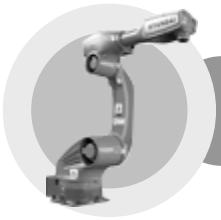
WARNING

INSTALLATION SHOULD ONLY BE PERFORMED BY QUALIFIED INSTALLATION PERSONNEL AND MUST CONFORM TO ALL NATIONAL AND LOCAL CODES

HYUNDAI ROBOTICS

Hyundai Robot

HH007C181101MMEN1



Manipulator Maintenance Manual

HH007C

HYUNDAI ROBOTICS

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Printed in Korea - Aug. 2018. 1th Edition

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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 complies with the safety regulation of EU Machinery Directive 98/37/EC(2006/42/EC) and US OSHA. And the robot manipulator and controller is manufactured to comply with the safety standards EN ISO 10218-1:2006 and ANSI/RIA R15.06-1999.

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.

Hyundai Robotics user of industrial robot has responsibility to observe the safety regulation related to robot adopted in corresponding countries and responsibility to design, install and operate safety equipment well in order to protect workers who work at robot system.

In high-risk areas concerning robot systems in which robots, tools, and accessories operate, there must be a method of protection to stop the workers or objects from entering the area according to ANSI/RIA R15.06-1999.

The areas for which the robot can be applied and the environment in which it can be used are as follows.

Applicable areas

It is applied to the 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
- Arc welding
- Cutting
- Handling
- Assembly
- Application such as Sealing
- 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.

Disable 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 10218-1:2006 safety standards for industrial robots, and furthermore in comply with ANSI/RIA R15.06-1999 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 highly dangerous situation, meaning that operating or handling in a wrong manner could result in death or serious injury to personnel, or damage to equipment. Attention should be paid to the operation and handling.
Mandatory		Indicate the compulsory measures that should be taken
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 Functions – IEC 204-1,10,7

There is one emergency stop button on the controller and teach pendant respectively. If necessary, additional emergency buttons can be connected to the robot's safety chain circuit. The emergency stop function, which overrides all other robot controls, can bring the current operation to a halt by cutting off the power supply to the motors of individual axes. This function will also shut down the power supply to other dangerous functions, which are controlled by the robot, to prevent them from being used

Safety Stop Function - EN ISO 10218-1:2006

A safety stop circuit needs to be configured, and, through this circuit, each robot should be connected with the safeguards and interlocks. 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 - EN ISO 10218-1:2006

In a manual mode, the maximum speed of the robot is limited to 250 mm per second.
The speed limitation applies not only to the TCP(Tool Center Point), 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

Operation area of each axis is restricted by soft limit and hardware limit. Axis 1, 2, and 3 can also be restricted by means of mechanical stopper.

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

The robot can be operated either in the manual mode or auto mode. In the manual mode, the robot can 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.

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 changing replacement, or to inspect welding equipment, opens the fence gate and approaches the equipment during operation.

