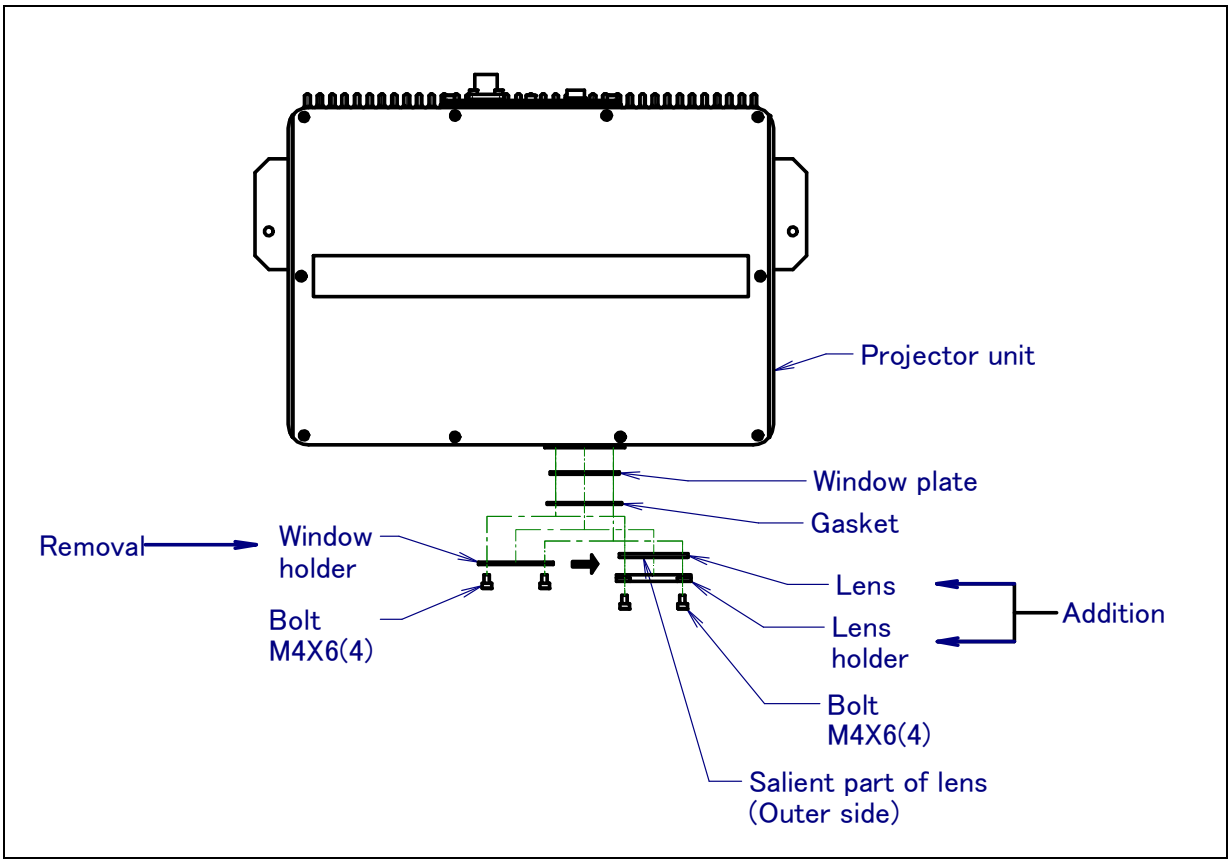


Fig.7.4.1 Addition method of front lens kit

7.4.2 Adjustment of Camera Unit Focus

When the distance of 3D area Sensor and work differs from standard position, it is necessary to adjust the focus and aperture of the lens. Adjust by the procedure below (See Fig.7.4.2.)

1 Make the distance between camera and work equal to it of work detection.
2 Remove M3X5 bolts (4 pcs) of camera unit and remove the cover.
3 Loosen the set screw which you want to adjust the focus and aperture.
4 Display the image of camera on *i*Pendant or the setup PC and adjust the focus and aperture of the lens while confirming the image.
5 Tighten the set screw, Rotate it until tip the set screw hit the tip of the lens.
6 After tip of set screw hit the lens side, rotate it 3/8 (135 degree).
7 Tighten the camera unit cover with M3x5 bolts (4 pcs).

Focus and aperture of lens were set to moderate setting for standard position when it was shipped.

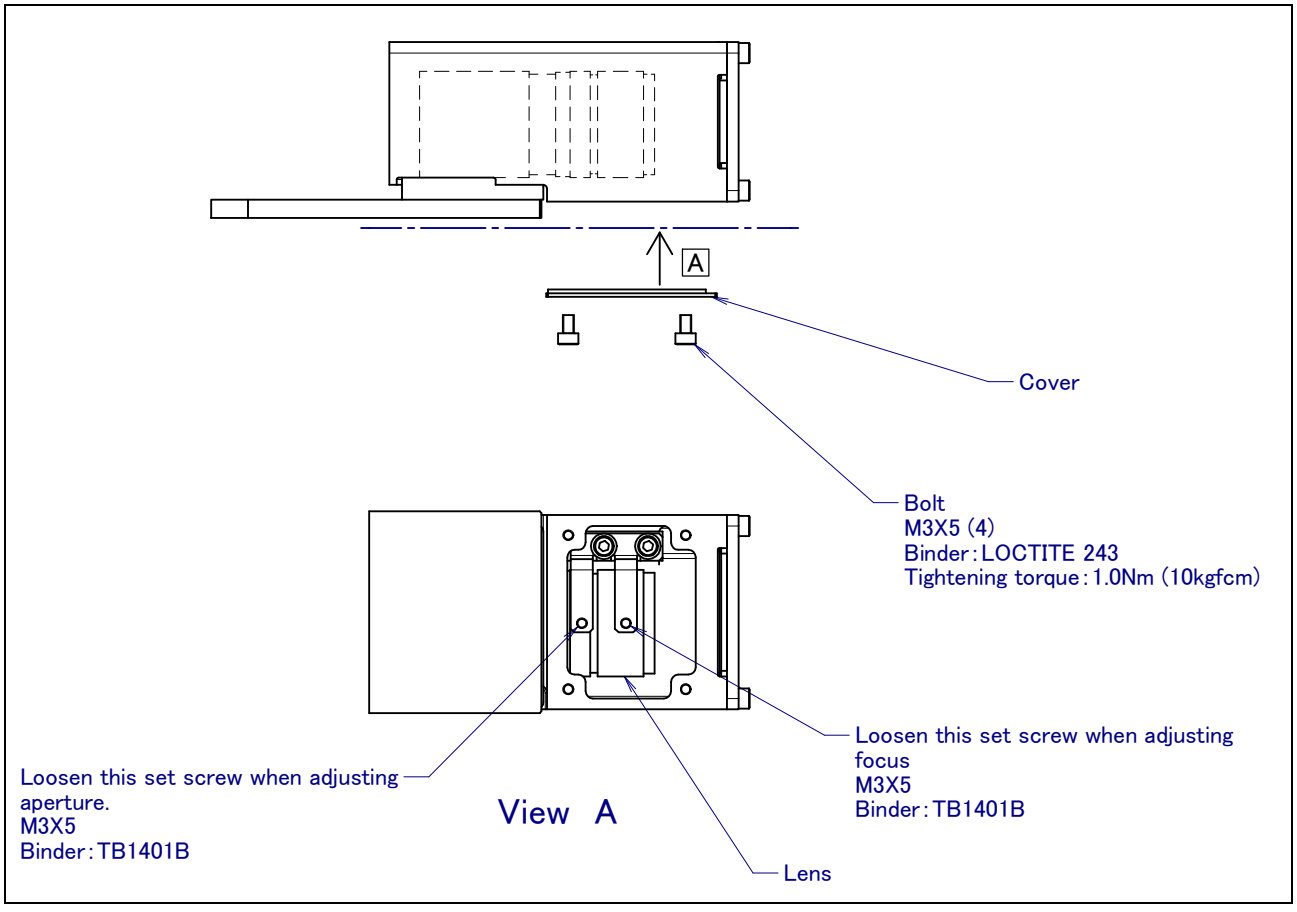


Fig.7.4.2 Adjustment of camera unit focus

8 PROTECTIVE MAINTENANCE

Performing daily and periodic inspection enables the sensors to maintain stable performance for a long period.

The periodic inspection items for the sensors are listed below:

Refer to the manual for explanations of the each robot mechanical unit.

Also, refer to the controller maintenance manual for explanations of the controller.

8.1 DAILY INSPECTION

(1) Before starting operation (before switching on the power)

Target	Inspection item	Inspection procedure
Force sensor	Cracking in the rubber cover	Check for cracking or any other abnormality in the sensor head rubber cover.
	Sensor cable abnormality	Check for a kink, abnormal bending, cracking, or any other abnormality in the sensor cable.
3D Laser Vision Sensor	Soiled window	Check to see if the window is soiled. If soiled, clean it. (See Subsection 9.2.1.)
	Sensor cable abnormality	Check for a kink, abnormal bending, cracking, or any other abnormality in the sensor cable.
Camera package	Soiled light cover and window	Check to see if the light cover and window are soiled. If soiled, clean it. (See Subsection 9.3.1.)
	Sensor cable abnormality	Check for a kink, abnormal bending, cracking, or any other abnormality in the sensor cable.
3D Area Sensor	Soiled window	Check to see if the window is soiled. If soiled, clean it. (See Section 9.4.)
	Sensor cable abnormality	Check for a kink, abnormal bending, cracking, or any other abnormality in the cable.

(2) Before starting operation (after switching on the power)

Target	Inspection item	Inspection procedure
3D Laser Vision Sensor	Laser lamp operation	Check that the laser lamp of the sensor head lights.

(3) After finishing operation

Target	Inspection item	Inspection procedure
Force sensor	Cleaning and inspection of individual components	Clean the sensor head and its surroundings. Check for cracking or any other abnormality in the rubber cover, cable, and other components.
3D Laser Vision Sensor	Cleaning and inspection of individual components	Clean the sensor head and its surroundings. Check for cracking or any other abnormality in the cable and other components.
Camera package	Cleaning and inspection of individual components	Clean the sensor head and its surroundings. Check for cracking or any other abnormality in the cable and other components.
3D Area Sensor	Cleaning and inspection of individual components	Clean the sensor and its surroundings. Check for cracking or any other abnormality in the cable and other components.

After finishing operation, return the robot to its zero point, and then switch off the controller power supply.

8.2 THREE-MONTH INSPECTION

Target	Inspection item	Inspection procedure
Force sensor	Loose mounting	Check that the sensor and sensor adapter are mounted securely.
	Loose connector	Check that the sensor head section and J3 casting section connectors are attached securely.
3D Laser Vision Sensor	Loose mounting	Check that the sensor, sensor adapter, are mounted securely.
	Loose connector	Check that the sensor head section and J3 casting connectors are attached securely.
Camera package	Loose mounting	Check that the sensor is mounted securely.
		Check that the sensor head section and J3 casting connectors are attached securely.
3D Area Sensor	Loose mounting	Check that the sensor, sensor adapter, are mounted securely.
	Loose connector	Check that the projector unit connectors are attached securely.

8.3 ANNUAL INSPECTION

Target	Inspection item	Inspection procedure
Force sensor	Loose mounting	Same as for three-month inspection
	Loose connector	Same as for three-month inspection
3D Laser Vision Sensor	Loose mounting	Same as for three-month inspection
	Loose connector	Same as for three-month inspection
Camera package	Loose mounting	Same as for three-month inspection
	Loose connector	Same as for three-month inspection
3D Area Sensor	Loose mounting	Same as for three-month inspection
	Loose connector	Same as for three-month inspection

8.4 THREE-YEAR INSPECTION

Target	Inspection item	Inspection procedure
Force sensor	Loose mounting	Same as for three-month inspection
	Loose connector	Same as for three-month inspection
3D Laser Vision Sensor	Loose mounting	Same as for three-month inspection
	Loose connector	Same as for three-month inspection
Camera package	Loose mounting	Same as for three-month inspection
	Loose connector	Same as for three-month inspection
3D Area Sensor	Loose mounting	Same as for three-month inspection
	Loose connector	Same as for three-month inspection

8.5 MAINTENANCE AND INSPECTION TOOLS

The following instruments and tools should be prepared for maintenance and inspection work.

(1) Measuring instrument
Calipers (150 mm)

(2) Tools

Torque wrenches:	M3 to M16 (Note)
Torque wrenches	width of two surface 30mm (only camera package)
Torque driver	M2, M3 (only camera package)
Hexagonal wrench set:	Dihedral width 1.5,2,3,4,5,6,8,10 ,12,14 (for replacing parts)
Cross-slot screwdrivers:	Large, medium, and small
Flat-blade screwdrivers:	Large, medium, and small
Socket wrench:	M3 to M6

Adjustable wrench
Pliers
Long-nose pliers
Diagonal cutter
Closed-end, double-head wrench
Grease gun
C-ring pliers
Flashlight

NOTE
For M4 and M6 torque wrenches, prepare a space-saving torque wrench head as shown the Fig. 8.5 (a) and (b) in the following examples.
M4 torque wrench
Used for replacing the force sensor and FS-40*i*A sensor adapter.
M5 torque wrench
Used for replacing the force sensor and FS-15*i*A sensor adapter.
M6 torque wrench
Used for replacing the force sensor and FS-100*i*A, FS-250*i*A sensor adapter.

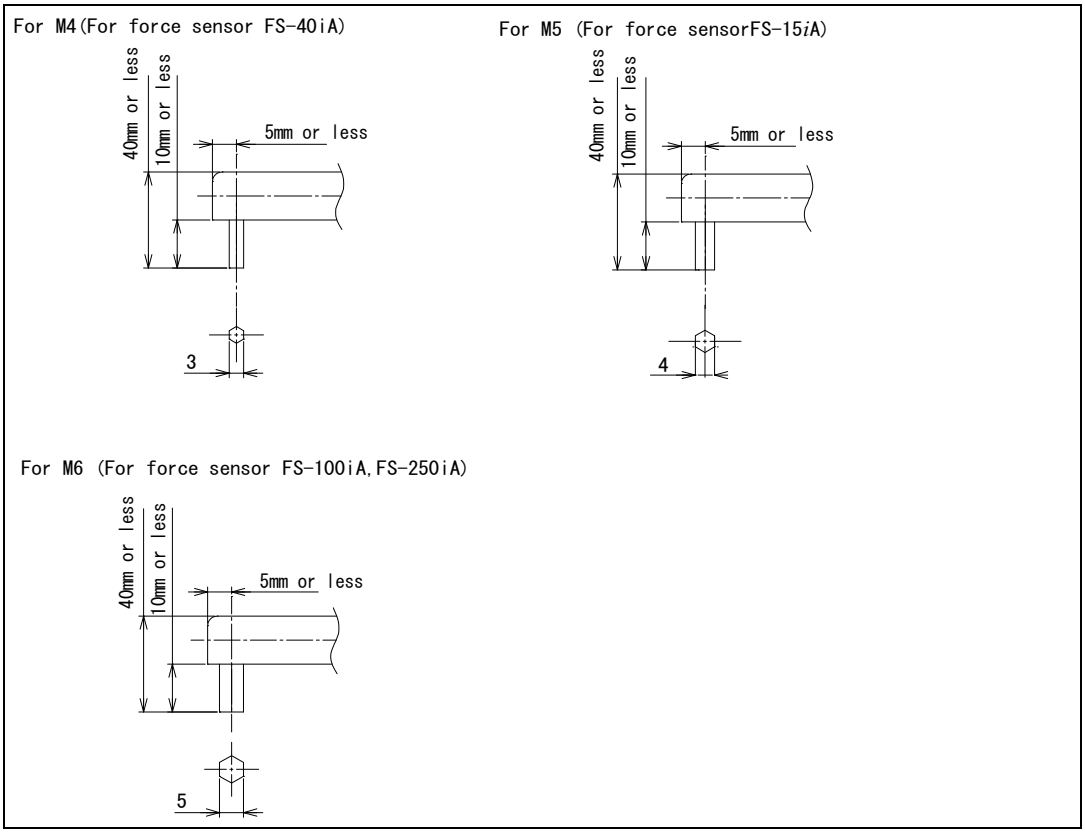


Fig.8.5 (a) Example of torque wrench heads 1

Some commercially available torque wrench heads as shown below can be used.

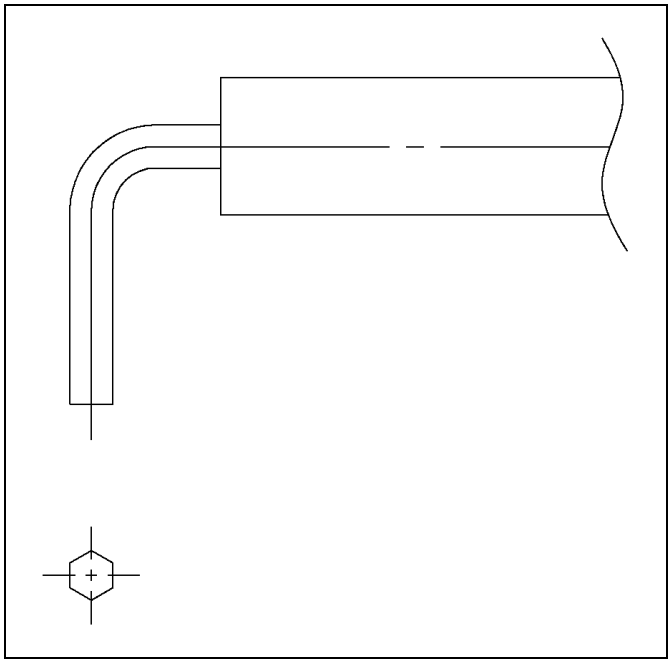


Fig.8.5 (b) Example of torque wrench heads 2

9 PERIODIC MAINTENANCE PARTS REPLACEMENT

Replacing maintenance parts periodically can prolong the normal performance of the sensor.

Replace periodic maintenance parts according to the procedures described below.

9.1 FORCE SENSOR

There are no periodic maintenance parts in the force sensor. However, do not skip periodic inspections. (See Chapter 2.)

9.2 3D LASER VISION SENSOR

If you find stains on the window surface of the 3D Laser Vision sensor, clean it. If it is impossible to remove stains by cleaning, or if there are scratches or cracking on the window, replace the sensor.

9.2.1 Cleaning the Window Plate

To clean the window plate of the sensor, follow the procedure described below:
(See Fig. 9.2.1.)

1 Stop the robot with the sensor head window plate facing downward and turn off the robot controller power, Beware of an axis not equipped with a brake, because it might drop by gravity.
2 Blow off any dust from the window holder surface and window plate using clean, dry air blast.
3 Wipe the window plate with lens cleaning paper dipped in alcohol. Repeat cleaning until stains are wiped off completely from the window plate. If it is impossible to clean completely, replace the window plate according to the procedure described in Section 9.2.2.

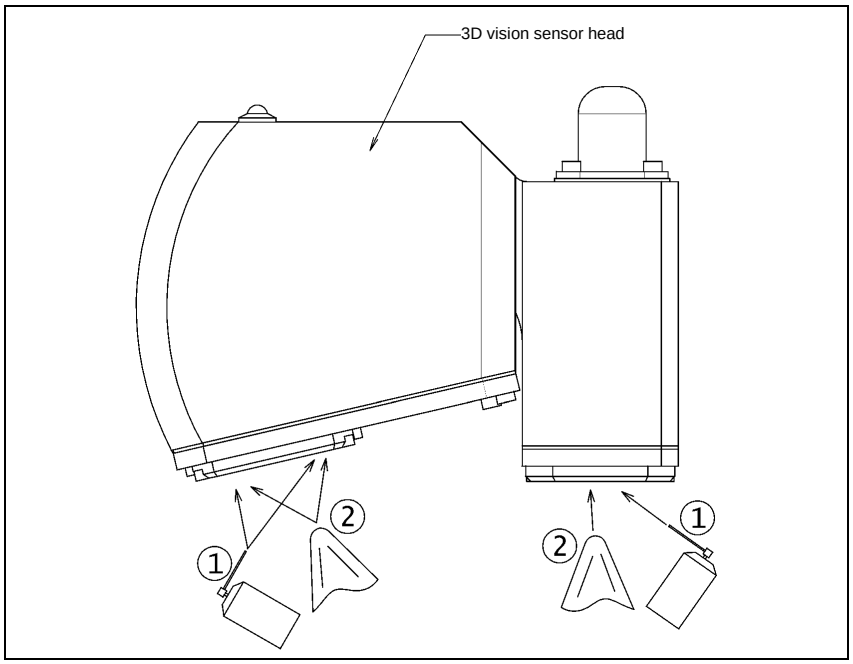


Fig. 9.2.1 Window plate cleaning

9.2.2 Replacing the Window Plate

To replace the window plate, follow the procedure described below:
(See Fig. 9.2.2.)

1 Stop the robot with the sensor head window plate facing downward and turn off the robot controller power, Beware of an axis not equipped with a brake, because it might drop by gravity. Beware of an axis not equipped with a brake, because it might drop by gravity.
2 Wipe off dust from the window holder surface and window using clean cloth.
3 Remove the window holder fastening bolts, and detach the window plate together with the window holder.
4 Take out the window plate from the window holder, blow off dust and dirt from the inside of the window holder using clean, dry air blast, or wipe them off using lens cleaning paper or clean cloth.
5 Assemble a new window plate into the window holder, and fix the window holder with the window holder fastening bolts, to put it back in the previous place.
6 Check that no stains are on the window surface. If there is any stain on the window surface, clean it by following the procedure described in Subsection 9.2.1.

