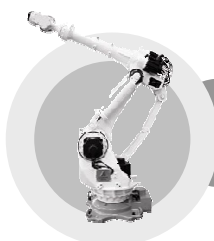




WARNING



**THE INSTALLATION SHALL BE
MADE BY QUALIFIED INSTALLATION
PERSONNEL AND SHOULD
CONFORM TO ALL NATIONAL AND
LOCAL CODES**



Manipulator Maintenance Manual

HX130

HX165 / HX165S

HX200 / HX200S



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Safety



1. Safety

HX130/HX165/HX165S/HX200/HX200S

1.1. Introduction

The main purpose of this chapter is to describe the safety precautions for users and operators who repair and manipulate the industrial robot.

This manual describes safety precautions for robot manipulator and controller, in comply with the requirement of ANSI/RIA R15.06-1999, Standard for Safety, Industrial Robots, and qualified with safety regulations. The technical description and installation method of robot system is presented in detail at the specifications regarding installation of robot manipulator and controller.

Every operator, who installs, replaces, adjusts, manipulates, maintains, and repairs, must read thoroughly and fully understand the manipulation and maintenance manual, in particular, the special attention must be paid to the WARNING symbol, the most important marking related to the safety.

Installation, replacement, adjustment, manipulation, maintenance, and repair of robot system must be performed by the personnel who was duly trained for these purposes, following the indicated operating procedure.

This company is planning and carrying out the relevant training such as maintenance, repair, and manipulation for the above operations, so robot users make sure that robot operators should get the relevant training. And make sure that the robot handling work should be carried out only by the operators who completed this training course.

The Users of HX industrial robots have a responsibility under the safety relevant regulations valid in the country where the robot is installed, and a responsibility to properly design, install, and operate the safety devices to protect workers.

The dangerous zone of robot system, that is the working range in which the robot, tool, and peripheral equipment are operated, must be safeguarded to prevent workers or objects from entering the zone. If a person or object should nevertheless enters the dangerous zone, make sure that the robot system is immediately shut down by emergency stop system. The operators of robot system have a responsibility to take all necessary steps to make correct installation, examination and operation of the relevant safety devices.

This manual is provided for the utilization of HX Series Manipulator models and Hi4a controller. Valid application and invalid environment of HX Series robots are as follows.

Application

It is applied to the 6-axis industrial robot used by installing on the surface of wall or plane (axes addable). It is also appropriate for controlling operation in the dotted section or consecutive section.

Major application is

- Spot welding
- Handling
- Assembly
- Application such as Sealing
- MIG/MAG welding
- Palletizing
- Grinding

For the other use than the above emergency application, make a contact with our company to consult on the robot use and possible applications.

Invalid environment

Our robot must not be used in a highly explosive environment and the areas contaminated by oil, flammable materials or chemical materials. (Prohibited to be installed and manipulated.)

1.2. Relevant Safety Regulations

The robot is designed as per ISO 10218. Jan. 1992, safety standards for industrial robots, and furthermore in comply with ANSI/RIA 15.06-1999 regulations.

1.3. Safety Training

All the personnel who intend to teach, operate or inspect the robot must be trained in an approved robotic operation and safety training course before start-up. The safety training course includes the following details:




- Purpose and functions of safety devices
- Safety procedure to handle the robot
- Performance of robot or the robot system and possible hazards
- Tasks associated with any specific robot applications
- Safety concepts, etc.

1.4. Safety Related Nameplate

1.4.1. Safety Marking

For the purpose of effective safety instructions, the following safety symbols are used in this manual.

Table 1-1 Safety marking

Symbols		Descriptions
Warning		Indicate a potentially hazardous situation which, if not avoided, could result in death or serious injury to personnel and damage to equipment. The special attention must be paid to the operation and handling.
Mandatory		Indicate the compulsory measures that should be performed.
Prohibited		Indicate the prohibited actions and/or operations that should not be performed.

1.4.2. Safety Nameplate

Identification plates, warning label and safety symbols are attached to the robot and to the inside and outside of control panel. The designation labels and cable Mark for wire harness between the robot and control panel, and the cables inside/outside of control panel are provided.

All of these plates, labels, symbols and marks constitute safety-relevant parts of the robot and the control panel. They must remain attached to the robot manipulator and control panel at their clearly visible positions all the time for the safety and their full performance.

The painted markings on the floor and signs indicating dangerous zones must be clearly distinguished in form, color, and style from other markings on the machine near the robot system or inside the plant facilities where the robot system is installed.



It is forbidden to remove, cover, or paint over by way of spoiling the clearly visible identification plates, warning labels, safety symbols, designation labels and cable marks.

1.5. Definition of Safety Functions

Emergency Stop Function - IEC 204-1,10,7

There is one emergency stop button on the controller and teaching pendant respectively. If necessary, additional emergency buttons should be able to connected to the robot's safety chain circuit. The emergency stop function, which overrides all other robot controls, stops all moving parts by disconnecting power supply, and removes drive power to prevent the use of other dangerous functions controlled by the robot.

Safety Stop Function - ISO 10218(EN 775),6.4.3

When a safety stop circuit is provided, each robot must be delivered with the necessary connections for the safeguards and interlocks associated with this circuit. The robot should have a number of electrical input signals which can be used to connect external safety devices, such as safety gates, safety pads, and safety lamps. These signals allow the robot's safety functions to be activated by all equipment, including peripheral equipment and the robot itself.

Speed Limitation Function - ISO 10218(EN 775),3.2.17

In a manual mode, the speed of robot is strictly limited to 250 mm per second as maximum. The speed limitation applies not only to the TCT(Tool Coordinate Time), but to all parts of manual mode robot. The speed of equipment mounted on the robot should be possibly monitored.

Restricting working Envelope - ANSI/RIA R15.06-1999

The working envelope of robot axes should be restricted using software limits. Axis 1,2, and 3 can also be restricted by means of mechanical stopper.

Operation Mode Selection - ANSI/RIA R15.06-1999

The robot must be operated either manually or automatically. In a manual mode, the robot must be operated only by using the teach pendant.

1.6. Installation

! 1.6.1. Safety Fence

Install safety fence against the possible collision between the robot and workers, so that no worker may approach the robot. When operators or other personnel enter the robot's working envelope by accident, it may cause an accident. Install the safety fence to stop the robot when one, who intends to replace for TIP DRESSING or TIP replacement, or to inspect welding equipment, opens the fence gate and approaches the equipment during operation.

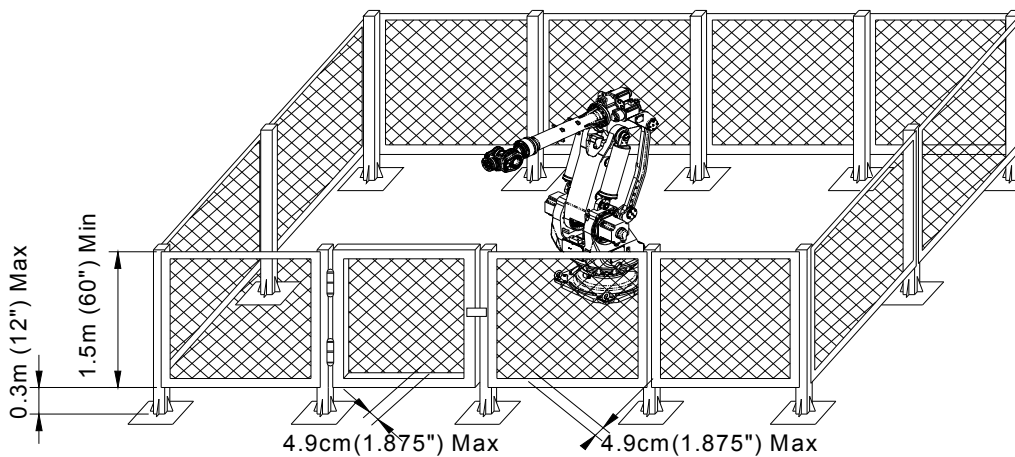


Fig 1.1 Recommended Size for Fence and Gate Hole (Square Gate)

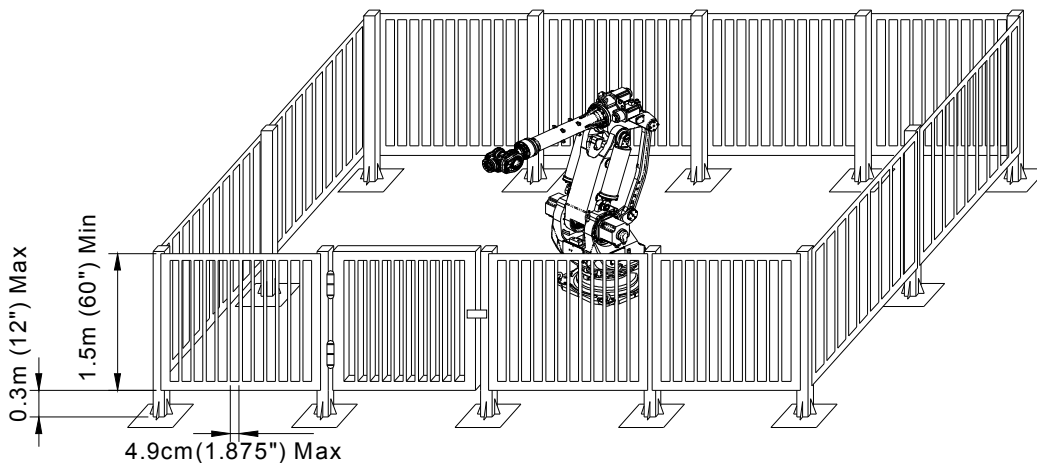


Fig 1.2 Recommended Size for Fence and Gate Hole (Slot Gate)

- (1) Install the safety fence to cover the robot's working envelope and to secure enough space for teaching and maintenance working. The safety fence should also be firmly installed so that it is hardly accessible and removable.
- (2) The safety fence should be a fixed type in principle, using harmless materials that do not have any broken surface or projecting part.
- (3) Install the safety fence with an entrance gate, and register the safety plug at the gate so that it does not open unless pulling the plug out. Interlock the robot to be MOTORS OFF when the safety plug is pulled out., or wire the robot to be MOTORS OFF when the safety fence is open. (Refer to "11. Various Signal Connections", Hi4a Controller Manual)
- (4) When intending to operate the robot with the safety plug pulled out, wire the robot as a low-speed play mode. (Refer to "11. Various Signal Connections", Hi4a Controller Manual)
- (5) For immediate emergency stop, install emergency stop button within operator's easily accessible distance.
- (6) If the safety fence is not installed, install other devices substituting for the safety plug in the whole place within the robot's working envelope, such as photoelectric switch and mat switch. These devices may stop the robot automatically when a person enters the working envelope.
- (7) The robot's working envelope(dangerous zone) should be distinguished from other zones by painting its floor.

1.6.2. Placement of Robot & Peripheral Equipment

- (1) Make sure that the power supply is off before operating, when connecting the primary power of controller or peripheral equipment. There is a possible danger of electric shock because the high voltage such as 220V and 440V is used as its primary power.
- (2) Post a sign [No enter during operation] up the safety fence gate, and inform the operators of its purport.

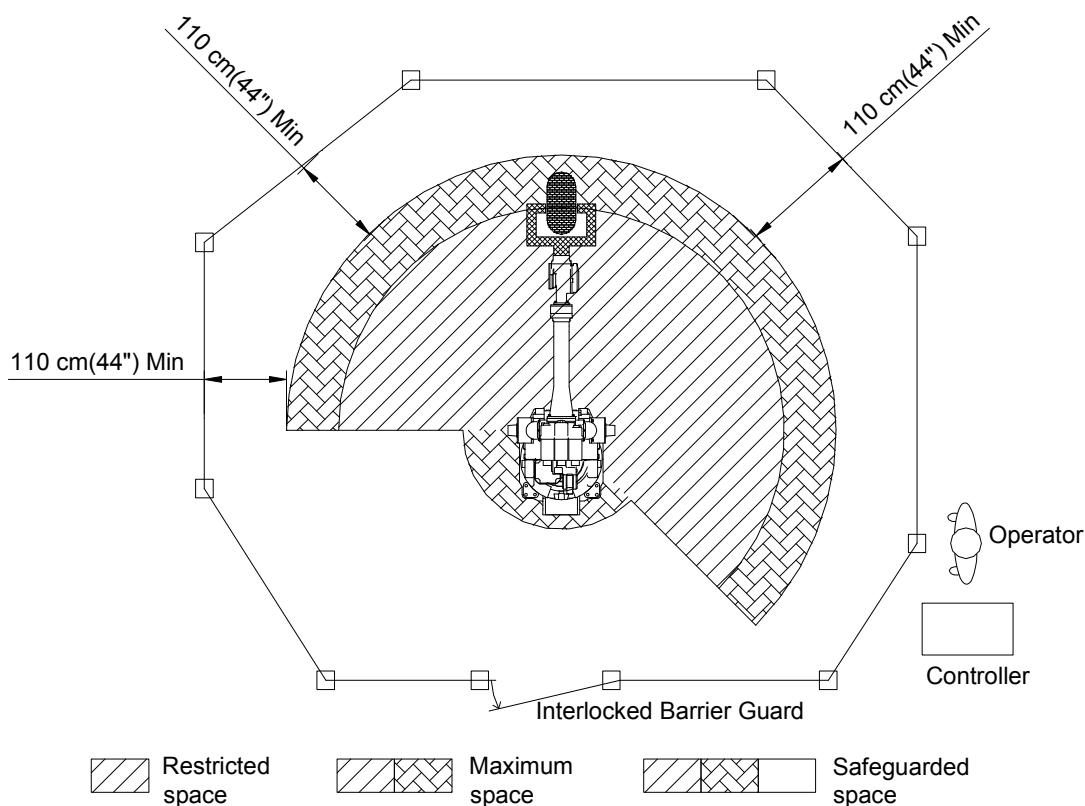


Fig 1.3 Placement of Peripheral Equipment and Operator

- (3) Arrange such devices as controller, interlock panel, and other manipulation panels to be handled outside of the safety fence.
- (4) When installing operation stand, install the emergency stop button on the stand. Make sure that the stand stops in an emergency wherever the robot is handled.
- (5) Make sure that the robot manipulator and the wiring and piping of controller, interlock panel, and timer should not be placed in the way of operator's working range so that they would not be directly stepped on by FORK and LIFT. There is a possible danger of accident if the workers are affected by electricity or the wiring is down.
- (6) Place the controller, interlock panel, and handling stand within the sight of robotic performance. It may cause a serious accident to operate the robot while the operator is working, or the robot is malfunctioning in an invisible sight.

- (7) Restrict the robot's working envelope by using soft limits and mechanical stopper if the necessary working envelope is narrower than the holding workable envelope. It is possible to stop the robot in advance when it moves beyond its normal working envelope due to an abnormal condition. (Refer to the 『Robot Manipulator Maintenance Manual』 .)
- (8) Welding spatters directly on the operator or around him may cause burning or fire. Install such devices as a glare shield or a cover in the full sight of robot's working envelope.
- (9) Make sure that the device indicating the robot's running condition whether automatic or manual mode must be noticeable even in the far distance. In the case of automatic start-up, warning with a buzzer or warning lamp is also valid.
- (10) Make sure that there is no projecting part in the robot's peripheral equipment. Cover it, if necessary. It usually may cause an accident if the operator comes in touch with it. And it may lead a serious accident if the operator is astonished at the sudden movement of robot, and conducts it.
- (11) Don't make the system designed to allow the workers to carry the Work in and out using their hands through the safety fence. It could be a cause of accident associated with compressing or amputating.



1.6.3. Installing the Robot

Install the robot as per the planning and layout which has been previously reviewed and studied for its optimized performance and functionality. In case of poor conditions for robot installation, the serious problems can take place, including error of relative position between robot and workpiece during operation, bad performance quality of robot caused by vibration, shortening lifetime, and cause of serious accidents. Thus, pay attention to the following precautions when installing the robot.

General Safety Precautions

- (1) Design and install the robot system properly in compliance with laws, regulations, and safety requirements valid in the country where the robot system is installed.
- (2) All the workers for the robot system must have the complete knowledge on the information specified in the application and supplementary manual, and proficiently operate and handle the industrial robot.
- (3) Installation workers of robot must follow the safety instructions and apply them to the installation when they face any safety problems.
- (4) System provider must ensure that all the circuits utilizing safety functions perfectly perform in a safe way.
- (5) Install main power supply to be disconnected from outside of the robot's working envelope.
- (6) System provider must ensure that all the circuits utilizing emergency stop function perfectly perform in a safe way.
- (7) For the immediate emergency stop, install emergency stop button within the accessible distance for the operator.

Technical Safety Precautions

- (1) Eliminate any interference with peripheral equipment considering the dimension and working envelope.
- (2) Avoid such places for installing which is directly exposed to the sun, extremely humid, contaminated by oil or chemicals, and containing a large amount of metal powder and explosive gas.
- (3) Install at the ambient temperature ranged 0~45℃.
- (4) Secure sufficient space for the easier disassembly and maintenance.
- (5) Install safety fence with a gate, and prohibit any person from entering the robot's working envelope.
- (6) Remove any obstacles out of the robot's working envelope.
- (7) Take a special measure, considering thermodynamics of controller, if the robot is installed near the heating elements or places exposed directly to the sun.
- (8) Take a special measure if the robot is installed in a place of abundant dust such as metal powder in the air.
- (9) Install the robot not to transmit welding electric current. (In other word, insulate SPOT GUN with/from the robot's wrist.)
- (10) Grounding is very critical in preventing electric shock and malfunction caused by noise, and thus install as following instructions.
 - ① Install an exclusive grounding terminal using class 3 or higher. (For the input voltage of 400V or higher, use special class 3 or higher.)
 - ② Connect grounding line into the grounding bus-bar inside of the control panel.
 - ③ In case of direct grounding on the floor by anchoring, two-point grounding both by robot manipulator and by controller can produce a "ground loop" and contrariwise cause abnormal operation. In this case, connect the grounding line to the base of robot manipulator and disconnect the second grounding point to the controller. If the robot vibrates even after stopping, double-check the grounding status because the possible main causes could be an incomplete grounding or "ground loop".
 - ④ In the use of internal transgun(GUN), there is a possible danger of dropping because the primary power cable is directly connected to the spot gun. In this case, directly connect the grounding line to the base of robot manipulator in order to prevent any electric shock and protect the control panel, but do not connect it to the controller.

1.6.4. Space for Robot Installation

Install robot after securing sufficient space for maintaining the robot manipulator, Hi4a controller, and other peripheral equipment. Install the robot manipulator and controller, securing space for installation as per the guideline as described in the figure below. Install Hi4a controller outside of the safety fence in order to monitor the robot manipulator and to operate in a safe way.

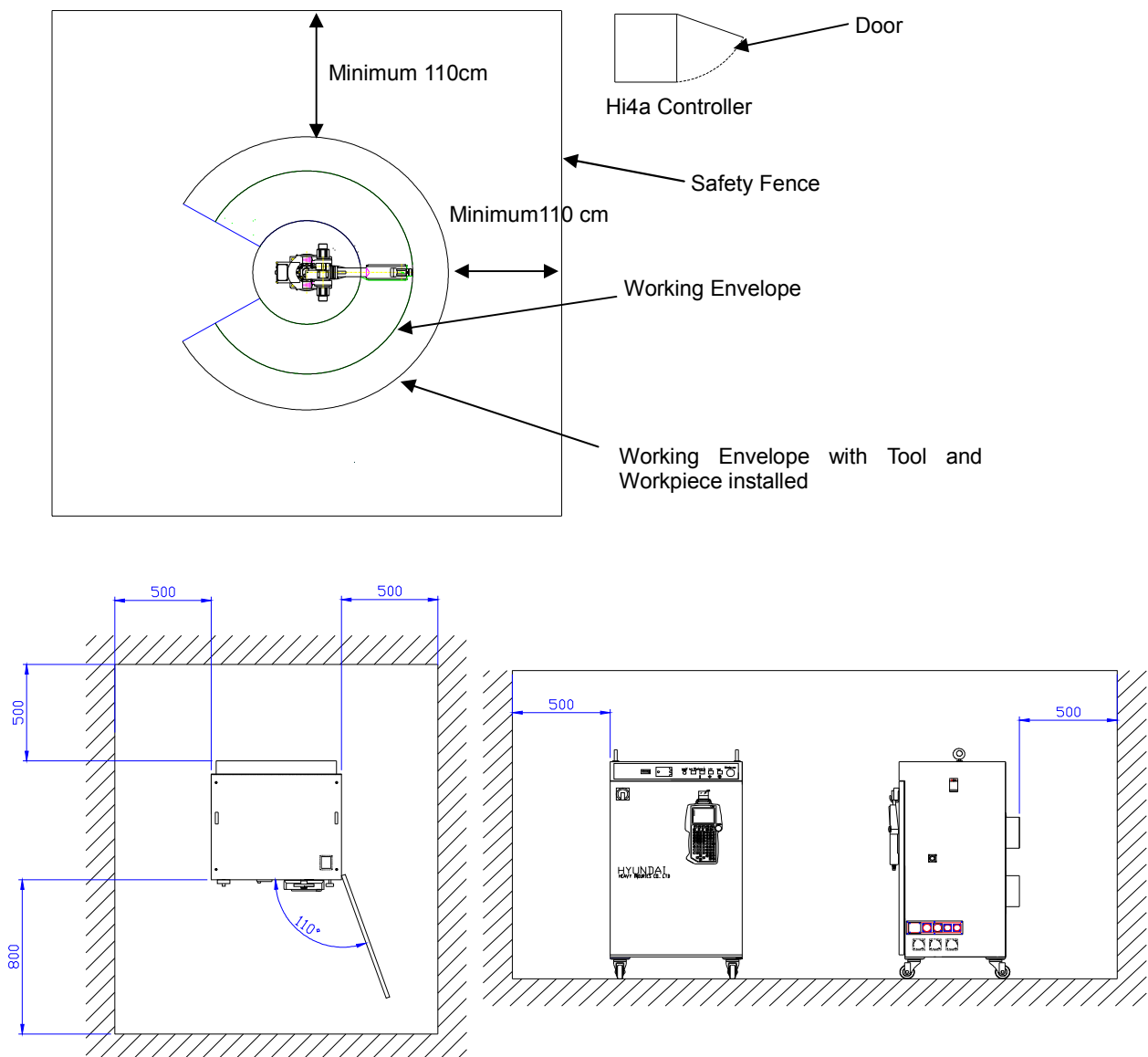


Fig 1.4 Space for robot installation


When installing, be sure to make it easier to perform the maintenance when opening the Hi4a Controller door. Secure the available space. The controller power in the above Figure could change depending on the kind of controller.

1.7. Safety Operation for Robot Handling

Follow the safety instructions to prevent any accidents. Don't modify nor ignore safety devices or circuits at any time, and be careful of electric shock.

All the normal operations in an automatic mode must be performed outside of the safety fence. Check the robot's working envelope if anyone is inside before operating.

1.7.1. Safety Precautions for Robot Handling

- (1) Do not handle the robot other than such personnel as operators handling the robot and other possible operators and supervisors who were designated as whom duly trained in an approved robotic training course and become familiar enough with the proper operation of the safety and robotic functions.
- (2) Be sure to wear helmets, goggles, and safety shoes.
- (3) Perform the work in pairs. One person must be ready to press the emergency stop button in an emergency while the other must perform his work quickly but carefully within the robot's working envelope. Always check the escape route before working.
- (4) Make sure that there is no one in the working envelope when the power source is on.
- (5) Operations such as teaching must be performed outside of the robot's working envelope. However, if the operation is performed within the working envelope after stopping the robot, enter the envelope with safety plug or key switch for converting to automatic mode. Make sure that other operators do not change it into automatic mode by accident. Also, pay close attention to the specific direction of robotic movement in case of abnormal operation and malfunction.
- (6) Supervisors should follow the instructions below.
 - ① Be located at a place where you could take an entire view of robot, and commit yourself to monitoring.
 - ② Press the emergency stop button immediately when abnormality is found.
 - ③ Anyone is forbidden to be near the operating area other than those who are engaged in the operation.
- (7) In a manual mode, the speed of teaching is limited to 250mm/sec
- (8) In teaching, post a sign [Under Teaching].
- (9) Operators must pull the safety plug out, and enter the safety fence with the plug.
- (10) Do not use any devices causing noise in and around the teaching area.
- (11) Handle the teaching pendant button, while checking the teaching point with your naked eyes, and do not handle it just relying on your sense.
-  (12) Do not work with your back against the robot, and always pay attention to the robot's movement.
- (13) In teaching, check and examine carefully under your feet. In particular, in high teaching for more than 2M, secure a safe zone on which you may step before teaching.



(14) Instructions for any abnormal operations.

- ① Press immediately the emergency stop button when any abnormal operations are found.
- ② Be sure to check if the relevant equipment is stopped when checking the abnormality in an emergency stop.
- ③ In case that the robot stops automatically due to power failure, investigate possible causes and take actions after confirming that the robot completely stops.
- ④ In case of malfunction of emergency stop devices, immediately disconnect the main power and investigate possible causes to take necessary actions.
- ⑤ Investigation of the failure must be conducted only by a designated person. For the re-operation after emergency stop, operators must clarify the cause of failure and take necessary actions, and then operate the robot again following the proper procedure.

(15) Write out the operating rules proper to working details and installing location regarding the operation and handling method for the robot, and the necessary actions for robot's any failure. In addition, it is recommended to operate the robot in accordance with the operating rules.

(16) Instructions when the robot stops

Make sure not to approach the robot even when it seems to be stopped. Most accidents occur from a sudden movement of robot which seemed to be stopped when one approaches it. The conditions that the robot stops is as follows.

Table 1-2 State of robot stop

No.	State of Robot	Drive Power	Access
1	Pause (Minor failure, Pause switch)	ON	X
2	Emergency stop (Major failure, Emergency stop switch, Safety gate)	OFF	O
3	Input signal standby of peripheral equipment (START INTERLOCK)	ON	X
4	Playback Completion	ON	X
5	Standby	ON	X

Even in the accessible state of robot, be watchful against any possible sudden movement of robot. Make sure to avoid approaching the robot without precautions for emergency under all circumstances.

- **Though the access during a pause is shown in the table as 「X」, allow the access to robot with the same precautions as teaching work if the entrance is open to take actions for minor failures(i.e. malfunction caused by failure in arc, nozzle contact and weldment detection).**

(17) Clean up any split oil, tools, and impurities in the safety fence after completing robotic operation. Accidents such as conduction may occur in the working envelope contaminated by oil, or scattered tools on its floor. Make a habit of organizing and cleaning things up.

1.7.2. Safety Precautions for Operating Test



In case of operating test, errors in design or teaching and inferiority in manufacturing are possibly seen in the entire system such as teaching program, jig, and sequence. Thus, be more careful and safe in case of operating test. Accidents may occur by these combined causes.

- (1) Before handling, check the stop buttons and signal functions to stop the robot such as emergency stop button or stop button. And then, check the abnormality - detective movements. Above all, it is the most critical to check all the stop signals. It would be the most important to stop the robot when any possible accidents are predicted.
- (2) In case of operating test, start the robot at low speed (approximately 20%~30%) in the variable speed function, and repeat it more than one cycle to check the movements. If any errors are found, immediately correct them. After then, increase in speed (50% → 75% → 100%) gradually, and repeat more than one cycle respectively to check the movements. Operating at high speed from the very beginning may cause a serious accident.
- (3) In case of operating test, it is hard to predict what problems would happen. Do not enter the safety fence during operating test. Unexpected accidents are likely to occur because of its low reliability.

1.7.3. Safety Precautions for Automatic Operation

- (1) While posting a sign [Do Not Enter During Operation] up the safety fence gate, ask the operators not to enter during operation. If the robot stops, you may enter the safety fence under your full understanding of the situation.



- (2) Be sure to check if any operators are inside of the safety fence when starting the automatic operation. Operating without checking the presence of operators may cause a personal injury.
 - (3) Before starting the automatic operation, check and confirm that the program number, step number, mode, and starting selection are in the possible state for automatic operation. If starting with the other programs or steps selected, the robot could move in an unpredicted way, and lead to an accident.
 - (4) Before starting the automatic operation, check if the robot is properly located to get started. Check whether the program number or step number is identical with the location of robot. Even if it's all identical, accidents are still possible to occur due to an abnormal movement when the robot is differently located.
 - (5) Be prepared to immediately press the emergency stop button when starting the automatic operation. Immediately press the emergency stop button in case of robot's unexpected movements or emergency.
 - (6) Be sure to detect any abnormalities by checking the route, condition, or sound of robot movement. Sometimes the robot may be abnormally operated including a sudden break down. However, it will show(give) a certain indication before the break down. Understand the robot's normal condition well in order to catch the symptom in advance.
- 
- (7) When any abnormality is detected from the robot, immediately stop and take proper actions on it. Using the robot before any proper actions taken may cause an interruption of produce as well as serious failure leading to a very serious personal injury.
- 
- (8) When checking the robot's movement after the proper actions taken for the abnormality, do not operate the robot with operators inside of the safety fence. Unexpected accidents are possibly to occur because its low reliability may cause another abnormality.



1.8. Safety Precautions for Access to Safety Fence

Robots are very powerful and heavy even at its low speed. When entering the safety fence, one must observe the relevant safety regulations of its pertinent country.

The operators always must be aware of the unexpected movements of robot. Robots are able to move fast shortly after being stopped. The operators should know that the robot is able to move in a different route, without any notice, by means of external signals. Thus, when trying to stop the robot during teaching or operating test, one should be able to stop the robot with a teaching pendant or control panel.