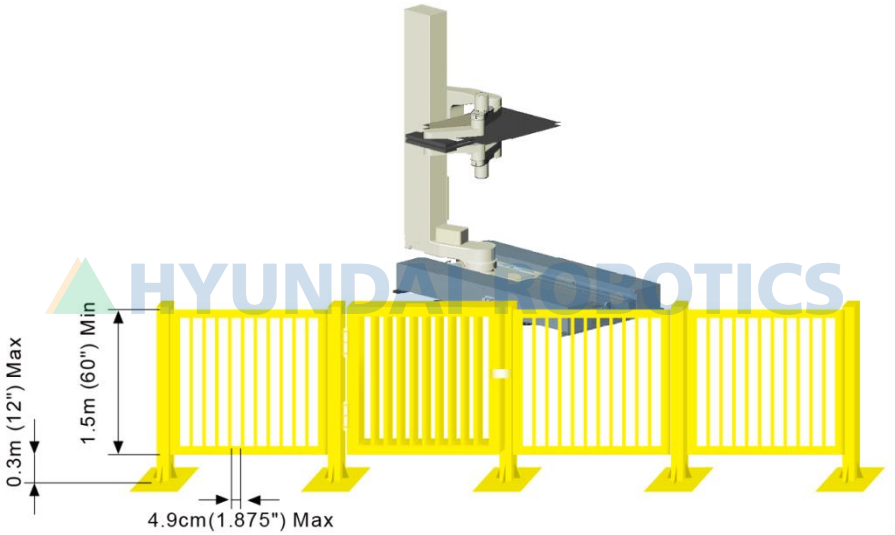


Figure 1.1 Recommended size for safety net and entrance gate (slot type entrance gate)

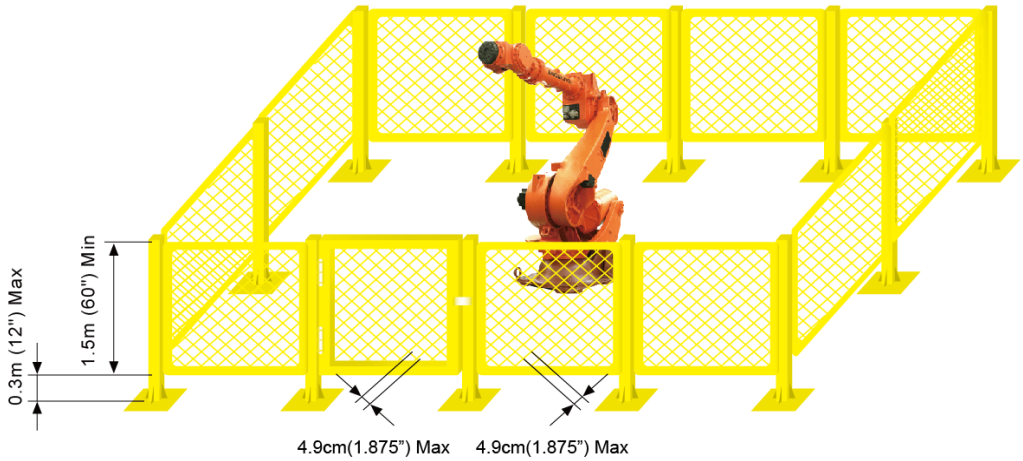


Figure 1.2 Recommended size for safety net and entrance gate (square type entrance gate)

(1) Enough space for safety net should be secured by covering robot operating area so as that workers would not have difficulty in teaching work or repairing work, and the safety net should have solid structure in order that it would not move easily and man cannot enter over easily.

(2) Safety net should be installed by static type in principle, and should not have hazardous parts such as prominence and depression or keen part, etc.

(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. Wiring should be carried out in a way that the robot should be in the operation ready OFF status as well as in the motor OFF status when the safety plug is pulled out or safety net is open.

(4) In order to operate the robot with the safety plug pulled out, wiring should be carried out in a way that will allow the playback to take place at a low speed.

(5) The emergency stop button should be installed at a place where it can be pushed quickly by the operator.

(6) If no safety net is to be installed, devices such as photoelectric switches, and mat switches, should be installed, instead of the safety plug, to cover the overall area within the robot's operation range in a way that the robot can be stopped automatically when a person enters the robot's operation range.

(7) Operation area of robot (hazardous area) should be distinguished by the method like painting on floor.

1.6.2. Placement of Robot & Peripheral Equipment

Please make sure that robot and peripheral equipment should be arranged by following method.

(1) In case of connecting primary power of controller or peripheral devices, please work after checking whether supply power has been deleted. 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.

(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 stopping in an emergency situation can be initiated from any place from which the robot is operated.

(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. Otherwise, the operator may suffer electrocution or the wire may suffer disconnection.

(6) Place the controller, interlock panel, and handling stand within the sight of robotic performance. It may cause a major accident to operate the robot while the robot is malfunctioning in an area where the robot’s activity can not be observed, or while the operator is working on it.