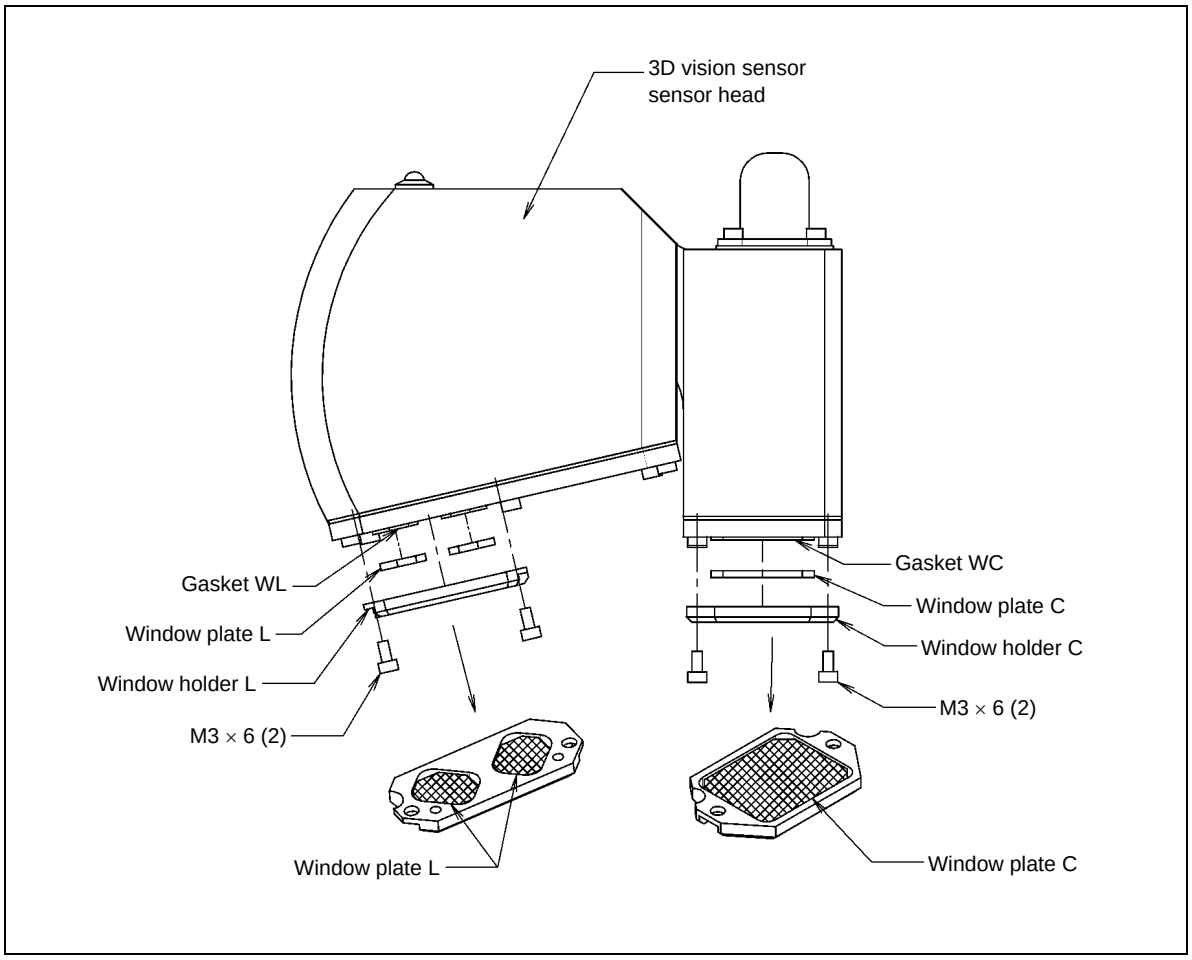


Fig. 9.2.2 Window plate replacement

9.3 CAMERA PACKAGE

If you find stains on the surface of the light cover and window of the camera package, clean it. If it is impossible to remove stains from it by cleaning, or there are scratches or cracking on it, replace the sensor.

9.3.1 Cleaning the Light Cover and Window

To clean the surface of the light cover and window, follow the procedure described below:
(See Fig. 9.3.1.)

1 Stop the robot with the light cover and window facing downward and switch off the robot controller power.
2 Blow off any dust from the window holder surface light cover and window plate using clean, dry air blast.
3 Wipe the light cover and window with lens cleaning paper dipped in alcohol. Repeat cleaning until stains are wiped off completely. If it is impossible to clean completely, replace the light cover and window according to the procedure described in Subsection 9.3.2.

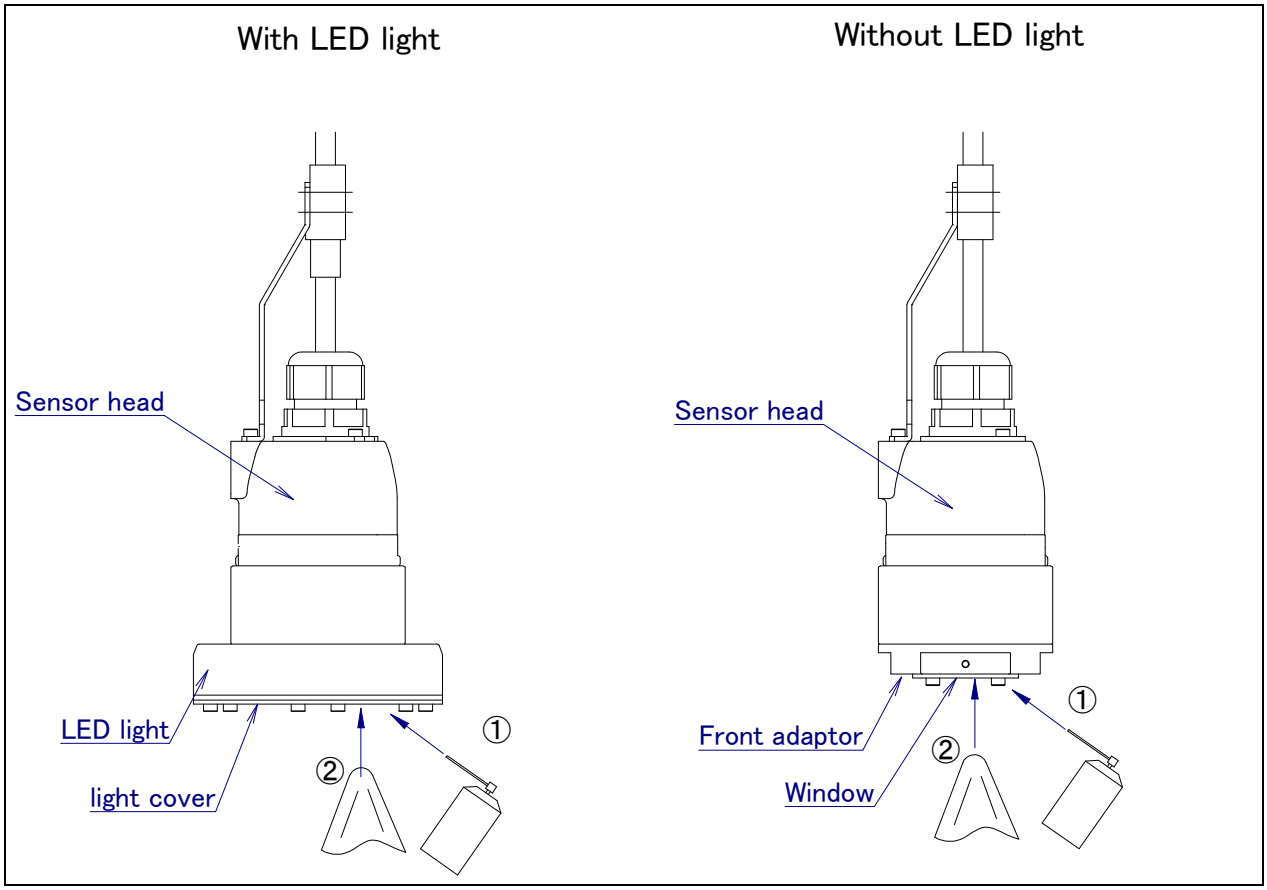


Fig. 9.3.1 light cover and window cleaning

9.3.2 Replacing the Light Cover and Window

To replace the window plate, follow the procedure described below: (See Fig. 9.3.2.)

1 Stop the robot with the light cover and window facing downward and switch off the robot controller power.
2 Blow off any dust from the window holder surface and window using clean, dry air blast.
3 Remove the light cover and window fastening bolts, and detach them together with the holder.
4 Blow off dust and dirt from the inside of the holder using clean, dry air blast, or wipe them off using lens cleaning paper or clean cloth.
5 Assemble new light cover and window with fasting bolt, and then put it back to the previous place.
6 Check that no stains are on the window surface. If there is any stain on the light cover or window, clean it by following the procedure described in Subsection 9.3.1.

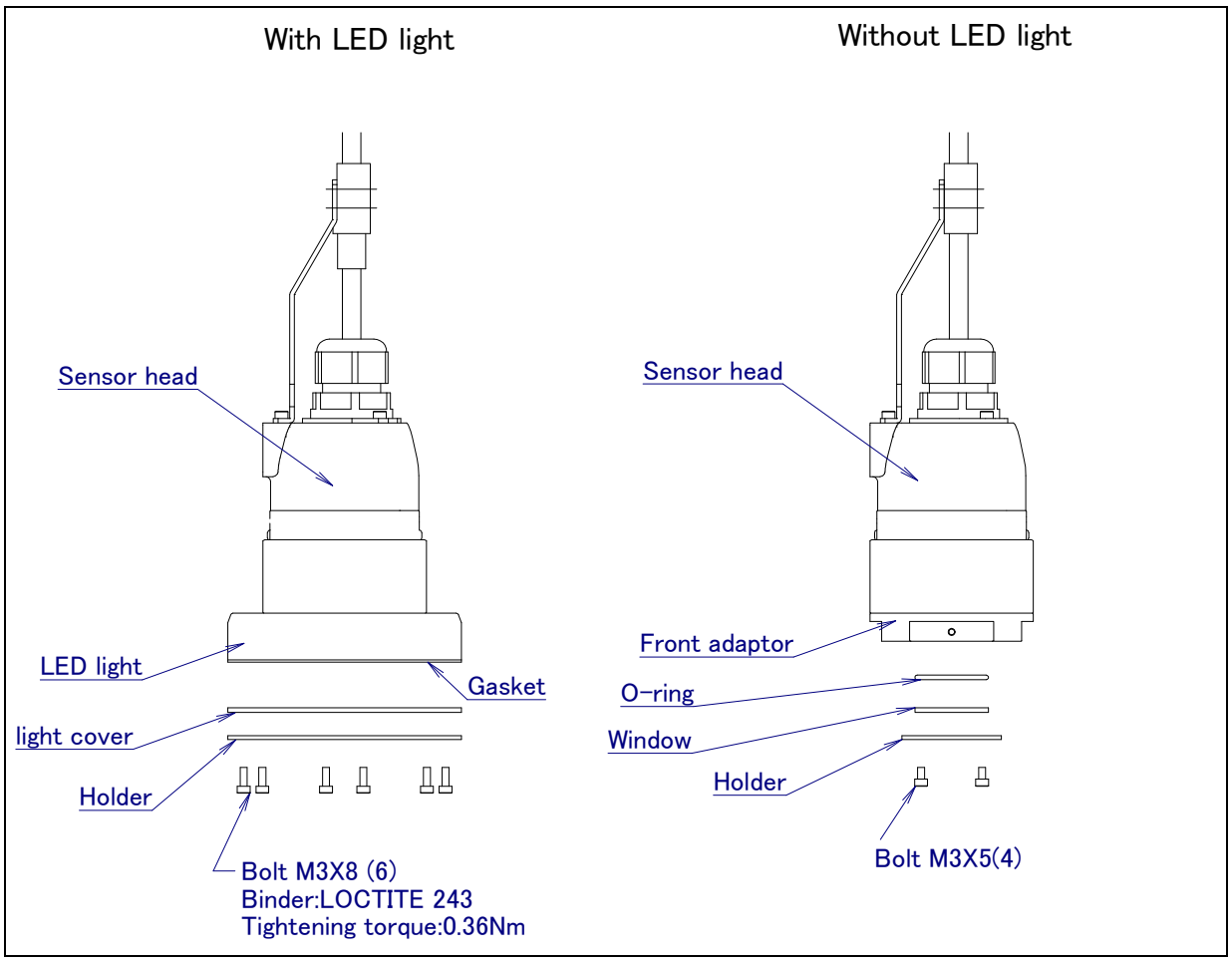


Fig. 9.3.2 Light cover and window replacing

9.4 3D AREA SENSOR

9.4.1 Cleaning of Projector Unit Window Plate

To clean the window plate of projector unit, follow the procedure described below. (See.Fig.9.4.1.)

1 Turn off the robot controller power.
2 Blow off the dust of window holder surface and window plate with clean and dried air, and remove it.
3 Wipe off the window plate with lens cleaning paper which is soaked with alcohol. Repeat it until dirt vanish. If dirt cannot be removed, replace the window plate referring to procedure of Subsection 9.4.2.

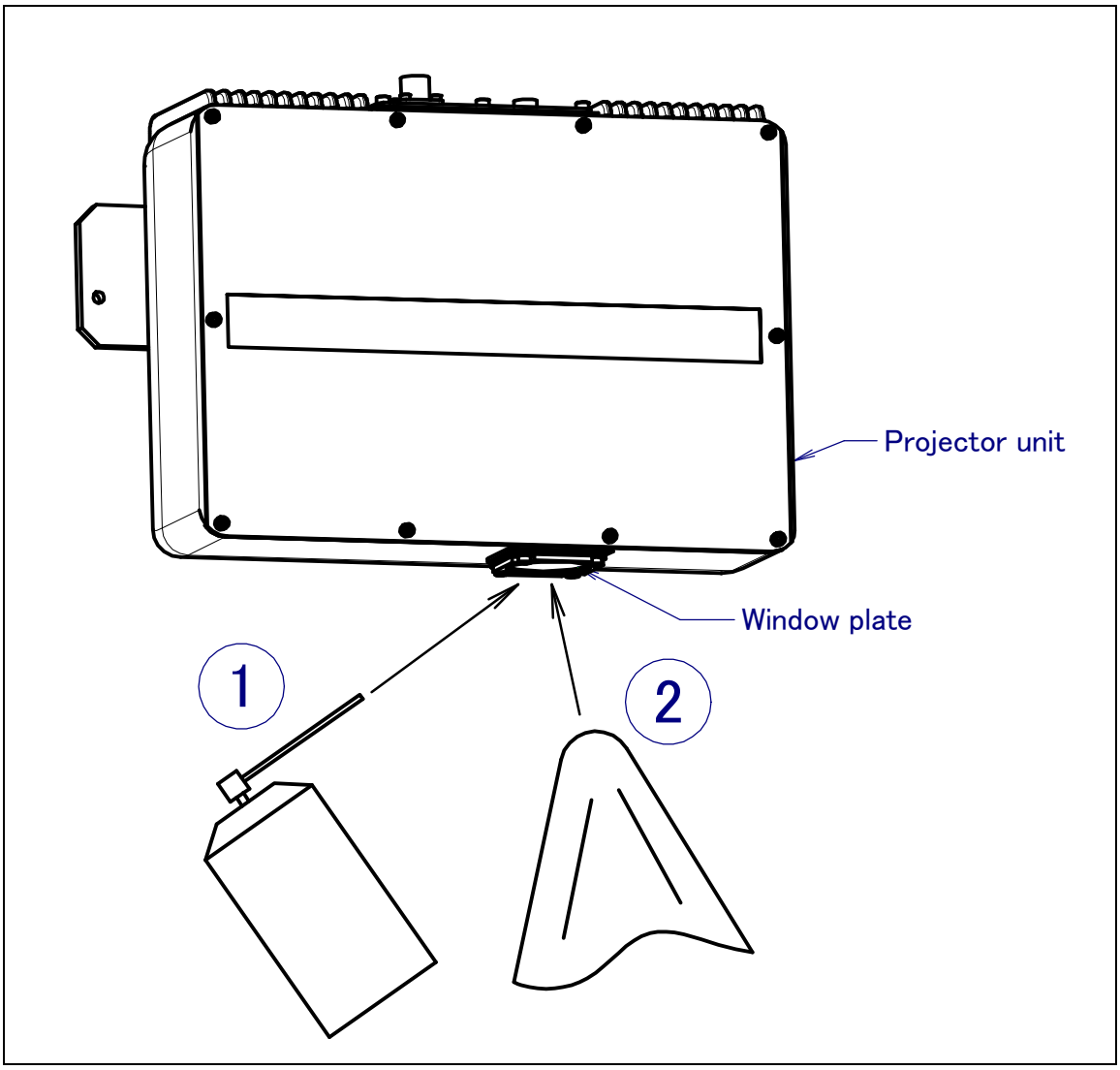


Fig.9.4.1 Cleaning of projector unit window plate

9.4.2 Replacing of Projector Unit Window Plate

To replace the window plate of projector unit, follow the procedure described below. (See Fig.9.4.2.)

1 Turn off the robot controller power.
2 Wipe off the dirt of window holder surface and window plate with clean waste.
3 Remove the bolts, then remove the window plate with window holder and gasket.
4 Blow off the dirt and dust inside the window holder with clean and dried air or wipe them off with lens cleaning paper or clean cloth.
5 Fix new window plate ,gasket and window holder with bolts and put them back.
6 Confirm there is no dirt on the window plate surface. If there is dirt, clean it by the procedure of Subsection 9.4.1.

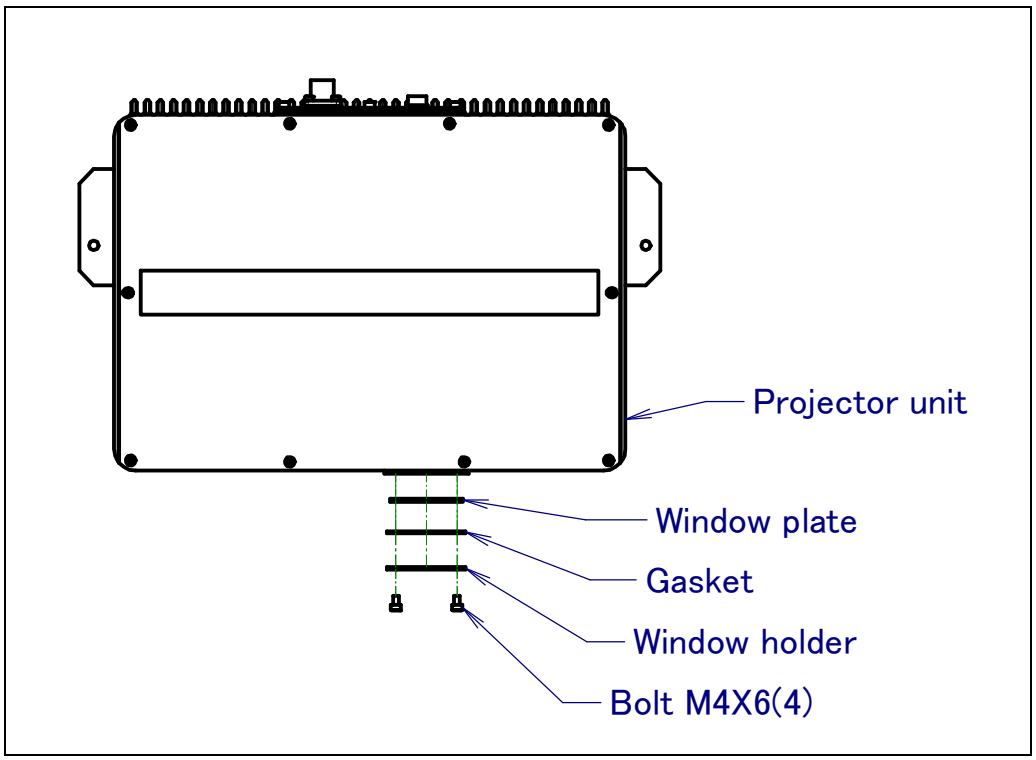


Fig.9.4.2 Replacement of projector unit window plate

9.4.3 Cleaning of Camera Unit Window Plate

To clean the window plate of camera unit, follow the procedure described below. (See Fig.9.4.3.)

1 Blow off the dust of window holder surface and window with clean and dried air, and remove them.
2 Wipe off the window plate with lens cleaning paper which is soaked with alcohol. Repeat it until dirt vanish. If dirt cannot be removed, replace the window plate by the procedure in Subsection 9.4.4.