When entering the working envelope through the safety gate, take the teaching pendant with you so that other people may not operate the robot. Make sure to post up the control panel a sign indicating the state of robot handling.

Read carefully and be aware of the follows when entering the working envelope.

- (1) Do not enter the working envelope other than teaching person.
- (2) Be sure to set the 'handling setting' on teaching pendant to TEACHING LOCK.
- (3) Operation set-up mode of controller must be a manual mode in the control panel.
- (4) Always wear the approved working suite.(Do not wear a loose clothes as you please)
- (5) Do not wear gloves when handling Hi4a controller.
- (6) Do not leave innerwear such as underwear, shirts, or necktie out of the working suite.
- (7) Do not wear personal accessories such as big earrings, rings, or necklaces.
- (8) Make sure to wear safety shoes, helmet, and goggles and if necessary, wear other self-protective outfit such as safety gloves.
- (9) Make sure that the emergency stop circuit is working correctly and in its proper function, turns MOTORS OFF when pressing the emergency stop button in the control panel and teaching pendant before handling the robot.
- (10) Make your posture face-to-face with the robot manipulator when performing your work.
- (11) Follow the predetermined working procedure.
- (12) Be prepared for emergency exit or safe place considering that the robot may unexpectedly rush at you.

1.9. Safety Precautions for Maintenance and Repair

1.9.1. Safety Precautions for Hi4a Controller Maintenance and Repair

- (1) Maintenance and repair of the robot must be performed by the personnel who was duly trained in the special maintenance training course and has a good knowledge of maintenance.
- (2) Perform your work following the maintenance procedures for controller.
- (3) Perform your maintenance and repair in a safe way by securing emergency exit or safe place.
- (4) Before the daily maintenance, repair, or changing parts, be sure to power down. In addition, post a warning sign [Do Not Input Power] up the primary power so that other operators may not input power by accident..
- (5) When changing parts, be sure to use the specified ones.
- (6) Be sure to power down when opening the Hi4a controller door.
- (7) Before performing, wait for three minutes after power down.
- (8) Do not touch the heat sink and regeneration resistor of servo amp because they generate an intense heat.
- (9) After completing maintenance, Be sure to close the door completely after checking if tools or other things are still remained in the Hi4a controller.

1.9.2. Safety Precautions for Robot System & Manipulator Maintenance

- (1) Refer to the safety precautions for Hi4a controller maintenance and repair.
- (2) Perform your maintenance and repair for the robot system and manipulator, following the indicated procedures.
- (3) Be sure to disconnect the primary power of controller. Post the warning sign [Do not input power] up the primary power to prevent other workers from connecting the power.
- (4) Make sure that the Arm is fixed and immovable before maintenance and repair since dropping or moving of the robot's Arm may cause a danger during maintenance and repair. (Refer to the 『Robot manipulator maintenance manual』 .)



1.9.3. Necessary Actions after Maintenance and Repair

- (1) Check if the cables or parts of controller are properly connected.
- (2) After maintenance is completed, carefully check that no tools are left around or inside of the controller and manipulator. Make sure that the door is firmly closed.
- (3) Do not turn on the power if any problems or critical failures are detected.
- (4) Be sure that there is no one within the working envelope, and that you are in a safe place before turning on the power
- (5) Turn on the main circuit breaker on the control panel.
- (6) Check the current position and status of robot.
- (7) Operate the manipulator at low speed.

1.10. Safety Functions

1.10.1. Operating a Safety Circuit

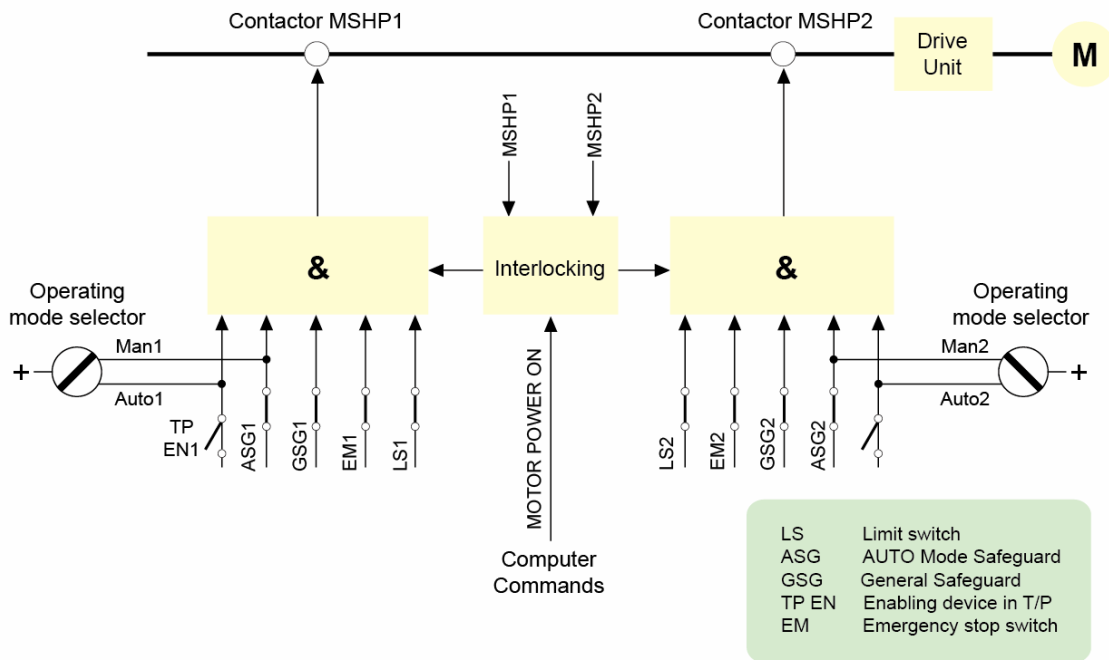


Fig 1.5 Robot's Safety Circuit

The robot's safety system is based on a two-channel safety circuit that is continuously monitored. If an error is detected, the power supply to the motors is disconnected and the motor brake is applied. To return the robot to MOTORS ON mode, the switches of two-channel circuit must be connected. If one of the two-channel circuit switches shorts, the contactor of motor will be disconnected leading to the application of brake, and finally the robot will be stopped. Furthermore, when safety circuit is disconnected, the interrupting call will be sent automatically to the controller to find out the possible reason for the interruption.

The safety control circuit of operation is based on dual safety electric circuit in which the controller and MOTORS ON mode are operated interactively. In order to be in MOTORS ON mode, the safety circuit consisted of several switches must be all connected. MOTORS ON mode indicates that drive power is supplied to the motors. If one of the contactors is disconnected, the robot will always return to MOTORS OFF mode.

MOTORS OFF mode indicates that drive power is removed from the robot's motors and the brakes are applied. The status of the switches is displayed on the teach pendant. (Refer to the I/O monitoring screen of "SERVICE" menu, 『Hi4a controller operation manual』.)

Safety circuit

The emergency stop buttons on the controller panel and on the teaching pendant and external emergency stop buttons are included in the safety circuit of operation. Users may install the safety devices (safety plug, safety stop device for safe place) which are operated in the AUTO mode. In a manual mode, the signals of these safety devices are ignored. You can connect the general safety stop devices that is active in all operating modes. No one can enter the working envelope in an automatic operation mode due to the unconditional operation of the safety devices (door, safety mat, safety plug etc.). These signals are also generated in a manual mode, but the controller will keep the robot operating while ignoring the robot's teaching. In this case, maximum speed of robot is restricted to 250mm/s. Thus, the purpose of this safety stop function is to secure the safe area around the manipulator while one approaches the robot for maintenance and teaching.

When the robot is stopped by a limit switch, it can be moved from the position by jogging it with the operation key on the teaching pendant. (Refer to "constant setting", 『Hi4a controller operation manual』 .)



The safety circuits must never be by-passed, modified or changed in any way.

1.10.2. Emergency stop

An emergency stop should be activated when people or equipment is located at the dangerous area. The emergency stop buttons are located both on the control panel and on the teaching pendant. All safety control devices such as emergency stop buttons on the control panel must be located outside the working envelope and easily accessible at any time.

Status of Emergency stop

When the button is pressed, the robot will operate as follows.
Robot stops immediately in any cases.

- Disconnect the servo system power.
- Motor brake is activated
- Emergency stop message is displayed on screen.

For the emergency stop, the following two methods can operated simultaneously. (Emergency stop for control panel and teach pendant is basic)

(1) Emergency stop for control panel and teach pendant (Basic)

The emergency stop switch is on the control panel and teach pendant of the controller.

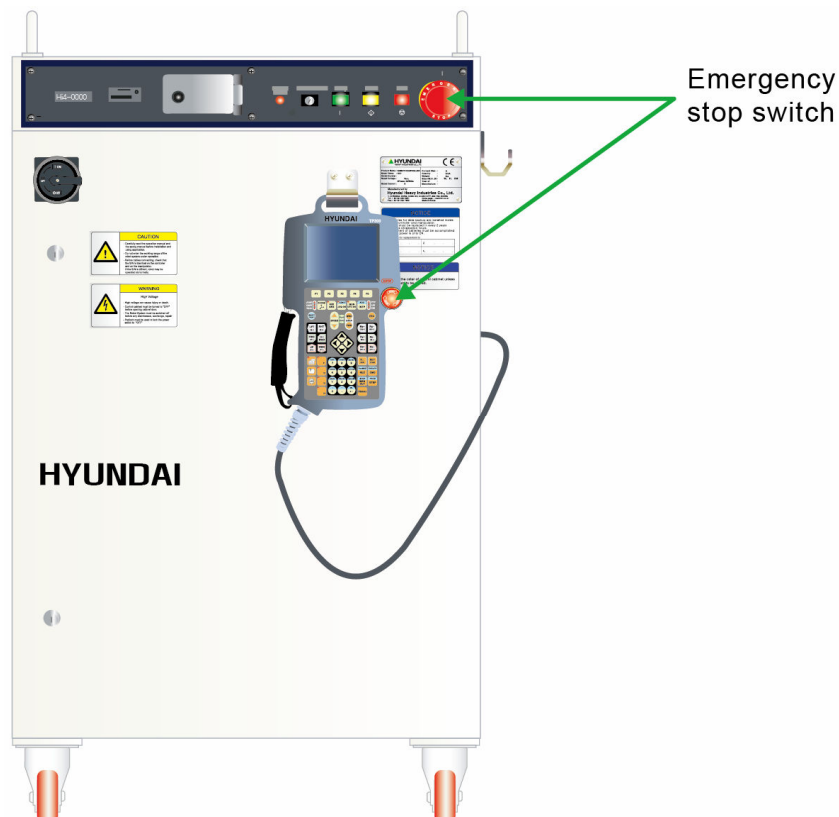


Fig 1.6 Emergency Stop

(2) Emergency stop of external system

External emergency stop device (button etc.) can be connected to the safety electric circuit in accordance with applied standard for the emergency stop circuit.

► Emergency stop connection of the external system

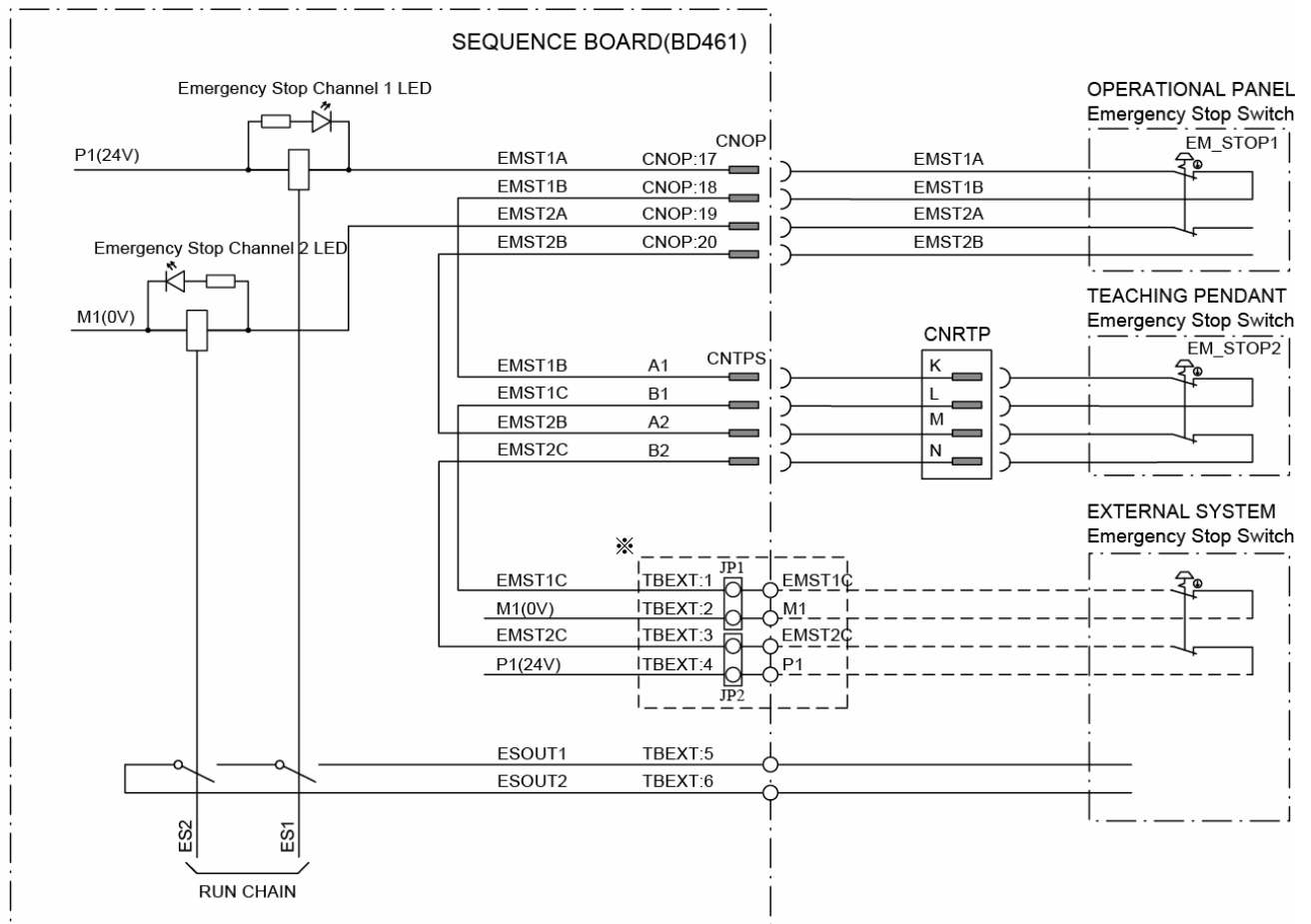


Fig 1.7 Emergency Stop Connection of External System

※ When using the emergency stop of the external system, connect the Terminal No. 1 (ES1) & No. 2 (M1,0V Common) or No. 3 (ES2) & No. 4 (P1,24V Common) of the terminal block of BD461 to the external emergency stop line, and you must open JP1 or JP2.

At this time, the emergency stop must be connected to be Normal On and it must be check for proper operation during test run.

1.10.3. Operating Speed

To teach the robot, the operating mode switch must be in a MANUAL mode. Then the maximum speed of robot is limited to 250mm/s.

1.10.4. Connecting the Safety Devices

External safety devices such as light beams, light curtains, safety plug, and safety mats which can be adapted by the system builder execute interlocking the controller by way of connecting with safety circuit within the controller. These devices are used for safety device during execution of normal program in an automatic mode.

1.10.5. Restricting the working Envelope

When the robot is not necessary to reach certain area for specific applications, working envelope of the robot can be limited to secure the sufficient safety working area. This will reduce the damage or loss in case of robot's collision with external safety devices such as safety fence, etc.. The movement of axes 1,2, and 3 of HX can be limited by means of mechanical stopper or electrical limit switches. In this case, the corresponding software limitation parameters must be also changed. The movement of the three wrist axes, if necessary, can be also limited by the Main CPU. Limitation of working envelope for all the axes could be carried out by the user. The robot is delivered to customer as the status of full working envelope setting.

Manual mode: Maximum speed is 250mm/s.

In a manual mode, by means of worker's selection, workers may enter the safeguard area.

Auto mode: The robot can be operated via remote controller.

All safety devices such as safety door, safety mats, etc. are activated.

No one may enter the safety device area of robot.

1.10.6. Monitoring Function

(1) Motor monitoring function

Motors are protected against overload by means of onboard sensors.

(2) Voltages Monitoring Function

For the protection of, the servo amp module turns off the power switch when the voltage is too low or too high.

1.11. Safety Related to End Effectors

1.11.1. Gripper

- (1) When a gripper is used to grip a workpiece, there should be safety precautions for unexpected dropping of the loaded workpiece.
- (2) When any end effectors or devices are installed on the robot arm, use the required size and piece of bolt, and securely fasten as per the required torque using torque wrench. Do not use the bolt which has rust or dirt on its surface..
- (3) End effector must be designed and manufactured not to exceed the maximum allowable load at the wrist of robot. Even though power or air supply stops, the gripped workpiece must not be dropped from the gripper. In order to remove any risks and problems which may cause personal injury and/or physical damage, the sharp edge and projecting part of end effector must be made dull and smooth.

1.11.2. Tool / Workpiece

- (1) It must be possible to replace tools such as milling cutters in a safe manner. Make sure that safety devices are working correctly until the cutters stop rotating.
- (2) Grippers must be designed to keep in gripping workpiece securely even though a power failure or a control failure takes place. It must be possible to release workpiece from the gripper in a manual mode.

1.11.3. Pneumatic and Hydraulic Systems

- (1) The special safety regulations will apply to pneumatic and hydraulic systems. .
- (2) Since residual energy of pneumatic and hydraulic systems can be still remaining even after the robot stops, particular care and attention must be paid by users. Internal pressure of equipment must be removed whenever starting the repair work for pneumatic and hydraulic systems.

1.12. Liabilities

The robot system has been built in accordance with the latest technical standards and approved safety rules. Nevertheless, the serious accidents such as death or personal injury still may take place due to the collision between the robot system and peripheral equipment.

The robot system must be used by operator who has a full technical knowledge on its designated use and also pay his close attention to the possible dangers and risks involved in its operation. The use of robot system is subject to compliance with these operating instructions and the operation and maintenance manual supplied together with the robot system. The safety related functions of robot system must not be used for any purposes other than safety.

When you use the robot system for any other or additional purposes than its designated usage, you must review whether it is valid in accordance with design criteria. The manufacturers cannot take any responsibility for any damage or loss which resulted from such misuse or improper use. The users shall have the full responsibility for the risks caused by such misuse or improper use. When you use and operate the robot system for its designated use, you must have a good command of all the information contained at these operating instructions as well as the maintenance manual.

The robot system may not be put into operation until it is ensured that the functional machine or plant into which the robot system has been integrated conforms to the specifications of the EC directives 89/392 EWG dated 14 June 1989 and 91/368 EWG dated 20 June 1991.

The following harmonized standards in particular were taken into account with regard to the safety of the robot system.

- IEC 204-1,10.7
- ISO 11161,3.4
- ISO 10218(EN 775),6.4.3
- ISO 10218(EN 775),3.2.17
- ISO 10218(EN 775),3.2.8
- ISO 10218(EN 775),3.2.7

Users must take the full responsibility for any accident caused by their negligence or non-observance of these instructions. The manufacturer will not take any liabilities and responsibilities for any damages or losses caused by the misuse or malfunction of such equipment which is not included in the contract between manufacturer and user and provided by user, or such equipment which is installed around the robot system arbitrarily by the user. User must take the full liabilities and responsibilities for any risks and damages caused by such equipment.



2

Specifications



2. Specifications

HX130/HX165/HX165S/HX200/HX200S

2.1. Robot Machinery Part

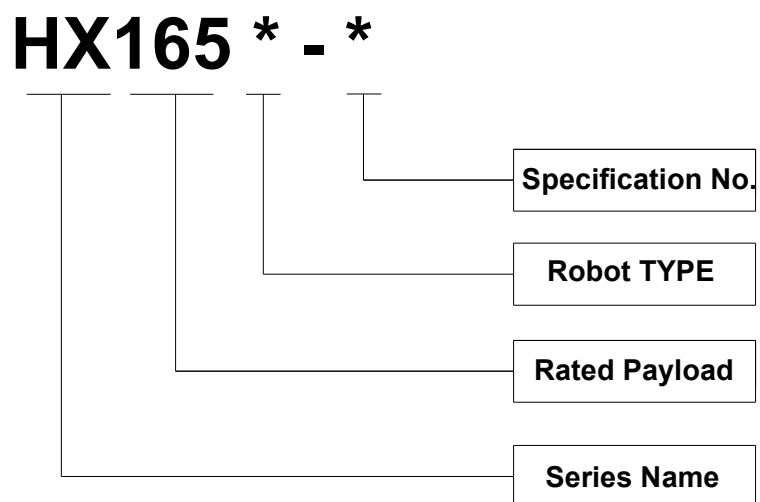


Fig 2.1 Robot Machinery Part

2.2. Location of Robot Identification Plate

The model name, serial number, and manufacturing date of robot are written down in the name plate. The name plate is located in the rear of axis H in the ARM.

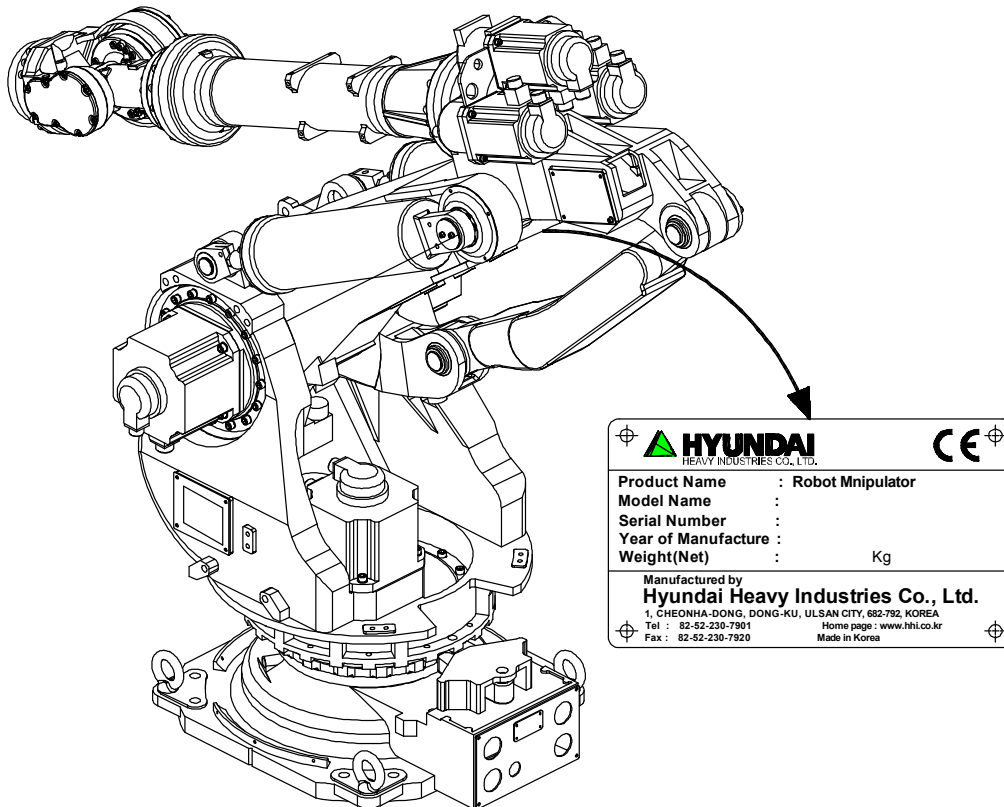


Fig 2.2 The location of identification plate

2.3. Basic Specifications

Table 2-1 Basic Specifications for Models

Item				Specification				
Model				HX130	HX165	HX165S	HX200	HX200S
Construction				Articulated				
Degree of freedom				6				
Drive system				AC servo system				
Max. Working envelope	Arm	S	Swivel	±3.142 rad (±180°)				
		H	For/Backward	+1.48 ~ -1.13 rad (+85°~ -65°)				
		V	Up/ downward	+1.05~-2.36 rad (+60°~ -135°)				
	Wrist	R2	Rotation 2	±6.283 rad (±360°)				
		B	Bending	±2.36 rad (±135°)	±2.27 rad (±130°)	±2.36 rad (±135°)	±2.18 rad (±125°)	
		R1	Rotation 1	±6.283 rad (±360°)				
Max. Speed	Arm	S	Swivel	2.09rad/s (120°/s)	1.83rad/s (105°/s)	1.66rad/s (95°/s)		1.48 rad/s (85°/s)
		H	For/Backward	2.18rad/s (125°/s)	1.83rad/s (105°/s)	1.74rad/s (100°/s)	1.66 rad/s (95°/s)	
		V	Up/ downward	2.18rad/s (125°/s)	1.66 rad/s (95°/s)	1.74rad/s (100°/s)	1.48 rad/s (85°/s)	1.40 rad/s (80°/s)
	Wrist	R2	Rotation 2	3.93 rad/s (225°/s)	2.62 rad/s (150°/s)		2.36 rad/s (135°/s)	2.09 rad/s (120°/s)
		B	Bending	3.93 rad/s (225°/s)	2.53 rad/s (145°/s)	2.62 rad/s (150°/s)	2.09 rad/s (120°/s)	
		R1	Rotation 1	5.32 rad/s (305°/s)	3.84 rad/s (220°/s)		3.31 rad/s (190°/s)	3.14 rad/s (180°/s)

2. Specifications

Item			Specification				
Model			HX130	HX165	HX165S	HX200	HX200S
Load Capacity			1,274 N (130 kg)	1,617 N(165 kg)		1,962 N(200 kg)	
Wrist Torque	R2	Rotation 2	735N·m (75 kgf·m)	980 N·m (100 kgf·m)		1,274 N·m (130 kgf·m)	
	B	Bending	735N·m (75 kgf·m)	980 N·m (100 kgf·m)		1,274 N·m (130 kgf·m)	
	R1	Rotation 1	392 N·m (40 kgf·m)	490 N·m(50 kgf·m)		608 N·m(62 kgf·m)	
Accuracy of position repeatability			±0.3 mm				
Ambient Temperature			0~ 45℃ (273~318 K)				
Relative humidity			20 ~ 85 %RH				
Robot's Weight			1,350 kg		1,500 kg	1,400 kg	1,600 kg
Working envelope section area			6.5 m²		5.18 m²	5.65	5.18 m²
Index of working envelope			5.13		4.09	5.13	4.09

2.4. Robot Dimension and Working Envelope

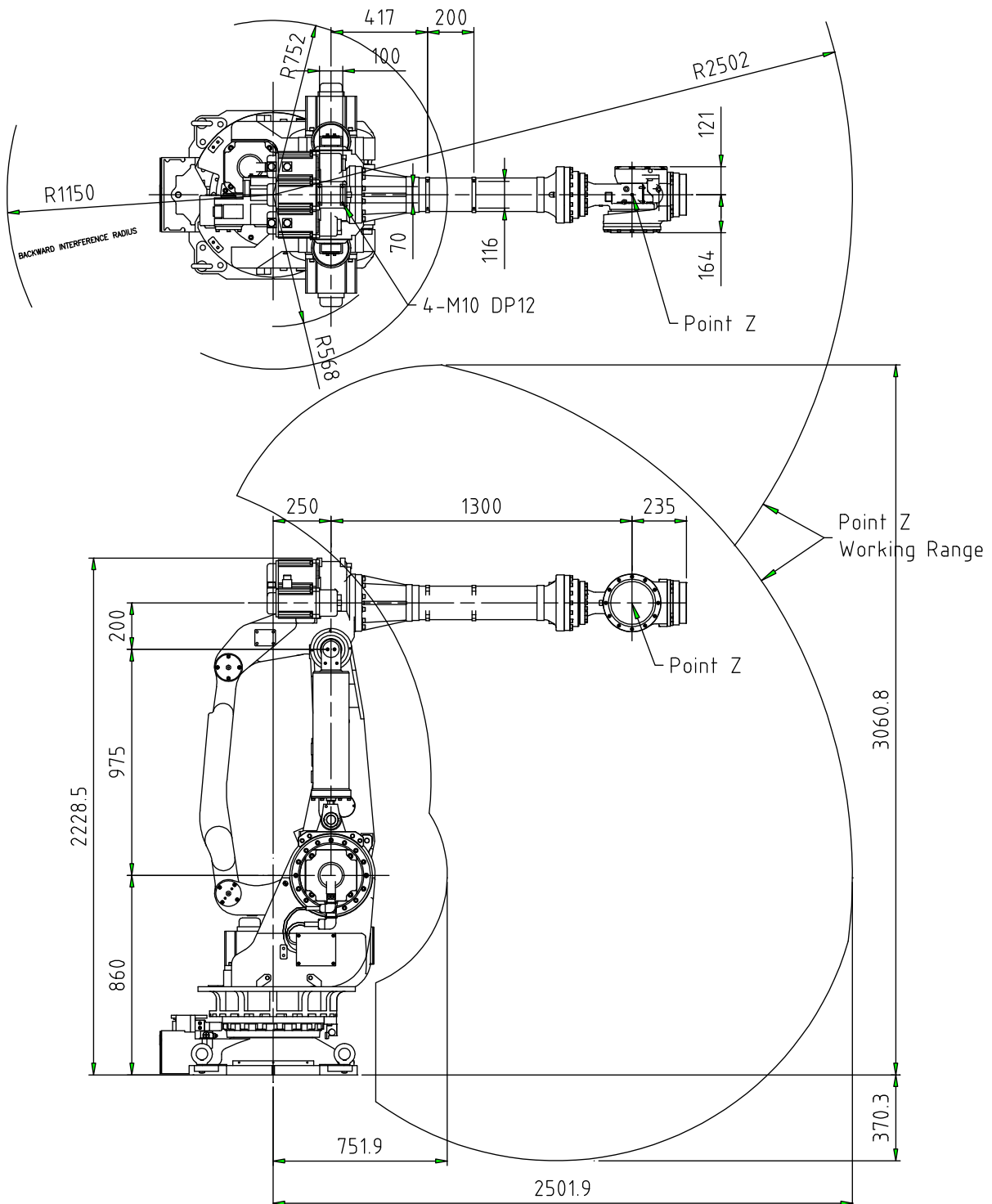


Fig 2.3 Robot Dimension and Working Envelope : [HX200]