(7) Restrict the robot's working envelope by using the soft limits and the mechanical stopper if the necessary working envelope is narrower than the robot’s workable envelope. When the robot is to move beyond the restricted envelop due to abnormal operation, such as the robot being handled in a wrong way, the robot will be stopped automatically in advance thanks to the function that restricts the workable envelop.

(8) During the welding work, spatter could fall down to workers or the workers could be injured by burning, or fire could break out. 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, can be noticeable even from a slightly distant location. In the case of automatic start-up, a buzzer or a warning lamp will be useful.

(10) Make sure that there is no projecting part in the robot's peripheral equipment. Cover it, if necessary. It usually could cause an accident if the operator comes in touch with it. And it may cause a major accident when the operator tumbles while being astonished at the sudden movement of the robot.

(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.

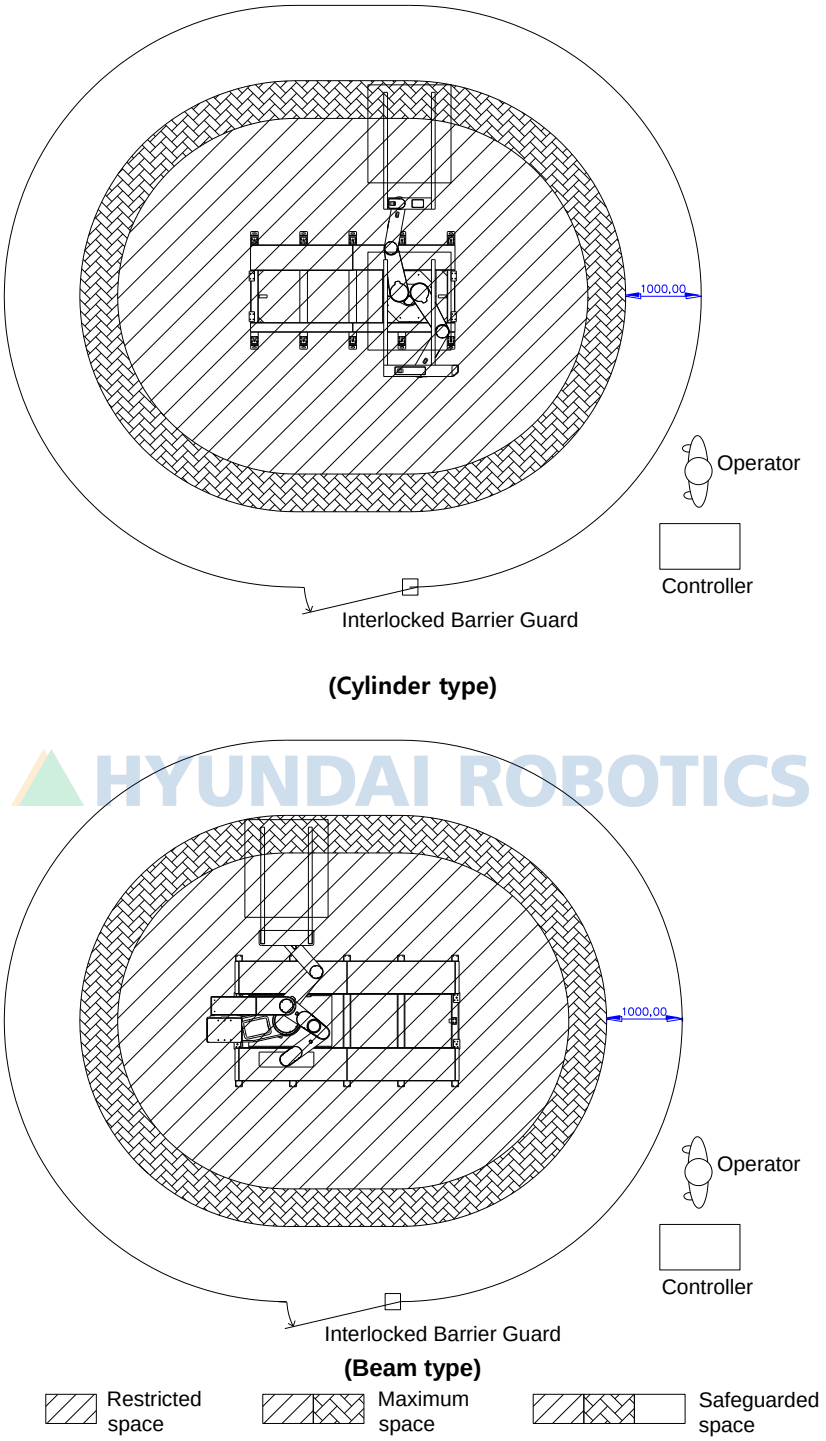


Figure 1.3 Arrangement of LCD robot peripheral devices and workers

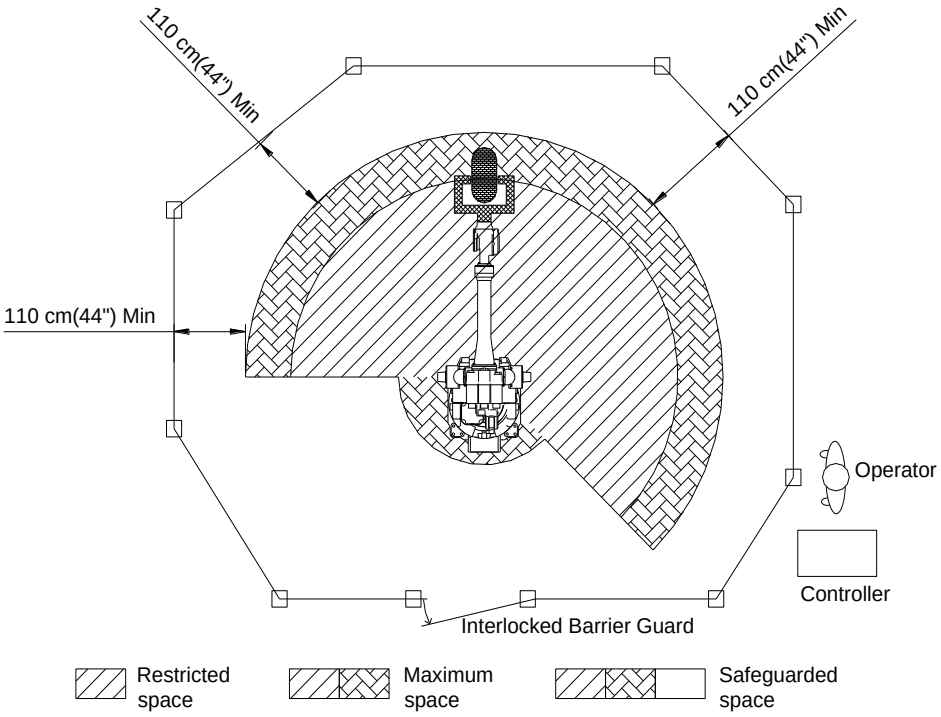


Figure 1.4 Arrangement of general robot peripheral devices and workers

1.6.3. Installing the Robot

Please install the robot in accordance with following method surely.

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 enable 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 place 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 of 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, controller, and other peripheral equipment. to install the main body and controller, please secure the above mentioned installation area. Install controller outside of the safety fence in order to monitor the robot manipulator and to operate in a safe way.
When installing, be sure to make it easier to perform the maintenance when opening the Controller door. Secure the available space. The specifications of the controller can change according to the type of the controller. (For more details, please refer to the “Maintenance manual”.)

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

Please observe following countermeasures because safety is very important for the test operation of the robot.

(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 teach pendant button, while checking the teaching point with your naked eyes, and do not handle it just relying on your sense.

(12) It is a repairing part to be prepared for when you buy many sets.

(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 are 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.