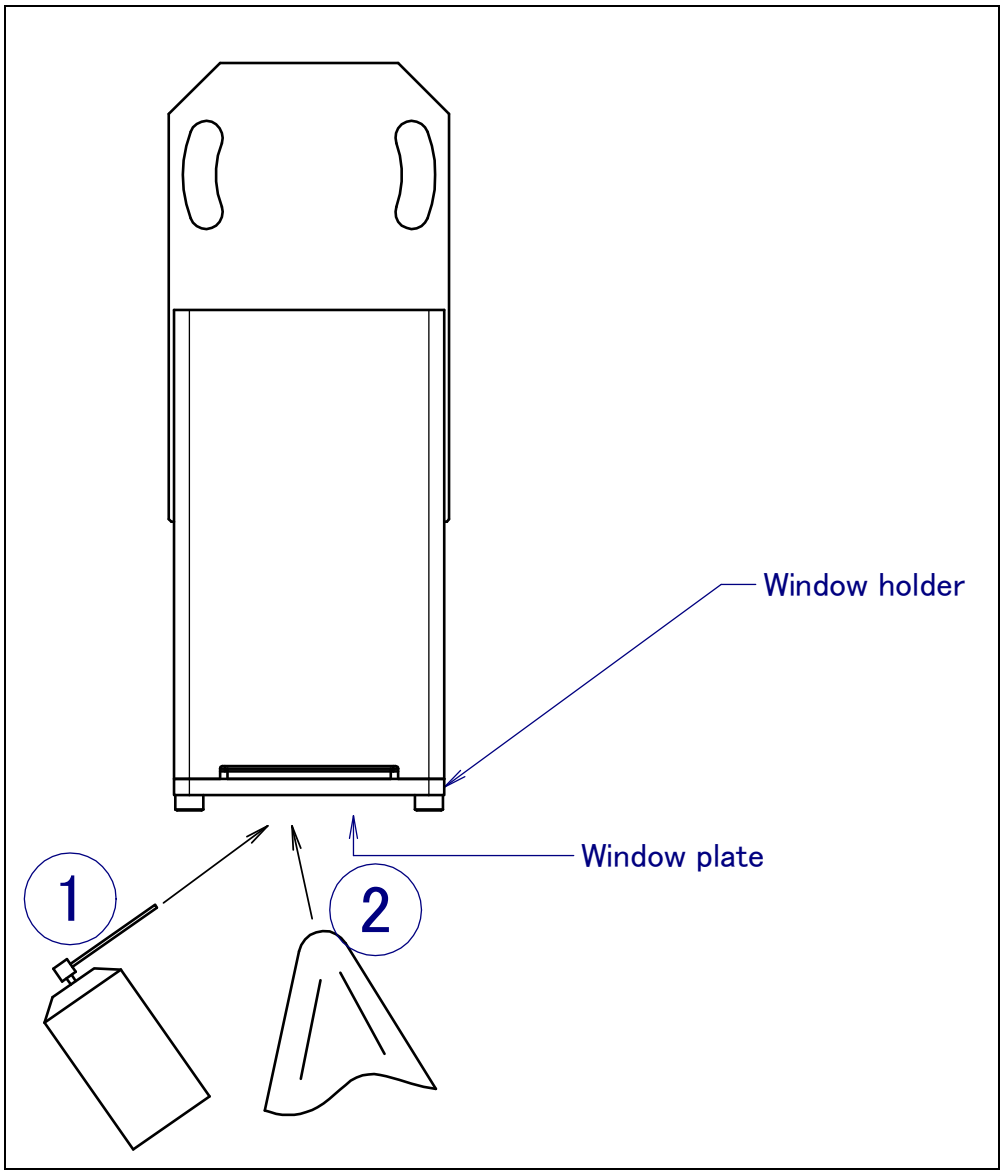


Fig.9.4.3 Cleaning of camera unit window plate

9.4.4 Replacing of Camera Unit Window Plate

To replace the window plate of camera unit, follow the procedure described below. (See Fig.9.4.4.)

1 Wipe off the dust of window holder surface and window plate with clean waste.
2 Remove bolts and remove window holder and window plate together.
3 Blow off the dust and dirt of inner side of window holder with clean and dried air or wipe it off with a lens cleaning paper or clean cloth and remove them.
4 Fix new window plate and window holder with bolts, and put them back.
5 Confirm there is no dirt on the window plate surface. If there is dirt, clean it by the procedure of Subsection 9.4.3.

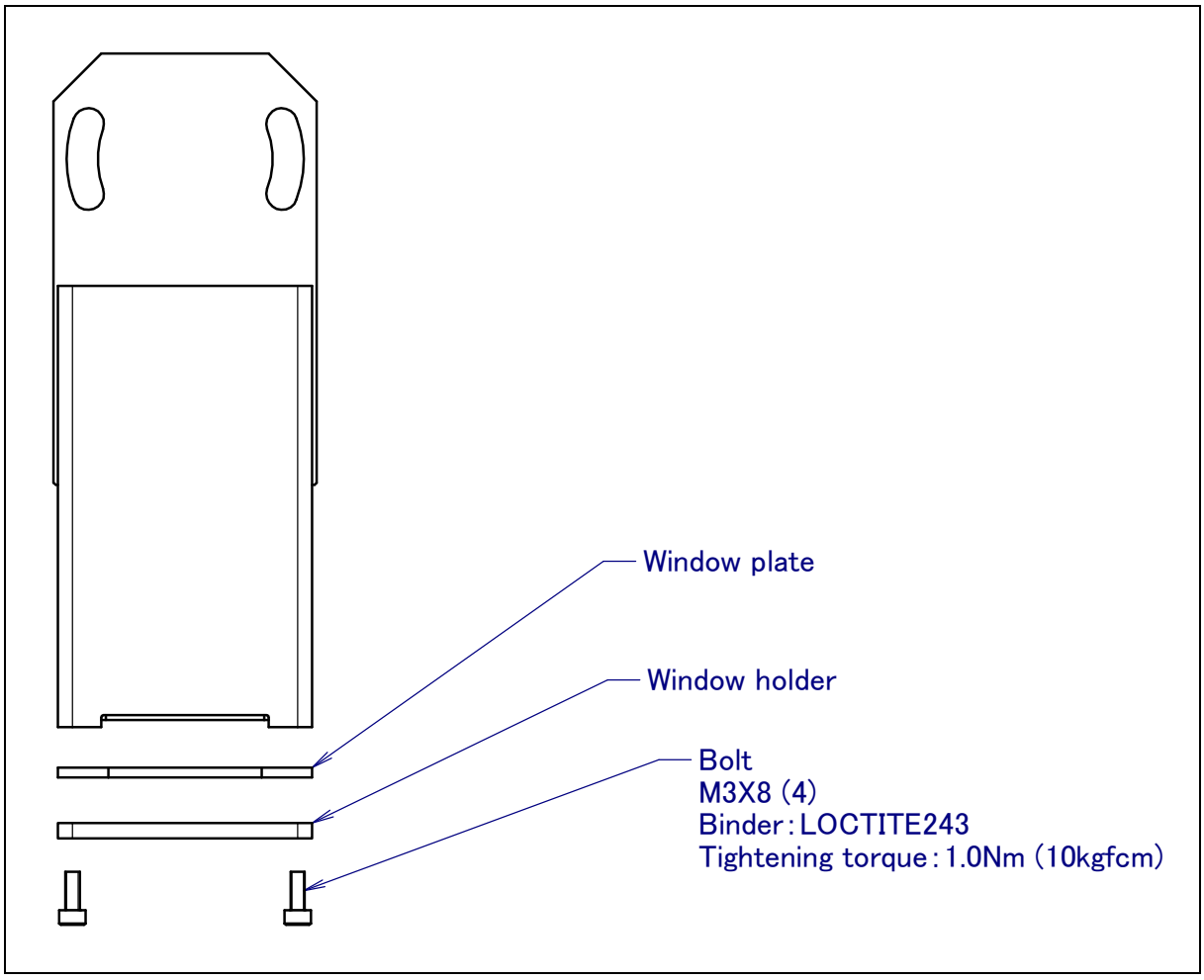


Fig.9.4.4 Replacement of camera unit window plate

10 PARTS REPLACEMENT

NOTE
When applying LOCTITE to the important bolt tightening points, make sure that it is applied to the entire longitudinal portion in the engaging section of the female threads. If it is applied to the male threads, the bolts may be loosened because sufficient adhesion cannot be obtained. Remove dust from the bolts and taps and wipe oil off the engaging section. Make sure that there is no solvent in the taps. Be sure to wipe the excess LOCTITE after tightening screw.

10.1 FORCE SENSOR MECHANICAL SECTION

10.1.1 Replacing the Sensor Head

If the force sensor head becomes faulty, replace it according to the following procedure. (See Fig. 10.1.1(a) to (i).)

Removal procedure

1 Set the robot to a position for replacing the sensor head. Ideally, the robot should be set to such a position that all of J1 to J4 are at 0°, J5 is at +90°, and J6 is at 0°. If this position cannot be achieved, the robot should be set so that J4 is at 0° and J3 + J5 are at +90°.
2 Press the emergency stop button.
3 Remove the hand (or the like) and hand mounting adapter. When the robot has a 3D Laser Vision sensor mounted, remove the sensor together with its sensor adapter. Put markings so that the mounting positions of these components can be determined later.

4 Loosen the sensor head mounting bolts, and put back the force sensor parameter to initial state.
To put back, follow installation procedure 5 to 8. (About FS-15*i*Ae is described later.)
Confirm the force and moment on the force sensor status screen of teach pendant.
If absolute value is less than the standard value listed below, sensor head is normal. So replacing sensor head is not necessary. Attach them by installation procedure 1 , 10 and later without replacing sensor head.
In case of FS-15*i*Ae: Set 6 system variables below to 0. Refer to R-30*i*B CONTROLLER OPERATOR'S MANUAL (Basic Operation) (B-83284EN) Appendix C.1 about display method of system variables.
$CCC_GRP.$CLR_FORCE[1] to [6].

Table 10.1.1 (a) Standard values (absolute values) after the sensor head is removed:

	FS-15*i*A	FS-40*i*A	FS-100*i*A	FS-250*i*A	FS-15*i*Ae
F x	10N or less	20N or less	50N or less	100N or less	-
F y	10N or less	20N or less	50N or less	100N or less	-
F z	30N or less	60N or less	150N or less	300N or less	60N or less
M x	0.3Nm or less	0.6Nm or less	1.5Nm or less	3.0Nm or less	0.6Nm or less
M y	0.3Nm or less	0.6Nm or less	1.5Nm or less	3.0Nm or less	0.6Nm or less
M z	0.6Nm or less	1.2Nm or less	3.0Nm or less	6.0Nm or less	-

5 Turn off the controller power.
6 Remove the sensor cable of the force sensor from the sensor head.
7 Remove the sensor head mounting bolts together with the washers, and remove the sensor head from the sensor adapter of the force sensor.

Cautions for removal

Do not disassemble the force sensor head. If it is disassembled, it becomes difficult for it to measure force and moment accurately after it is reassembled. In addition, the service life of the sensor may be significantly reduced.

Installation procedure

A torque wrench having a special shape is required. Also, see Section 8.5, "Inspection Instruments and Tools."

1 Attach a new sensor head to the sensor adapter loosely with the mounting bolts and insulating washers. Tighten the bolts lightly in an even, crisscross pattern.
2 Attach the sensor cable.
3 Turn on the controller power.
4 Press the emergency stop button.
5 A CD-R is attached to sensor head. The CD-R including parameter file is attached. (File name CCSCB2. CM, it is called "CCSCB2.CM "below.) First, copy CCSCB2.CM to memory card by using personal computer. (Note 1)
Next, insert memory card to memory card slot of robot controller , press [MENUS] , [7] (file) and display file menu screen. Press [F2] (DIR) and select (*.*) among the displayed list, and display file list. Move cursor to CCSCB2.CM press [ENTER], and finally press [F4] (YES) . (Note 2)
If it is finished correctly, message "Execution is completed successfully" is displayed bottom of the screen.
Note 1)Refer to Chapter 8 [FILE INPUT//OUTPUT] of R-30*i*B controller operator's manual (Basic Operation) (B-83284EN) about kind of usable memory card and basic operation.
Note 2) Press [ENTER]. Do not press [F3] (LOAD).
In case of FS-15*i*Ae : Procedure 5 is not necessary.
6 Turn off the controller power and then back on.
7 Press the emergency stop button.
8 While observing the sensor temperature on the force sensor status screen of the teach pendant, wait for 15 to 60 minutes until the temperature becomes stable and constant. (The time before the stability of the temperature is achieved depends on the ambient temperature.)
In case of FS-15*i*Ae: Procedure 8 is not necessary.
9 Check the force and moment values displayed on the force sensor status screen of the teach pendant. When the values are not greater than the standard values listed below, follow step 10 and later to continue with the mounting. If any of the values are greater than the appropriate standard values, the sensor head may be in some defective condition. Remove the sensor head, and return to step 1 to redo mounting from the beginning.

Table 10.1.1 (b) Standard values (absolute values) after the sensor head is lightly attached:

	FS-15*i*A	FS-40*i*A	FS-100*i*A	FS-250*i*A	FS-15*i*Ae
F x	20N or less	40N or less	100N or less	200N or less	-
F y	20N or less	40N or less	100N or less	200N or less	-
F z	60N or less	120N or less	300N or less	600N or less	60N or less
M x	0.6Nm or less	1.2Nm or less	3.0Nm or less	6.0Nm or less	0.6Nm or less
M y	0.6Nm or less	1.2Nm or less	3.0Nm or less	6.0Nm or less	0.6Nm or less
M z	1.2Nm or less	2.4Nm or less	6.0Nm or less	12.0Nm or less	-

10 Tighten the sensor head mounting bolts completely in an even, crisscross pattern with specified torques given in Fig. 10.1.1 (a) to (i).
11 Confirm the system variables of below of teach pendant. When the values are not greater than the standard values listed below, follow step 12 and later to continue with the mounting. If any of the values are greater than the appropriate standard values, the sensor head mounting bolts may be tightened unevenly. Loosen all the bolts, and return to step 10 to retighten them. If bolts are tightened completely, however force displayed in the screen becomes larger, it is not the abnormality

of the sensor.

In case of FS-15*i*Ae : Reconfirm the force and moment value which are displayed in the force sensor situation screen of the teach pendant.

Table 10.1.1 (c) System variables (absolute value):

$CCC_GRP[1].$GAGE_DATA	FS-15*i*A, FS-40*i*A, FS-100*i*A, FS-250*i*A
[1]	15000 or less
[2]	15000 or less
[3]	15000 or less
[4]	15000 or less
[5]	15000 or less
[6]	15000 or less
[7]	15000 or less
[8]	15000 or less

Table 10.1.1 (d) System variables (absolute value):

	FS-15*i*Ae
Fz	60N or less
Mx	0.6Nm or less
My	0.6Nm or less

12 Wrap a sponge around the sensor cable connector section and fasten them with a nylon band.
13 Attach the hand mounting adapter. To mount the 3D Laser Vision sensor, first mount its sensor adapter. When tightening the bolts for these components, monitor the force and moment values displayed on the force sensor status screen of the teach pendant, and take caution to prevent all the values from changing significantly from the values checked in step 11.
14 Attach hand to hand mounting adapter.
15 While observing the sensor temperature on the force sensor status screen of the teach pendant, wait for 15 to 60 minutes until the temperature becomes stable and constant. (The time before the stability of the temperature is achieved depends on the ambient temperature.)
16 Confirm the absolute value of the system variable below of teach pendant.

Table 10.1.1 (e) Rated loads for measurement (absolute values):

$CCC_GRP[1].$GAGE_DATA	FS-15*i*A, FS-40*i*A, FS-100*i*A, FS-250*i*A
[1]	28000 or less
[2]	28000 or less
[3]	28000 or less
[4]	28000 or less
[5]	28000 or less
[6]	28000 or less
[7]	28000 or less
[8]	28000 or less

Be sure to reset the force display after confirmation. To perform the reset, display force sensor status screen of the teach pendant. If [F →] button is pressed, [F1] changes to [Clear]. When [F1] is pressed in this time, force value of the screen is reset and become the neighborhood of 0° .

In case of FS-15*i*Ae :

Confirm force and moment which is displayed in force sensor status screen of the teach pendant. Confirm value is not abnormally apart from the value of before installing them by guessing from the shape and mass of the hands and hand mounting adapter which were installed to the tip of the force sensor. In addition, if value exceeds the measured rating load, the load may exceed allowable wrist load condition of the robot, so confirm the load of the hands.

After confirmation, be sure to reset the force display.

Table 10.1.1 (f) Measured load (absolute value):

	FS-15*i*Ae
Fz	150N or less
Mx	12Nm or less
My	12Nm or less

17 Ensure that 0 is set to the system variable below. If a nonzero value is set, perform a control start and set the variable in the teach pendant. For details of the control start procedure, refer to Appendix B.1, "Start Modes" in the R-30*i*B OPERATOR'S MANUAL (Basic Function) (B-83284EN) .
$CCC_GRP.$FSGD_TYPE=0

Cautions for installation

- First, tighten the mounting bolts lightly in an even, crisscross pattern. Then tightening them completely with a specified torque in an even, crisscross pattern.
- The flatness and surface roughness of the member (hand mounting adapter) that contacts the force sensor shall comply with what is specified in Section 4.1, "Wrist Section End Effector Mounting Surface". If the mounted member does not comply with the specified flatness and surface roughness, the value of the force sensor might exceed the standard value stated above.

⚠ CAUTION
In case of FS-15*i*A,FS-40*i*A,FS-100*i*A or FS-250*i*A, it is necessary to load parameter file to robot controller. When sensor head is replaced, load parameter file of attached CD-R and use it.

⚠ CAUTION
In case of F-15*i*Ae, original parameter is stored in each sensor head. When sensor head is replaced, original parameter is load to the robot controller automatically. So it can be used without any operation.

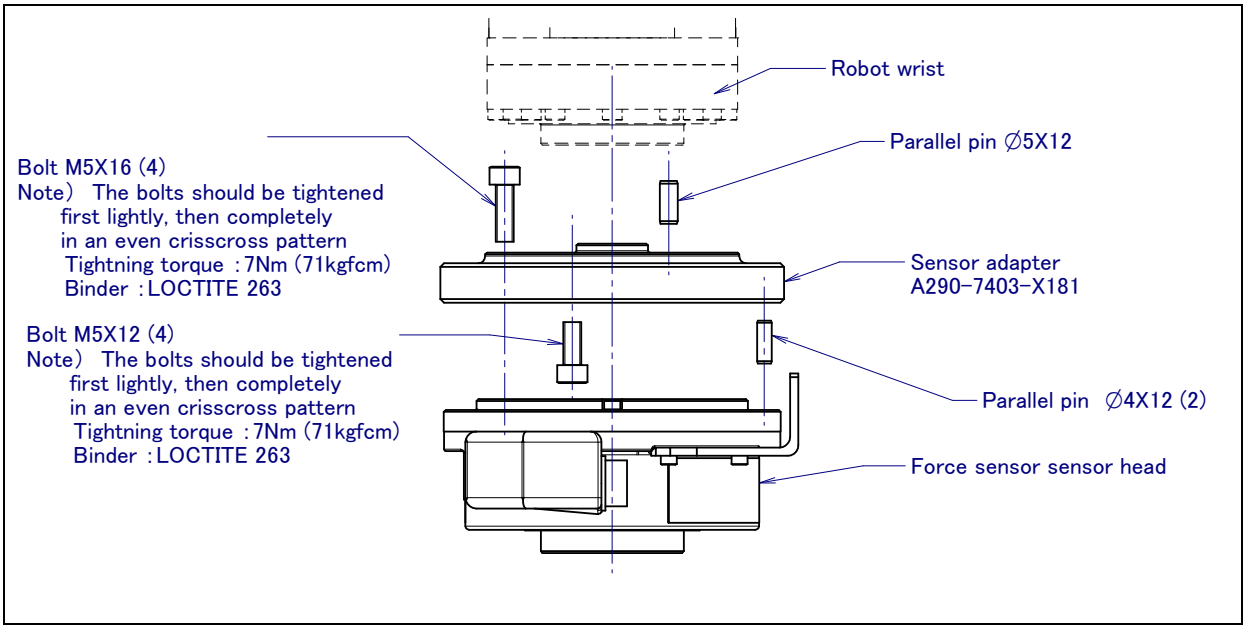


Fig. 10.1.1 (a) Replacing the force sensor, sensor head and adapter (LR Mate 200*i*C + FS-15*i*A)

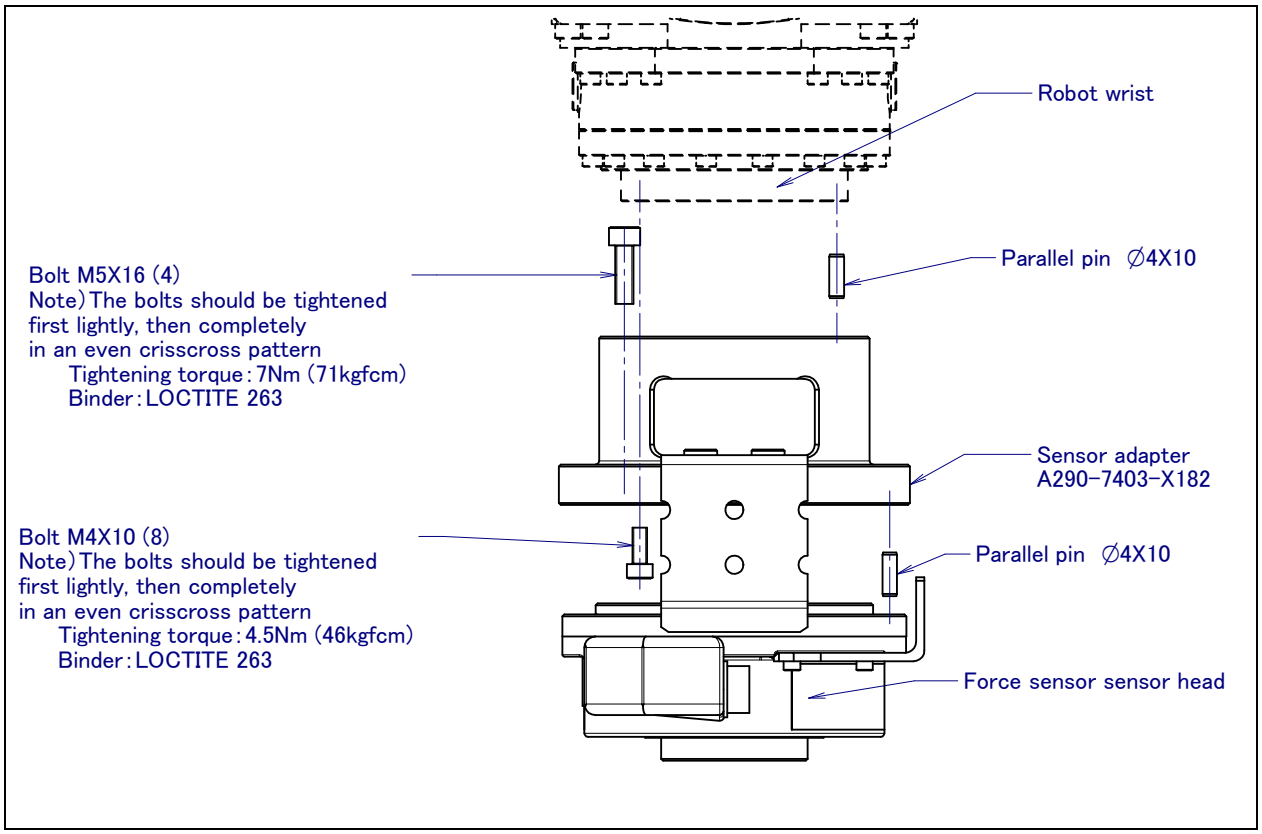


Fig. 10.1.1 (b) Replacing the force sensor, sensor head and adapter (M-10*i*A+FS-15*i*A)