2. Specifications

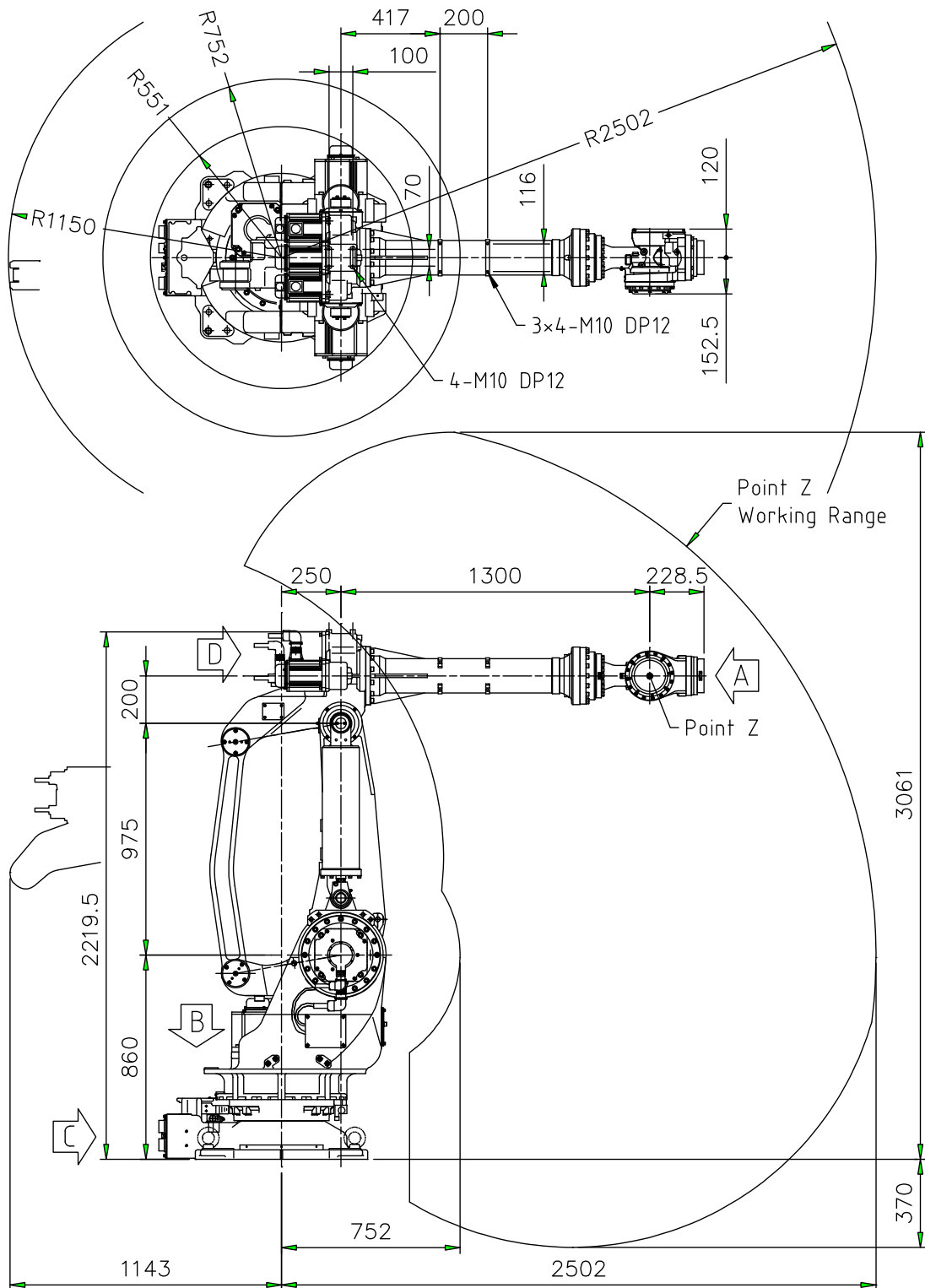


Fig 2.4 Robot Dimension and Working Envelope : [HX130/HX165]

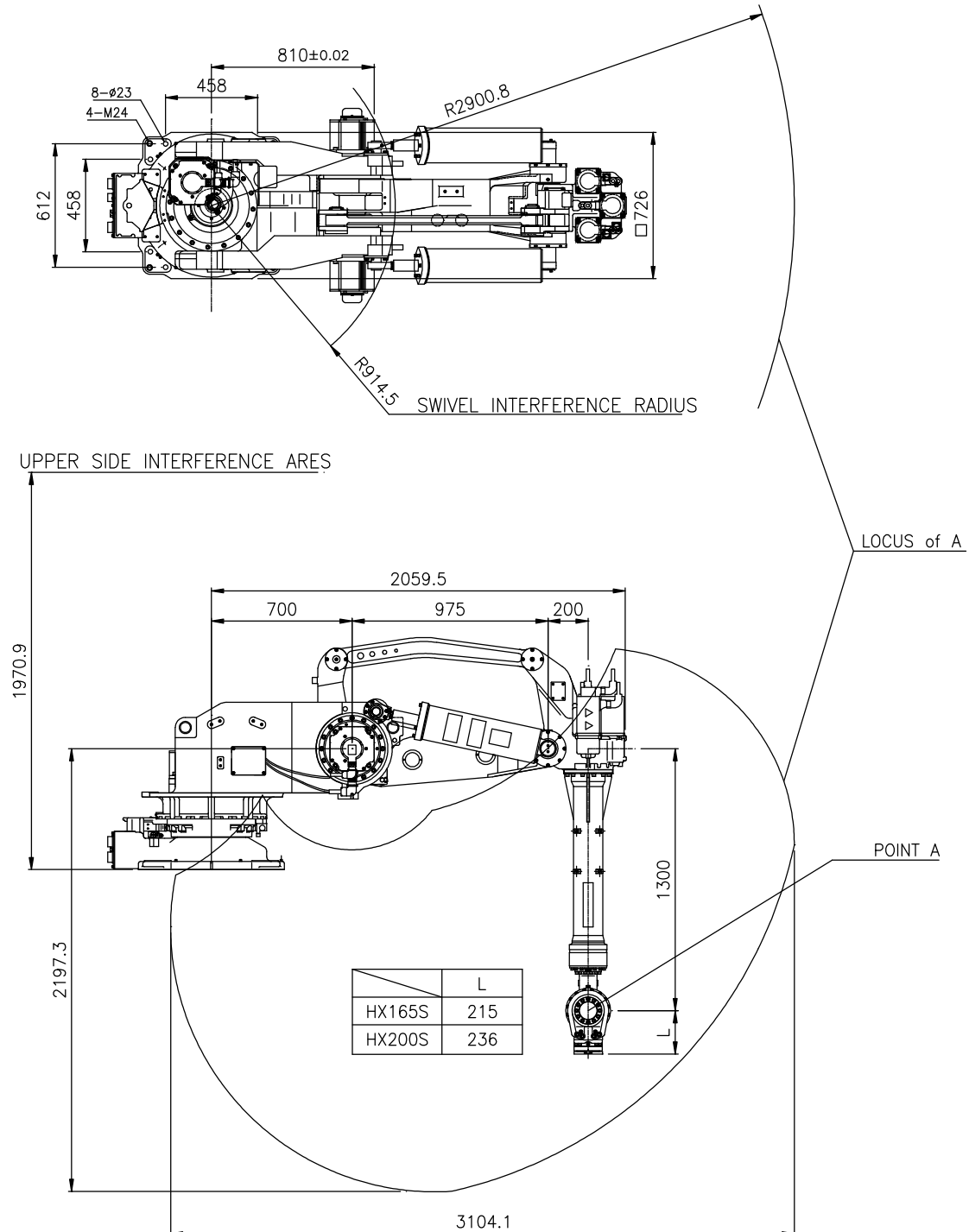


Fig 2.5 Robot Dimension and Working Envelope : [HX165S/HX200S]

2.5. Axis Identification

Table 2-2 Axis Motion

Axis Name	Operation	Teaching Pendant Button	
S	Arm Swivel	LFT(S+)	RHT(S-)
H	Arm Forward and Backward	BWD(H+)	FWD(H-)
V	Arm Upward and Downward	UP(V+)	DOWN(V-)
R2	Wrist Rotation 2	Rx+(R2+)	Rx-(R2-)
B	Wrist Bend	Ry+(B+)	Ry-(B-)
R1	Wrist Rotation 1	Rz+(R1+)	Rz-(R1-)

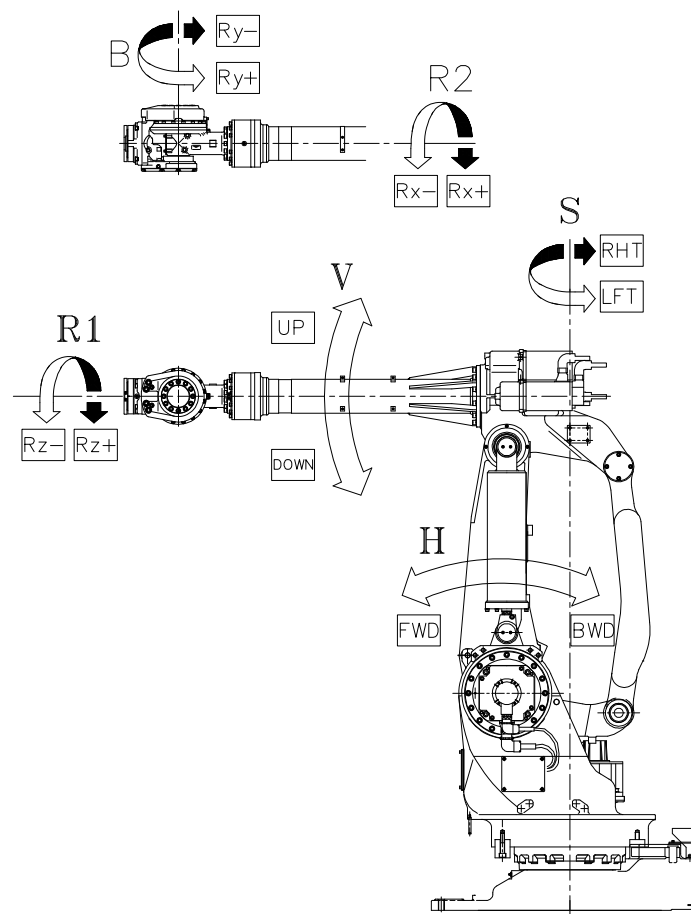


Fig 2.6 Robot Dimension and Axis [HX130/HX165/HX200]

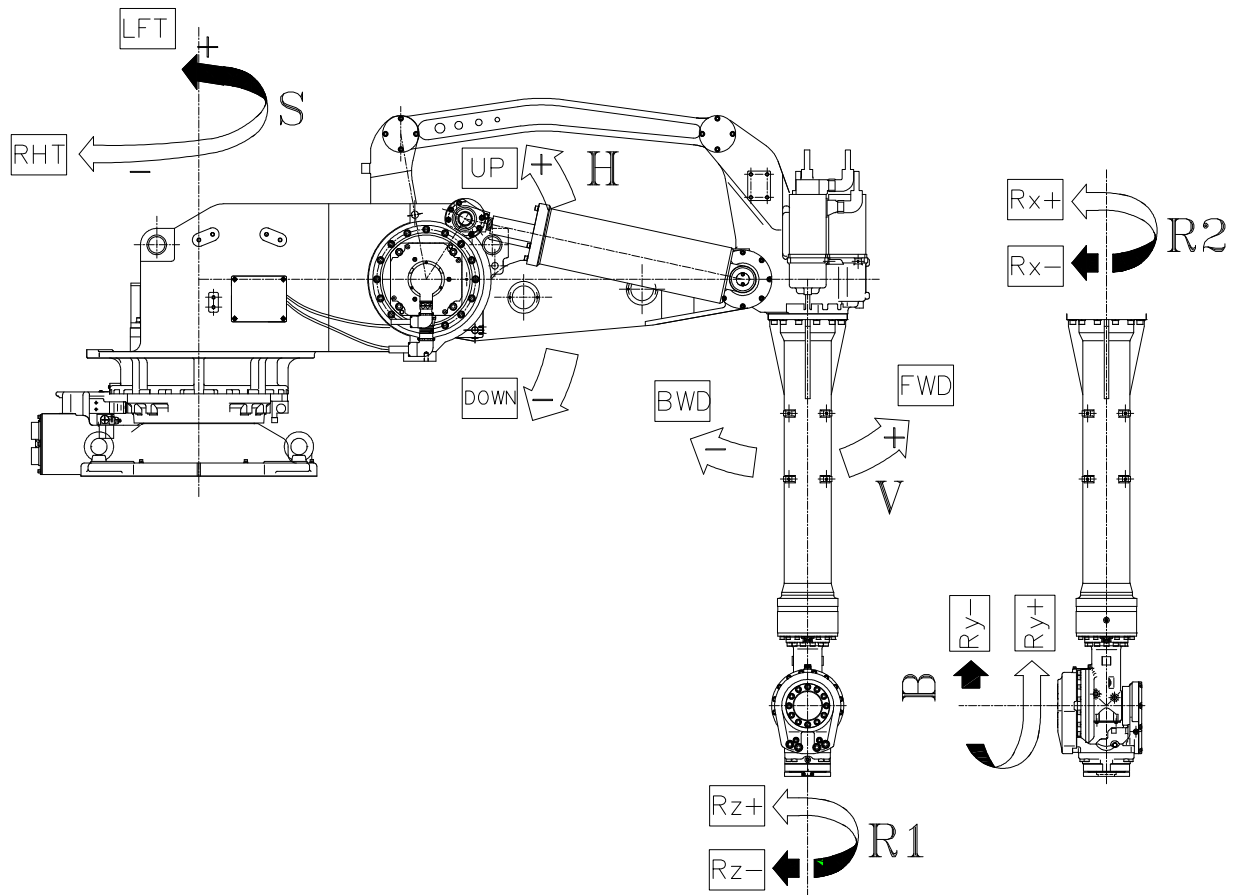


Fig 2.7 Robot Dimension and Axis [HX165S/HX200S]

2.6. Details of Wrist Axis Attachment Surface

When attaching the operating tool to the mechanical interface of robot's wrist flange, fasten it with a bolt at P.C.D. 125.

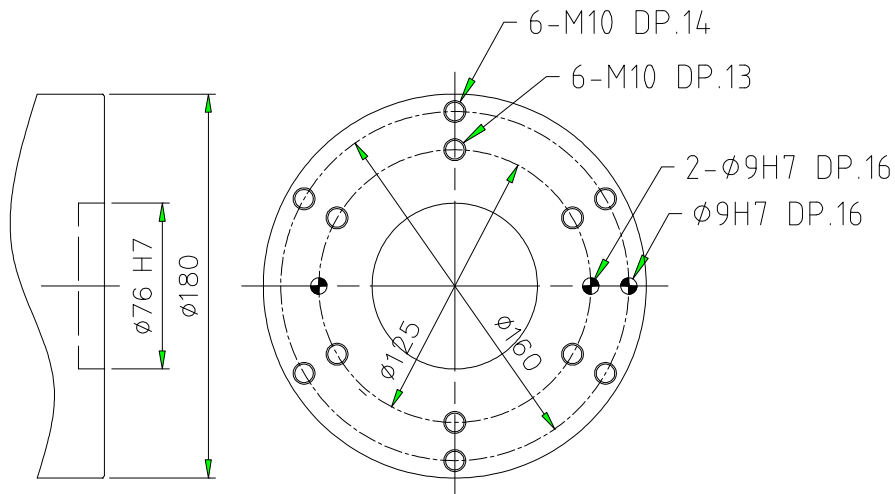


Fig 2.8 Details of Wrist Axis Attachment Surface : [HX200/HX200S]

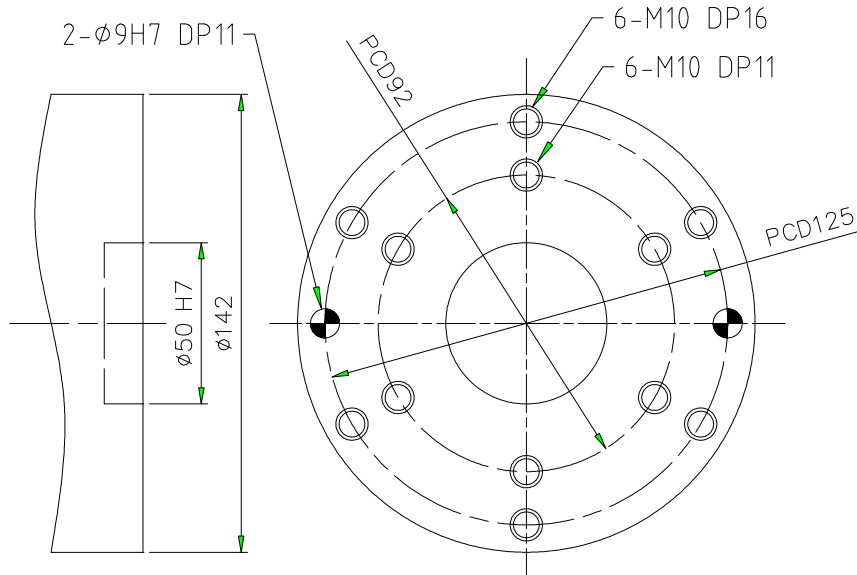




Fig 2.9 Details of Wrist Axis Attachment Surface : [HX130/HX165/165S]

2.7. Details of Upper 1st ARM Attachment Surface

There is a Tap in upper 1st ARM to attach peripheral equipment.
Attach peripheral equipment within the range marked as .

[Attention]

Attach peripheral equipment to the upper side of the 1st ARM, or to only one side of upper axis V.
When attaching, be sure to the center position of gravity should be located within the range marked as .

- Max weight on the A1 Frame : 80kg
- Max weight on the 1st ARM: 80kg

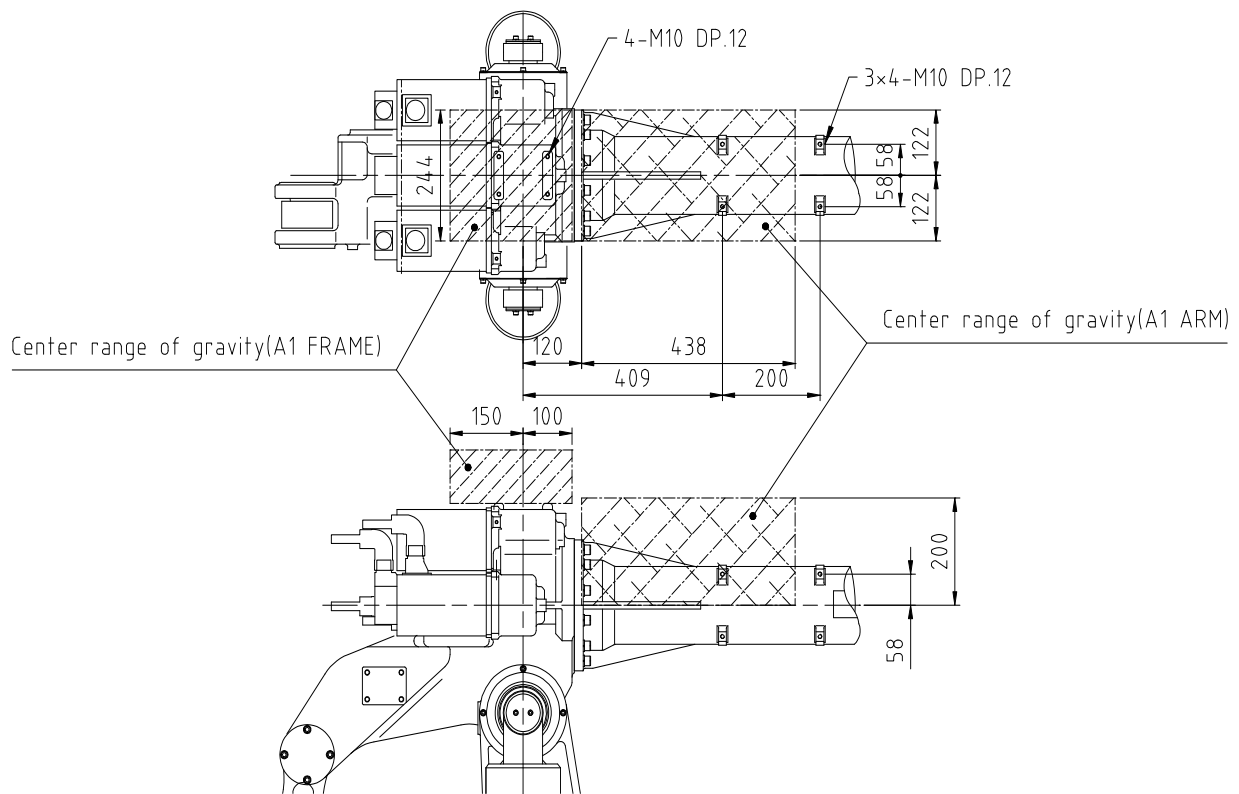


Fig 2.10 Details of Upper 1st ARM Attachment Surface

2.8. Application Wiring and Inspection Wiring Diagram

There are air unit and connector to connect the additional equipment to the robot manipulator. Application connectors are indicated as follows.

[Note] Max air pressure of air connection : 5bar (5.1 kgf/cm² ,72.5 psi)

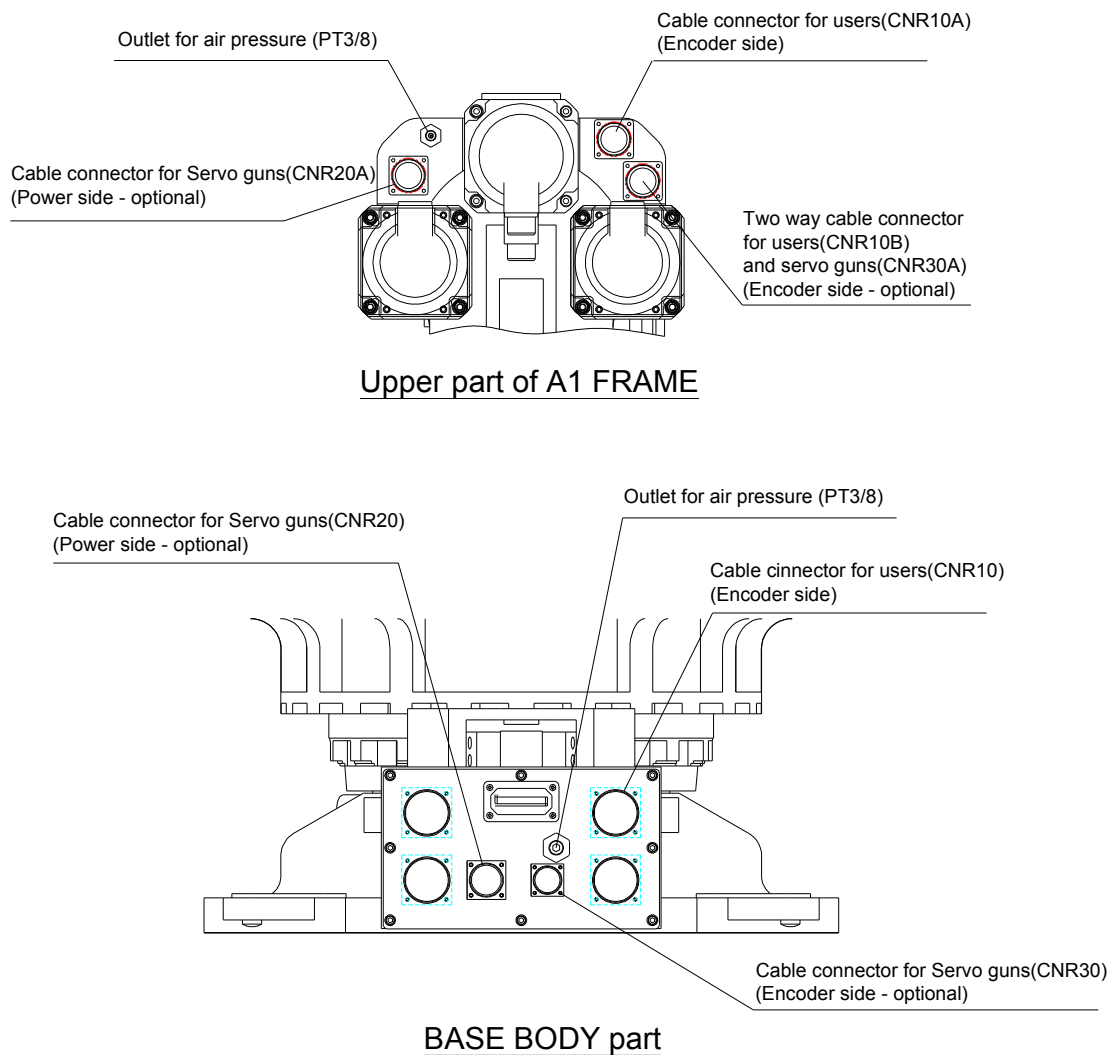


Fig 2.11 Application Wiring and Inspection Wiring Diagram

2.8.1. Details of Customer Application Connectors

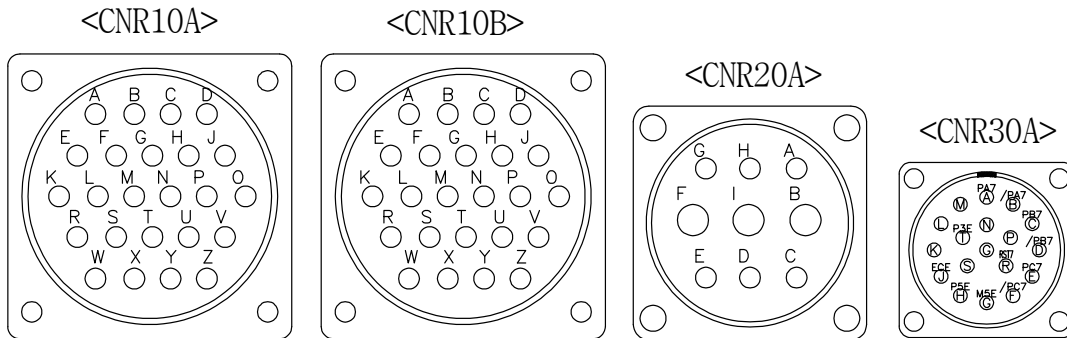


Fig 2.12 Details of Application Connector

- ① CABLE SPECIFICATION
 - CNR10A : 0.3sq * 20pcs
 - CNR10B : 0.3sq * 20pcs
 - CNR20A : 2.0sq * ETFE Line 11 pcs
 - CNR30A : 0.3sp * 5P
- ② CONNECTOR TYPE(Receptacle)
 - CNR10A : MS3102B24-28S (for Signal)
 - CNR10B : MS3102B24-28SX (for Signal - Option)
 - CNR20A : MS3102B20-11S (for Power - Option)
 - CNR30A : MS3102B20-29S (for Signal - Option)
- ③ CONNECTOR TYPE(Plug)
 - CNR10A : MS3106B24-28P
 - CNR10B : MS3106B24-28PX
 - CNR20A : MS3106B20-11P
 - CNR30A : MS3106B20-29P

2.9. Restricting the Working Envelope

When installing the robot, take into account that the working envelope can be adjusted freely within the entire working envelope.

In case of possible collision between the robot and peripheral equipment, the working envelope must be limited mechanically and by means of software.

Following instructions explain how to install switches or additional stoppers for setting the working envelope of main axes. This is an optional part.

2.9.1. Axis 1(Axis S)

By adding one more mechanical stopper, the working envelope of the 1st axis can be limited. (by 15°). If the 1st STOPPER BLOCK and STOPPER are deformed due to a great impact, they must be replaced.



3

Instructions



3. Instructions

HX130/HX165/HX165S/HX200/HX200S

3.1. Robot Component Name

The following [Fig 3.1] and [Fig 3.2] show and name each component of the robot.