■ **During temporary halt, the entrance countermeasure same as entrance of teaching work should be considered at the case (nozzle contact, welded part detected, arc error, and so on) of opening entrance gate for simple management against error.**

(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

Please observe following countermeasures because safety on robot operation is very important.

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

Please observe following countermeasures because safety on robot automatic operation is very important.

(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 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

Please observe following countermeasures because safety on robot automatic operation is very important.

The robot is very heavy and strong, even at low speeds. 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 teach pendant or control panel.

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

People must understand the followings when they are to enter the robot's working envelope

(1) Do not enter the working envelope other than teaching person.

(2) Operation set-up mode of controller must be a manual mode in the control panel.

(3) Always wear the approved working suite.(Do not wear a loose clothes as you please)

(4) Do not wear gloves when handling controller.

(5) Do not leave innerwear such as underwear, shirts, or necktie out of the working suite.

(6) Do not wear personal accessories such as big earrings, rings, or necklaces.

(7) Make sure to wear safety shoes, helmet, and goggles and if necessary, wear other self-protective outfit such as safety gloves.

(8) Make sure that the emergency stop circuit is working correctly and in its proper function, turns MOTOR OFF when pressing the emergency stop button in the control panel and teach pendant before handling the robot.

(9) Make your posture face-to-face with the robot manipulator when performing your work.

(10) Follow the predetermined working procedure.

(11) 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 Controller Maintenance and Repair

Please observe following safety countermeasures on repair and check for robot controller.

(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) When you open the door of controller, you should turn off power, and please start working after 3 minutes.

(7) Please do not touch heat radiating plate of servo AMP and recovery resistance because they are very hot.

(8) After completing maintenance, be sure to close the door completely after checking if tools or other things are still remained in the controller.

1.9.2. Safety Precautions for Robot System & Manipulator Maintenance

Please observe following safety countermeasures on repair and check for robot controller.

(1) Refer to the safety precautions for 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

Please install the robot in accordance with following method surely.

(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

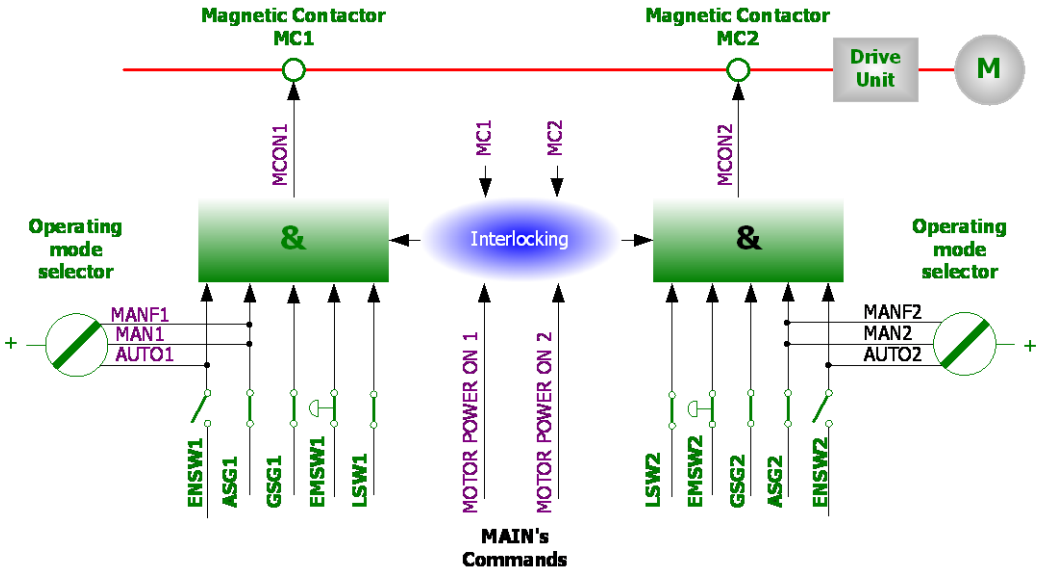


Figure 1.5 Configuration for safety chain

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 MOTOR 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 MOTOR ON mode are operated interactively. In order to be in MOTOR ON mode, the safety circuit consisted of several switches must be all connected. MOTOR ON mode indicates that drive power is supplied to the motors. If one of the contactors is disconnected, the robot will always return to MOTOR OFF mode.