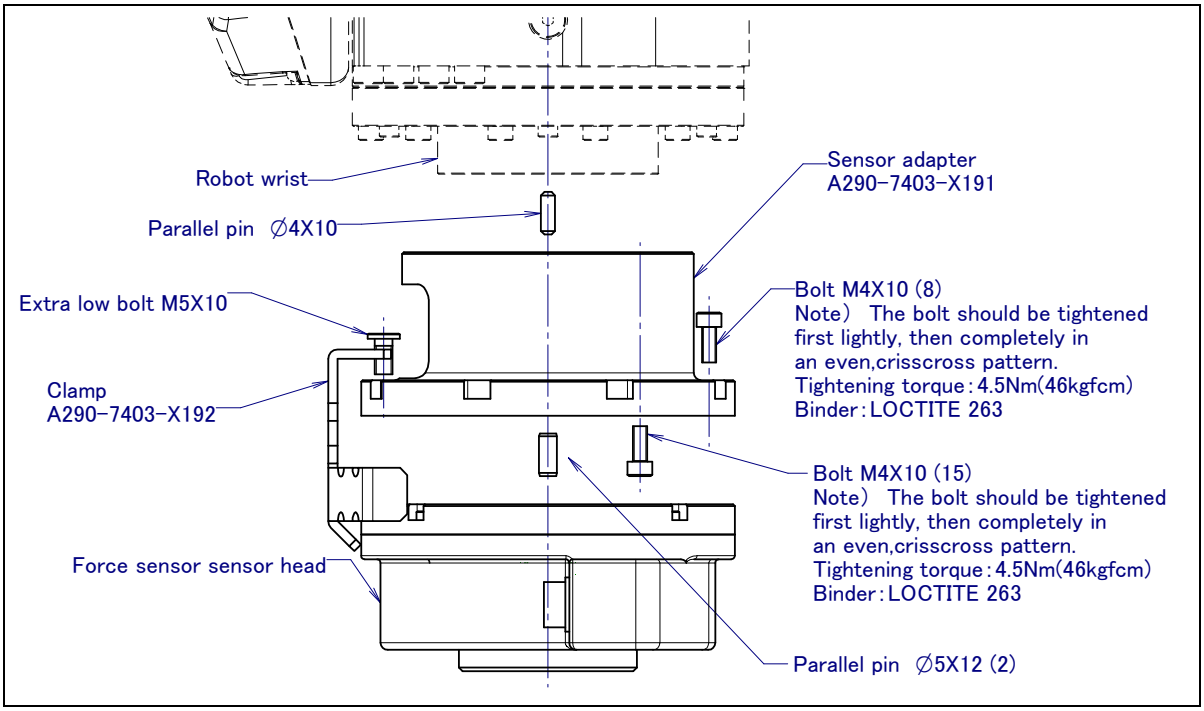


Fig. 10.1.1 (c) Replacing the force sensor, sensor head and adapter (FS-40*i*A)

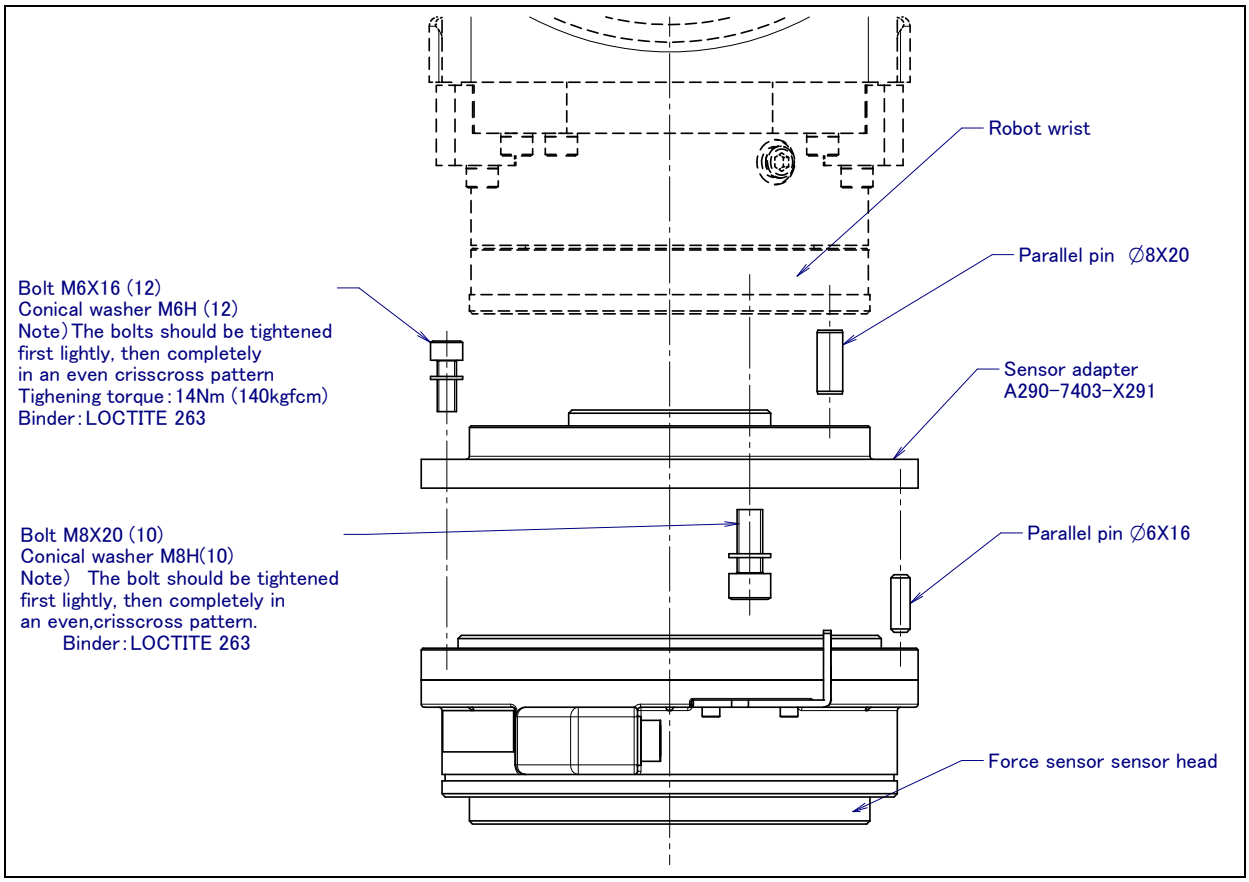


Fig. 10.1.1 (d) Replacing the force sensor, sensor head and adapter (M-710*i*C+FS-100*i*A)

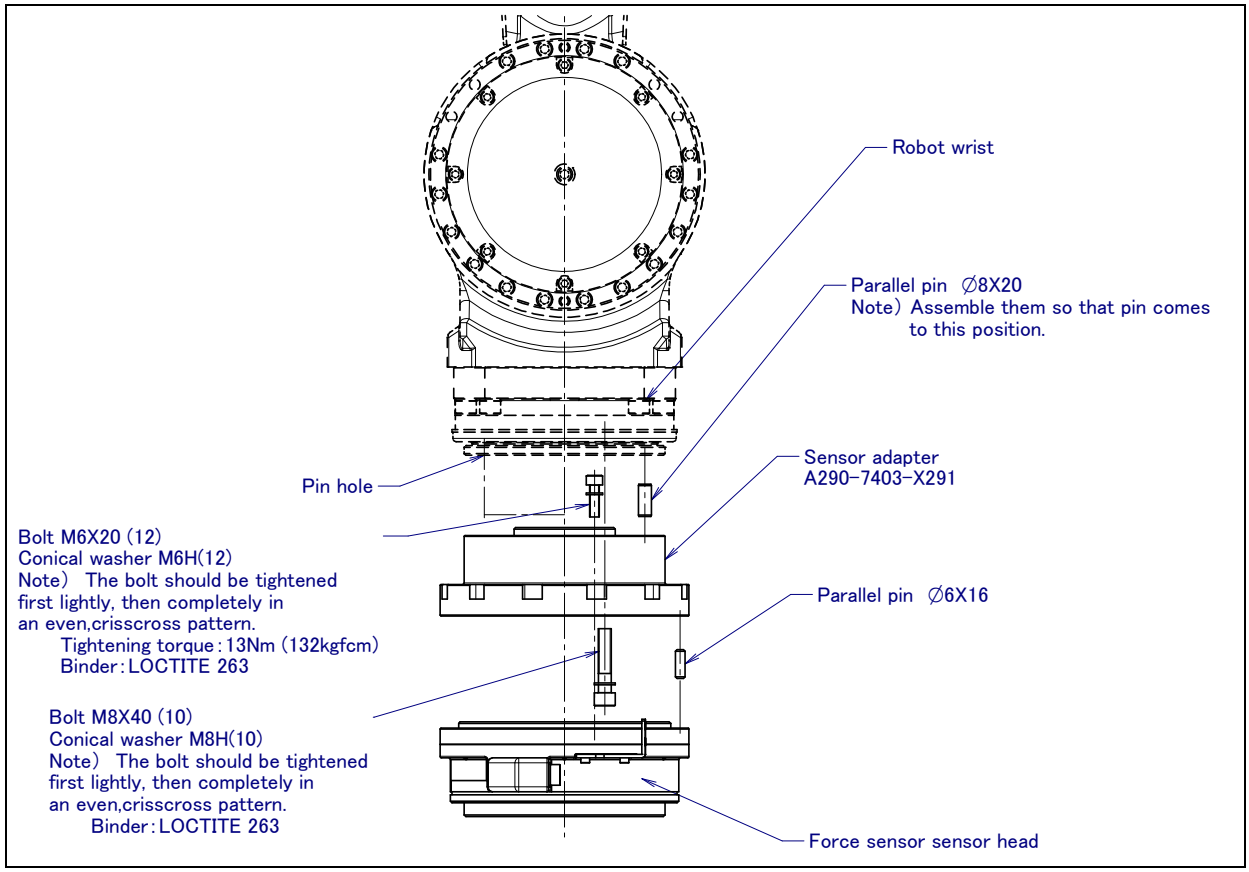


Fig. 10.1.1 (e) Replacing the force sensor, sensor head and adapter (R-1000*i*A/80F+FS-100*i*A)

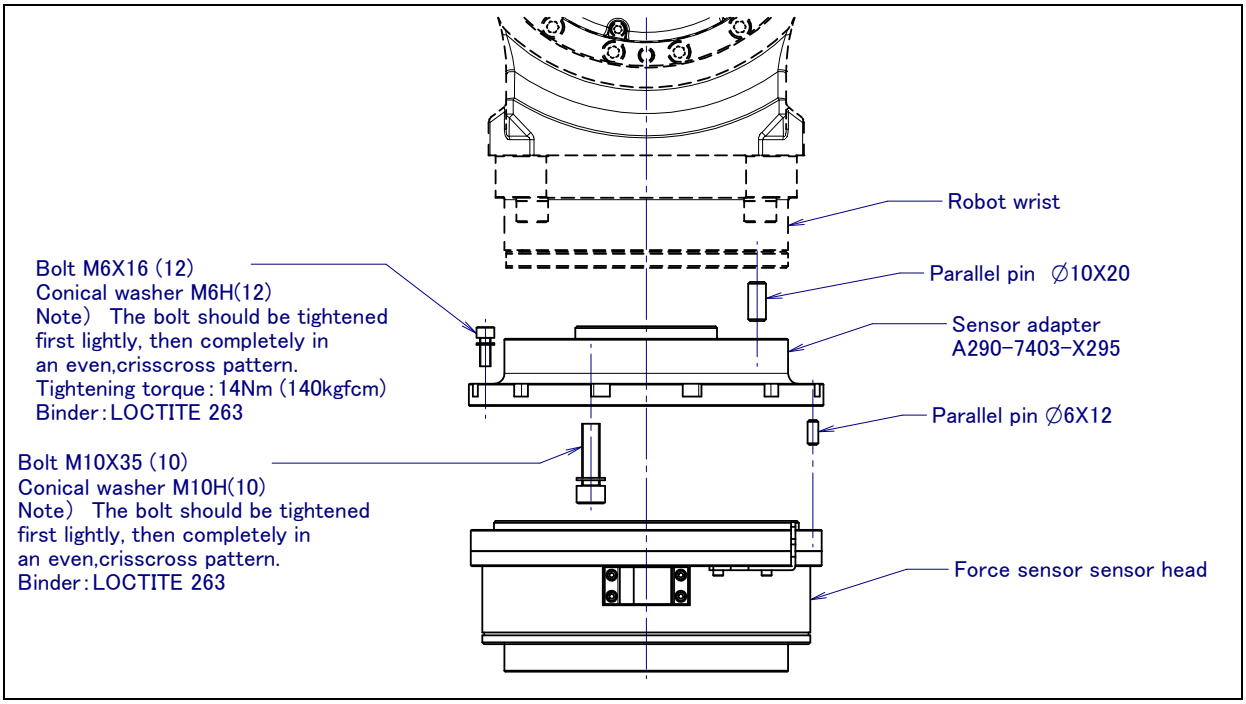


Fig. 10.1.1 (f) Replacing the force sensor, sensor head and adapter (R-2000*i*B+FS-250*i*A with standard adapter)

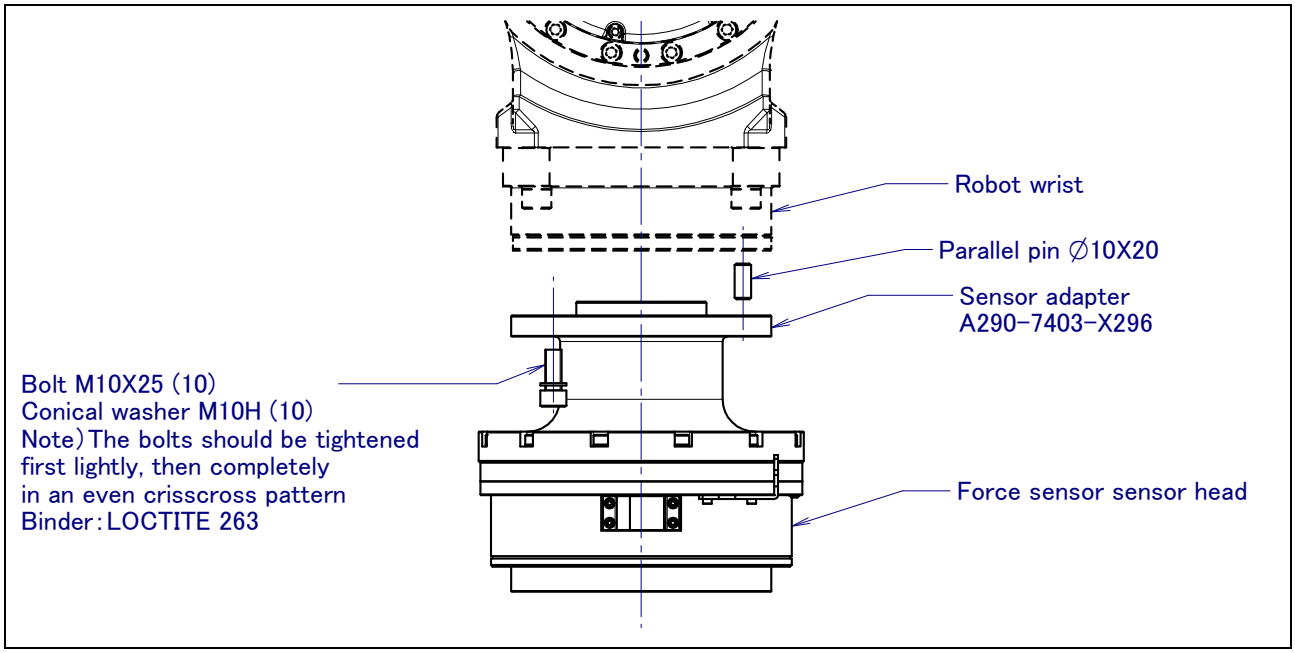


Fig. 10.1.1 (g) Replacing the force sensor, sensor head and adapter (R-2000*i*B+FS-250*i*A with adapter which does not need torque wrench)

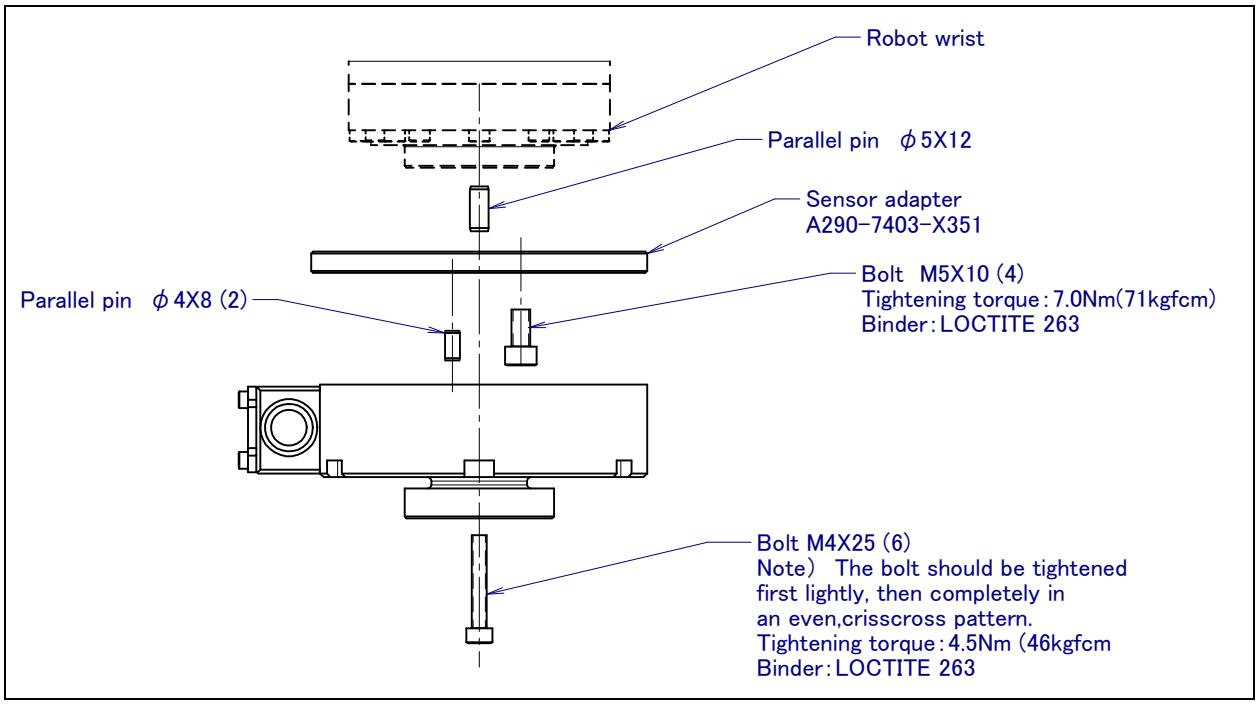


Fig. 10.1.1 (h) Replacing the force sensor, sensor head and adapter (LR Mate 200*i*C+FS-15*i*Ae)

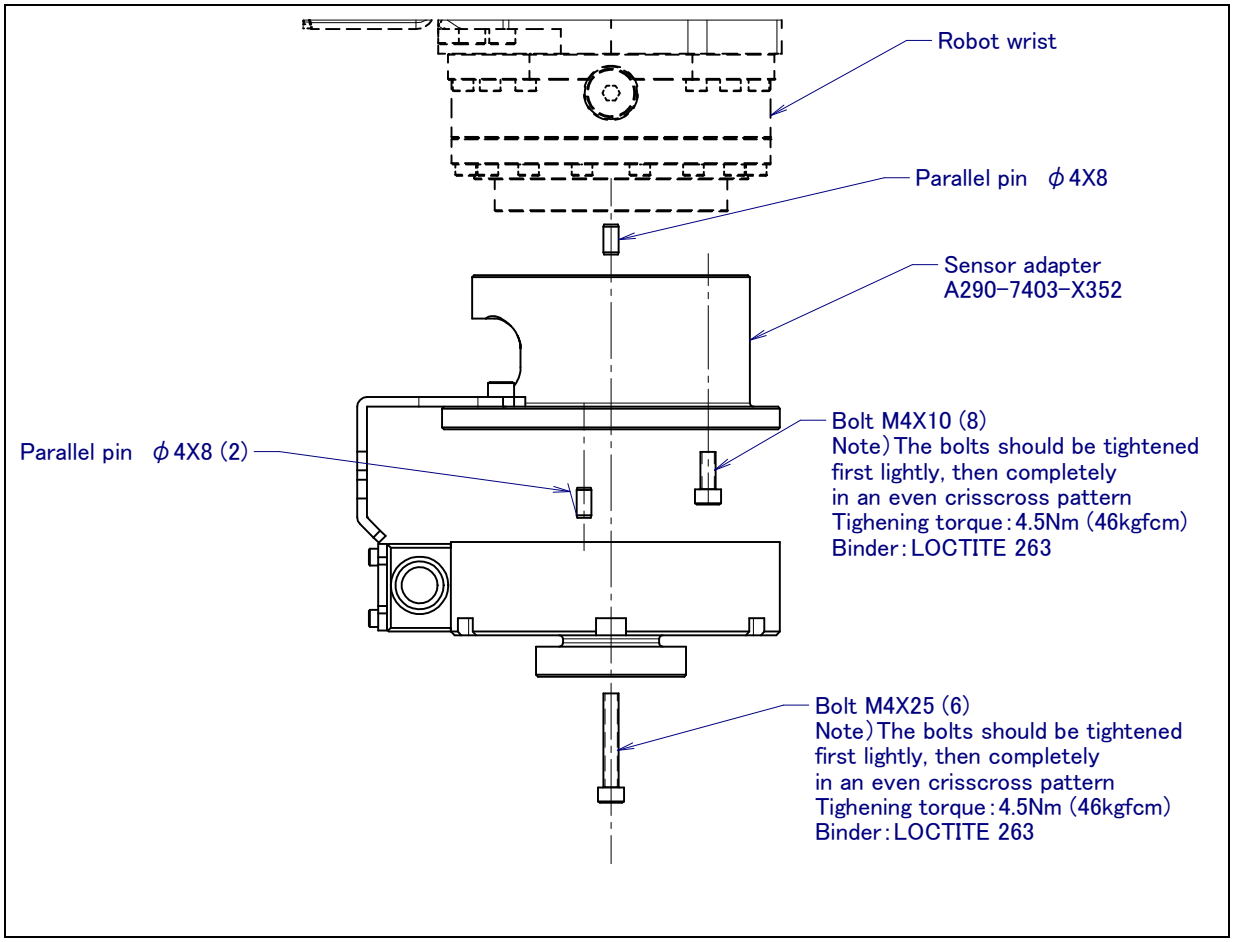


Fig. 10.1.1 (i) Replacing the force sensor, sensor head and adapter (M-10*i*A+FS-15*i*Ae)

10.1.2 Replacing the Sensor Adapter

To replace the sensor mounting adapter, follow the procedure described below. (See Fig. 10.1.1 (a) to (i).) A torque wrench having a special shape is required. Also, see Section 8.5, "Inspection Instrument and Tool."