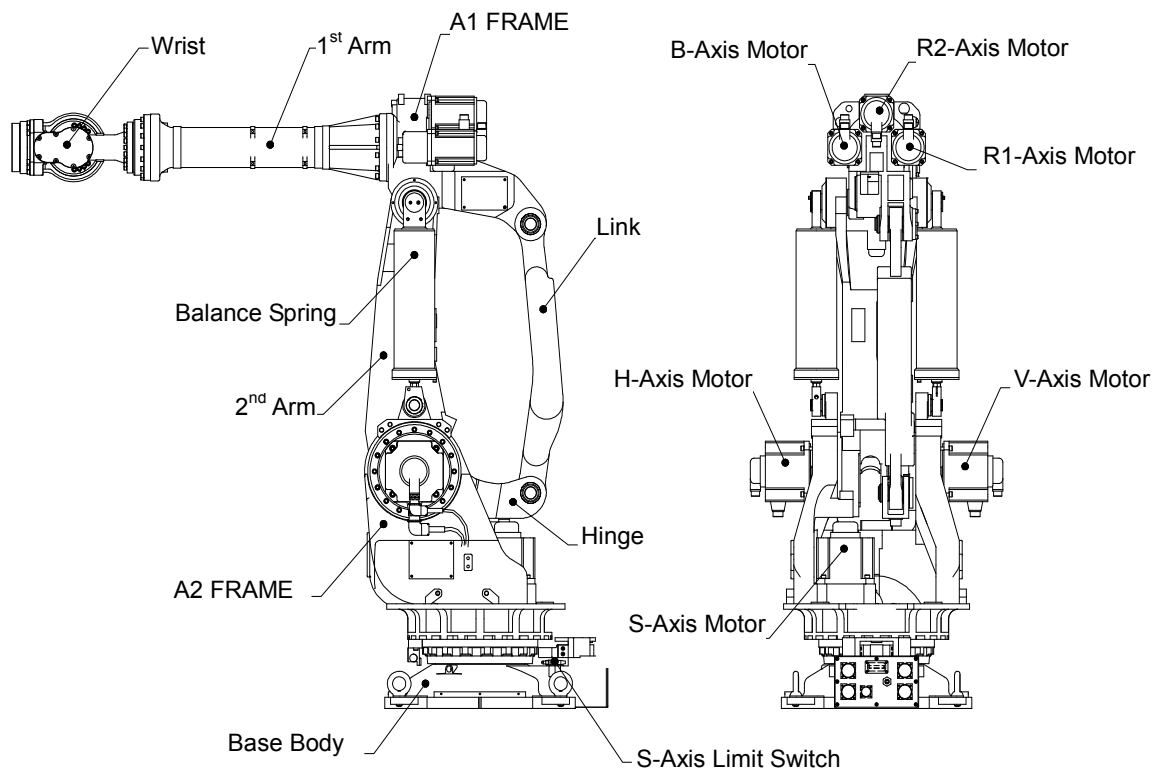


Fig 3.1 Name of Robot Components: [HX130/HX165/HX200]

3. Instructions

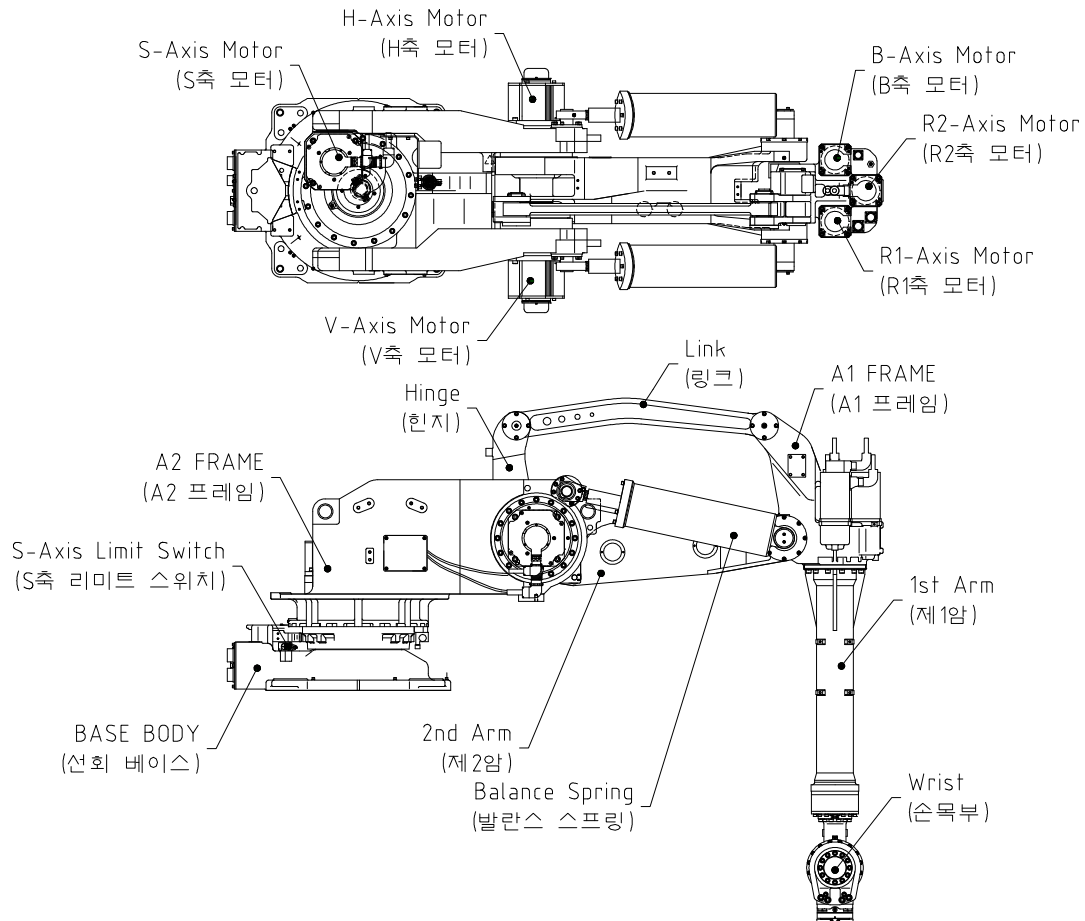


Fig 3.2 Name of Robot Components : [HX165S/HX200S]

3.2. Location of Safety Nameplate

In order to prevent any accidents, safety marking plates such as [Fig 3.3] and [Fig 3.4] are attached to the robot. Do not remove or replace it unnecessarily.

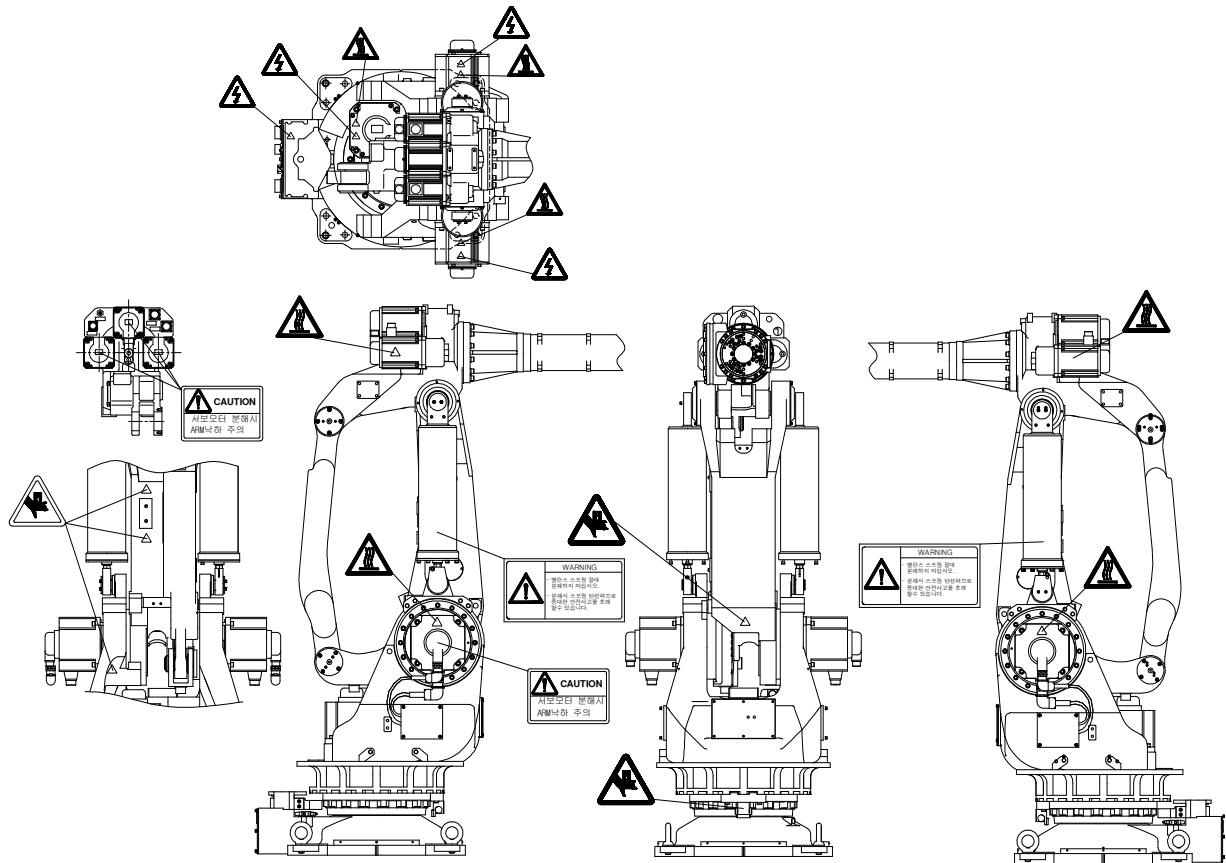


Fig 3.3 Location of Safety Nameplate: [HX130/HX165/HX200]

3.3. How to operate

3.3.1. Using Crane

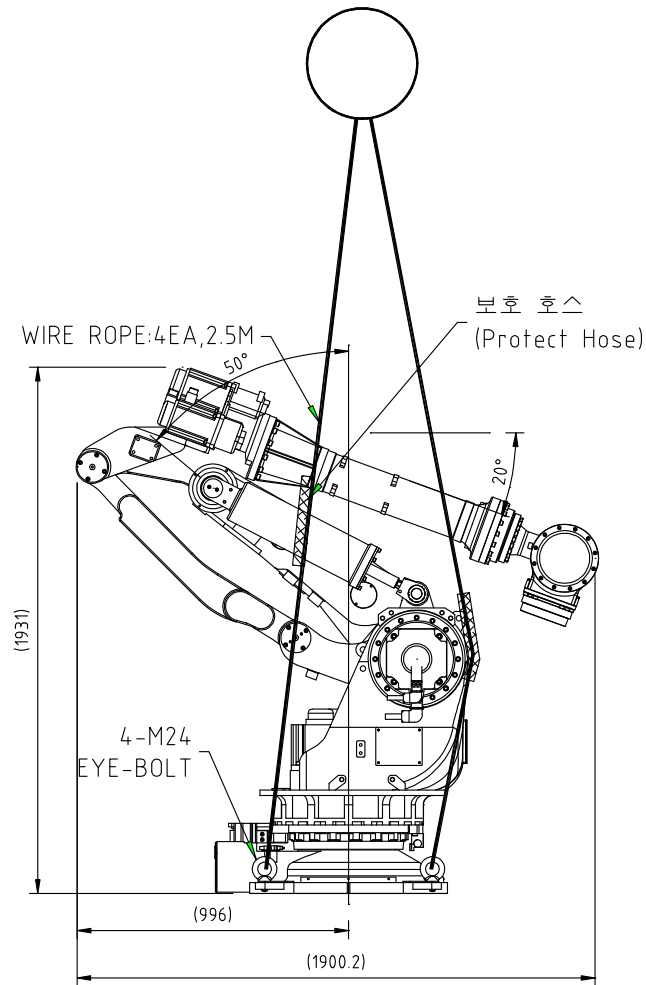


Fig 3.5 How to Transport: Using crane [HX130/HX165/HX200]

3. Instructions

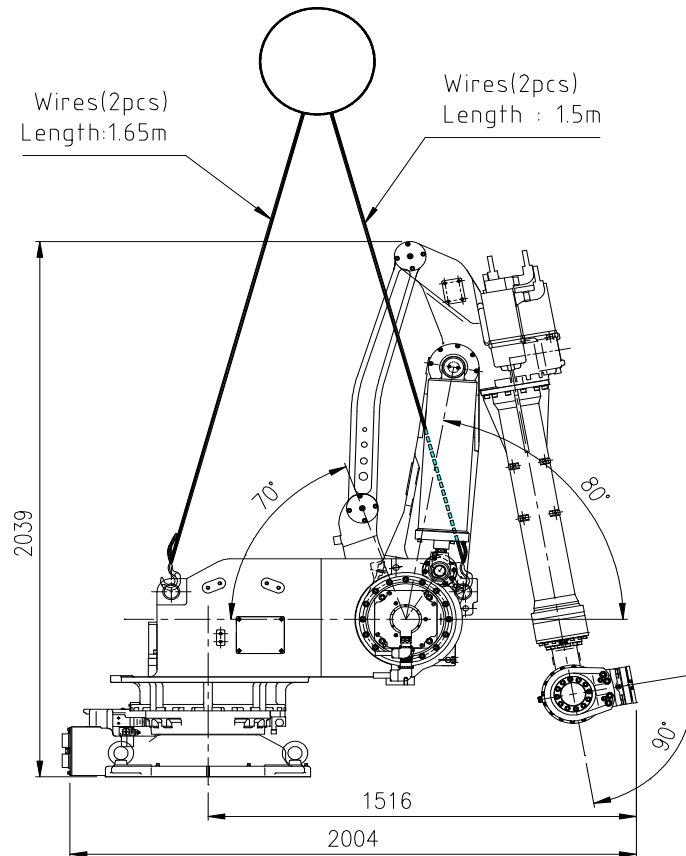


Fig 3.6 How to Transport : Using crane [HX165S/HX200S]

The following lifting instructions are valid for a "naked" robot. If additional equipment is put on the robot, the center of gravity may change and make lifting dangerous.



- Never walk under the robot.
- Pose the robot as shown in the Figure.
- Mount four pieces of EYE BOLTS at the four parts of Base Body.
- Hook 4 piece of wire hooks up with EYE BOLTS.
- Use 4 piece of protective hose(four parts/ 50cm) to prevent damage.
- Keep the safety regulations during Lifting process.
- Weight of manipulator : 1400kg(HX200)/1360kg(HX165)/1500kg(HX165S)/1600kg(HX200S)
- Minimum crane capacity: 2 tons



※ Use wire rope in its length of 2.5m(4EA). Insert a protective hose to prevent damage of painting at the parts contacted with robot body. Refer to Figures for the proper location of protective hose..

3.4. How to Install

**NOTE:**

Before starting to unpack and install the robot, read the safety regulations and other instructions very carefully..

**Warning:**

The installation shall be made by qualified installation personnel and should conform to all national and local codes.

When unpacking the robot, check if it has been damaged during transporting or unpacking. In addition, strictly keep the following installation instructions because installation method and foundation are very important to maintain a good robot performance.

3.4.1. Operating Conditions

- (1) Ambient temperature should range from 0°C to 45°C.
- (2) Ambient humidity should range from 20% to 85% RH, without dew condensation.
- (3) Less dust, oil, or moisture.
- (4) No flammable, corrosive liquid or GAS.
- (5) No impact and shacking.
- (6) No electrical noise generator near the robot.
- (7) If the robot is not immediately installed, keep it in a dry area at an ambient temperature between -15°C ~ and 40°C.

3.4.2. Installation the Robot Manipulator

The base floor to install the robot should be constructed with concrete with a thickness of 300mm or more so that the hardness minimizes dynamic effect to the robot. Repair bumps and cracks on the concrete surface of the floor during installation, and fix the mounting place with M20 Chemical Anchor. And if the thickness of the concrete floor is less than 300mm, it requires an independent base construction that must be reviewed beforehand.

Locate the robot unit on the mounting plate and tightly assemble 8 M20 bolts.

- Bolt: M20*70 (Hardness level: 12.9)
- Flat washer: T = 4mm or above, internal diameter (ID) = 24, hardness of HrC 35
- Assembly torque: 530±20Nm

3.4.3. Accuracy of Installation Surface

The degree of flatness for the four attachment plate surfaces should satisfy the specification. Use a shim, if necessary. The rest of the surface must be flat within $\pm 2\text{mm}$.

■ Cautions

The flatness of mounting plate must be within 1.0 mm.

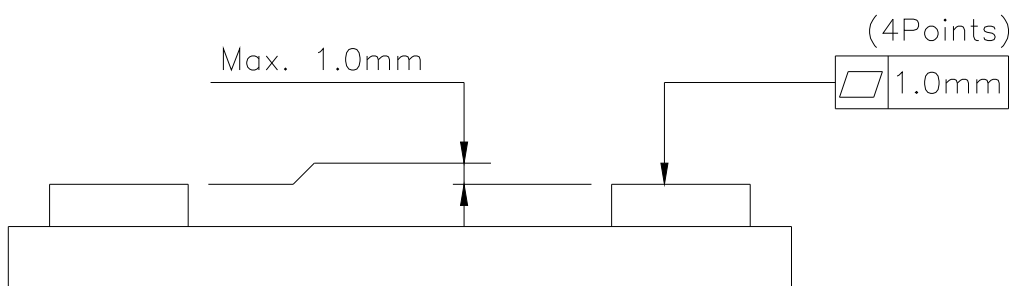


Fig 3.7 Accuracy of Installation surface

3.4.4. Dimension of Installation Surface

Fix the swivel base for robot's installation.
Refer to [Fig 3.8] for the dimension.

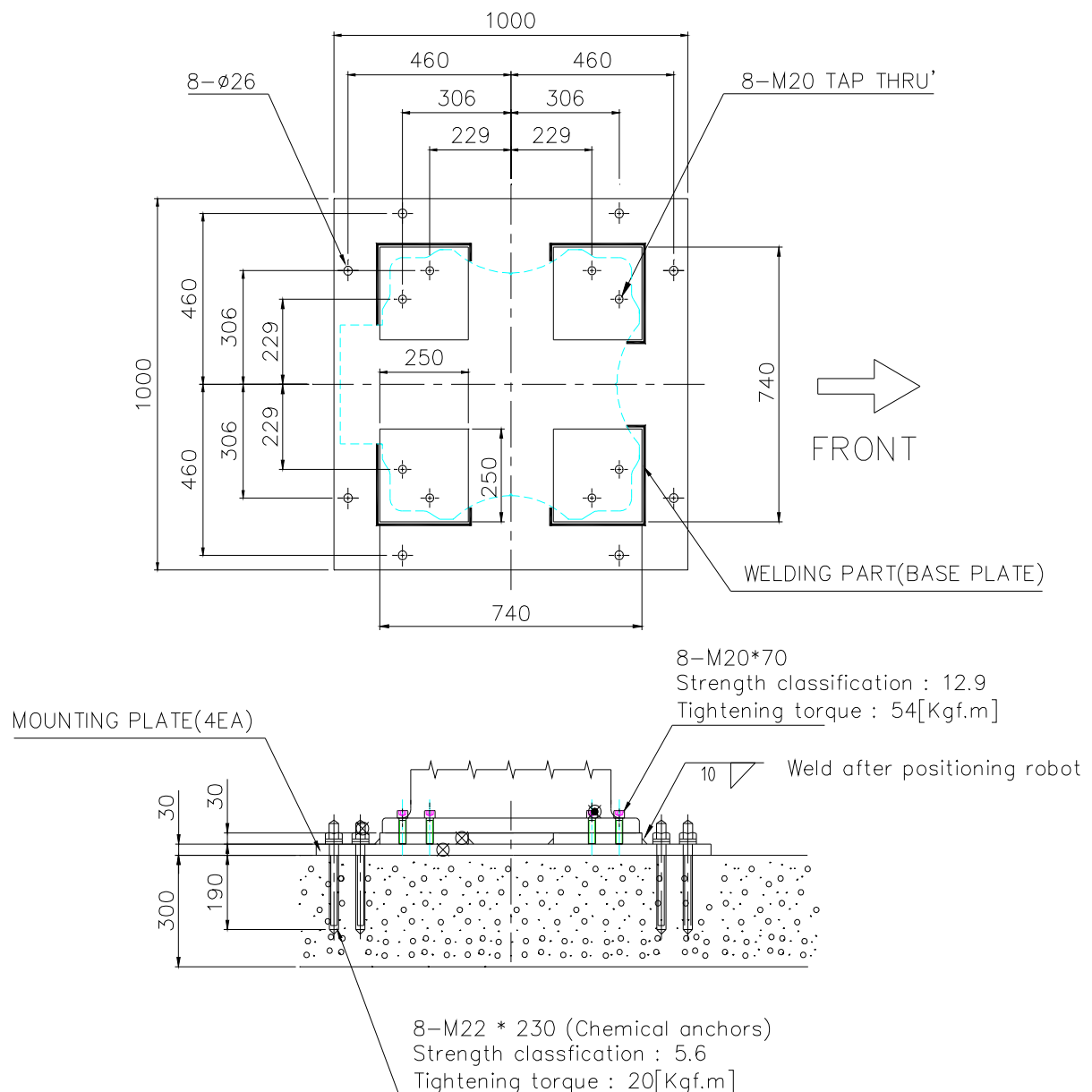


Fig 3.8 Dimension of Robot Installation

3.5. Allowable Load of Wrist Axis

3.5.1. Permitted load torque estimation

The load, which will be applied to the mechanical interface of robot's wrist axis, is restricted by allowable weight, allowable load torque and allowable moment of inertia.

- Step 1
Calculate the location of the weight center from the B axis rotation center (L_X , L_Y , L_Z)
 L_X : Location of weight center in X axis
 L_Y : Location of weight center in Y axis
 L_Z : Location of weight center in Z axis
- Step 2
Check the location from the center of B and R1 axis to the weight center based on the torque map.

$$L_B = L_X, \quad L_{R1} = \sqrt{L_Y^2 + L_Z^2}$$

Length in B axis (L_B) ≤ 0.606 m

Length in R1 axis (L_{R1}) ≤ 0.303 m

L_X : Location of the weight center in X axis direction from the B axis rotation center

L_Y : Location of the weight center in Y axis direction from the B axis rotation center

L_Z : Location of the weight center in Z axis direction from the B axis rotation center

L_B : Length from B axis rotation center to weight center

L_{R1} : Length from R1 axis rotation center to weight center

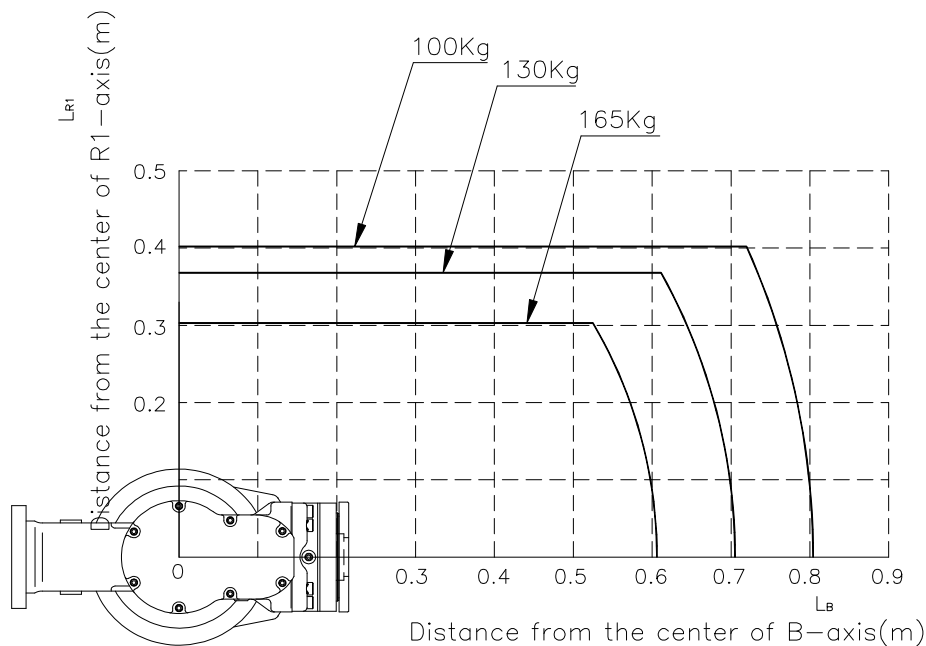


Fig 3.9 Wrist Axis Torque Mapping : [HX165-04]

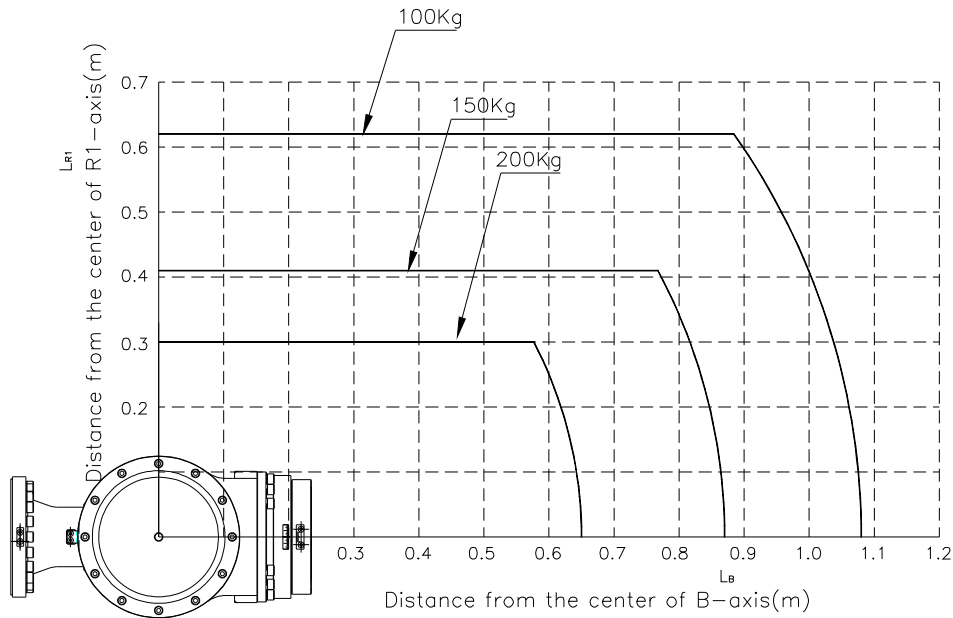


Fig 3.10 Wrist Axis Torque Mapping:[HX200]



Allowable Load Torque

Table 3-1 Allowable Load Torque

Robot Model	Allowable Load Torque		
	R2 Axis Rotation	B Axis Rotation	R1 Axis Rotation
HX200/HX200S	Less than 1274N·m (130kgf·m)		Less than 608 N·m (62 kgf·m)
HX165/165S	Less than 980N·m (100kgf·m)		Less than 490 N·m (50 kgf·m)
HX130	Less than 736N·m (75kgf·m)		Less than 392 N·m (40 kgf·m)

3.5.2. Permitted inertia moment estimation

Loads must be kept below maximum conditions shown in [Fig. 3.9~Fig 3.10].

- Step 1
Calculate the inertia moment value of the load at each wrist axis center (J_{a4} , J_{a5} , J_{a6})
 J_{a4} - Inertia moment from R2 axis rotation center
 J_{a5} - Inertia moment from B axis rotation center
 J_{a6} - Inertia moment from R1 axis rotation center
- Step 2
Check if the inertia moment value of the static load based on the inertia map is within the limited range.

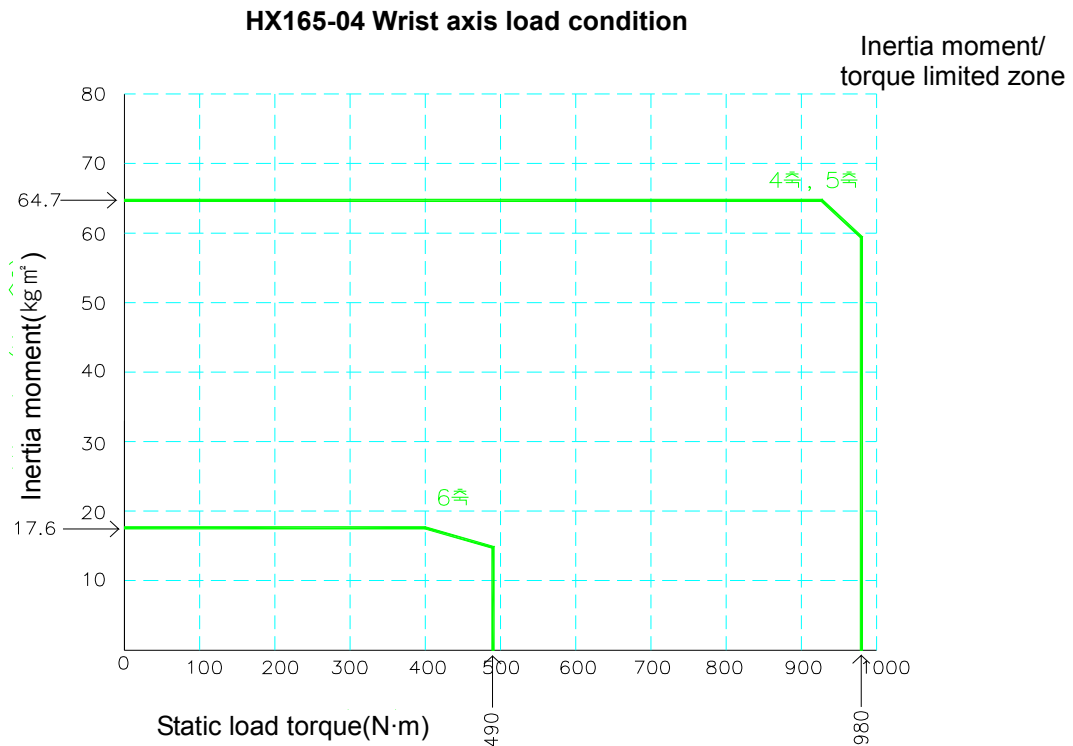


Fig 3.11 Wrist Axis Load Condition:[HX165-04]

**Allowable Moment of Inertia**

Table 3-2 Allowable Moment of Inertia

Robot Model	Allowable Moment of Inertia		
	R2 Axis Rotation	B Axis Rotation	R1 Axis Rotation
HX200/HX200S	117.5kg·m ² (12kgf·m·s ²)		60kg·m ² (6.1kgf·m·s ²)
HX165/165S	64.68kg·m ² (6.6kgf·m·s ²)		17.64kg·m ² (1.8kgf·m·s ²)
HX130	46.06kg·m ² (4.7kgf·m·s ²)		13.72kg·m ² (1.4kgf·m·s ²)

3.5.3. Example of permitted torque and inertia moment calculation

1) Case #1 Simple 2-D model

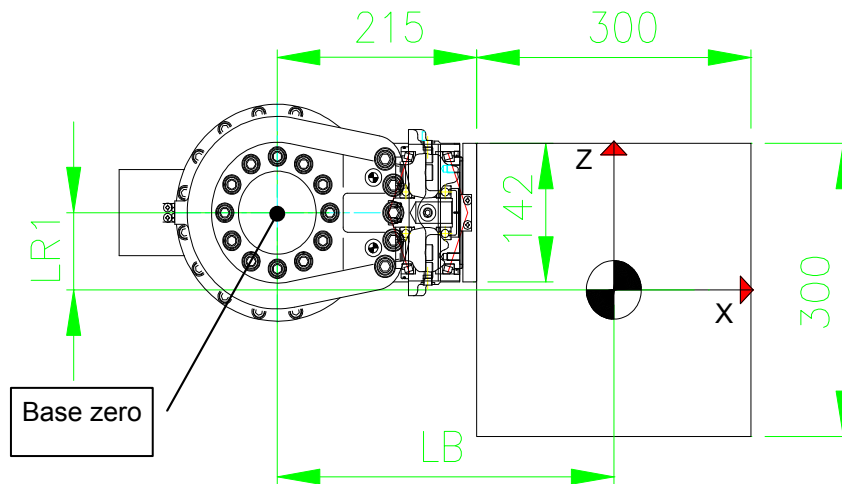


Fig 3.12 HX165-04 2-D load model

M – Load weight

J_{xx} – Inertia moment in X direction from weight center of load

J_{yy} – Inertia moment in Y direction from weight center of load

J_{zz} – Inertia moment in Z direction from weight center of load

J_{a4} – Inertia moment from R2 axis rotation center

J_{a5} – Inertia moment from B axis rotation center

J_{a6} – Inertia moment from R1 axis rotation center

Load condition: Stainless steel with length and width of 300mm and thickness of 200mm (Mass 141.3kg)

① Permitted torque limit

Location of B axis weight center $L_x = 365\text{mm}$, $L_y = 0\text{mm}$, $L_z = -79\text{mm}$

If you apply the B and R1 axis length limit in the torque map, it is shown as follows.

$$\text{B axis based length } L_B = L_x = 0.365 \leq 0.606\text{m}$$

$$\text{R1 axis based length } L_{R1} = \sqrt{L_y^2 + L_z^2} = 0.079 \leq 0.303\text{m}$$

② Permitted inertia moment limit

Inertia moment of load from the weight center $J_{xx} = 1.53\text{kgm}^2$, $J_{yy} = 2.12\text{kgm}^2$, $J_{zz} = 1.53\text{kgm}^2$

B axis inertia moment (J_{a5})

$$J_{a5} = M \cdot (L_x^2 + L_z^2) + J_{yy} = 141.3 \cdot (0.365^2 + 0.079^2) + 2.12 = 21.8 \leq 64.7\text{kgm}^2$$

R1 axis inertia moment (J_{a6})

$$J_{a6} = M \cdot (L_y^2 + L_z^2) + J_{xx} = 141.3 \cdot (0 + 0.079^2) + 1.53 = 2.41 \leq 17.6\text{kgm}^2$$

③ Conclusion

It is safe because the weight, torque and inertia moment all satisfy the limited condition.

2) Case #2 Complicated 3-D model

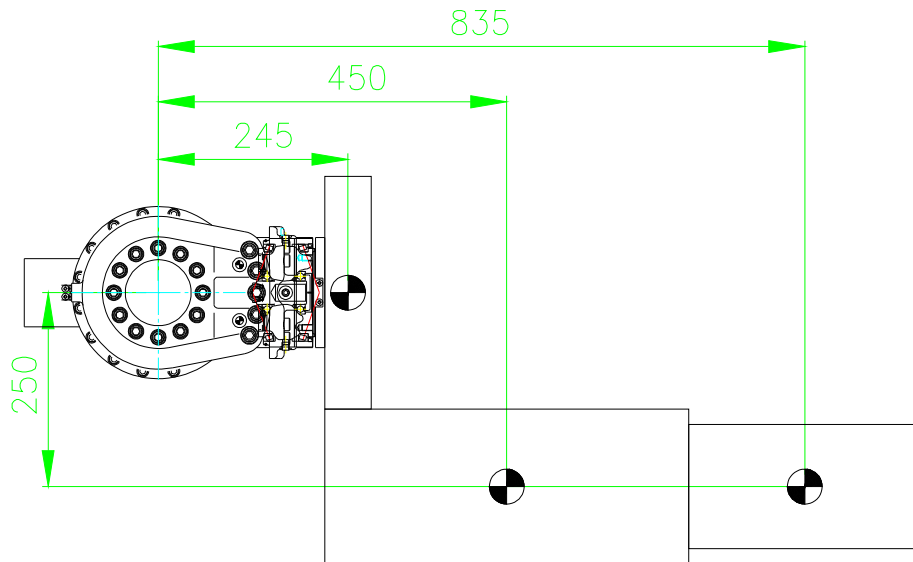


Fig 3.13 HX165-04 3-D load model 2-D shape

Aluminum block shape combination

($\sigma=0.00287 \text{ g/mm}^3$, : 164.7 kg)

m_1 (60×300×300) 15.5kg

m_2 (470×400×200) 107.9kg

m_3 (300×300×160) 41.3kg

m_i – Weight of i block load

L_{xi} – Weight center location in X axis direction of I block

L_{yi} – Weight center location in Y axis direction of I block

L_{zi} – Weight center location in Z axis direction of I block

① Permitted torque limit

You can calculate the weight center location for the total load from the B axis rotation center as follows.

$$L_X = \frac{m_1 \cdot L_{x1} + m_2 \cdot L_{x2} + m_3 \cdot L_{x3}}{m_1 + m_2 + m_3} = \frac{15.5 \times 245 + 107.9 \times 450 + 41.3 \times 835}{164.7} = 527.3 \text{ mm}$$

$$L_Y = 0 \text{ mm} \quad (\text{Symmetric to Y axis})$$

$$L_Z = \frac{m_1 \cdot L_{z1} + m_2 \cdot L_{z2} + m_3 \cdot L_{z3}}{m_1 + m_2 + m_3} = \frac{15.5 \times 0 + 107.9 \times 250 + 41.3 \times 250}{164.7} = 226.5 \text{ mm}$$

The weight center location for the total load from the B axis rotation center $L_X = 527.3 \text{ mm}$, $L_Y = 0 \text{ mm}$, $L_Z = -226.5 \text{ mm}$

3. Instructions

If you apply the B and R1 axis length limit in the torque map, it is shown as follows.

B axis based length $L_B = L_X = 0.527 \leq 0.606m \rightarrow$ torque value 945.4Nm

R1 axis based length $L_{R1} = \sqrt{L_Y^2 + L_Z^2} = 0.226 \leq 0.303m \rightarrow$ torque value 37.2Nm

$x_1 y_1 z_1$ – x, y and z direction length of block m_1

$x_2 y_2 z_2$ – x, y and z direction length of block m_2

$x_3 y_3 z_3$ – x, y and z direction length of block m_3

L_{X1}, L_{Y1}, L_{Z1} – Weight center location of block m_1 from B axis rotation center

L_{X2}, L_{Y2}, L_{Z2} – Weight center location of block m_2 from B axis rotation center

L_{X3}, L_{Y3}, L_{Z3} – Weight center location of block m_3 from B axis rotation center

$J_{xx1}, J_{yy1}, J_{zz1}$ – Inertia moment by x, y and z axis from the weight center of block m_1

$J_{xx2}, J_{yy2}, J_{zz2}$ – Inertia moment by x, y and z axis from the weight center of block m_2

$J_{xx3}, J_{yy3}, J_{zz3}$ – Inertia moment by x, y and z axis from the weight center of block m_3

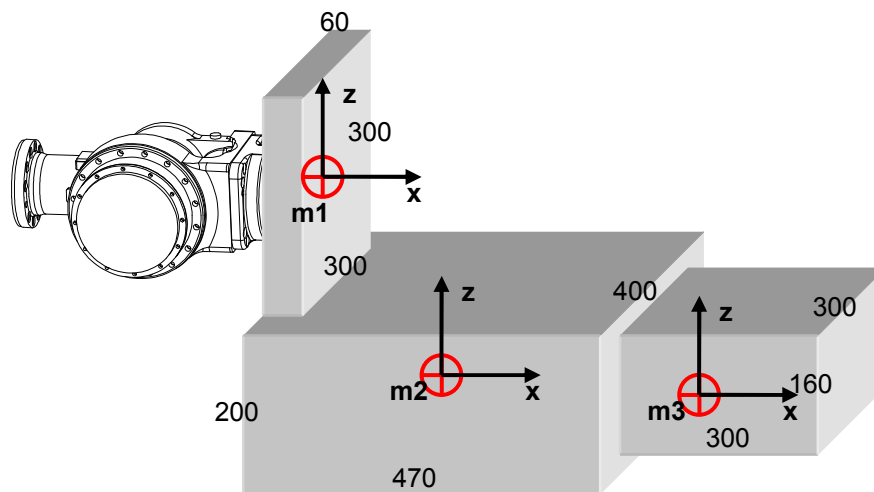


Fig 3.14 HX165-04 3-D load model 3-D shape

② Permitted inertia moment limit

Inertia moment from weight center by block

Block weight (kg)	Weight center (L_X, L_Y, L_Z)	J_{xx}	J_{yy}	J_{zz}
m_1 (15.5)	(0.245, 0, 0)	0.232 kgm ²	0.121 kgm ²	0.121 kgm ²
m_2 (107.9)	(0.45, 0, -0.25)	1.799 kgm ²	2.346 kgm ²	3.425 kgm ²
m_3 (41.3)	(0.835, 0, -0.25)	0.398 kgm ²	0.398 kgm ²	0.620 kgm ²

Ex) Calculating the inertia moment by axis from the weight center of block m1

$$J_{xx1} = \frac{1}{12} \cdot m_1 \cdot (y_1^2 + z_1^2) = \frac{1}{12} \times 15.5 \times (0.3^2 + 0.3^2) = 0.232$$

$$J_{yy1} = \frac{1}{12} \cdot m_1 \cdot (z_1^2 + x_1^2) = \frac{1}{12} \times 15.5 \times (0.3^2 + 0.06^2) = 0.121$$

$$J_{zz1} = \frac{1}{12} \cdot m_1 \cdot (x_1^2 + y_1^2) = \frac{1}{12} \times 15.5 \times (0.06^2 + 0.3^2) = 0.121$$

B axis inertia moment (J_{a5})

$$\begin{aligned} J_{a5} &= \sum_{i=1}^3 \{m_i \cdot (L_{Xi}^2 + L_{Zi}^2) + J_{yyi}\} \\ &= \{m_1 \cdot (L_{X1}^2 + L_{Z1}^2) + J_{yy1}\} + \{m_2 \cdot (L_{X2}^2 + L_{Z2}^2) + J_{yy2}\} + \{m_3 \cdot (L_{X3}^2 + L_{Z3}^2) + J_{yy3}\} \\ &= \{15.5(0.245^2) + 0.121\} + \{107.9(0.45^2 + 0.25^2) + 2.346\} + \{41.3(0.835^2 + 0.25^2) + 0.398\} \\ &= 63.8 \leq 64.7 \text{ kgm}^2 \end{aligned}$$

R1 axis inertia moment (J_{a6})

$$\begin{aligned} J_{a6} &= \sum_{i=1}^3 \{m_i \cdot (L_{Yi}^2 + L_{Zi}^2) + J_{xxi}\} \\ &= \{m_1 \cdot (L_{Y1}^2 + L_{Z1}^2) + J_{xx1}\} + \{m_2 \cdot (L_{Y2}^2 + L_{Z2}^2) + J_{xx2}\} + \{m_3 \cdot (L_{Y3}^2 + L_{Z3}^2) + J_{xx3}\} \\ &= \{15.5(0^2) + 0.232\} + \{107.9(0.25^2) + 1.799\} + \{41.3(0.25^2) + 0.398\} \\ &= 11.8 \leq 17.6 \text{ kgm}^2 \end{aligned}$$

3.6. Recommended Standby Posture

Selecting a good standby posture can save energy and reduce motor temperature.

If the tool is positioned as the figure below, the load on H and V-axes may be minimized.
In case that the posture shown below might not be attained due to the limited space and time caused by peripheral equipment or cycle times, then contact our company.

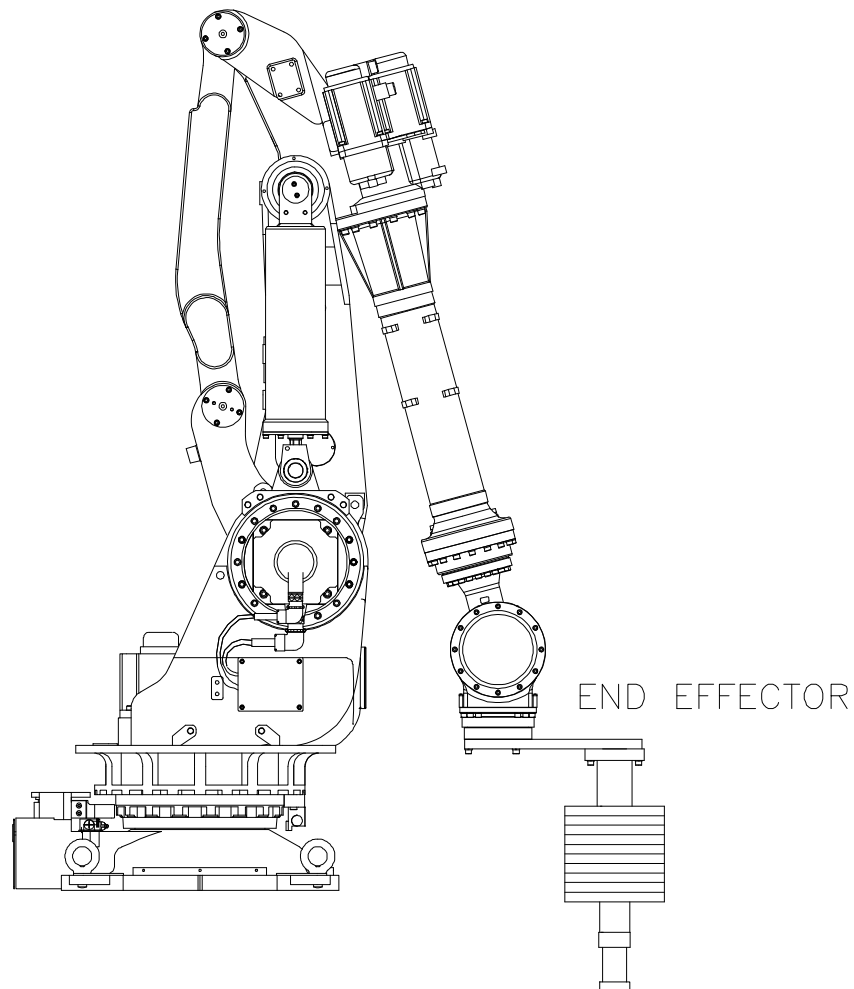


Fig 3.15 Recommended Standby Posture



4

Inspection



4. Inspection

HX130/HX165/HX165S/HX200/HX200S

This chapter provides the instructions for regular inspection and overhaul necessary for the prolonged lifetime of robot performance.

4.1. Inspection Item and Period

Inspection is positively necessary to continue and maintain the high performance of robot for long-term operation.

There are daily inspection and regular inspection. [Table 4-1] shows basic periods for regular inspections, so inspectors should make an inspection according to the indicated periods.

And overhaul every 35,000 operating hours.

The inspection periods have been reviewed for SPOT Welding. In case of high precision work such as handling, it is recommended to inspect at the half intervals of that period as shown in [Table 4-1].

Table 4-1 Inspection Schedule

Yearly Inspection				Yearly Inspection			
3 months	6 months	9 months	12 months	3 months	6 months	9 months	12 months
3 months	6 months	9 months	1 year	1 year & 3 months	1 year & 6 months	1 year & 9 months	2 years
Daily Inspection							

4.2. Inspection Item and Period

Table 4-2 Inspection Items and Periods

No.	Inspection Intervals			Inspection Items	Inspection method	Standards	Remark
	Daily	3 months	1 year				
Robot Manipulator and Axes common							
1	○			Cleaning	Examine dirt and dust with naked eyes		
2		○		Inspection wiring	Examine any cable damages Examine cable fixing bracket tightening bolts paint marking with naked eyes Examine any cable cover damages with naked eyes		
3		○		Main bolts	Examine paint marking with naked eyes		
4			○	Limit Switch/ Dog	Check the ON-OFF function of limit switch	Check if the emergency stop lamp is on when the limit switch is ON.	
5	○			Motor	Check the abnormal heating Check the abnormal sound		
6			○	Brake	Check the ON/OFF operation of brake release switch Note) Turn the switch off in a second because the ARM of working axis may be dropped when the brake release switch is on	When the brake release switch is OFF, ARM of End Effect will not be dropped.	
Axis S, H, V							

No.	Inspection Intervals			Inspection Items	Inspection method	Standards	Remark
	Daily	3 months	1 year				
7	○			Reduction gear	Check the abnormal sound Check the shaking(vibrating)		
Axis R2, B, R1							
8		○		Reduction gear	Check the abnormal sound Check the vibrating		
9		○		End Effect tightening bolts	Examine paint marking with naked eyes		
10		○		Diversion	there is any diversion by rotating each axis to the right and reverse direction	should not feel diversion by touch	

- If the robot is utilized in adverse condition(such as spot welding, grinding, etc.), perform the inspection more frequently to ensure proper reliability of the robot system
- Inspect all visible cabling, and replace them if damaged.
- Check the mechanical bumper devices for deformation and damage. If the bumper or Dog is bent, replace it immediately.
- Check the tightening torque of main bolts as shown in [Fig 4.1] ~ [Fig 4.2].
- Check the abnormal noise in an automatic or teaching mode in order to ensure the condition of power transmission(such as motor, reduction gear, etc).

4.3. Inspection of Main External Bolts



The recommended bolt torque is shown in [Fig 4.1] and [Fig 4.2].

Apply the appropriate torque, where required, using the torque wrench and place the paint marking where the check-up is completed

Table 4-3 Inspection part for main bolts

No	Inspection parts	No	Inspection parts
1	H & V axis reduction gear case attachment	9	Link attachment
2	H & V axis motor attachment	10	R2 axis reduction gear attachment
3	Hinge and Link attachment	11	Wrist attachment
4	Balance spring attachment	12	B axis reduction gear attachment
5	R1 axis motor attachment	13	Wrist CAP attachment
6	R2 axis motor attachment	14	Wrist COVER attachment
7	B axis motor attachment	15	R1 axis reduction gear attachment
8	1st ARM attachment	16	End-effector attachment

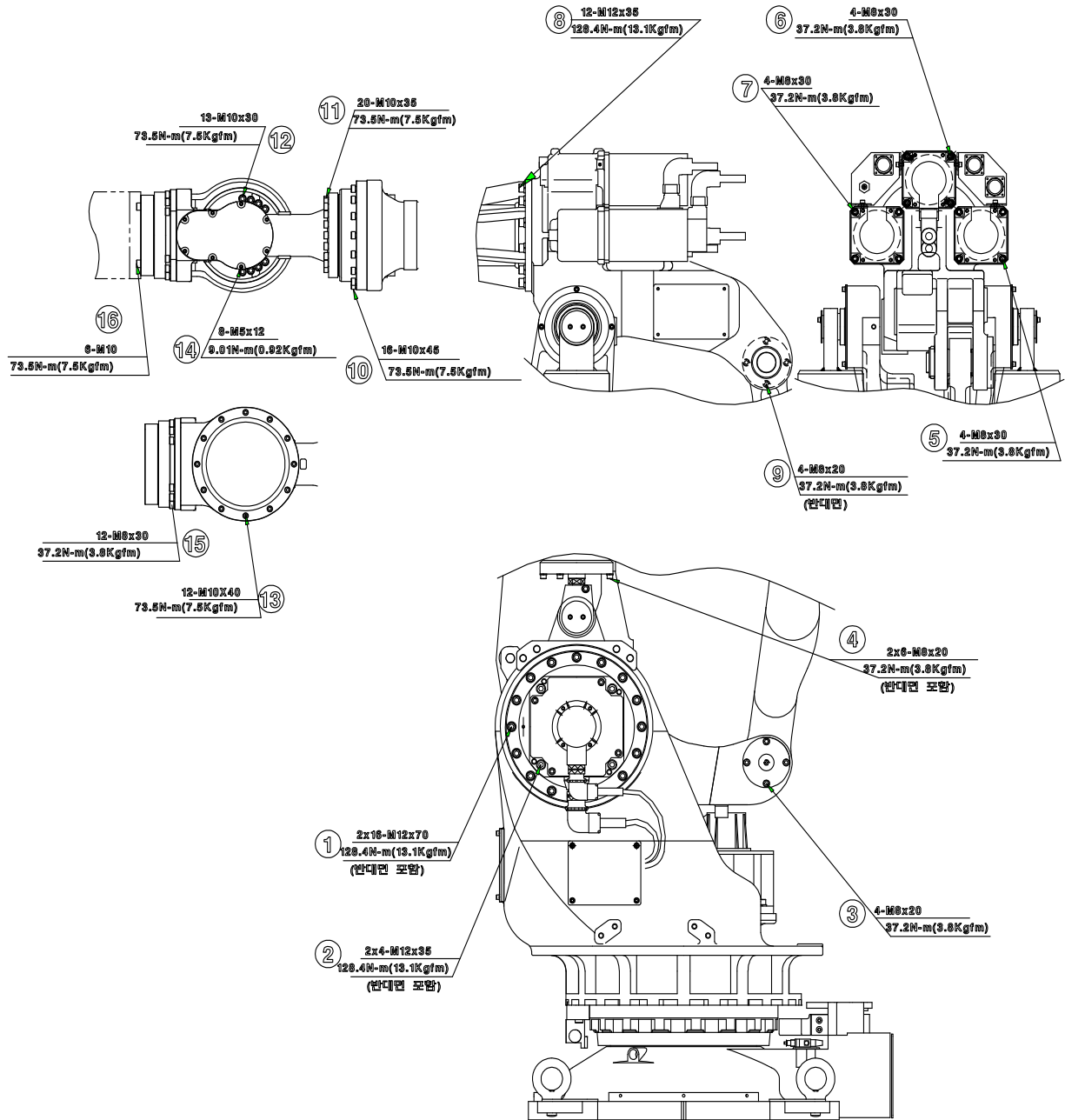


Fig 4.1 Inspection Part for Main Bolts [HX130/HX165/HX200]

4. Inspection

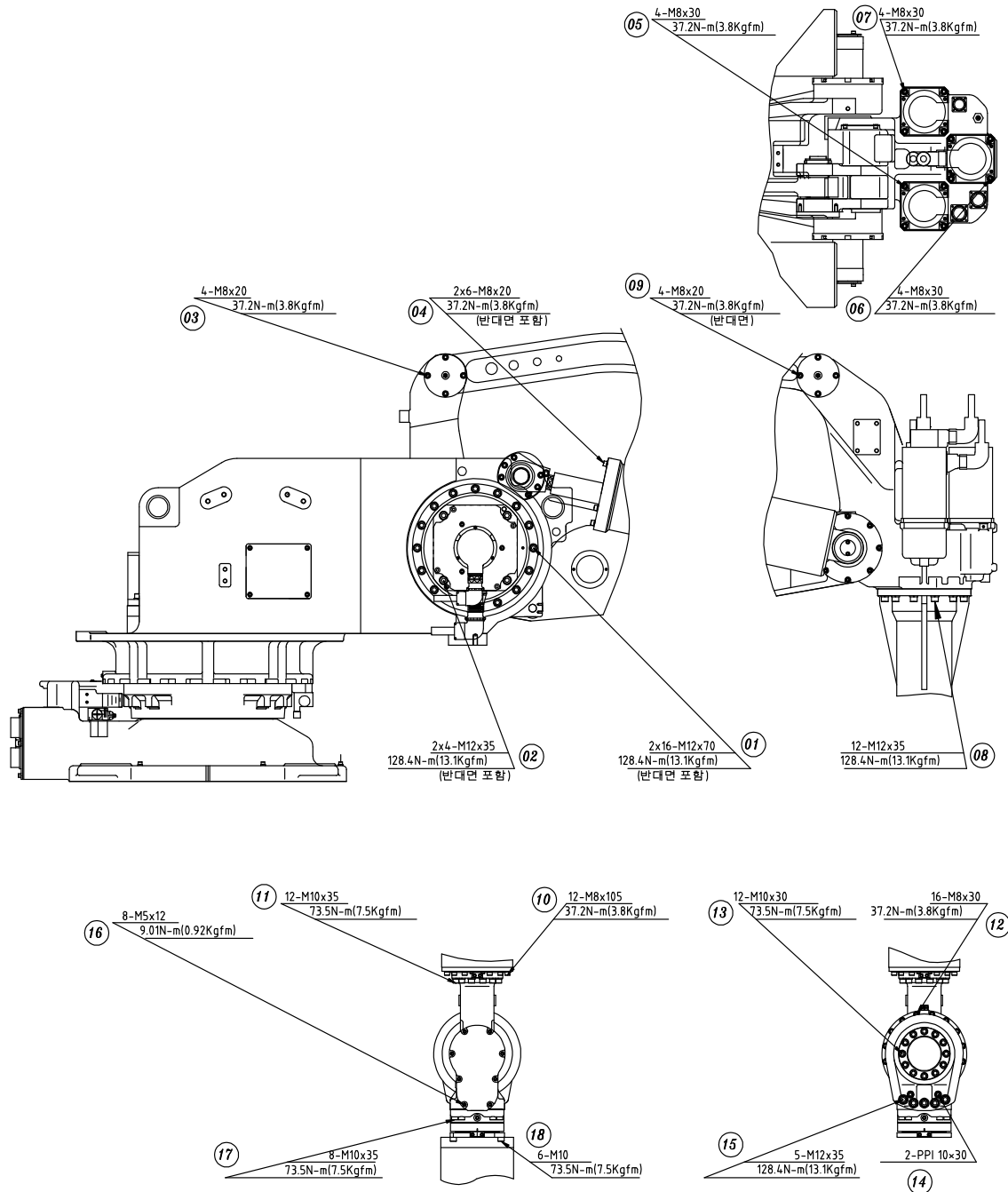


Fig 4.2 Inspection Parts of Main Bolts [HX165S]

4.4. Inspection of Wrist Backlash

Check a diversion by forcing the end-effector (End Effector : spot gun, hand device, etc.), which is attached to the vertical hem of Wrist, in the direction of back and forth, right and left, and up and down.

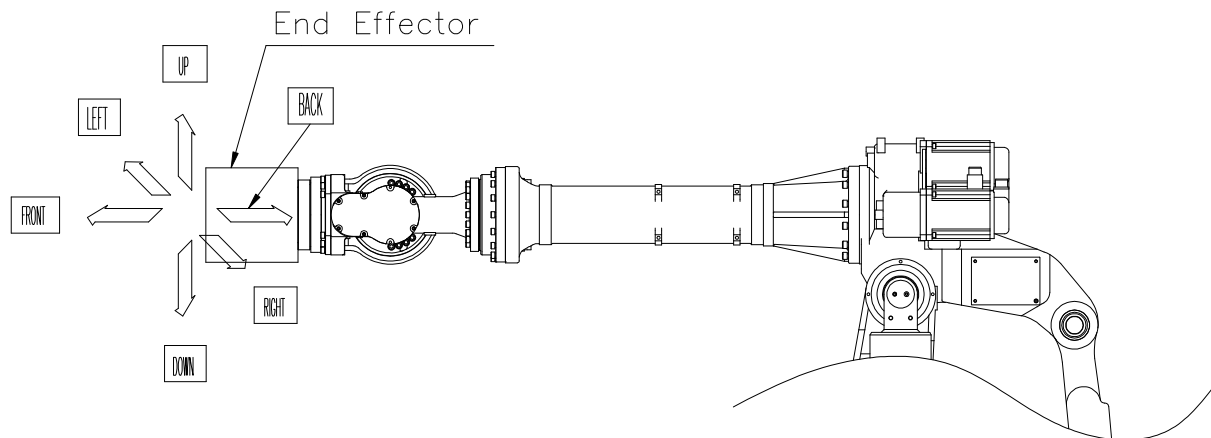


Fig 4.3 Abnormal Backlash Inspecting Directions

4.5. Inspection Internal Wiring

Flexible cables are used for internal wiring of robot manipulator. However, when an internal cable is broken or crushed, the robot may malfunction. Therefore, regular inspection is required. When operating in the working envelope according to following inspection conditions, inspection must be completed in advance.

4.5.1. The Conditions of Safety Inspection

When performing the operating work such as teaching (except shutting off driving source of industrial robot) in the working envelope, check the following articles before the work. If abnormality is found, correct the problem on the spot and then take necessary actions.