Removal procedure

1 Remove the force sensor head.
2 Remove the sensor adapter mounting bolts, and detach the sensor adapter and pin.

Installation procedure

1 Attach the pin to the robot flange.
2 Fasten the sensor adapter using the sensor adapter mounting bolts. Be careful about the sensor adapter mounting orientation. Tighten the bolts first lightly, then completely with the specified torque.
3 Mount the force sensor head using the sensor head mounting bolt and the washer.
See the installation procedure of the sub-section 10.1.1 "Replacing the sensor head for detail procedure".

Cautions for installation

If the bolts on which insulating and other washers have been put are tightened unevenly or the specified torque is not used, loose mounting or faulty insulation may be caused. Be sure to tighten the bolts evenly with a specified torque.

10.2 3D LASER VISION SENSOR MECHANICAL SECTION

10.2.1 Replacing the 3D Laser Vision Sensor

If the 3D Laser Vision sensor head or pre-unit becomes faulty, replace it according to the following procedure. (See Fig.10.2.1.)

Removal procedure

1 Detach the sensor cable and camera cable from the sensor.
2 Put a marking to indicate the current mounting position of the sensor head, and then remove the sensor head mounting bolts.
3 Detach the sensor head from the sensor adapter.

Caution for removal

Do not disassemble the 3D Laser Vision sensor head. If they are disassembled, it becomes impossible for them to make accurate measurement after they are reassembled.

Installation procedure

1 Attach the sensor head to the sensor adapter using mounting bolts and pins.
2 Attach the sensor cable and camera cable to the sensor head.

Caution for installation

The mounting location of the sensor can be selected according to the application for which the robot is used. Be sure to mount the sensor exactly at the same location as before removal.

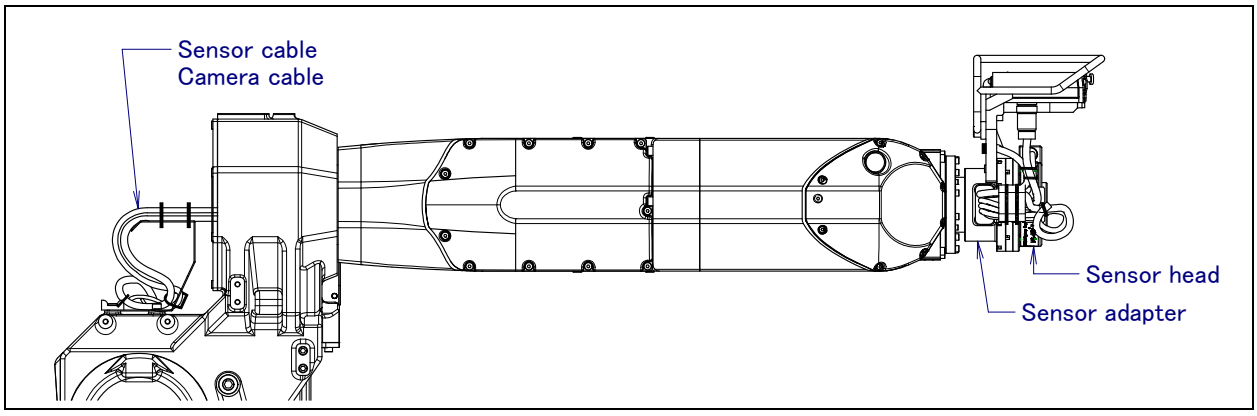


Fig. 5.2.1 Replacing the 3D laser vision sensor head (Example of M-20*i*A)

10.3 CAMERA PACKAGE MECHANICAL SECTION

10.3.1 Replacing the Sensor Head of Camera Package

If the sensor head of camera package becomes faulty, replace it according to the following procedure. (See Fig. 10.3.1.)

Removal procedure

1 Cut the nylon band of the cable clamp.
2 Detach nut of bushing, and detach bushing.
3 Detach camera cable from sensor head.
4 Detach the sensor head fasting bolt.
5 Detach the sensor head.

Installation procedure

1 Attach the sensor head to the sensor adapter using mounting bolts and pins.
2 Pass the bushing on to the cable and attach camera cable to sensor head.
3 Attach the bushing to sensor head and attach nut of the bushing to sensor head also.
4 Attach the cable to the cable clamp using a nylon band.

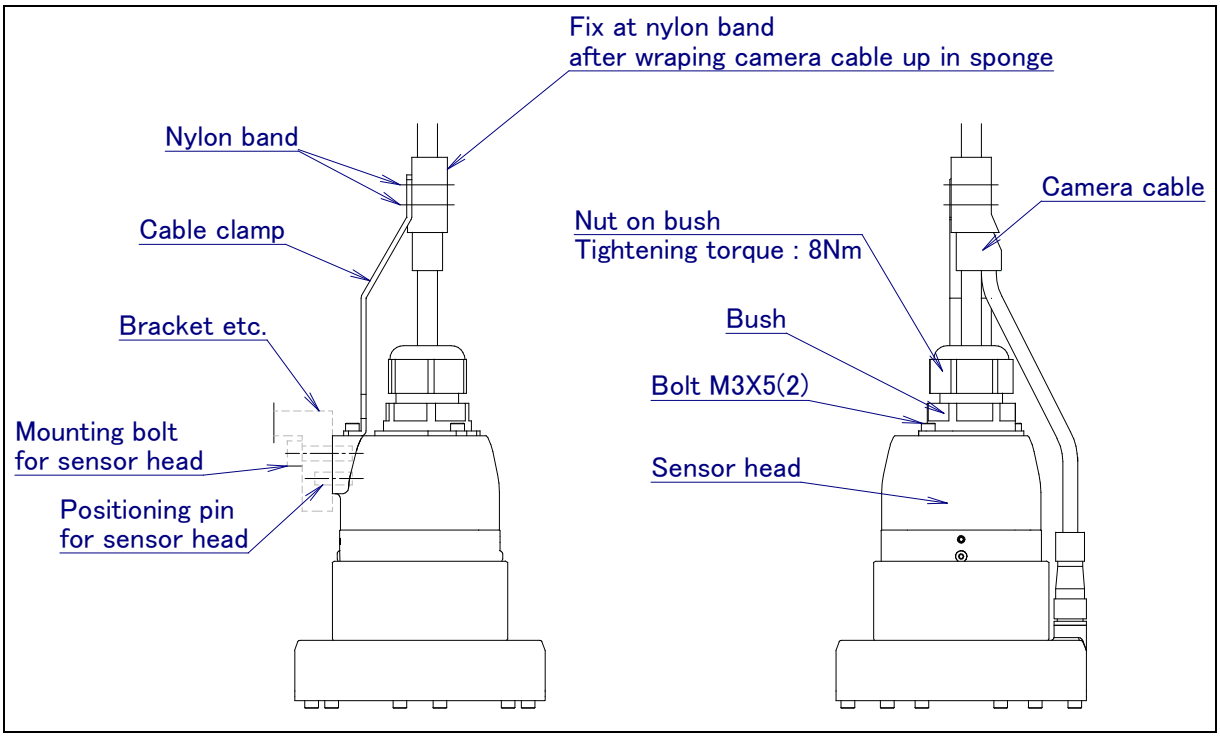


Fig. 10.3.1 Replacing the sensor head of camera package

10.4 3D AREA SENSOR

10.4.1 Replacing 3D Area Sensor Projector Unit and Camera Unit

If 3D Area Sensor projector unit or camera unit becomes failure. replace it according to the following procedure. (See Fig. 10.4.1.)

Removal procedure

1 Turn off the robot controller power.
2 Remove cable from projector unit or camera unit.
3 Remove mounting bolts, and remove projector unit or camera.

Installation procedure

1 Attach projector unit or camera unit with mounting bolts.
2 Attach cable to projector unit or camera unit.

In addition, when camera unit is replaced, perform focus adjusting of camera (See Subsection 7.4.2.) and Calibration.

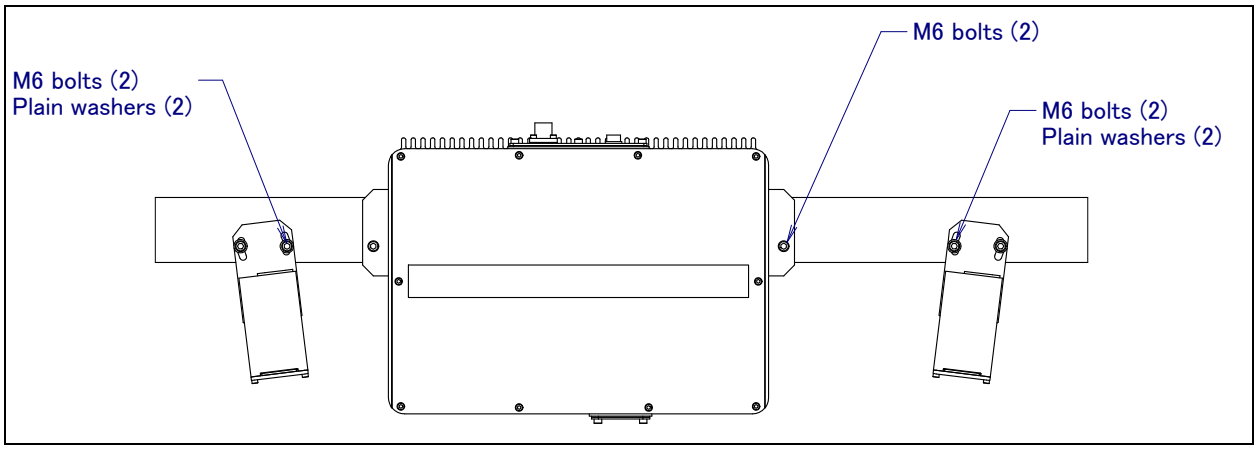


Fig.10.4.1 Replacement of 3D area sensor

11 CABLE REPLACEMENT

The following robot is available to be included with a sensor (see Section 6.2, “Wiring”):

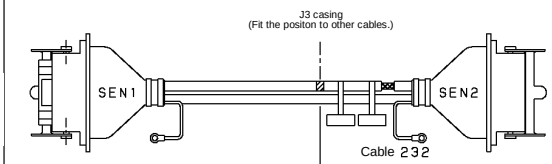
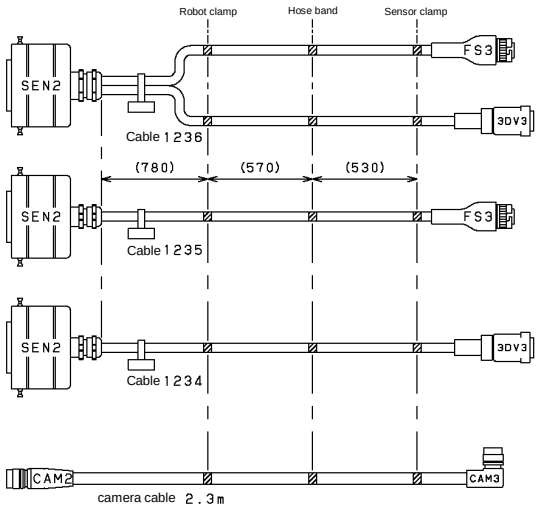
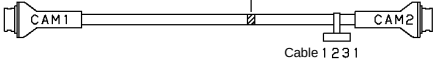
Cable name
Mechanical unit cable (Robot main body)
Mechanical unit cable (Sensor)
Sensor cable (J3 casing to the sensor head)
Camera cable (J3 casing to the sensor head)

Refer to the robot specific manual for explanations of how to replace the each robot’s main body mechanical unit cable.

11.1 CABLE FORMING

Table 11.1 shows those portions of the mechanical unit cable (for sensor), sensor and camera cable, which must be clamped. Be sure to clamp the cables at the specified portions.

Table 11.1 Cable forming

Sensor	Mechanical cable	Sensor cable camera cable
Force sensor / 3D vision sensor		
3D vision sensor (camera)		

The measure of the sensor cable and the camera cable are the standard mounting positions.

11.2 REPLACING THE SENSOR CABLE AND CAMERA CABLE

> ⚠ **CAUTION**
> For the sensor cable kit, a sponge is attached for protection of the cable from clamping band. When assembling, perform the correct clamping according to Fig.11.2.

If the force sensor or 3D Laser Vision sensor cable or camera cable is damaged, replace the cable by the following procedure.

Removal procedure

1 Detach the sensor cable or the camera cable from the force sensor head or 3D Laser Vision sensor head.
2 Detach the sensor cable or the camera cable from the connector on the J3 casing.
3 Detach the sensor cable or the camera cable from the hose tie of the cable hanger.
4 Detach the cable clamp and nylon tie, and then the sensor cable or camera cable.

Installation procedure

1 To attach the sensor cable or the camera cable, reverse the removal procedure, while using caution for the cable clamping portions.
2 Adjust the interval between the cable and hose tie by wrapping sponge around the cable at the hose mounting portion as shown in Fig. 11.2.
3 Wrap sponge and tie nylon band around the Sensor side connector positions for each cable as shown in Fig. 11.2.
Fasten the J3 casing-side connector and J1 base-side connector of the camera cable with nylon ties.

Caution for installation

After attaching the sensor and camera cable, operate the robot wrist section, and check that the cable is free from excessive tension and twisting.
Check that the connector of the camera cable is free from excessive tension and twisting.

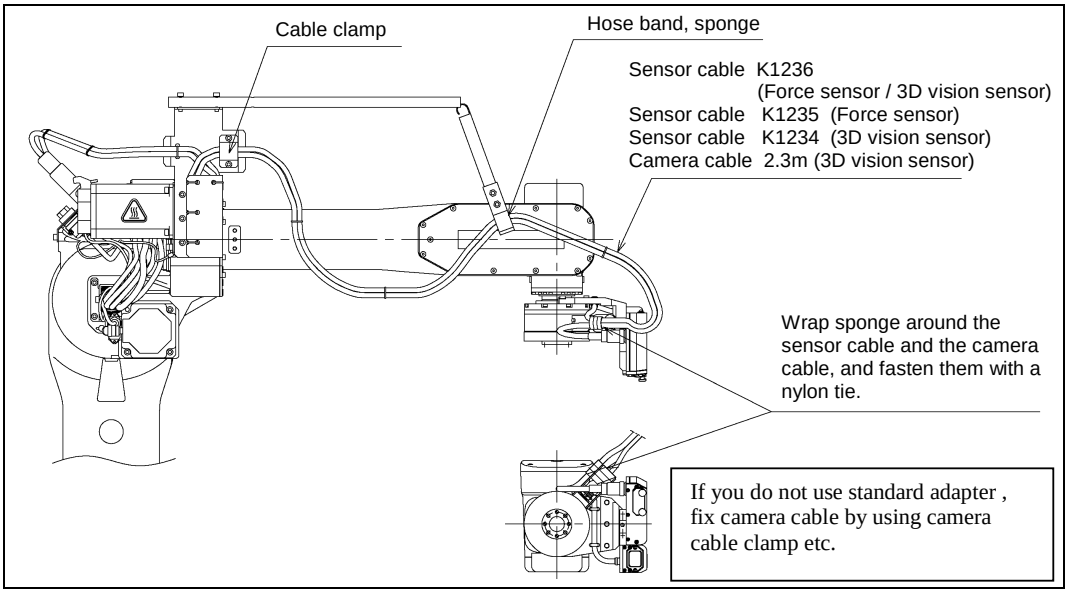


Fig. 11.2 Replacing the sensor cable and the camera cable

11.3 REPLACING THE CAMERA CABLES OF CAMERA PACKAGE

> ⚠ **CAUTION**
> For the camera cable kit, a sponge is attached for protection of clamping part.
> When assembling, perform the correct clamping according to Fig.11.3.

When camera cable of camera package is disconnected, replace it by the procedure below.

The mechanical unit cables have the following differences from normal cables. Take caution to ensure that new cables after replacement are in the same condition as the previous cables.

Removal procedure

1 Cut the nylon band of the cable clamp of the sensor head.
2 Detach the nut of the bushing for the sensor head, and detach the bushing.
3 Detach the camera cable from sensor head.
4 Detach the camera cable from the connector of J3 casing.

Installation procedure

1 Attach camera cable to the connector of the J3 casing.
2 Pass cable through bushing and attach camera cable to sensor head.
3 Attach the bushing to sensor head and attach nut to sensor head.
4 Wrap a sponge around the camera cable and attach cable to cable clamp using nylon band.

Caution for installation

After attaching the camera cable, operate the robot wrist section, and check that the cable is free from excessive tension and twisting.
Check that the connector of the camera cable is free from excessive tension and twisting.

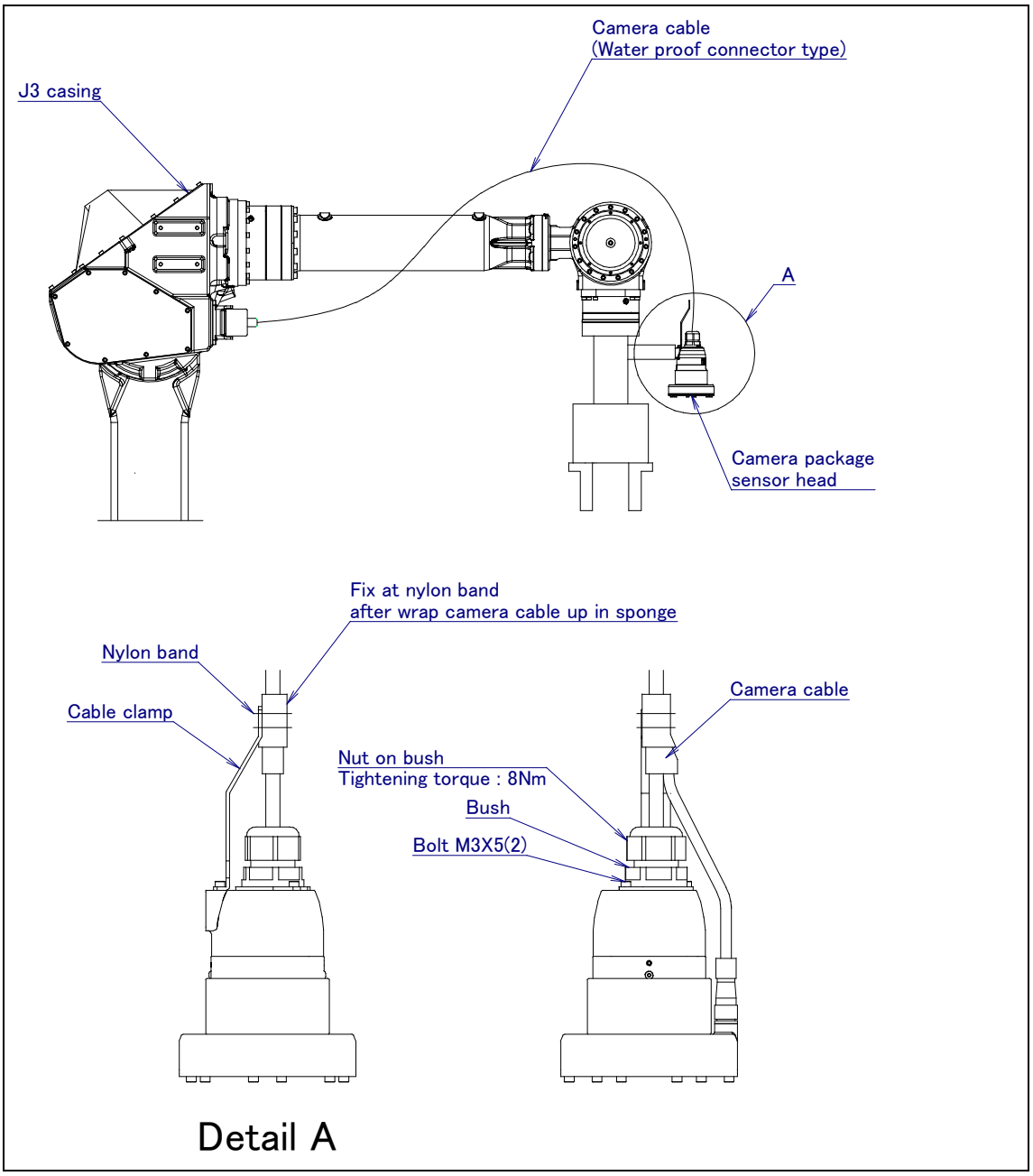


Fig. 11.3 Replacing the camera cable (M-710*i*C)