- Check if the covered wire and sheathing are damaged or not.
- Check if the manipulator can be operated or not.
- Check emergency stop function

4.5.2. Inspection Part

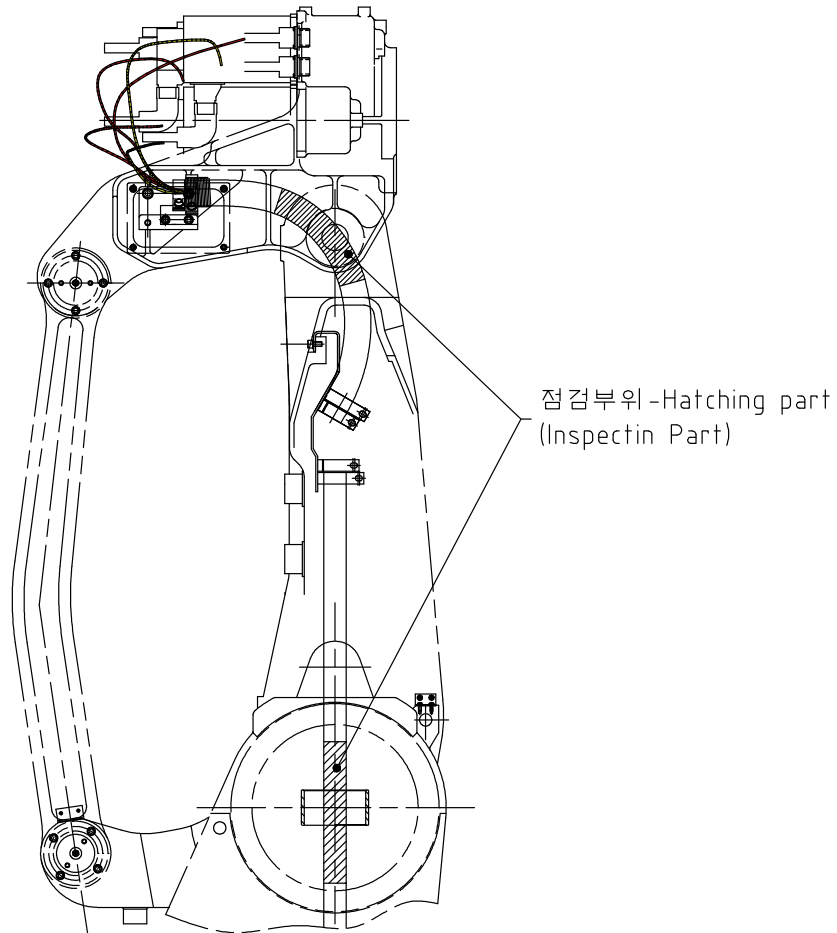


Fig 4.4 Cable Inspection Parts



5

Maintenance



5. Maintenance

HX130/HX165/HX165S/HX200/HX200S

5.1. Grease Replenishment/Replacement



Attention

If greasing is performed incorrectly, the internal pressure of the grease bath may suddenly increase, possibly causing damage to the seal, which would in turn lead to grease leakage and abnormal operation. When performing greasing, therefore, observe the following cautions.

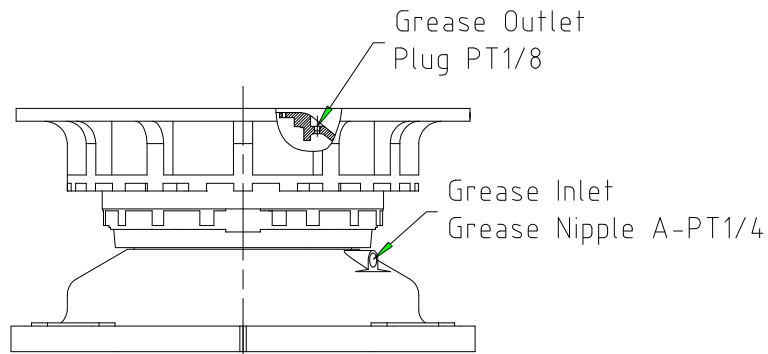
- ① Before starting to grease, remove the plug from the grease outlet.
- ② Whenever possible, avoid using a compressed-air pump, powered by the factory air supply. If the use of a compressed-air pump is unavoidable, restrict the greasing pressure less than 7bar(7kgf/cm²)
- ③ Use grease only of the specified type. If not, may damage the reducer or lead to other problems.
- ④ After greasing, confirm that no grease is leaking from the grease outlet and that the grease bath is not pressurized, then re-attach the plug in the grease outlet.
- ⑤ To prevent accidents caused by slipping, completely remove any excess grease from the floor or robot.
- ⑥ When an ambient temperature is more than 40℃, be sure to shorten the period of replenishment in half.

■ Periodic Replenishment / Replacement

Lubrication Cycle

- ✓ Grease Replenishment : 6,000 hours
- ✓ Grease Replacement : 12,000 hours

5.1.1. S-Axis Reduction Gear



Attention

If grease is added without removing the outlet plug, the grease will go inside the motor and may damage it. It is absolutely necessary to remove the plug.

■ Grease Replenishment

- ① Remove the grease outlet plug.
- ② Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 500cc

- ③ Attach the outlet plug with seal tape.

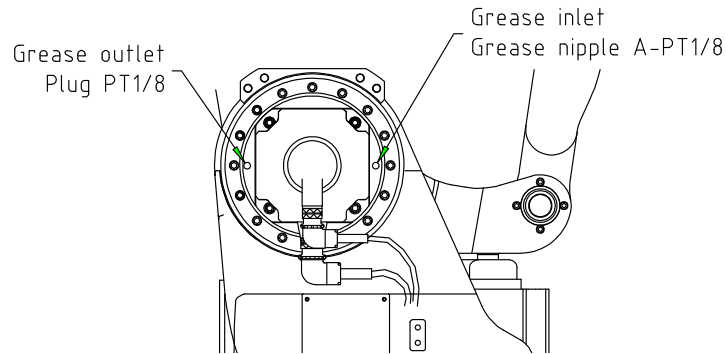
■ Grease Replacement

- ① Remove the grease outlet plug.
- ② Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 3,650cc

- ③ The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- ④ Move the S-Axis for a few minutes to eject the old grease and then add grease until the new grease appears in the outlet port
- ⑤ Wipe the outlet port with a cloth and attach the plug with seal tape.

5.1.2. H-Axis Reduction Gear



Attention

If grease is added without removing the outlet plug, it cause damage to the seal of reducer and grease will go inside the motor and may damage it. It is absolutely necessary to remove the plug.

■ Grease Replenishment

- ① Make the H-Axis Arm vertical for ground.(H:90°-Floor Type, H:0°-Shelf Type)
- ② Remove the grease outlet plug.
- ③ Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 300cc

- ④ Wipe the outlet port with a cloth and attach the plug with seal tape.

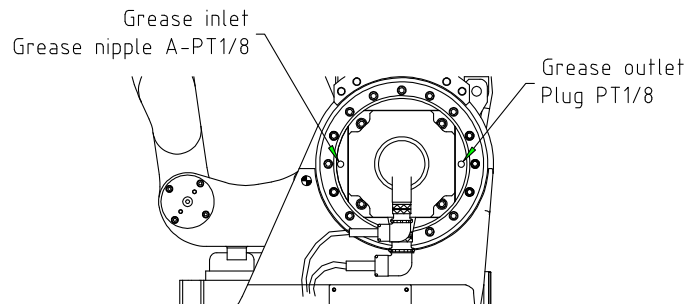
■ Grease Replacement

- ① Make the H-Axis Arm vertical for ground.(H:90°-Floor Type, H:0°-Shelf Type)
- ② Remove the grease outlet plug.
- ③ Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 1,600cc

- ④ The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- ⑤ Move the H-Axis for a few minutes to eject the old grease and then add grease until the new grease appears in the outlet port.
- ⑥ Wipe the outlet port with a cloth and attach the plug with seal tape.

5.1.3. V-Axis Reduction Gear



Attention

If grease is added without removing the outlet plug, it cause damage to the seal of reducer and grease will go inside the motor and may damage it. It is absolutely necessary to remove the plug.

■ Grease Replenishment

- ① Make the V-Axis Arm horizontal for ground.(V:0°-Floor Type, V:-90°-Shelf Type)
- ② Remove the grease outlet plug.
- ③ Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 300cc

- ④ Wipe the outlet port with a cloth and attach the plug with seal tape.

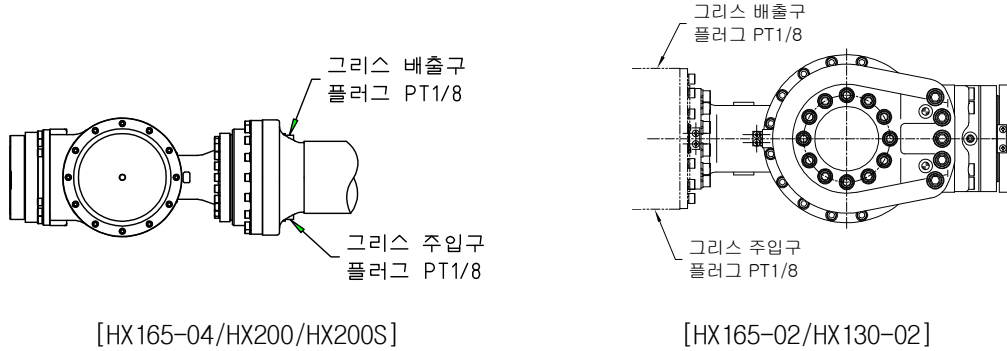
■ Grease Replacement

- ① Make the V-Axis Arm horizontal for ground. (V:0°-Floor Type, V:-90°-Shelf Type)
- ② Remove the grease outlet plug.
- ③ Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 1,600cc

- ④ The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- ⑤ Move the V-Axis for a few minutes to eject the old grease and then add grease until the new grease appears in the outlet port.
- ⑥ Wipe the outlet port with a cloth and attach the plug with seal tape.

5.1.4. R2-Axis Reduction Gear



Attention

Do not inject excessive grease. The excessive grease would cause an abnormal operation.

■ Grease Replenishment

- ① Prepare a grease nipple A-PT1/8.
- ② Remove the grease outlet plug.
- ③ Remove the grease inlet plug and install grease nipple A-PT1/8.
- ④ Inject the grease into the grease inlet using a grease gun.

HX165-04/200/200S

- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 250cc

HX165-02/HX130-02

- ✓ Grease type : Alvania0769
- ✓ Amount of grease : 30cc

- ⑤ Wipe the outlet port with a cloth and reinstall the inlet/outlet plugs with seal tape

■ Grease Replacement

- ① Prepare a grease nipple A-PT1/8.
- ② Remove the grease outlet plug.
- ③ Remove the grease inlet plug and install grease nipple A-PT1/8.
- ④ Inject the grease into the grease inlet using a grease gun.

HX165-04/200/200S

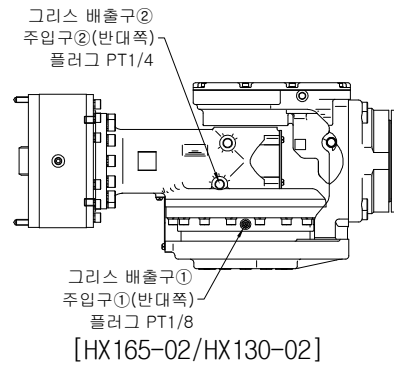
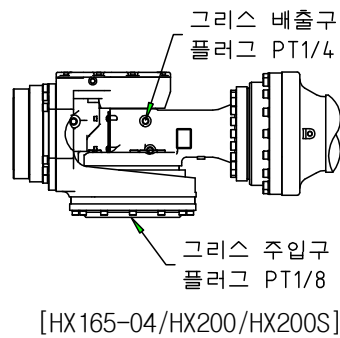
- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 1,100cc

HX165-02/HX130-02

- ✓ Grease type : Alvania0769
- ✓ Amount of grease : 140cc

- ⑤ The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- ⑥ Wipe the outlet port with a cloth and reinstall the inlet/outlet plug with seal tape.

5.1.5. B-Axis Reduction Gear



Attention

Do not inject excessive grease. The excessive grease would cause an abnormal operation.

■ Grease Replenishment

- ① Prepare a grease nipple A-PT1/8 and then Make the R2-Axis 0°degree.
- ② Remove the grease inlet plug and install grease nipple A-PT1/8.
- ③ Make the R2-Axis -90°degree and then Remove the grease outlet plug.
- ④ Inject the grease into the grease inlet using a grease gun.

HX165-04/200/200S

- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 250cc

HX165-02/HX130-02

- ✓ Grease type : Alvania0769
- ✓ Amount of grease : 30cc

- ⑤ Wipe the outlet port with a cloth and reinstall the inlet/outlet plugs with seal tape

■ Grease Replacement

[HX165-04/HX200/HX200S]

- ① Prepare a grease nipple A-PT1/8 and then Make the R2-Axis 0°degree.
- ② Remove the grease inlet plug and install grease nipple A-PT1/8.
- ③ Make the R2-Axis -90°degree and then Remove the grease outlet plug.
- ④ Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 950cc

- ⑤ The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- ⑥ Wipe the outlet port with a cloth and reinstall the inlet/outlet plug with seal tape.

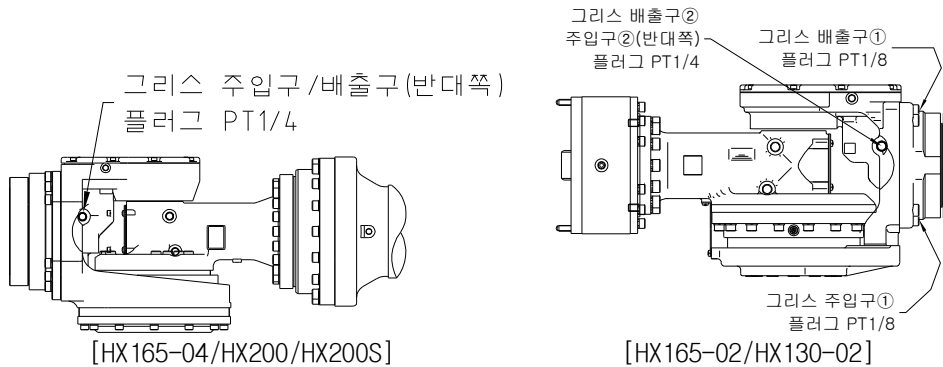
[HX165-02/HX130-02]

- ① Prepare a grease nipple A-PT1/8, A-PT1/4 and then make the R2-Axis 0°degree.
- ② Remove the grease inlet plug ①, ② and install grease nipple A-PT1/8, A-PT1/4.
- ③ Remove the grease outlet plug ①, ②.
- ④ Inject the grease into the grease inlet ①, ② using a grease gun.

- ✓ Grease type : Alvania0769
- ✓ Amount of grease : Inlet① - 140cc
: Inlet② - 250cc

- ⑤ The grease replacement is complete when new grease appears in the outlet port. The new grease can be distinguished from the old one by color.
- ⑥ Wipe the outlet port with a cloth and reinstall the inlet/outlet plug with seal tape.

5.1.6. R1-Axis Reduction Gear



Attention

There is no grease outlet. Do not inject excessive grease. The excessive grease would cause an abnormal operation.

■ Grease Replenishment

- ① Prepare a grease nipple A-PT1/8, A-PT1/4 and then Make the R2-Axis 90° degree.
- ② Remove the grease inlet/inlet① plug and install grease nipple A-PT1/8.
- ③ Inject the grease into the grease inlet using a grease gun.
- ④ Remove the grease outlet plug.

HX165-04/200/200S

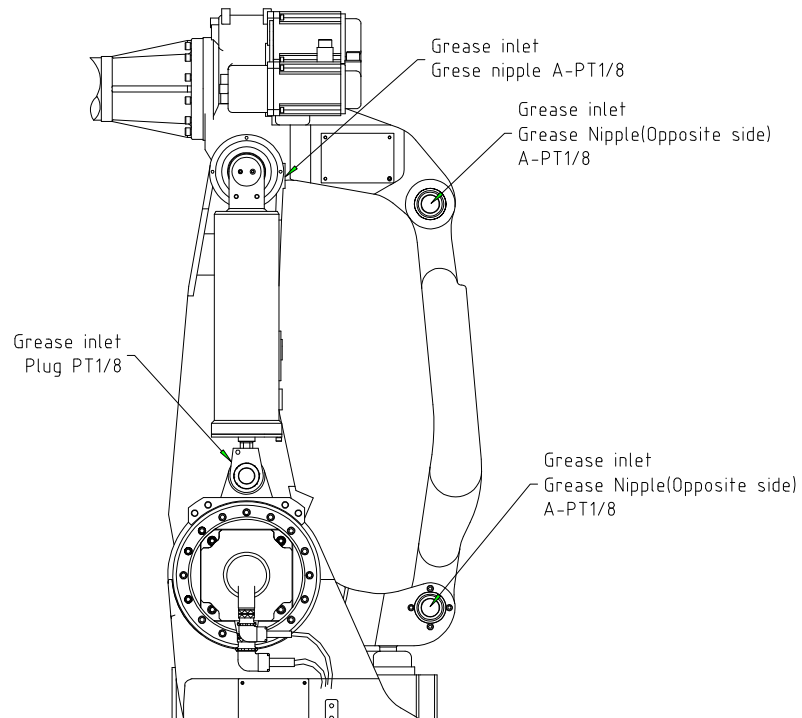
- ✓ Grease type : Molywhite RE00
- ✓ Amount of grease : 200cc

HX165-02/HX130-02

- ✓ Grease type : Alvania0769
- ✓ Amount of grease : 10cc

- ⑤ Wipe the outlet port with a cloth and reinstall the inlet/outlet plugs with seal tape

5.1.7. Bearing Joint Parts



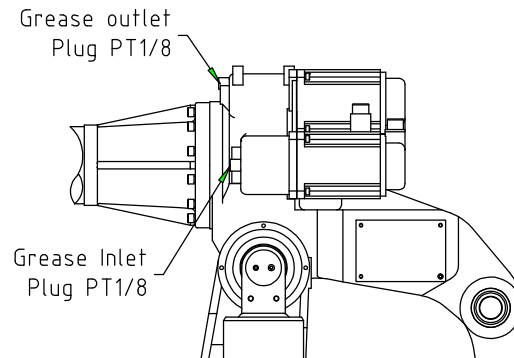
■ Grease Replenishment

- ① Prepare a grease nipple A-PT1/8.
- ② As necessary, remove grease inlet plug and install grease nipple A-PT1/8.
- ③ Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Alvania0769
- ✓ Amount of grease : 3cc

- ④ Remove grease nipple A-PT1/8 from grease inlet port.
- ⑤ Reinstall the grease plugs with seal tape.

5.1.8. A1 Frame - Gear Box



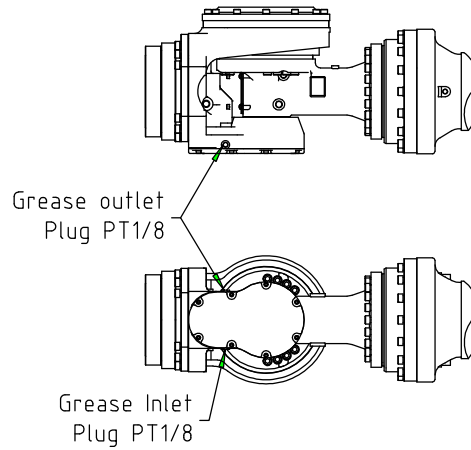
■ Grease Replenishment

- ① Prepare a grease nipple A-PT1/8.
- ② Remove the grease outlet plug.
- ③ Remove the grease inlet plug and install grease nipple A-PT1/8.
- ④ Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Alvania0769
- ✓ Amount of grease : 30cc

- ⑤ Remove grease nipple A-PT1/8 from grease inlet port.
- ⑥ Reinstall the grease plugs with seal tape.

5.1.9. Wrist - Gear Box



■ Grease Replenishment

- ① Prepare a grease nipple A-PT1/8.
- ② Remove the grease inlet plug and install grease nipple A-PT1/8.
- ③ Inject the grease into the grease inlet using a grease gun.

- ✓ Grease type : Alvania0769
- ✓ Amount of grease : 30cc

- ④ Remove grease nipple A-PT1/8 from grease inlet port.
- ⑤ Reinstall the grease plugs with seal tape.

5.2. Battery Replacement

The position data of each axis is preserved by the backup batteries. The batteries need to be replaced every two years. To replace batteries observe the following procedure.

- ① Keep the power on. Press the Emergency Stop button to prohibit the robot motion.



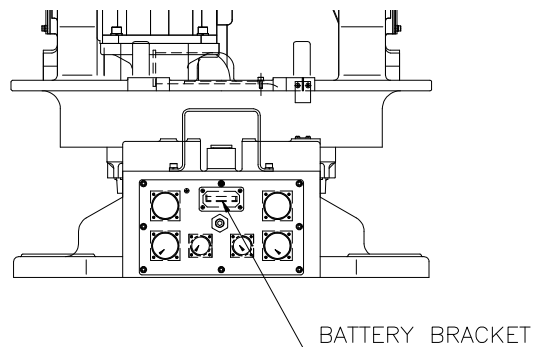
Attention

Replacing the batteries with the power supply turned off causes all current position data to be lost. Therefore, zeroing will be required again.

- ② Detach the battery bracket.
- ③ Take out the old batteries from the battery bracket.
- ④ Insert new batteries into it. Pay attention to the direction of batteries.

- ✓ Battery Spec. : ER6C(AA) 3.6V
- ✓ Manufacturer : Maxell

- ⑤ Reinstall the battery bracket.



Attention

- ✓ Do not dispose the batteries. Dispose of the battery with industrial waste according to the laws and other rules in the country where the controller is installed.
- ✓ Do not recharge the batteries, otherwise batteries may result in exploding or overheating.
- ✓ Do not use any batteries other than the recommended one.
- ✓ Change the batteries only with the specified one.
- ✓ Do not short positive and negative terminals of battery.
- ✓ Do not expose batteries to high temperature or flame

5.2.1. Instructions for Battery Storage

- (1) Do not keep the batteries at a high temperature and humidity. Keep it in the well-ventilating place without dew condensation.
- (2) Keep it in a normal temperature, at relatively constant temperature($20\pm 15^{\circ}\text{C}$) and at relative humidity of less than 70%.
- (3) Check the battery storage every six months, and manage them with first-in-first-out.

5.3. Internal Wiring

Replacement cycle of internal wiring depends on follows.

Continuous operation
Operating speed
Atmosphere/environment

Inspect on a regular basis, every three months and check any damage on the cables or cable protect spring. If any damage, replace it.

Replace the cable every 16,000 operating hours regardless of working condition.

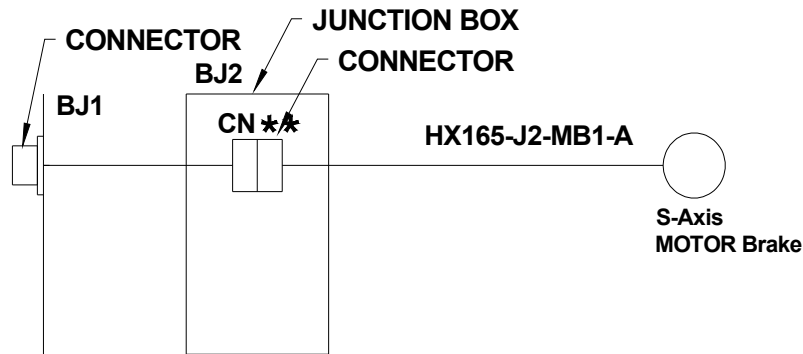


Attention

- ✓ As all the wires are flexible type, do not use any wires other than specified one.
- ✓ Wiring replacement must be done by unit.
- ✓ Do not use any Cable, protective spring, and Hose that have external damage as they may cause future problems.
- ✓ When purchasing robot cables, make inquiry of our service office about wiring type.
- ✓ Specify the length of wiring for connecting the robot with the controller.

5.3.1. Wiring Connection Diagram

Refer to [Fig 5.1] for part symbols of the internal wiring.



HX165 - J2 - MB1 - A

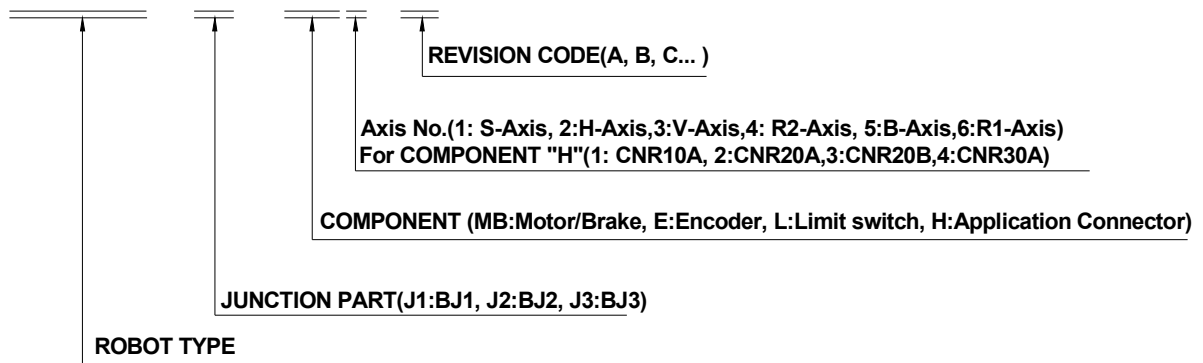
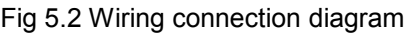


Fig 5.1 Explains of internal wiring





6

Troubleshooting



6. Troubleshooting

HX130/HX165/HX165S/HX200/HX200S

6.1. Troubleshooting Procedure

If a failure occurs during robot's operation, but it does not stem from the controller, it must be caused by damage on machine parts. The way to troubleshoot as quick and easy as possible should be to diagnose the problem. In addition, it is necessary to determine which parts cause the problem.

- (1) Step 1 : Which axis occurs the problem?
First of all, check which axis causes the malfunction. In case that it is hard to detect the problem, check the following possible mechanical defaults.
 - Is there any parts making noise?
 - Is there any parts generating an overheating?
 - Is there any parts have a play or backlash?
- (2) Step 2 : Which parts have been damaged?
If the abnormal axes are determined, investigate which parts cause trouble. There could be many causes for one phenomenon. Refer to [Table 6-1] for the cause and phenomenon of the trouble.
- (3) Step 3 : Dealing with malfunction parts
If the malfunction parts are confirmed, conduct relevant repair procedure based on the chapter 『6.3 Diagnostics and Resolutions for Major Parts Failure』. Contact our service office if you have any difficulties in dealing with problems.

6.2. Trouble Symptoms and Possible Causes

As shown in [table 6-1], there may be many parts as the cause of one phenomenon.
Refer to next page to determine which part is malfunction.

Table 6-1 Trouble phenomenon and cause

Trouble phenomenon \ Defect parts	Reduction gear	Brake	Motor	Encoder	Fulcrum bearing
Overload [Note 1]	○	○	○		○
Displacement	○		○	○	
Abnormal sound occurrence	○	○	○		○
Noise in operation [Note 2]			○		○
Staggering at stop [Note 3]			○	○	○
Irregular twitching [Note 4]			○	○	○
Abnormal deviation			○	○	
Free fall of an axis	○	○			
Overheating	○	○	○	○	
Incorrect action and out of control movement			○	○	

[Note 1] Overload ----- Phenomenon occurring when a load exceeds the rated motor load.
In specific, thermal relay of circuit protector is tripped.

[Note 2] Noise in operation ----- Phenomenon which occurs vibration on operation.

[Note 3] Staggering at stop ----- Phenomenon which gives oscillating motion when the robot stops.

[Note 4] Irregular twitching ----- Phenomenon which gives sporadic twitching when the robot is not in motion.

6.3. Diagnostics and Resolutions for Major Parts Failure

6.3.1. Fulcrum Bearings

Vibration, abnormal sound and overloads are observed when a fulcrum bearing is damaged. When the Nut holding bearings becomes loose, bearing play occurs. It may damage the bearings.

■ Diagnostics

- ① Shake the 1st ARM and 2nd ARM back and forth to check if bearing exhibits any play. (In case of using a chain block, check the bearings for the play, with the 1st ARM and 2nd ARM posture maintaining and without any overload to the reduction gear.
- ② Check to see if the robot touched other peripheral equipment before the malfunction.

■ Resolution

Replace the bearing. A Chain Block is needed to lift and hang the robot ARM. Contact our service office for any difficulties.

6.3.2. Reduction Gear

Vibration and abnormal sound will be occurred when a reduction gear is damaged. In this case, it causes overload and abnormal deviation disturbing normal operation. Sometimes overheating may result. The robot may also become completely immovable, or a position offset error may occur.

[Main Axes (S, H, V)]



When turning [ON][OFF] the brake release switch of axis H and axis V, be sure to take necessary precautions to prevent the ARM from dropping, and then switch the brake release [ON][OFF]..

■ Diagnostics

- ① Check out any vibration, abnormal sound or overheating of the reduction gear when the robot is in operation.
- ② Check out any play and abrasion in the reduction gear. And check if any abnormality is felt by hand when shaking 1st ARM back and forth with the brake release switch of axis S [ON].
- ③ Check if peripheral equipment has been contacted with the robot before the abnormality. (Damage may occur to the reduction gear due to the contacting impact.)

■ Resolution

Replace the reduction gear. A chain block is needed to lift and hang the robot ARM. Contact our service office for any difficulties.

[Wrist Axes (R2, B, R1)]



When turning [ON][OFF] the brake release switch, be sure to take necessary precautions to prevent the ARM from dropping, and then switch the brake release [ON][OFF].

■ Diagnostics

- ① Check out any vibration, abnormal sound, or overheating of the reduction gear when the robot is in operation.
- ② Check out any play in the reduction gear by shaking the End Effector (such as spot gun and hand devices, etc.) back and forth.
- ③ Turn motors off , with the brake release switch [ON], and check that the axis can be rotated by hand. If not, the reduction gear is in bad condition.
- ④ Check if peripheral equipment has been contacted with the robot before the abnormality. (Damage may occur to the reduction gear due to the contacting impact)

■ Resolution

- ① Replace the reduction gear.
- ② Replace the entire wrist section.
(The replacement of entire wrist should be a quick and reliable resolution as it takes time and necessary equipment for reduction gear replacement)

6.3.3. Brakes

In case of brakes failure, each axis possibly drops with the motors [OFF]. Or, in reverse, brakes possibly operate even with the motors [ON]. The latter causes overload and noise.



When intending to operate the entire robot without the motors [ON], operate it with the brake release switch [ON]. Before turning the switch [ON], take necessary precautions to prevent the ARM from dropping as the robot ARM will drop by gravity.

■ Diagnostics

Check if the brake can be heard in operation, by turning the brake release switch [ON] [OFF] alternately with the motors[OFF]. If not heard, the brake cable may be broken. (When operating the brake release switch [ON][OFF], be careful of ARM dropping. The brake release switch is located on the panel in the controller cabinet door.)

■ Resolution

If cables turn out to be good condition, replace the motor.

6.3.4. Motor

Motor failure causes abnormal operation of robot such as staggering at stop, irregular twitching and noise in operation. Besides, It may cause overheating and abnormal sound.

Check the reduction gear and fulcrum bearing as well in order to determine which part causes the abnormality. It is because that similar phenomenon is observed when the reduction gear is damaged.

■ Diagnostics

Check for overheating and abnormal sound. .

■ Resolution

Replace the motor.

6.3.5. Encoder

Position offset, malfunction, and out of control movement as well as staggering at stop, irregular twitching may occur when the Encoder is in bad condition. This case has nothing to do with such phenomena as mechanical abnormal sound, overheating, and vibration

■ Diagnostics

- ① Check for any encoder data failure.
- ② Use reference pins and blocks to check the positional data is correct at pin position.
- ③ Check for any irregular variations in the encoder data when moving each robot axis.
- ④ Replace the servo amp board, BD440 to check errors.

■ Resolution

- ① If cabling turns out to be in good condition without any damage, replace the encoder.
- ② If there is no error after replacing the servo amp board BD440, replace the servo amp board.

6.4. Motor Replacement



Warning:

When motor is separated, the ARM will drop due to its built-in brakes inside the motor for holding robot's posture. Take necessary precautions such as fixing A2 FRAME with 2nd ARM by using M20×250 bolts or lifting and hanging the ARM by using crane as shown in the Figure in order to prevent such dropping. Do not hold the ARM in your hand.

In case of contacting the motor right after it stops, ensure the motor temperature. Motor weights are listed as follows. Be careful when dealing with the motor.

Table 6-2 Motor Weight

Robot model	Weight of main axes motor	Weight of wrist axes motor
HX130/HX165/HX165S/HX200/HX200S	27 kg	10.7 kg

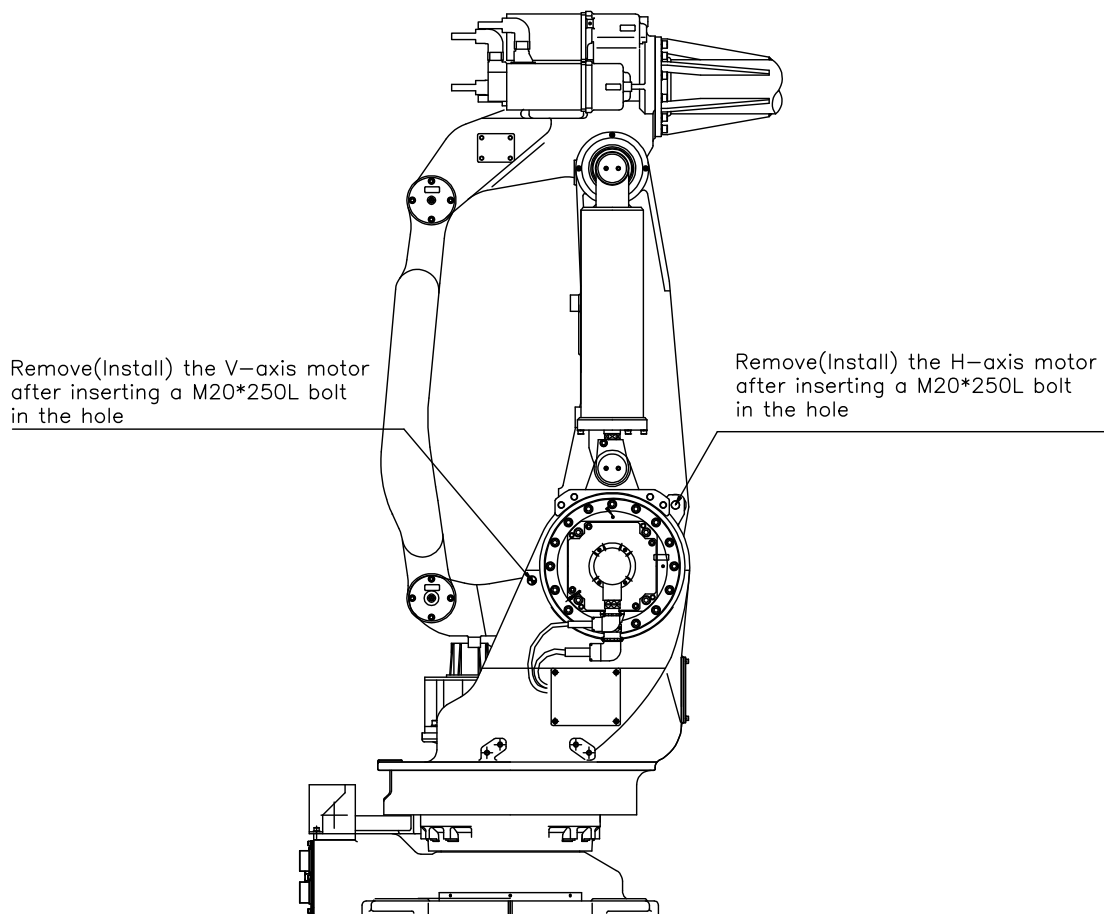


Fig 6.1 How to prevent dropping of ARM Axis H & V : (HX130/HX165/HX200)

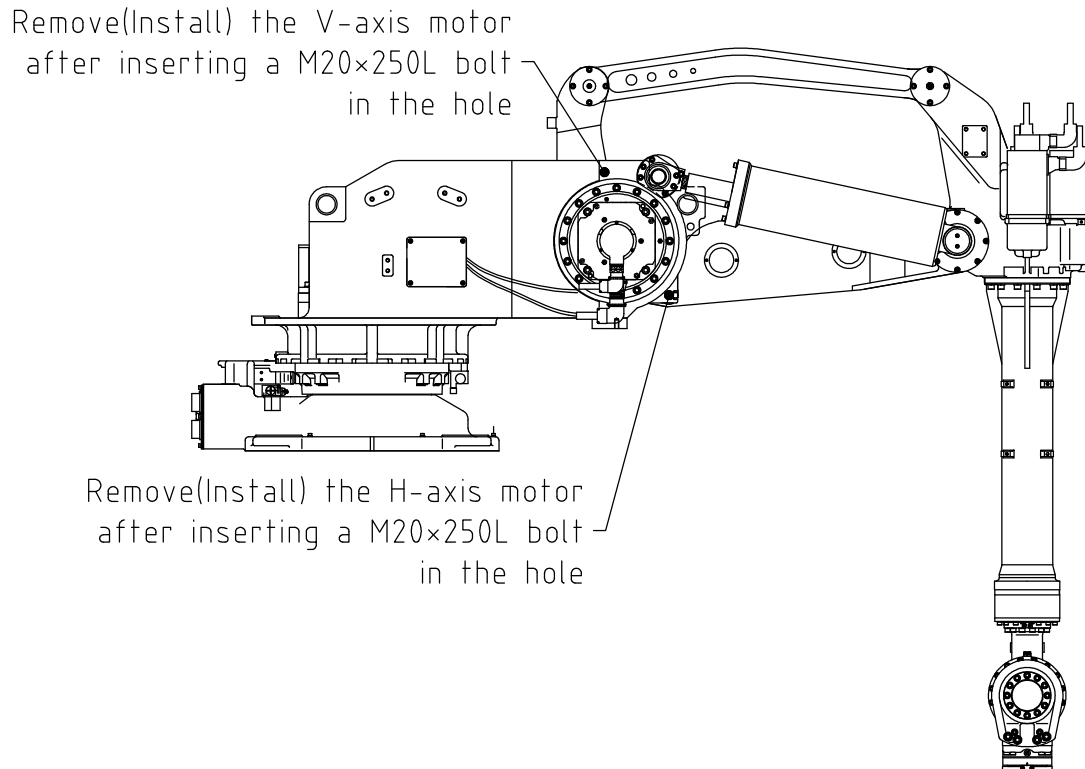


Fig 6.2 How to prevent dropping of ARM Axis H & V : (HX165S/HX200S)



Warning:

In this work, there is a part performed with the motor [ON]. Therefore, perform the work in pairs. An observer must always be ready to activate an emergency stop. The other perform the work quickly and carefully. An escape route should be determined before starting work.

After replacing axis H or V, ensure that M20 bolt for supporting ARM has been removed before operating the robot.

6.4.1. Necessary Tools and Parts

Table 6-3 Necessary Tools

Tool Name	Axis Name	Part No.(Model)	Remark
Torque wrench (prepared by user)	S, H, V	M12 Torque wrench(Lock type)	Use torque wrench and extension on the market
	R2, B, R1	M8 Torque wrench (Lock type) M5 Torque wrench (Lock type)	

Table 6-4 Necessary parts

Part Name	Axis Name	Use or not	Part No.(Model)
Dropping preventive bolt (optional)	main axes (H, V)	○	M20×250(Standard)
	Wrist Axis(R2, B, R1)	-	-

6.4.2. How to Replace Motor

- (1) Put the controller into TEACH mode and select motors [ON]. When the motors [On] state cannot be obtained, check the respective ARM is firmly fixed while supporting it to prevent dropping. And then begin at step No.4.
- (2) The axis requiring motor replacement takes basic posture.
- (3) In case of main axes(S, H, V) : Refer to [Fig 6.1] and [Fig 6.2].
Insert a supporting bolt to prevent ARM dropping.
In case of wrist axes (R2, B, R1) : Set the origin by using SCALES.
- (4) Turn the main power[OFF] with the controller power [OFF].
- (5) Disconnect the connector from the motor.
- (6) Remove attachment bolts of motor and pull the motor out of robot. When removing motors of axis H or V, be sure not to damage the lip of oil seal due to the gear attached to the axis of motor.
- (7) Detach the gear from the motor shaft. not give excessive impact to the motor shaft.
- (8) Assemble the gear after lightly applying grease to the shaft.
The bolt used to attach the gear to the shaft should be cleaned and removed of grease before using. Apply loctite 243 to the screw part of the bolt, and then tighten it using a torque wrench in a regular torque. , Besides, slowly tighten the bolt in a symmetrical order.
- (9) Assemble the motor on the robot after applying a small amount of grease to the lip of oil seal and applying a moderate amount of grease to the teeth of gear. When assembly the main axis motor, be sure not to damage the lip of oil seal.
- (10) Connect the connector to the motor.
- (11) When replacing the axis H or V, replenish the grease as the amount as it lost.
- (12) Reset the encoder of the axis whose motor is replaced.



Warning

Before encoder correction, check motor connections, with motors [ON], while pressing the Enable switch for 2~3 seconds.

- (13) Perform the encoder calibration about the axis whose motor is replaced. Refer to the chapter [Encoder Calibration] in the controller operating manual..
- (14) Remove M20 bolt, a supporting bolt for preventing possible dropping of axis H or V.
- (15) Confirm that there is no error in robot's motion.

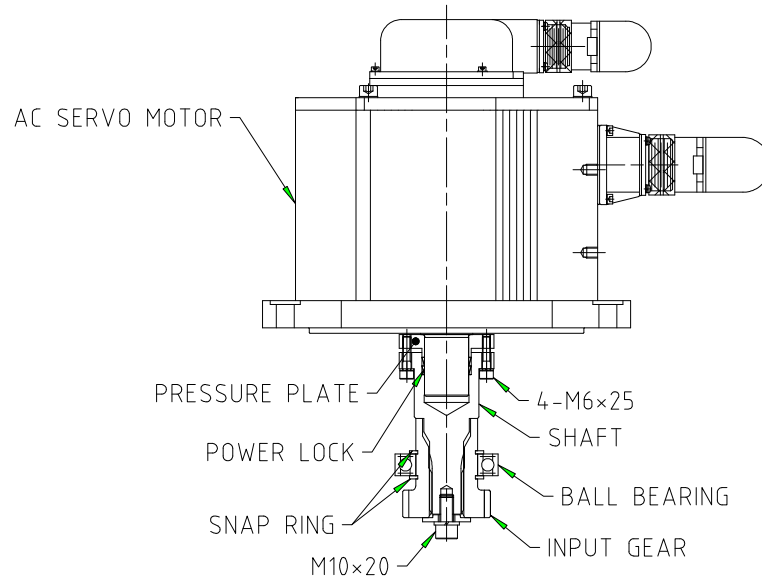


Fig 6.3 Axis S motor assembly

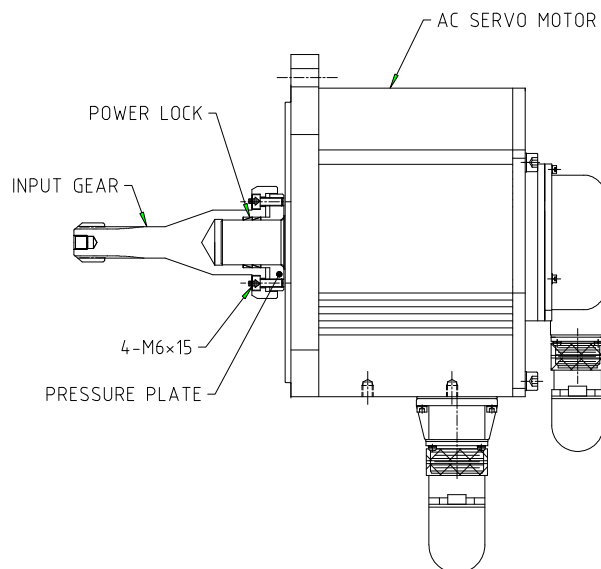


Fig 6.4 Axis H & V motor assembly

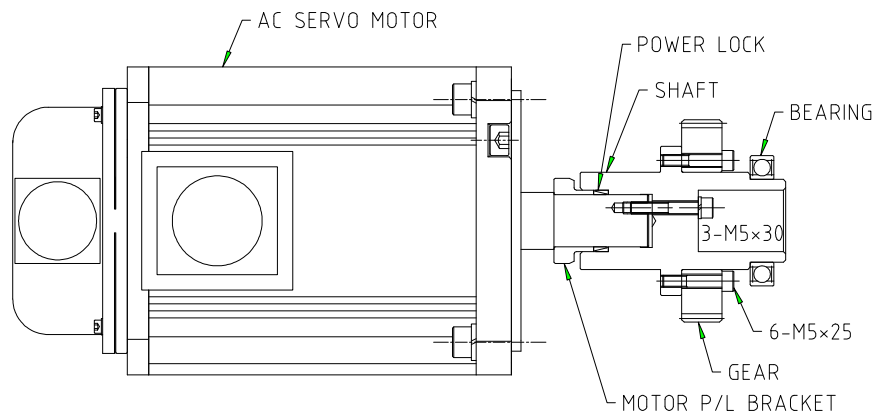


Fig 6.5 Wrist axis motor assembly

6.5. Encoder Zero Setting

It is necessary to reset the origin when encoder data has been corrupted due to some problems and when the motor is replaced.

Level and Block is adopted as the position setting method for each axis. The origin must be set in order of axis 4, 5, and 6 considering axis interference of the wrist due to its structural characteristic.



Warning

In this work, there is a part performing in the state of motor [ON]. Therefore, this work must be performed in pairs. One must always be ready to activate an emergency stop. The other must perform the work quickly but carefully.

An escape route should be determined before starting work.

6.5.1. Zero Setting

- (1) Put the controller into TEACH mode and select [MOTORS ON]. If you cannot select MOTOR On due to abnormality, set the origin position of the robot by using the brake release switch.
- (2) Move respective axes to the basic posture, then set them by the scale mark.
- (3) Reset the Encoder. Refer to 『6.5.2 Encoder Reset』 for the method of encoder reset.
- (4) Correct the encoder. Refer to 『Hi4a Controller Operation Manual』.
- (5) Confirm that there is no problem in robot motion.

6.5.2. Encoder Reset

- (1) Turn the controller power [ON] for 3 minutes, and then turn it [OFF].
- (2) Take off the rear cover of the robot. (Check the batteries/encoder backup batteries are well connected.)
- (3) Turn the controller power [ON].
- (4) After connecting the reset connector(CNRST1~6) of the axis to reset with the plug located in the cover of the rear robot for 5 seconds, pull the reset plug out. (Reset connectors of the respective axis should be connected for the reset work only. Besides, there is usually no connection in the reset connector.
- (5) Cover the rear of the robot.

Table 6-5 Reset connectors corresponding to axes

Axis Name	Connection of Reset connector pin [CNRST1 ↔ RESET CONNECTOR]
S	RST1 ↔ RST(1), P5E ↔ RST(2)
H	RST2 ↔ RST(1), P5E ↔ RST(2)
V	RST3 ↔ RST(1), P5E ↔ RST(2)
R2	RST4 ↔ RST(1), P5E ↔ RST(2)
B	RST5 ↔ RST(1), P5E ↔ RST(2)
R1	RST6 ↔ RST(1), P5E ↔ RST(2)

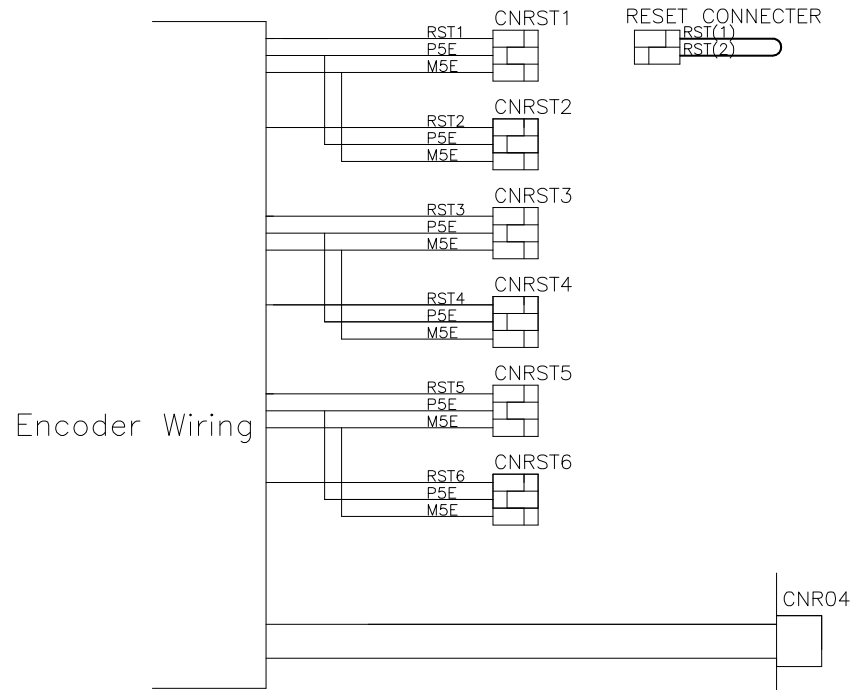


Fig 6.6 Encoder Reset Connector

6.5.3. Confirming the Reset



Warning

This operation is used to verify an encoder reset was performed correctly. Note this procedure is different from 『Encoder Calibration』 which determines encoder data from basic posture of the robot.

The number of pulses per revolution of the currently used encoder data is 8192bit irrespective of the robot model. The current value of encoder displays what is added by compensation value to the actual encoder value. In other word, the difference between the current value of encoder and the absolute compensation value of encoder is real encoder value.

After reset, the actual encoder value is classified as what it becomes less than 1 revolution and as what it becomes less than minus 1 revolution depending on the robot model. Follow the procedure below to confirm the encoder has been successfully reset.

- ① Connect the encoder connectors of motors and turn controller power on. Select 『Encoder Calibration』 in a constant setting mode, and select 『Encoder Calibration (Input Value)』 at the next display. The encoder calibration value for each axis is displayed in left-side and the present encoder value in right-side.
- ② Move the cursor to the encoder calibration value of axis that were reset, and press 『0』.
- ③ Confirm that the present encoder value is within the range of 0~8191. If not, reset the encoder again.



Warning

After connecting the motor, the following errors may occur according to the discharge of electricity of the encoder internal capacitor.

- E0107 Encoder error: Poor bit sequence
- W1014 : Voltage drop of encoder battery.

In this case, turn controller power on for more than 10 minutes, and reset encoder.

And then, turn controller power 『OFF』 once again, and power 『ON』. It will be restored to normal condition.

6.5.4. Encoder Calibration(Data input) and Selection

- IT is necessary to compensate encoder data for the basic position of each axis.
- Refer to 『Encoder calibration』 in the Controller Manual for details.
- Select 『Encoder calibration (Position Rec)』 in the mode of Constant.

[Encoder Calibration Screen]

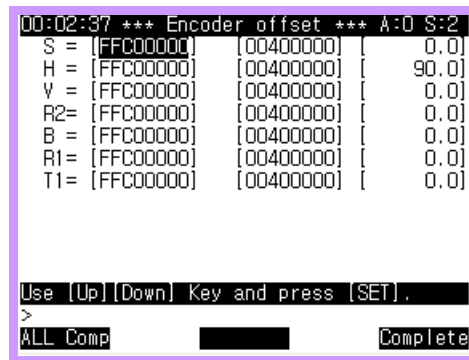


Table 6-6 Data range after resetting

Axis	Data range after resetting	Number of pulses per an encoder revolution
All of Axes	0 ~8191	8192

- (1) Press [SET] key after moving the revolving bar into the desired location to set by using [↓][↑] keys, and the following message is displayed.



- (2) Move the robot to the position that the origin pin becomes [ON] with axis operating button, and press [REC] key.
- (3) Press 『[PF5]: Complete』 to complete setting.



Warning

In case of encoder DATA compensation after replacing motor, check if the motor power is on with the power 『ON』.



7

**Recommended
Spare Parts**



7. Recommended Spare Parts

HX130/HX165/HX165S/HX200/HX200S

The recommended spare parts for robot are as follows. Please check robot serial number and manufacturing date when purchasing, and contact our service office.

[Category]

A : Regular maintenance parts(what is replaced regularly)

B : Essential spare parts (what is of high frequency)

C : Essential component parts

D: Machine parts

Table 7-1 Spare Parts List I

Category	Part Name	Manufacturer	Applicable Model	Per Unit		Application
		Specification		Use	Rec.	
B	AC servo Motor	HHI		3EA	1EA	Common use for Axis S, H, and V
		TS4923N8030E230	★			
B	AC servo Motor	HHI		3EA	1EA	Common use for Axis R2, B, and R1
		TS4836N8030E230	★			
C	RV Reduction gear	HHI		1EA	1EA	Axis S
		RV320C-35.61	★			
C	RV Reduction gear	HHI		1EA	1EA	Axis H
		RV320E-185	HX200/165S			
		RV320E-171	HX165			
		RV320E-141	HX130			
C	RV Reduction gear	HHI		1EA	1EA	Axis V
		RV320E-219.46	HX200			
		RV320E-190.09	HX165			
		RV320E-185(PIN)	HX165S			
		RV320E-141	HX130			

7. Recommended Spare Parts

Category	Part Name	Manufacturer	Applicable Model	Per Unit		Application
		Specification		Use	Rec.	
C	RV Reduction gear	HHI		1EA	1EA	Axis R2
		RV110F-70.76	HX200			
		RV110F-65	HX165			
		F2CS-A35Mup-89	HX165S			
		F2CS-A35Mup-59	HX130			
C	RV Reduction gear	HHI		1EA	1EA	Axis B
		RV110E-111	HX200			
		RV70F-93.85	HX165			
		F2CS-A35-89	HX165S			
		F2CS-A35-59	HX130			
C	RV Reduction gear	HHI		1EA	1EA	Axis R1
		RV80E-101	HX200			
		RV40E-81	HX165			
		F2CS-A35Mup-89	HX165S			
		F2CS-A35Mup-59	HX130			

- ※ 1. ★ is applied for HX130/HX165/165S/200 models in common.
 2. Here, HX165 Model means HX165-04 Model.

Table 7-2 Spare Parts List II

Category	Part Name	Manufacturer	Applicable Model	Per Unit		Application
		Specification		Use	Rec.	
A	Grease	HHI	★		16kg/ CAN	RV Reduction gear
		MOLY WHITE RE00				
	Grease	HHI	★		16kg/ CAN	CYCLO Reduction gear, Gear and Bearing of each axis
		Alvania 0769				
A	Encoder Battery	HHI	★	3EA	3EA	Replace every 2 years, regardless of operating hours
		HX130?LB*-A,*:1~6				
C	Wrist ass'y	HHI	HX200	1EA	1EA	
		R12-127013-02				
		R11-290400-01	HX165			
		R11-187014-02	HX165S			
C	Axis S Wiring ASS'Y	HHI		1EA	1EA	Cable from BJ1 to main axis motor and right/left side of robot
		R11-290501-01	★			
C	Axis A2 Wiring ASS'Y	HHI		1EA	1EA	Cable from right/left side of robot to each wrist axis motor
		R11-290502-00	HX200,HX165			
		Make inquiry	HX165S			
		R11-290502-00	HX200S			

7. Recommended Spare Parts

Table 7-3 Spare Parts List III

Category	Part Name	Manufacturer	Applicable Model	Per Unit		Application
		Specification		Use	Rec.	
D	Ball bearing	HHI		1 EA	1 EA	Support center shaft in A2
		6017ZZ	HX165/HX200/HX200S			
		6017DDU	HX165/HX200/HX200S	1 EA	1 EA	
D	Taper Roller Bearing	32014XJ	HX130/HX165S	2EA	2EA	
D	Taper Roller Bearing	HHI		4 EA	4 EA	Joint lower and upper Link of axis V in A2
		32009XJ	★			
D	Taper Roller Bearing	HHI		2 EA	2 EA	Joint upper ARM in A2
		32019XJ	★			
D	Double Row Roller Bearing	HHI		2 EA	2 EA	Support lower balance spring in A2
		NAG4909UU	★			
D	shperical Roller bearing	HHI		2 EA	2 EA	Support upper balance spring in A2
		GE45EC-2RS	★			
D	Oil-Seal	HHI		1 EA	1 EA	Wrist holder cast-iron (holder) in W1
		AE3932A9	HX200/HX200S			
		AE3842A0	HX165/HX130/HX165S			
D	Oil-Seal	HHI		1 EA	1 EA	Center shaft in A2
		AC3994E0	HX165/HX200/HX200S			
		AE3527E0	HX130/HX165S			

Category	Part Name	Manufacturer	Applicable Model	Per Unit		Application
		Specification		Use	Rec.	
D	Oil-Seal	HHI		1 EA	1 EA	Motor Base in S1
		AC4451F2	★			
D	Oil-Seal	HHI		2 EA	2 EA	Motor H and V assemble surface in A2
		AC3744A0	HX165/HX200/HX200S			
D	V-ring	HHI		2 EA	2 EA	Upper shaft of upper ARM in A2
		V95A	★			

7. Recommended Spare Parts

Table 7-4 Spare Parts List IV

Category	Part Name	Manufacturer	Applicable Model	Per Unit		Application
		Specification		Use	Rec.	
D	O-ring	HHI		1 EA	1 EA	Case surface of axis B reduction gear
		G190	HX200/HX200S			
		ARP568-263	HX130/HX165S			
D	O-ring	HHI		1 EA	1 EA	Case surface of axis R1 reduction gear
		ARP568-263	HX200/HX200S			
		ARP568-258	HX165			
D	O-ring	HHI		1 EA	1 EA	Bearing housing in W1
		AS568-042	HX200/HX200S			
		S75	HX165			
		AS568A-041	HX130/HX165S			
D	O-ring	HHI		1 EA	1 EA	Assemble surface of frame and pipe in A1
		AS568A-169	★			
D	O-ring	HHI		1 EA	1 EA	Case of Axis R2 reduction gear in A1
		190*3	HX165/HX200/HX200S			
		S150	HX130/HX165S			
D	O-ring	HHI		2 EA	2 EA	Case of Axis H and V reduction gear in A2
		G270	★			
D	O-ring	HHI		1EA	1EA	Mechanical Interface assemble surface
		S135	HX165			

Table 7-5 Spare Parts List V

Category	Part Name	Manufacturer	Applicable Model	Per Unit		Application
		Specification		Use	Rec.	
D	O-ring	HHI		2 EA	2 EA	Balance spring ASS'Y in A2
		G135	HX130			
		G150	HX165S/HX200S			
		P40	HX165S/HX200			
		P55	HX165S/HX200S			
		S140	HX165/HX200			
D	O-ring	HHI		1 EA	1 EA	Assemble surface of reduction gear shaft and base body in S1
		G290	★			
D	O-ring	HHI		1 EA	1 EA	Axis S1 reduction gear case and output shaft
		ARP568-281	★			
D	O-ring	HHI		1 EA	1 EA	Assemble surface of base body and reduction gear shaft in S1
		G210	★			



8

Internal Wiring Diagram



8. Internal Wiring Diagram

HX130/HX165/HX165S/HX200/HX200S

Internal wiring is shown in a connection diagram per unit, and thus utilize it to inspect and replace the wiring.