12 INTRA-CONTROLLER PCB AND UNIT REPLACEMENT

12.1 REPLACING ANALOG MULTIPLEXER BOARD FUSE

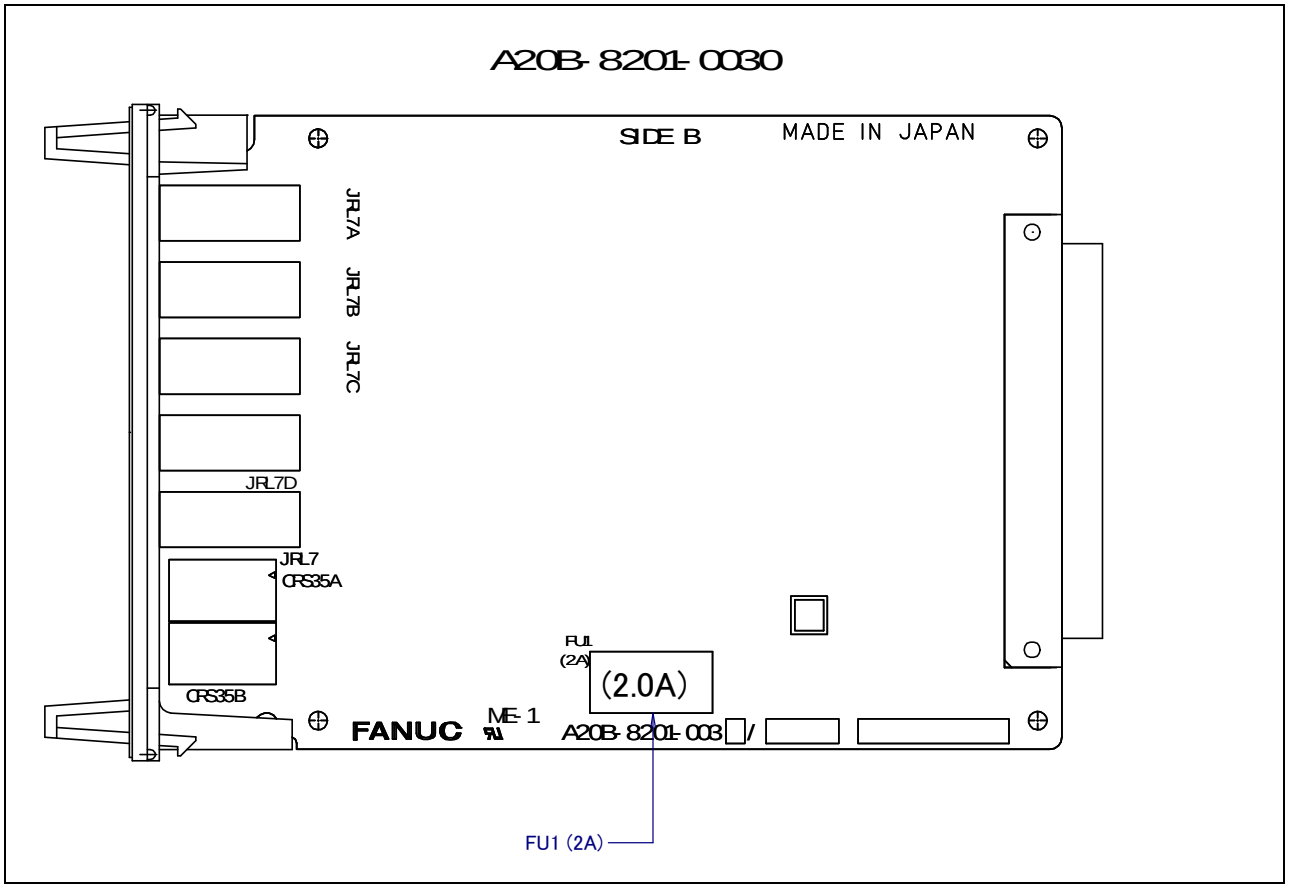


Fig. 12.1 Replacing analog multiplexer board (for wide mini slot) fuse

12.2 REPLACING ANALOG MULTI PLEXER BOARD

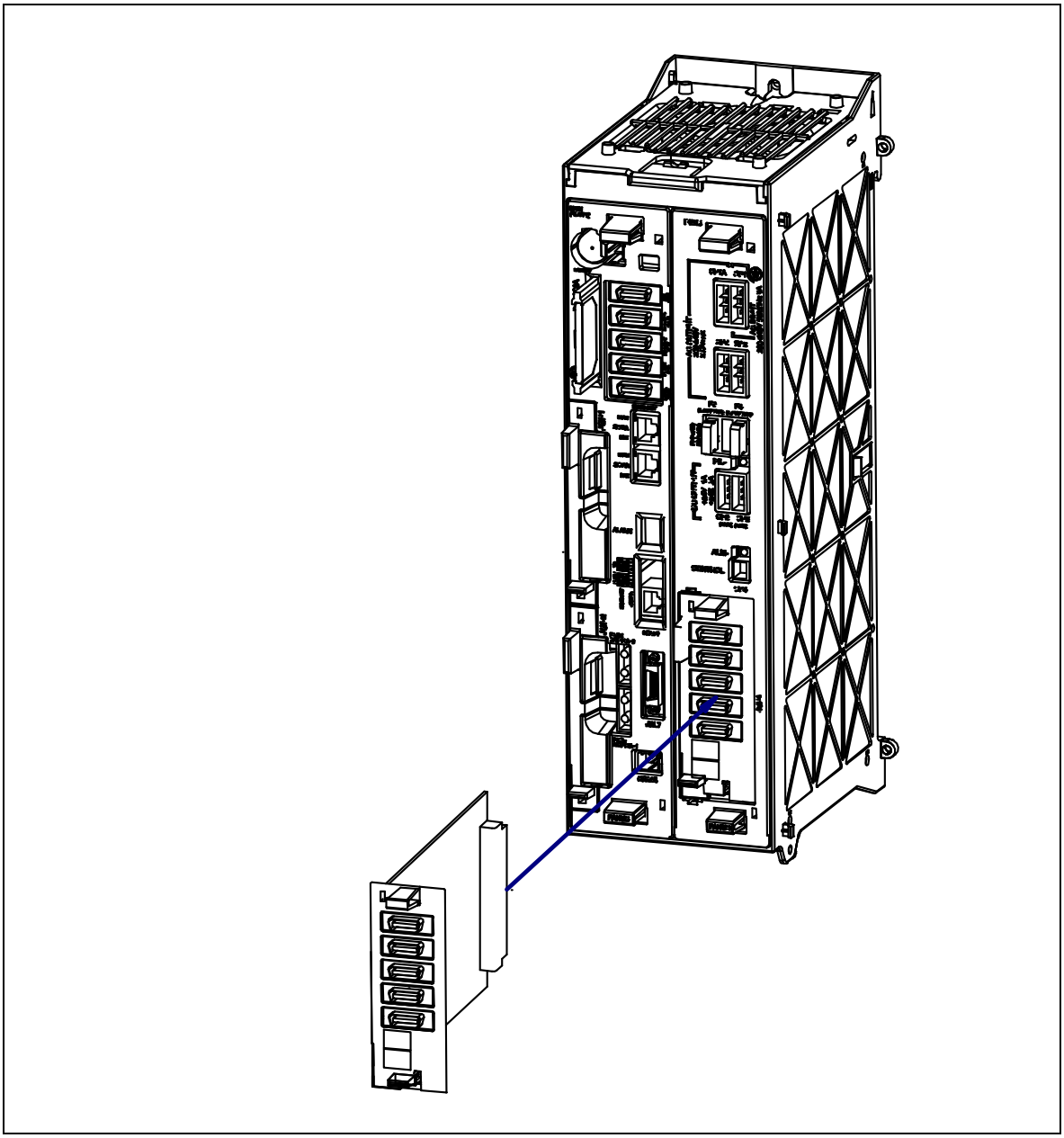


Fig. 12.2 Replacing analog multiplexer board

12.3 REPLACING DIGITAL CCU (A-CABINET)

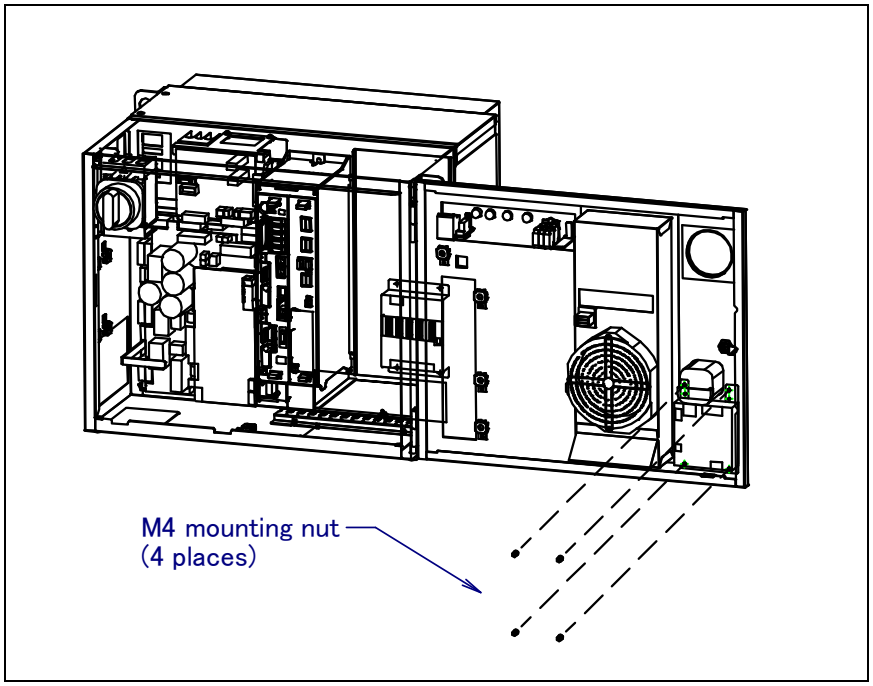


Fig.12.3 Replacing digital CCU (A-cabinet)

12.4 REPLACING DIGITAL CAMERA MULTIPLEXER (A-CABINET)

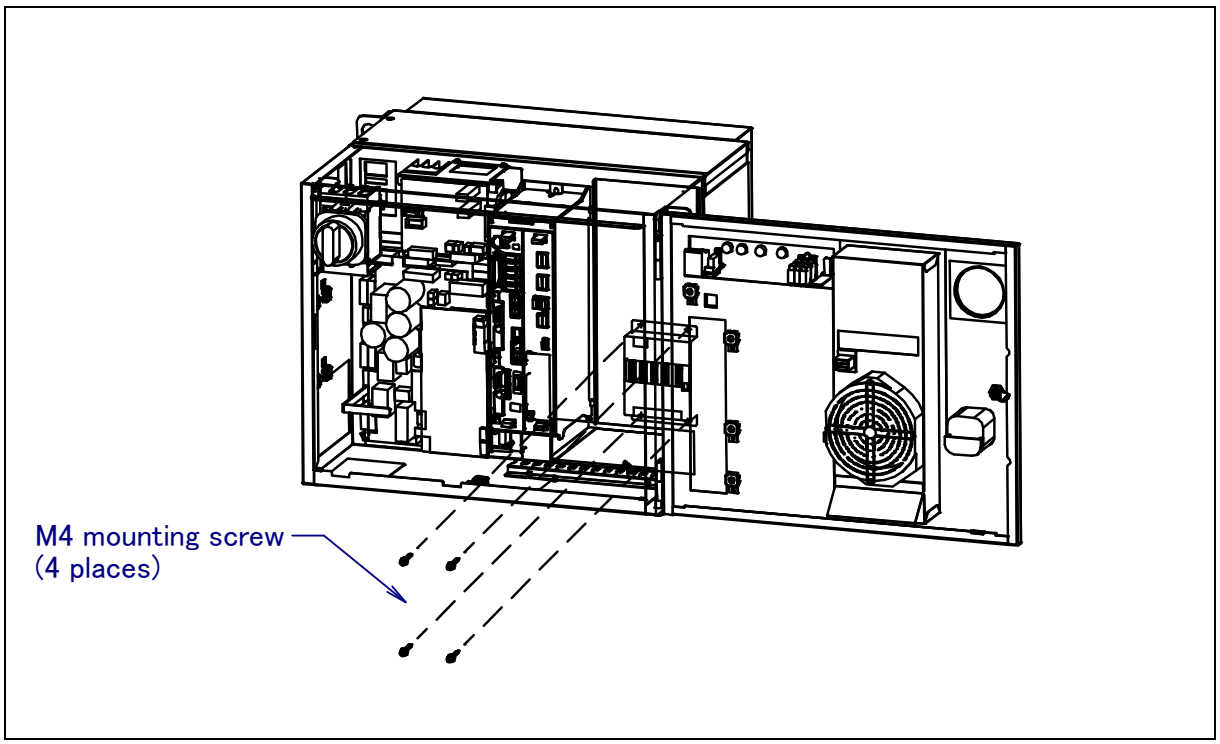


Fig.12.4 (a) Replacing digital camera multiplexer (A-cabinet, installed to main box)

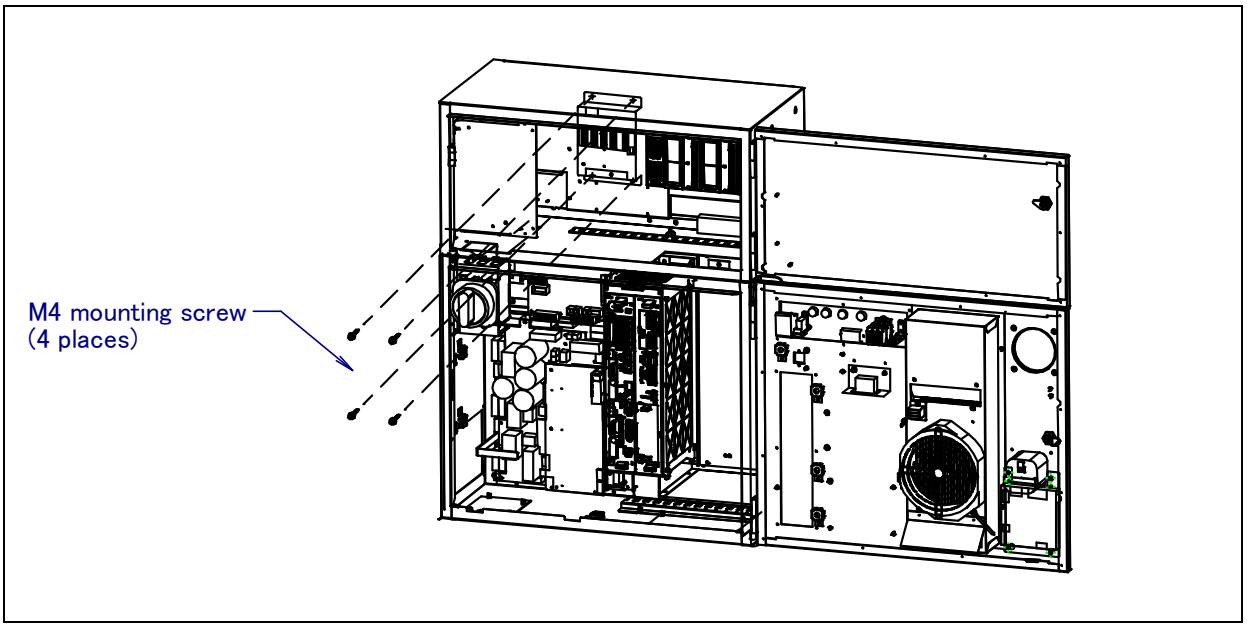


Fig.12.4 (b) Replacing digital camera multiplexer (A-cabinet, installed to top process box)

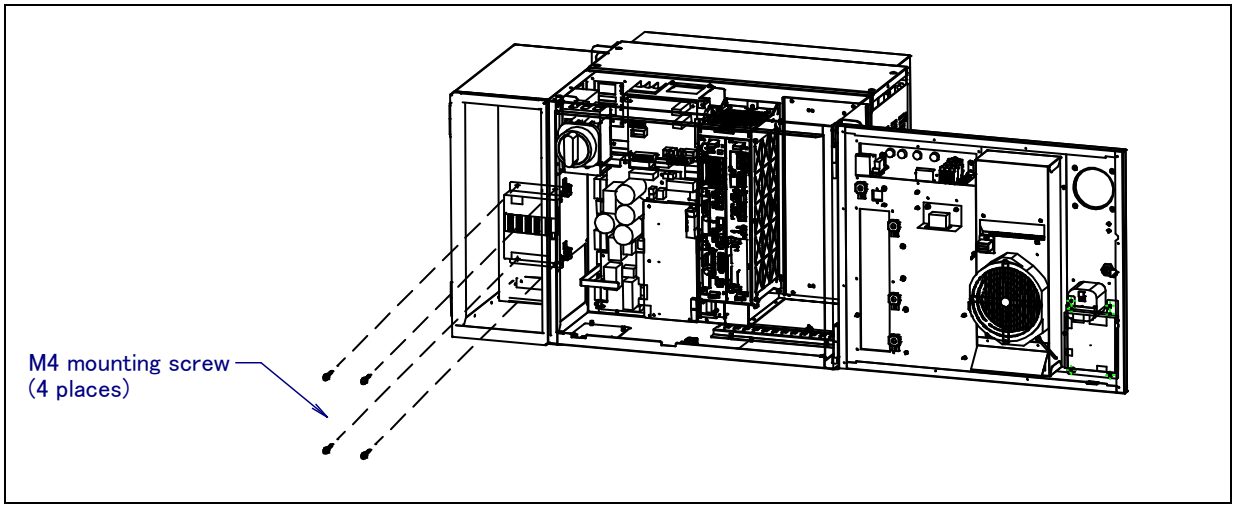


Fig.12.4 (c) Replacing digital camera multiplexer (A-cabinet, installed to side process box)

12.5 REPLACING DIGITAL CCU (B-CABINET)

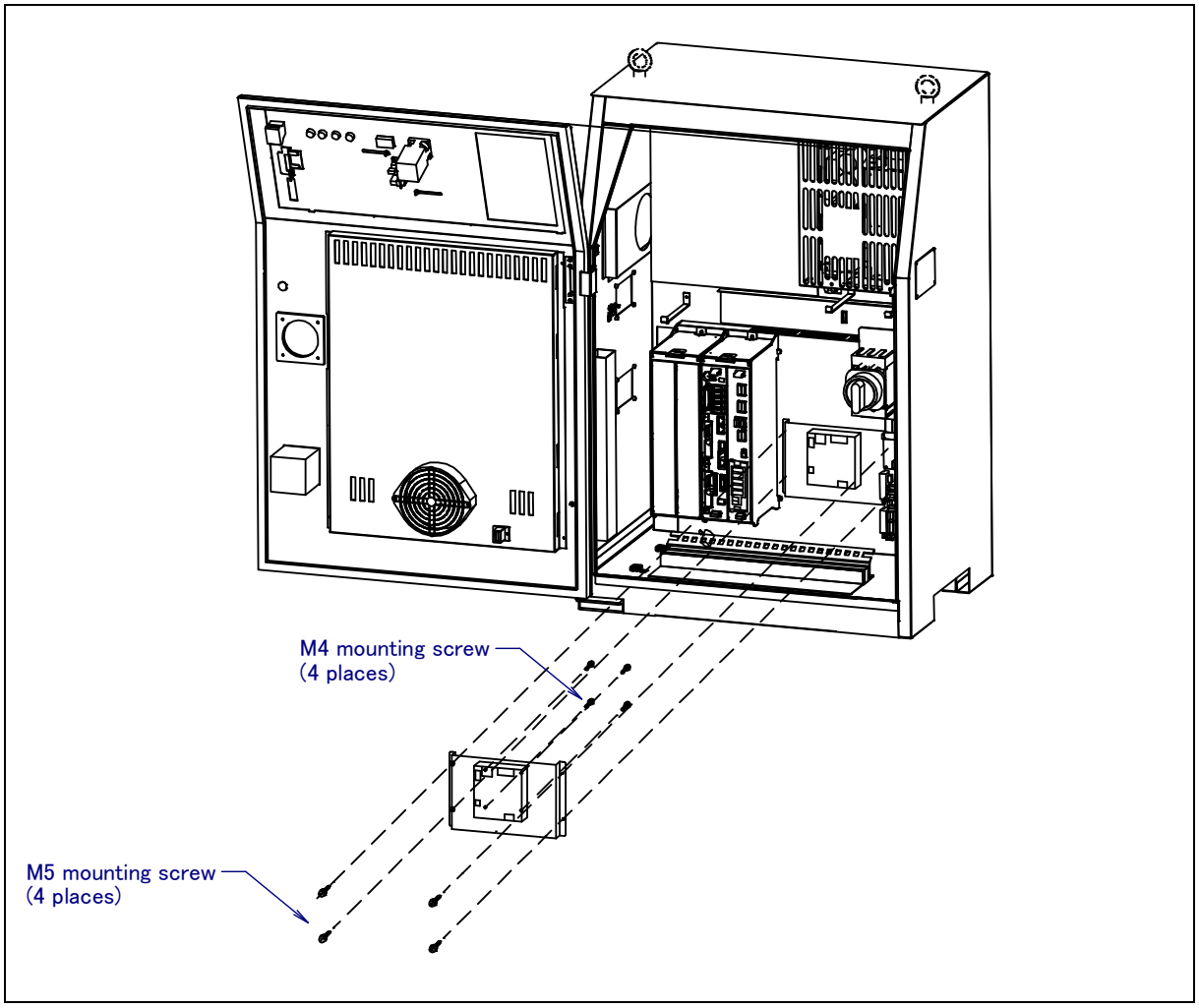


Fig. 12.5 Replacing digital CCU (B-cabinet)