8.1. Manipulator Configuration

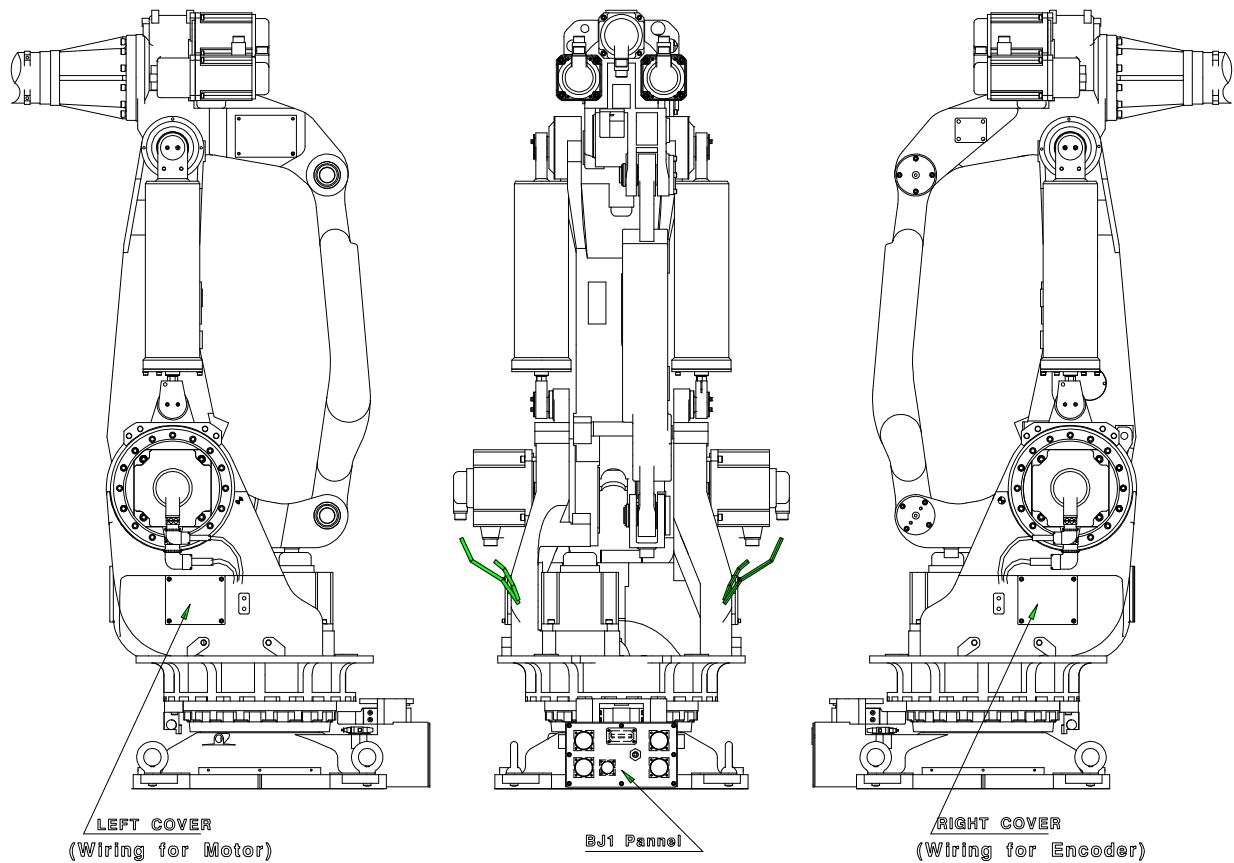


Fig 8.1 Manipulator Configuration

8.2. Wiring Diagram

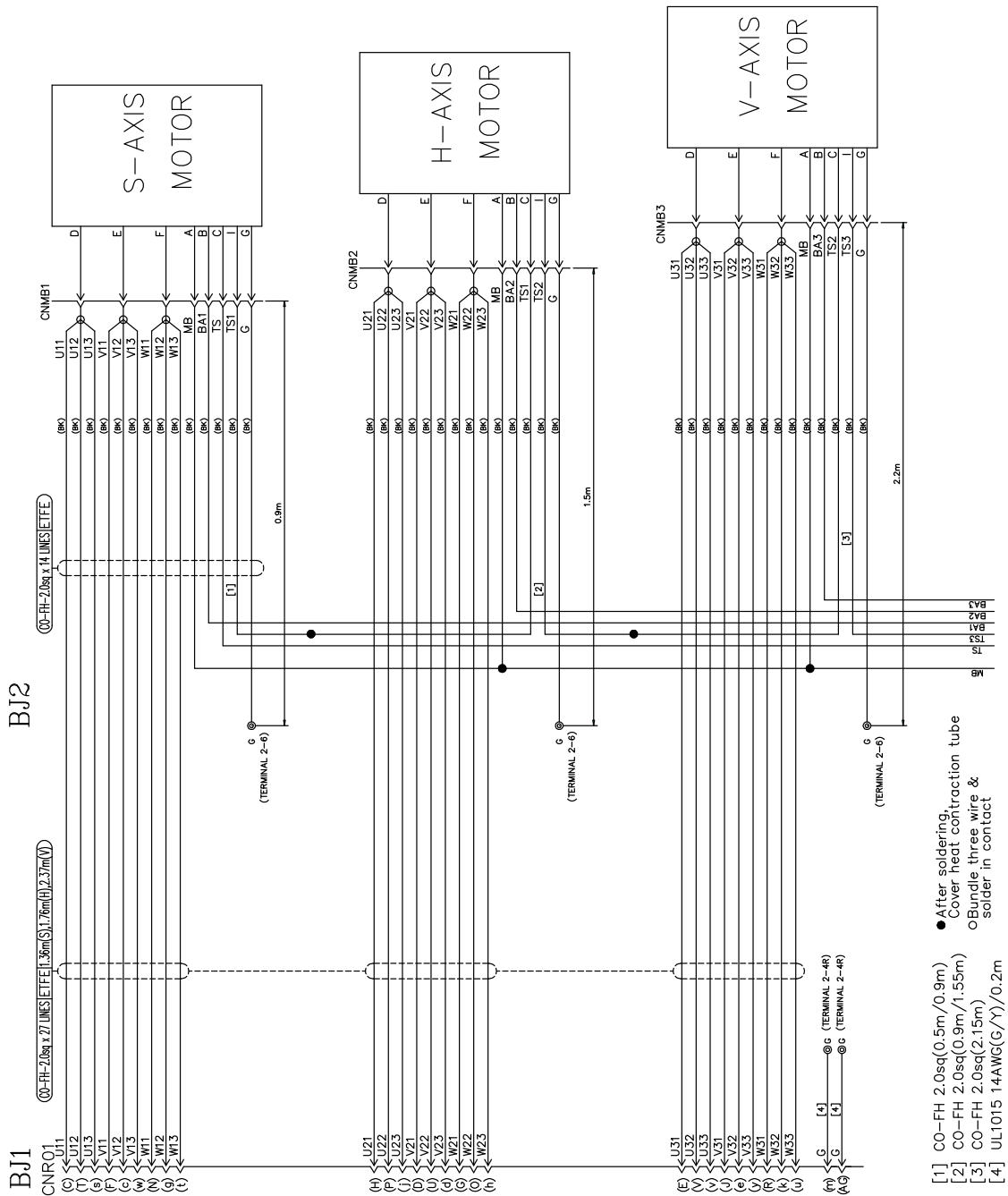


Fig 8.2 Motor and Brake wiring connection No.1

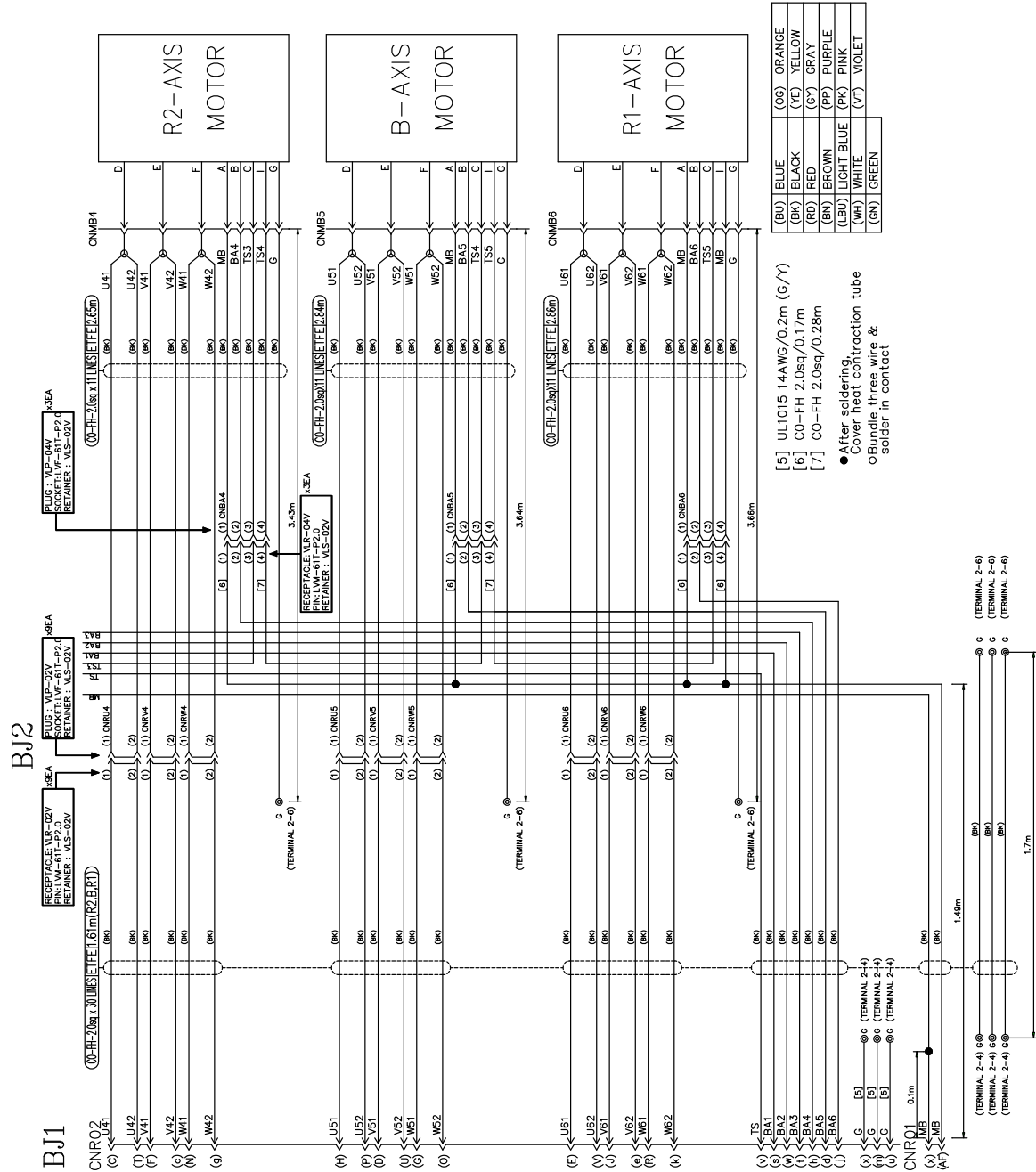


Fig 8.3 Motor and Brake wiring connection No.2

8. Internal Wiring Diagram

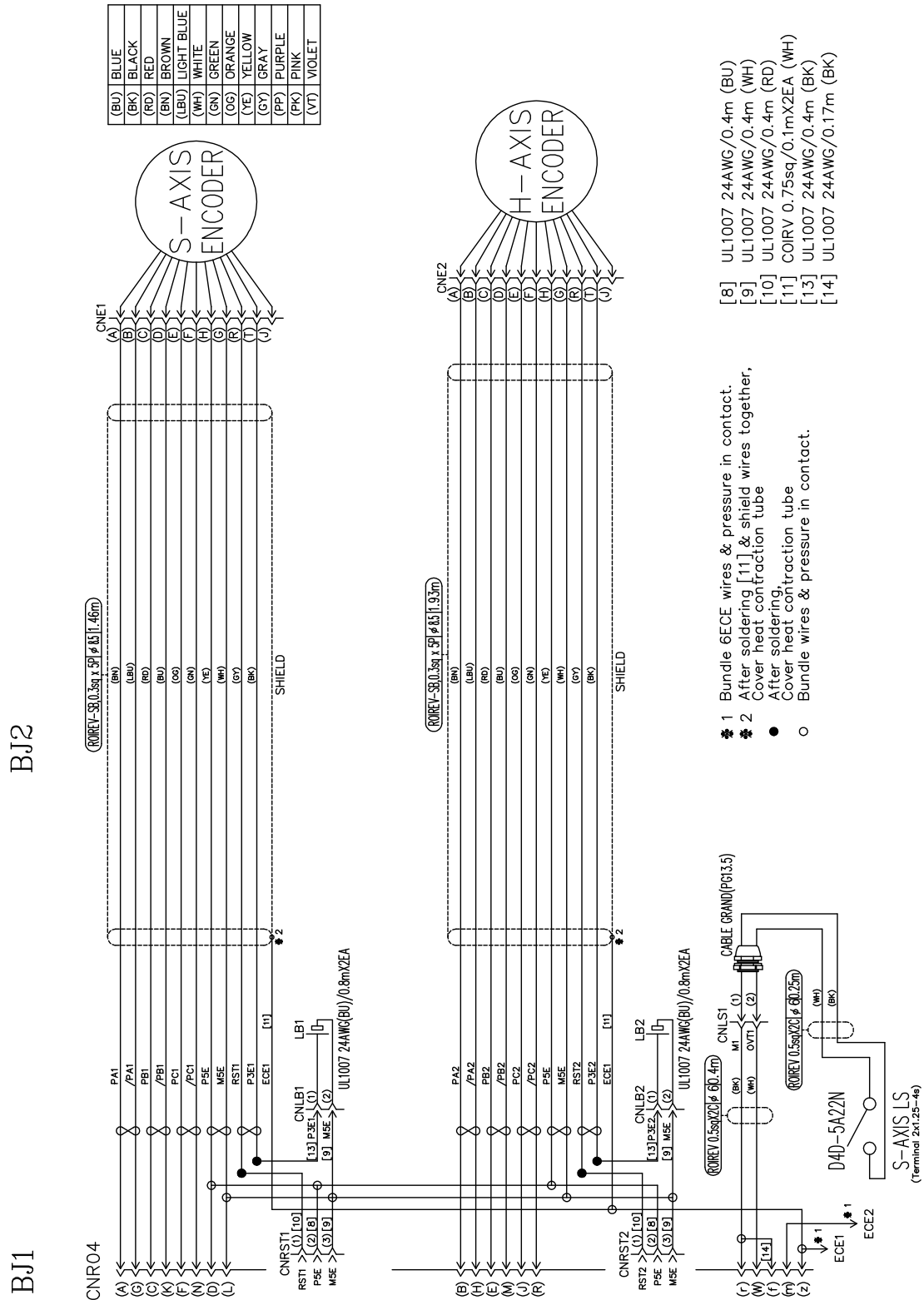
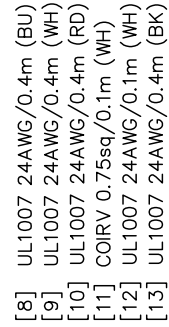


Fig 8.4 Encoder wiring Connection No.1



8. Internal Wiring Diagram

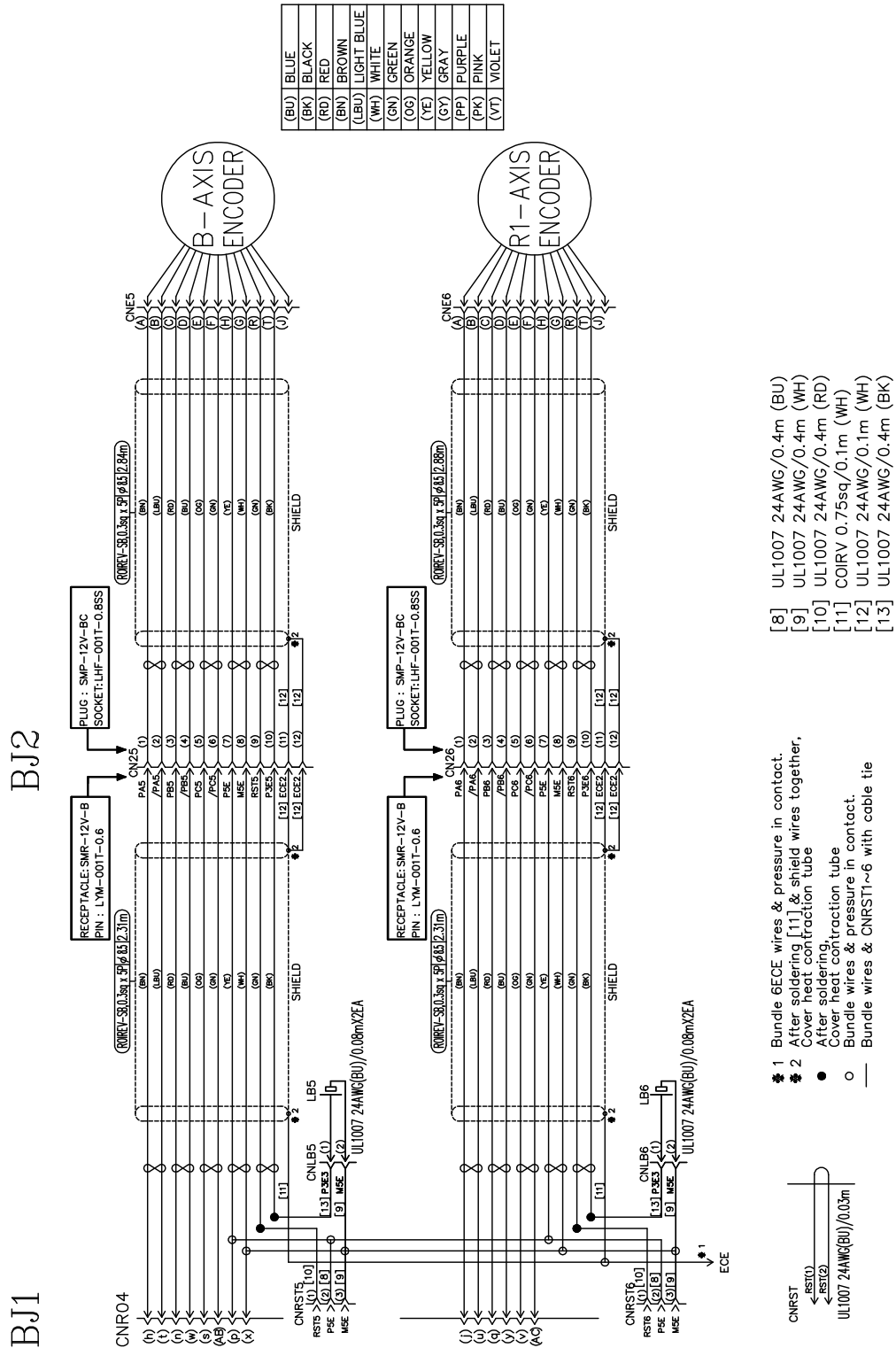


Fig 8.6 Encoder Wiring Connection No.3

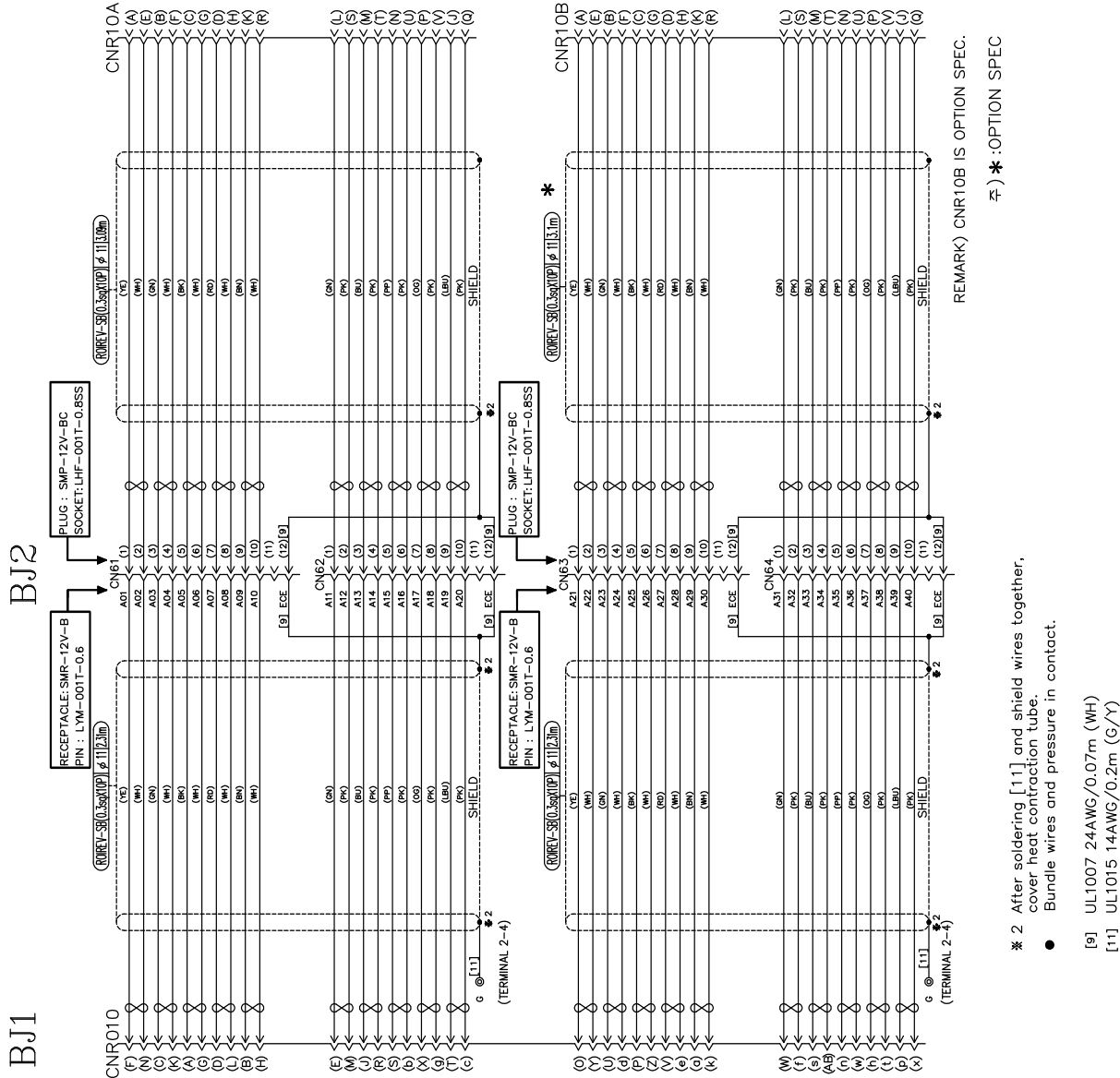


Fig 8.7 Application Wiring Connection No.1

8. Internal Wiring Diagram

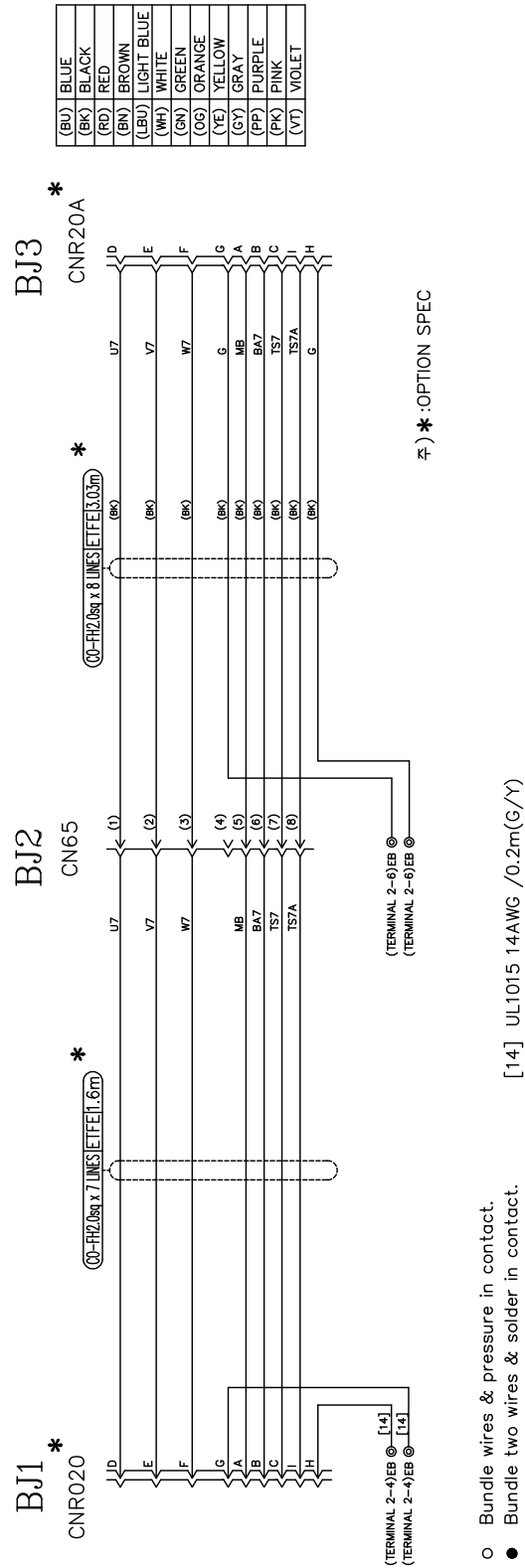


Fig 8.8 Application Wiring Connection No.2

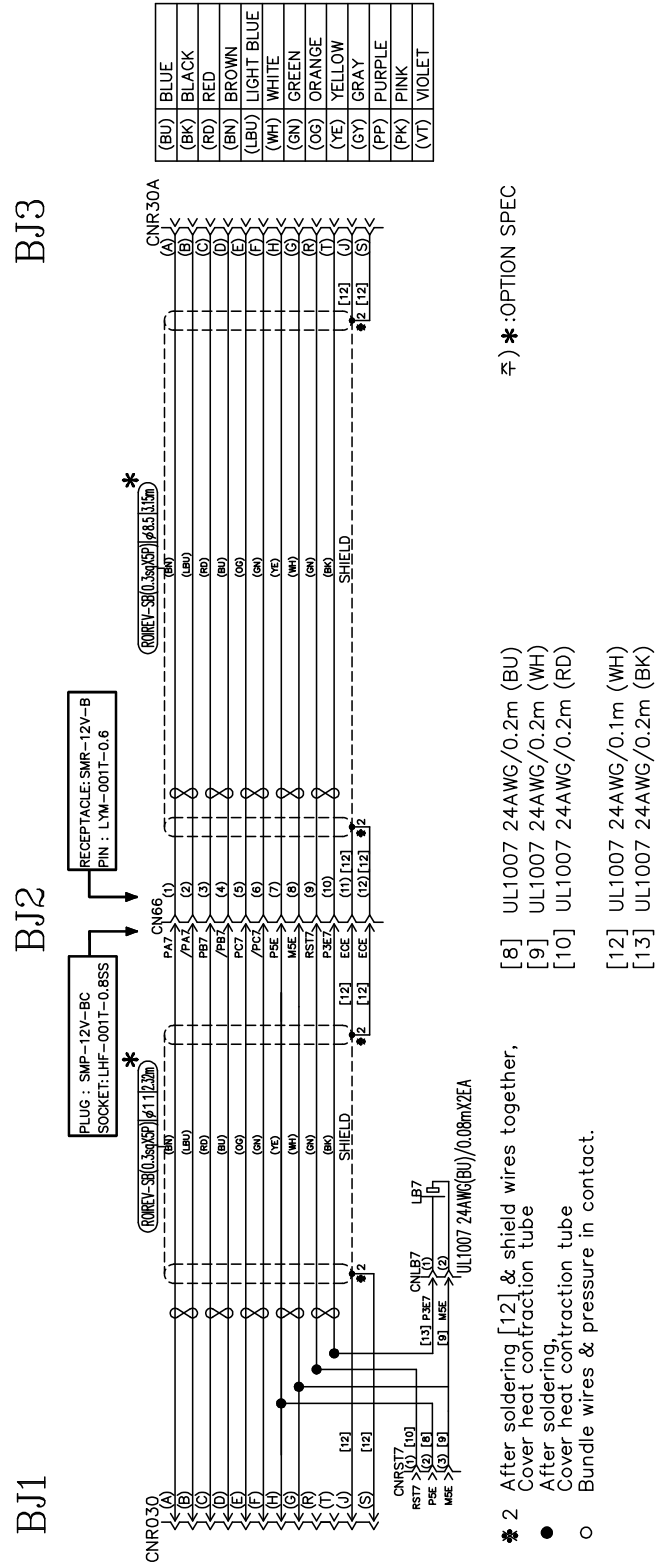


Fig 8.9 Application Wiring Connection No.3



9

Decommissioning



9. Decommissioning

HX130/HX165/HX165S/HX200/HX200S

The robot is made up of several materials as shown in [Table 9-1]. Some of them should be properly arranged and sealed up to eliminate any bad influence on the human body or environment.

Table 9-1 Materials of each part

Parts	Materials
Battery	NiCad or Lithium
Wiring, Motor	Copper
Base body, A2 frame, Upper arm, Link, Hinge etc.	Cast Iron
A1 pipe	Steel
Brakes, Motors	Samarium Cobalt(or Neodymium)
Wiring, Connectors	Plastic / Rubber
Reducers, Bearings	Oil / Grease
Wrist cover etc.	Aluminum alloy cast



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