12.6 REPLACING DIGITAL CCU AND DIGITAL CAMERA MULTIPLEXER (B-CABINET)

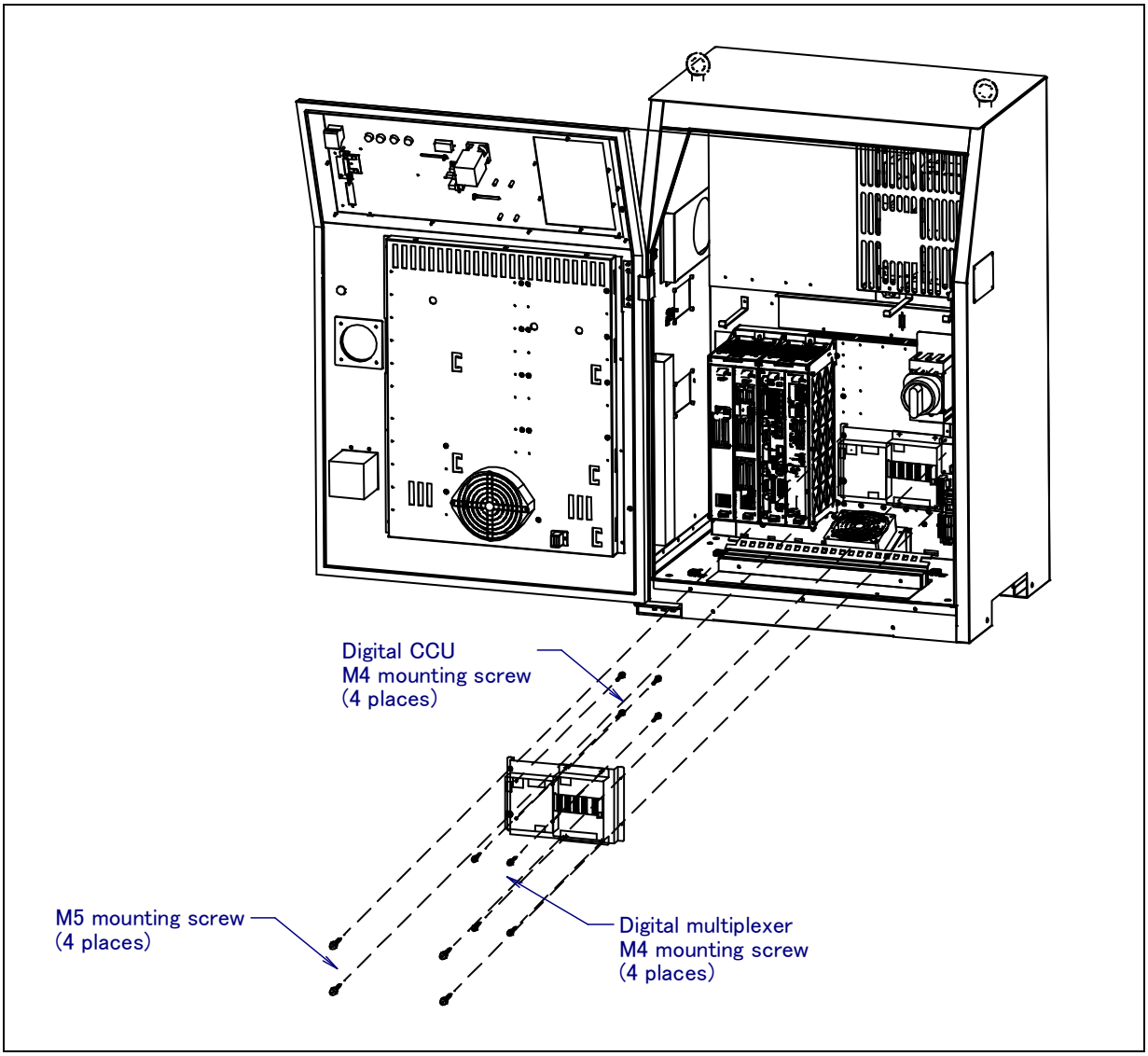


Fig. 12.6 Replacing digital CCU and digital camera multiplexer (B-cabinet)

APPENDIX

A CIRCUIT DIAGRAM

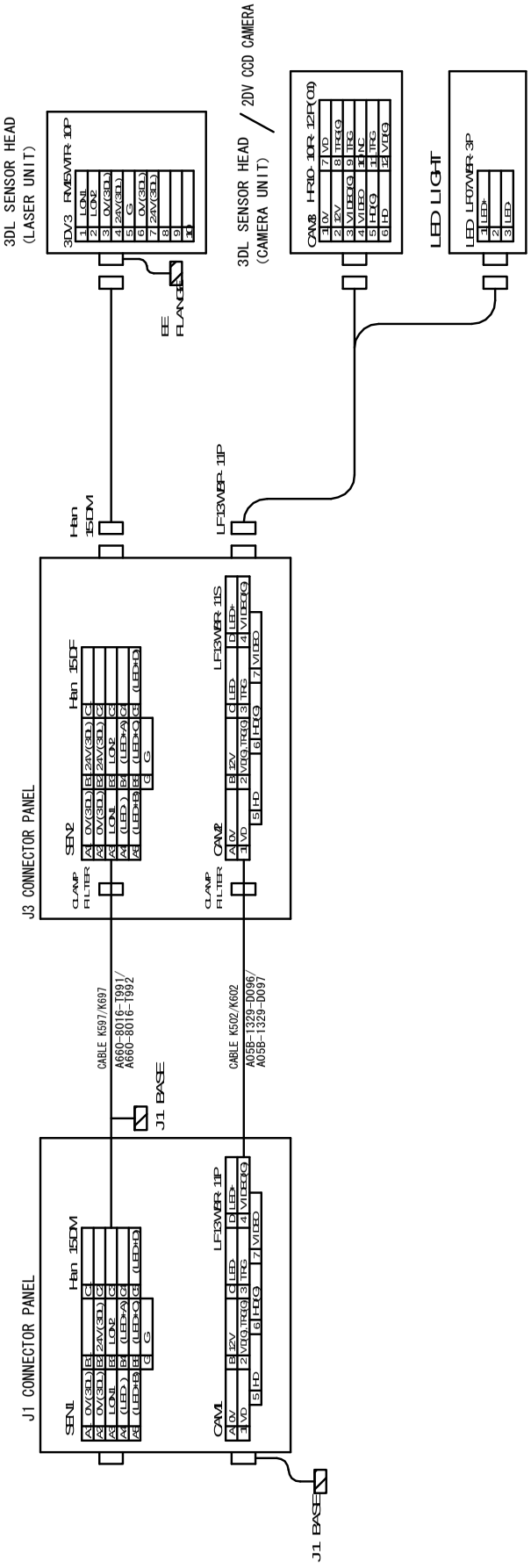


Fig. A (a) Circuit diagram in the mechanical unit (Example of SEN interface with R-2000*i*B)

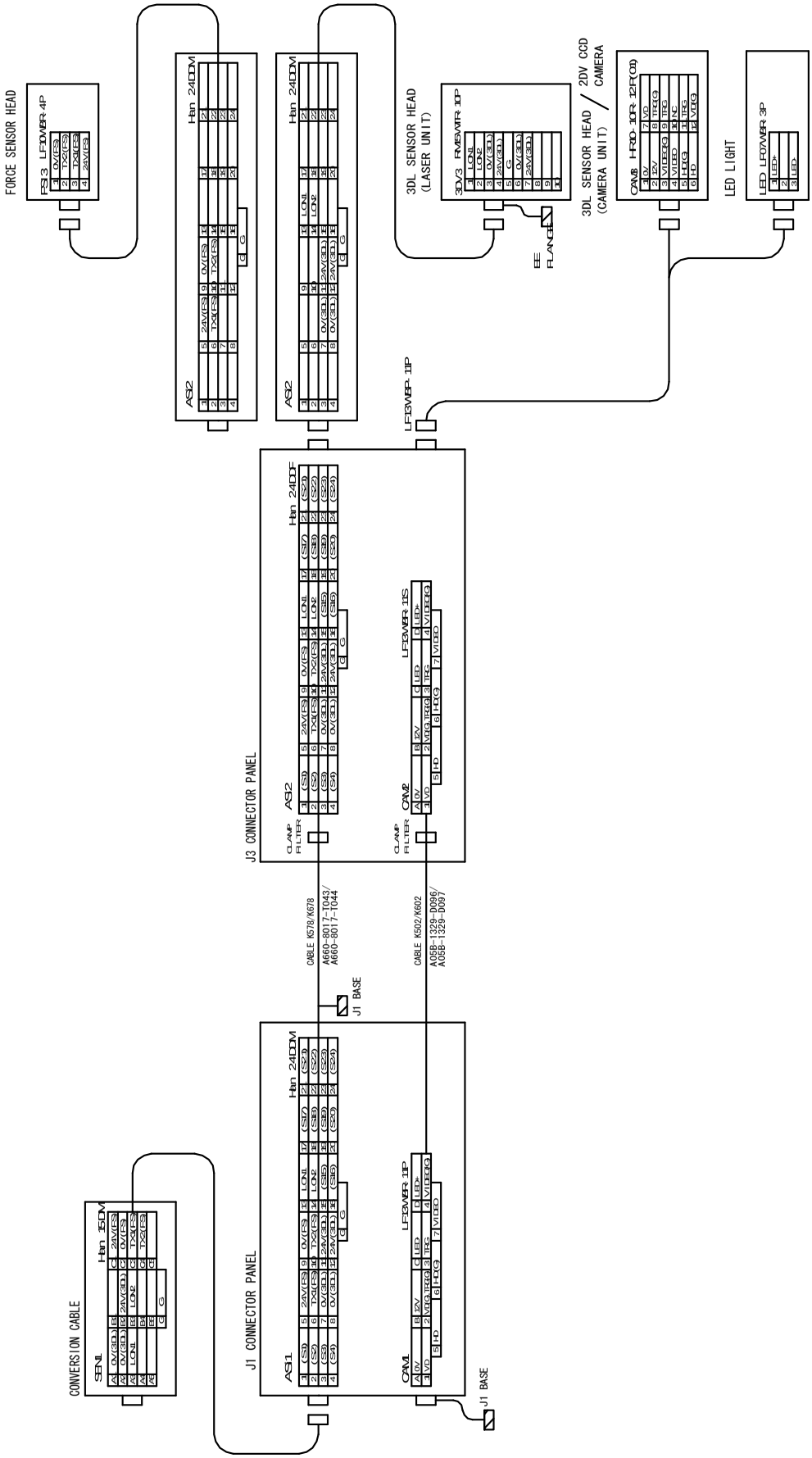


Fig. A (b) Circuit diagram in the mechanical unit (Example of ASi interface with R-2000*i*B)

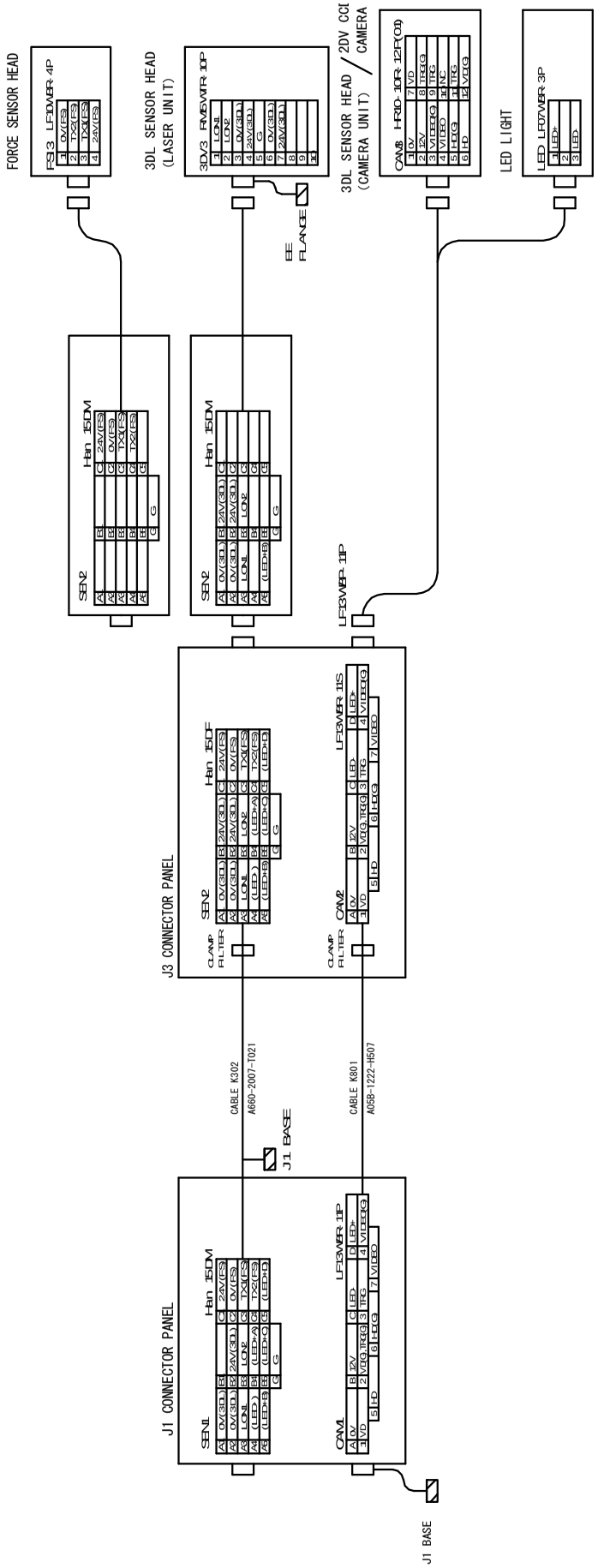


Fig. A (c) Circuit diagram in the mechanical unit (Example of M-20*i*A)

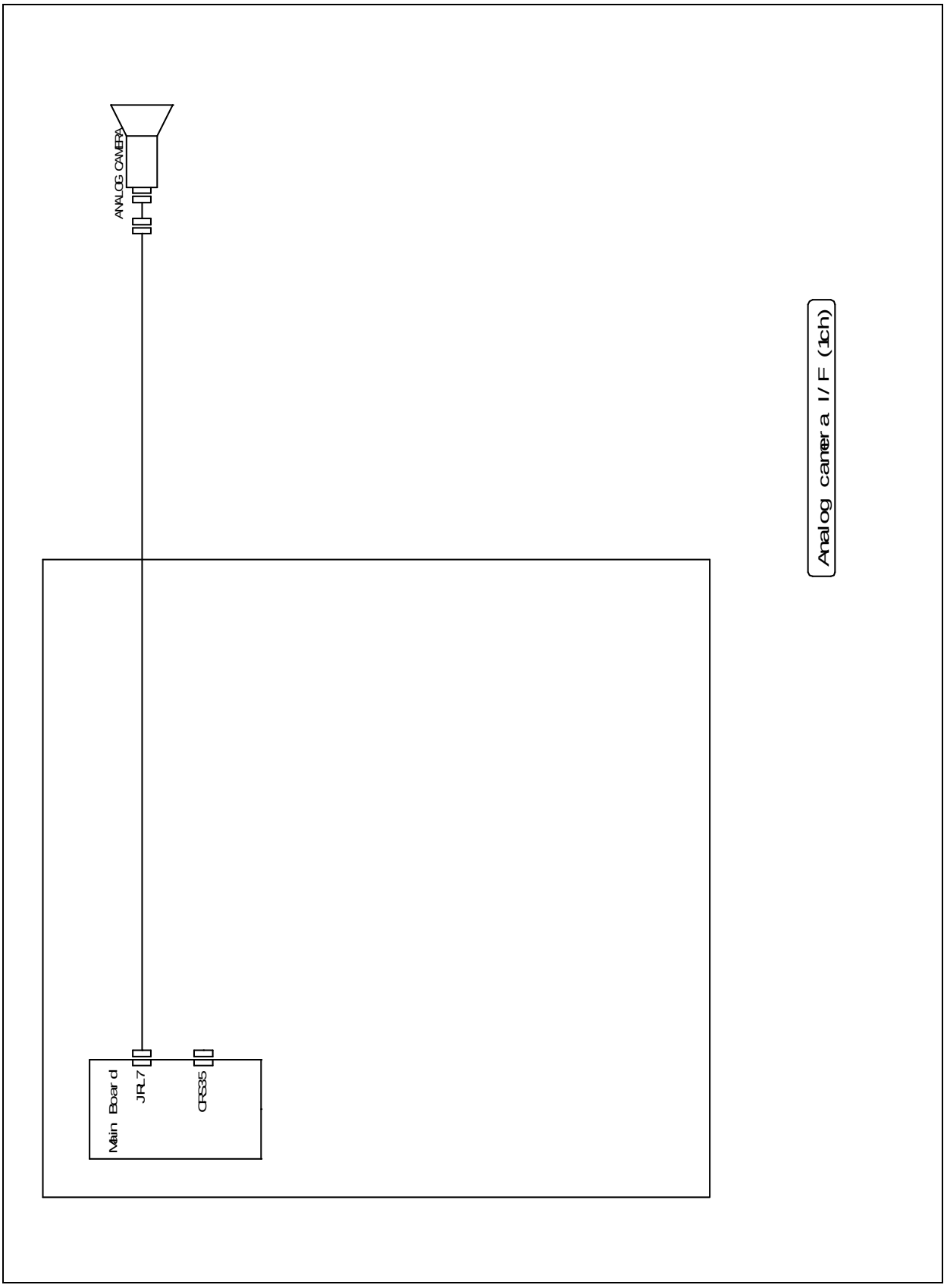


Fig. A (d) Circuit diagram in the controller (*i*RVision, analog camera without multiplexer)

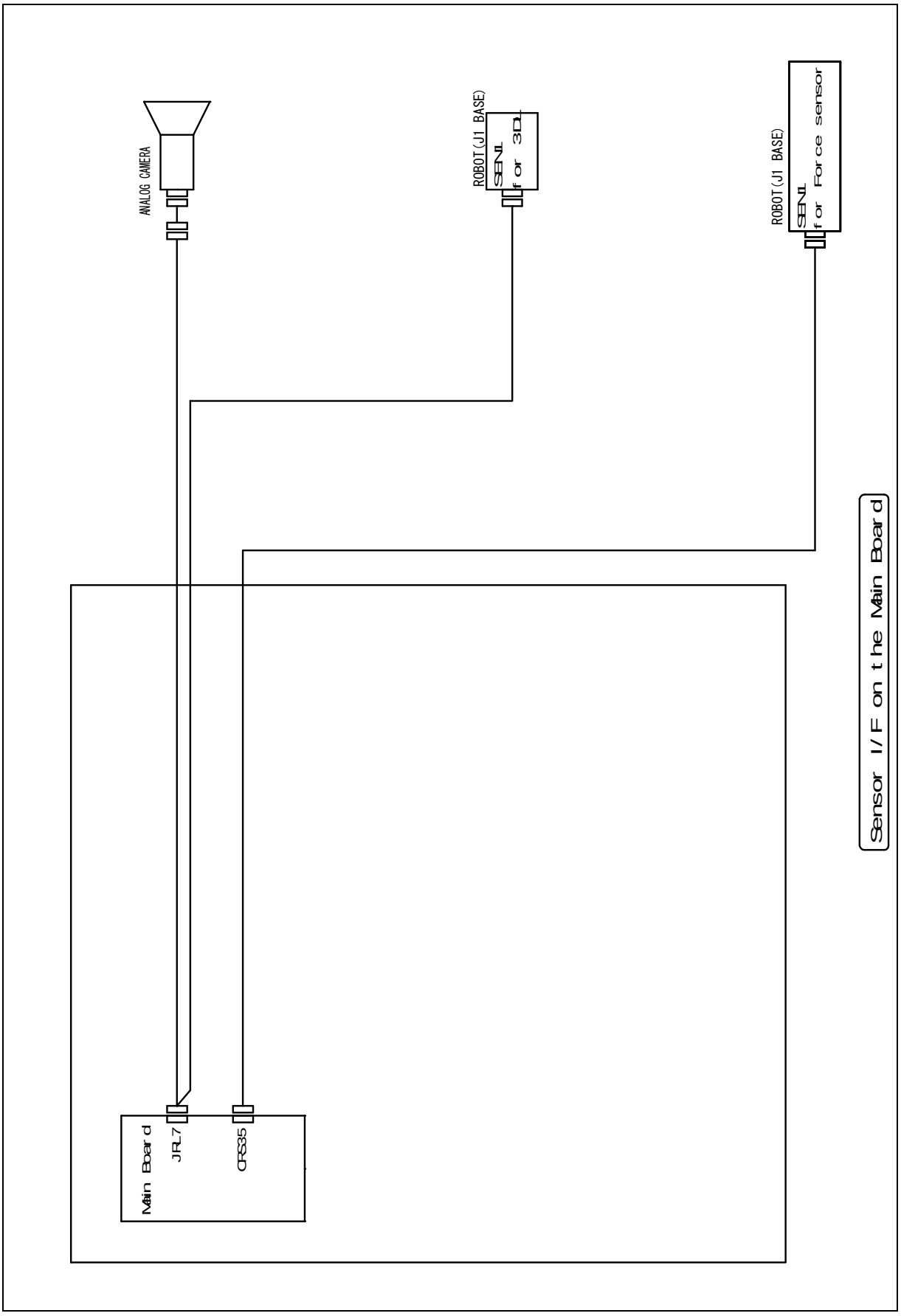


Fig. A (e) Circuit diagram in the controller (*i*RVision, analog camera, 3D Laser Sensor and Force Sensor)

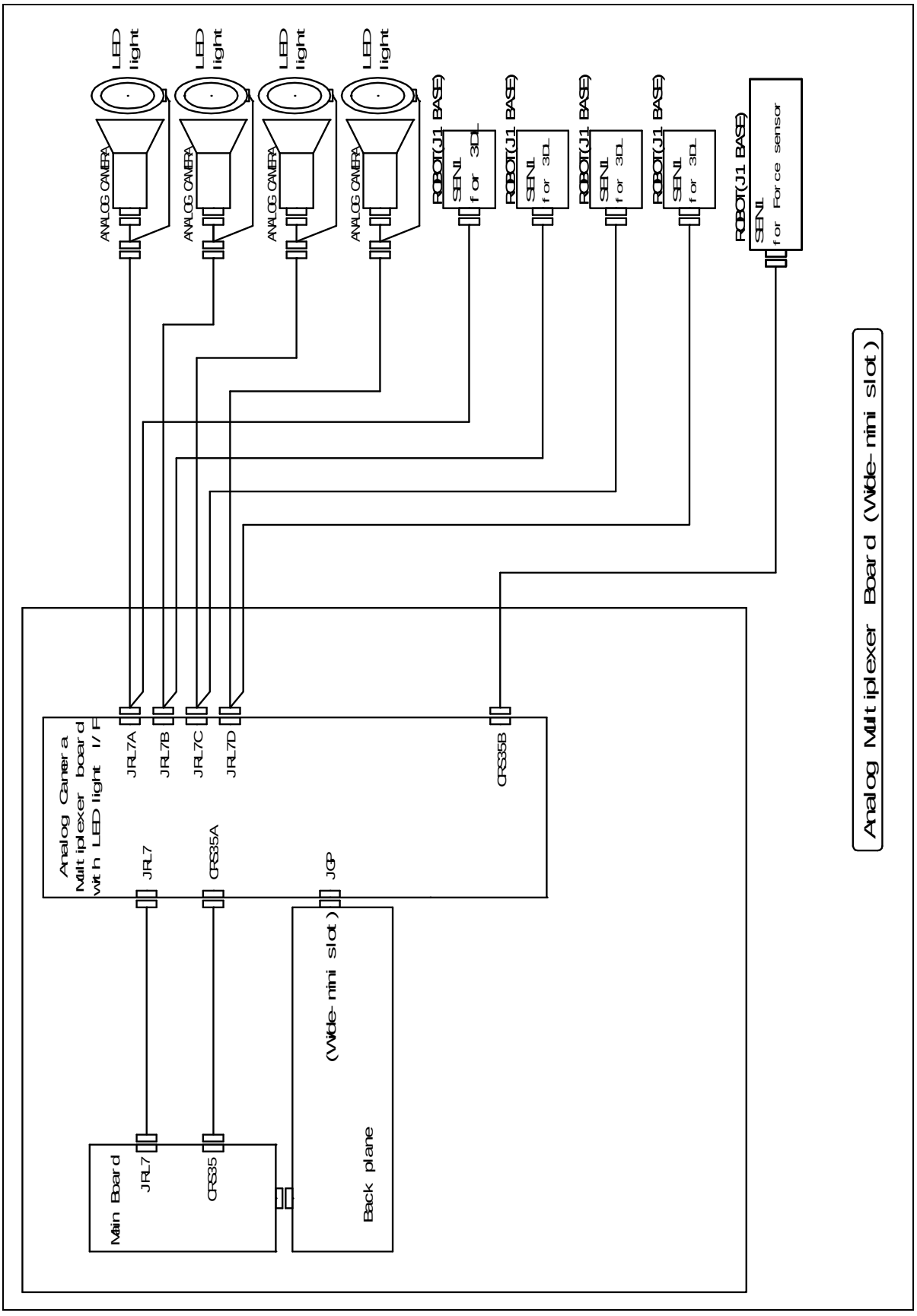


Fig. A (f) Circuit diagram in the controller
(*i*RVision, analog camera (with LED light), 3D Laser Vision Sensor, Force Sensor and analog multiplexer)

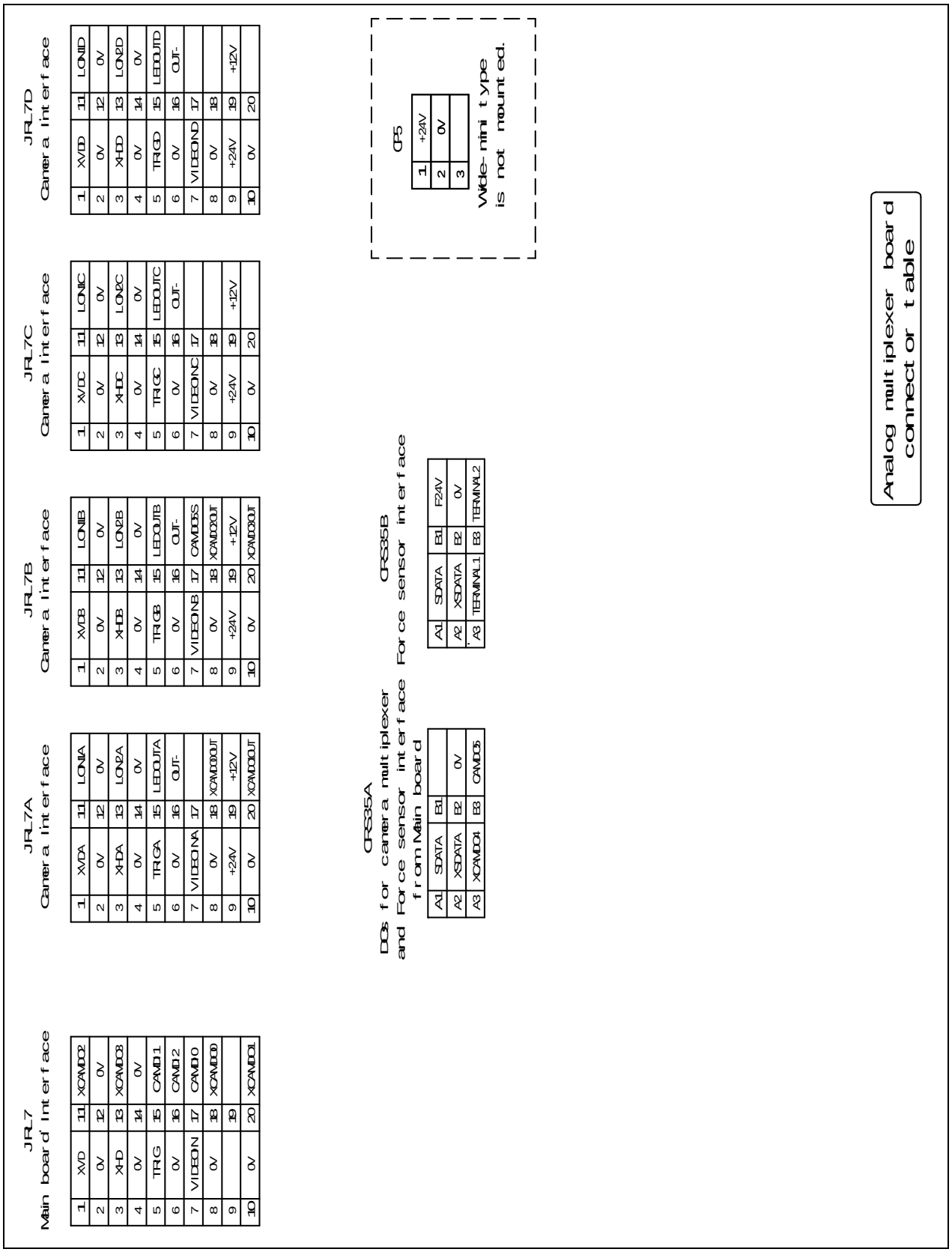


Fig. A (g) Circuit diagram in the controller
(*i*RVision connector table of analog multiplexer)

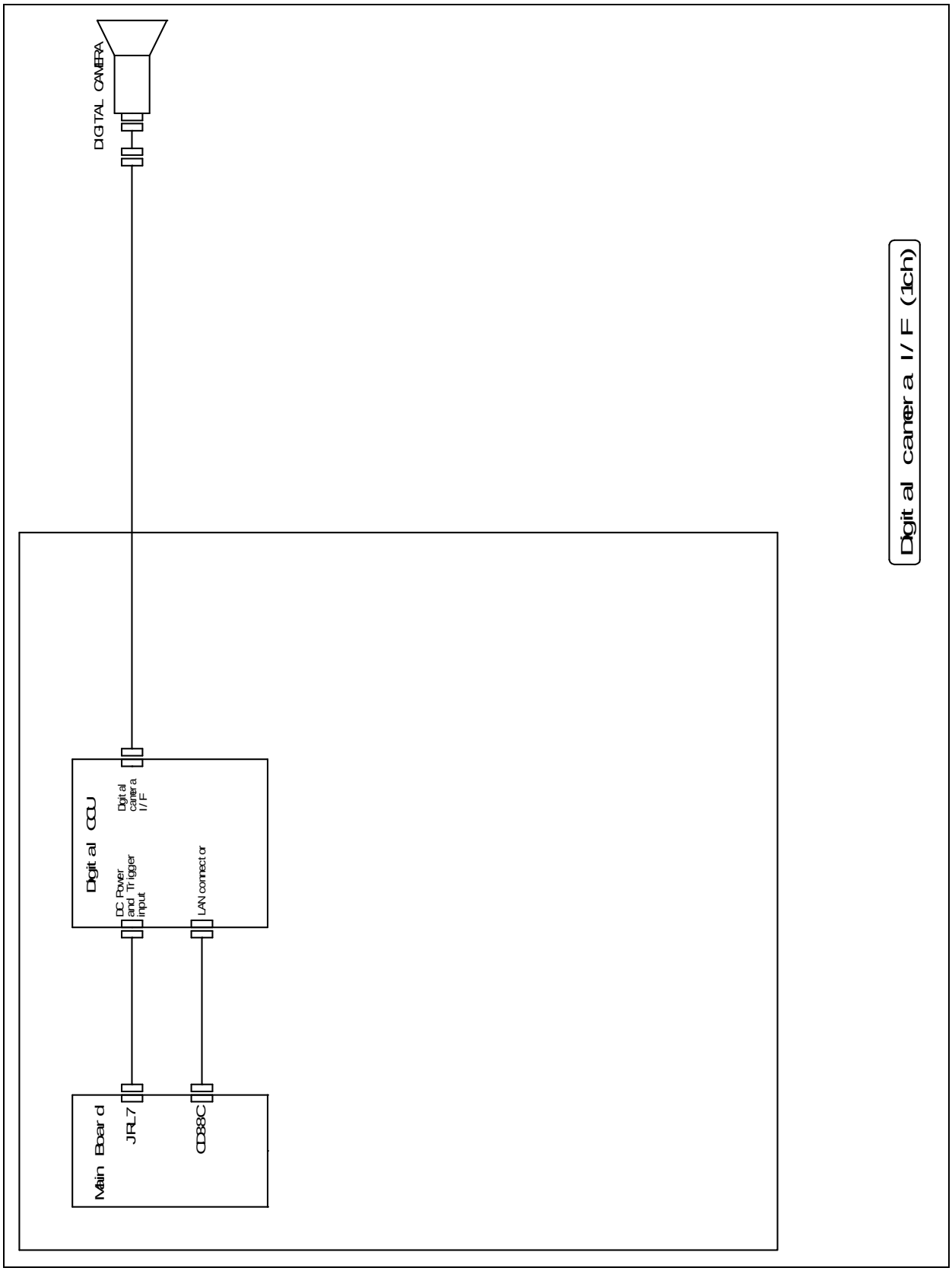


Fig. A (h) Circuit diagram in the controller
(*i*RVision, digital camera without digital multiplexer)

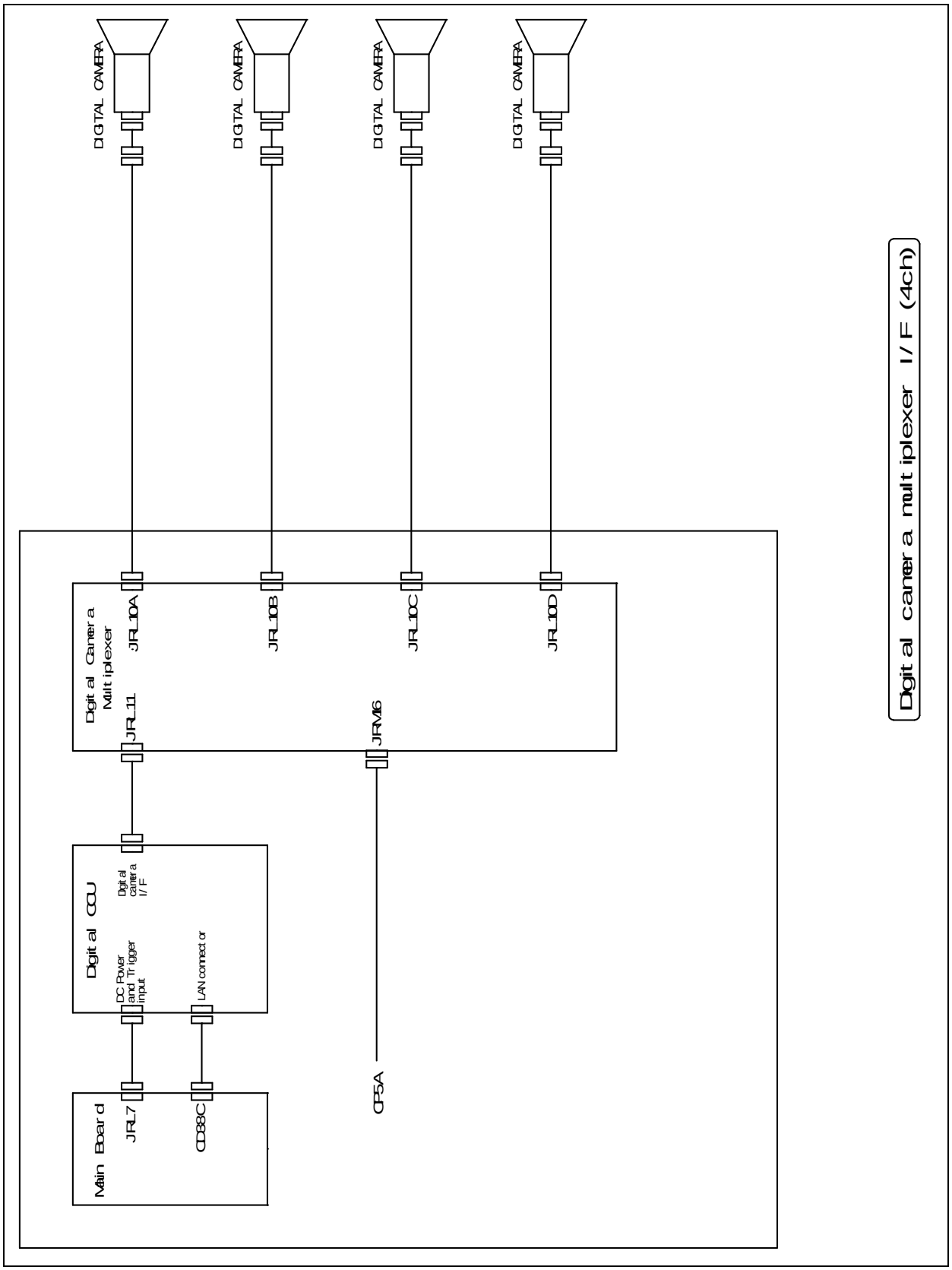


Fig. A (i) Circuit diagram in the controller (*i*RVision, digital camera with digital multiplexer)

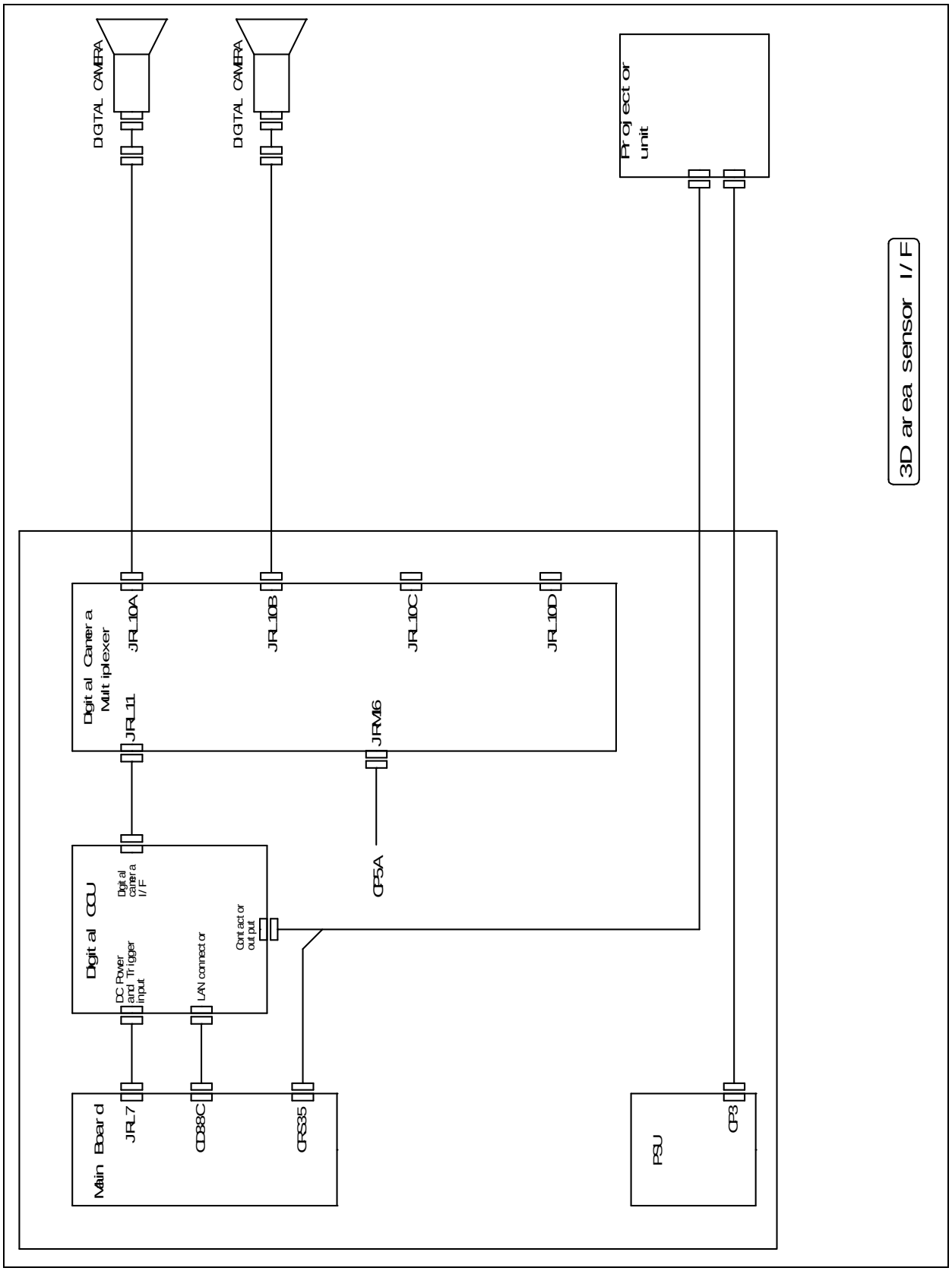


Fig. A (j) Circuit diagram in the controller (*i*RVision, connection to 3D Area Sensor)

B STRENGTH OF BOLT AND BOLT TORQUE LIST

NOTE

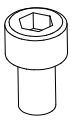
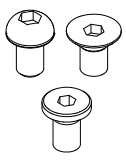
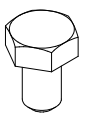
When applying LOCTITE to the important bolt tightening points, make sure that it is applied to the entire longitudinal portion in the engaging section of the female threads. If it is applied to the male threads, the bolts may be loosened because sufficient adhesion cannot be obtained. Remove the dust within the bolts and taps and wipe oil off the engaging section. Make sure that there is no solvent in the taps. Be sure to wipe the excess LOCTITE after tightening bolt.

Use bolt which strengths are below.
But if it is specified in text, obey it.
Hexagon socket head bolt made by steel
Size is M22 or less : Tensile strength 1200N/mm^2 or more
Size is M24 or more : Tensile strength 1000N/mm^2 or more
All size of bolt of the plating : Tensile strength 1000N/mm^2 or more

Hexagon bolt, stainless bolt, special shape bolt (button bolt, low-head bolt, flush bolt .etc)
Tensile strength 400N/mm^2 or more

If no tightening torque is specified for a bolt, tighten it according to this table.

Recommended bolt tightening torques **Unit: Nm**

Nominal diameter	Hexagon socket head bolt (Steel)		Hexagon socket head bolt (stainless)		Hexagon socket head button bolt Hexagon socket head flush bolt Low-head bolt (steel)		Hexagon bolt (steel)	
	Tightening torque		Tightening torque		Tightening torque		Tightening torque	
	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit
M3	1.8	1.3	0.76	0.53	———	———	———	———
M4	4.0	2.8	1.8	1.3	1.8	1.3	1.7	1.2
M5	7.9	5.6	3.4	2.5	4.0	2.8	3.2	2.3
M6	14	9.6	5.8	4.1	7.9	5.6	5.5	3.8
M8	32	23	14	9.8	14	9.6	13	9.3
M10	66	46	27	19	32	23	26	19
M12	110	78	48	33	———	———	45	31
(M14)	180	130	76	53	———	———	73	51
M16	270	190	120	82	———	———	98	69
(M18)	380	260	160	110	———	———	140	96
M20	530	370	230	160	———	———	190	130
(M22)	730	510	———	———	———	———	———	———
M24	930	650	———	———	———	———	———	———
(M27)	1400	960	———	———	———	———	———	———
M30	1800	1300	———	———	———	———	———	———
M36	3200	2300	———	———	———	———	———	———
								

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REVISION RECORD

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B-83434EN/01