MOTOR 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, 『Operation manual』.)

Safety circuit

The emergency stop buttons on the controller panel and on the teach 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 with the limit switch, change the robot’s position by operating it with the pendant key at the constant setting mode. (Constant setting mode refers to the state of entry into the menu『[F2]: System』 menu)

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 teach 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.

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

Above the control and teach pendant console.

(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.
(Please refer to system board in “basic configuration of controller”) At this time, the emergency stop must be connected to be “Normal On” and it must be check for proper operation during test run.

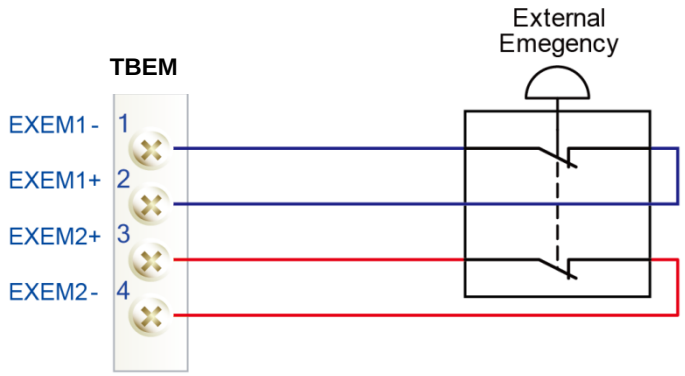


Figure 1.6 Connection with external emergency halt switch through system board terminal block TBEM

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 HR, HX, HS and HA can be limited by means of mechanical stopper or electrical limit switches. In this case, the corresponding software limitation parameters must be also changed. If necessary, movement of wrist 3 axes can be restricted, too. 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) Voltage 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) Tool 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 enable 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 EU Machinery Directive 98/37/EC(2006/42/EC) and US OSHA.

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

- ANSI/RIA R15.06-1999
  Industrial Robots and Robot Systems - Safety Requirements
- ANSI/RIA/ISO 10218-1-2007
  Robots for Industrial Environment - Safety Requirements - Part 1 - Robot
- ISO 11161:2007
  Safety of machinery - Integrated manufacturing systems - Basic requirements
- EN ISO 13849-1:2008
  Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2006)
- EN 60204-1:2006
  Safety of machinery - Electrical equipment of machines - Part 1: General requirements (IEC 60204-1:2005 (Modified))
- EN ISO 10218-1:2006
  Robots for industrial environments - Safety requirements - Part 1: Robot (ISO 10218-1:2006)

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.

HYUNDAI ROBOTICS

2
Specifications

2.1. Robot Machinery Part

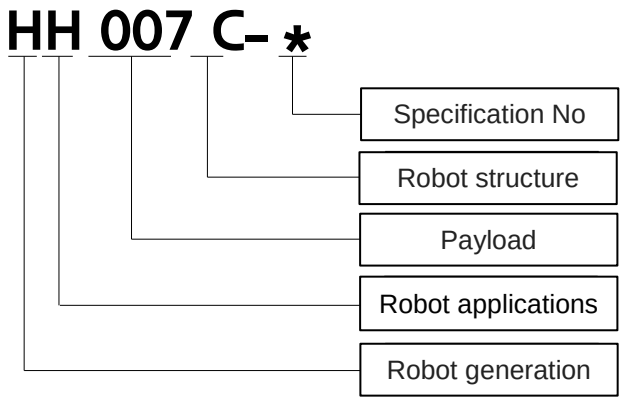


Figure 2.1 Robot Machinery Part

2.2. Location of Robot Identification Plate

The model name, serial number, and manufacturing date of robot are written down in the name plate. Identification plate is located at the bottom of the main body (Left or right side) as shown in the following figure.

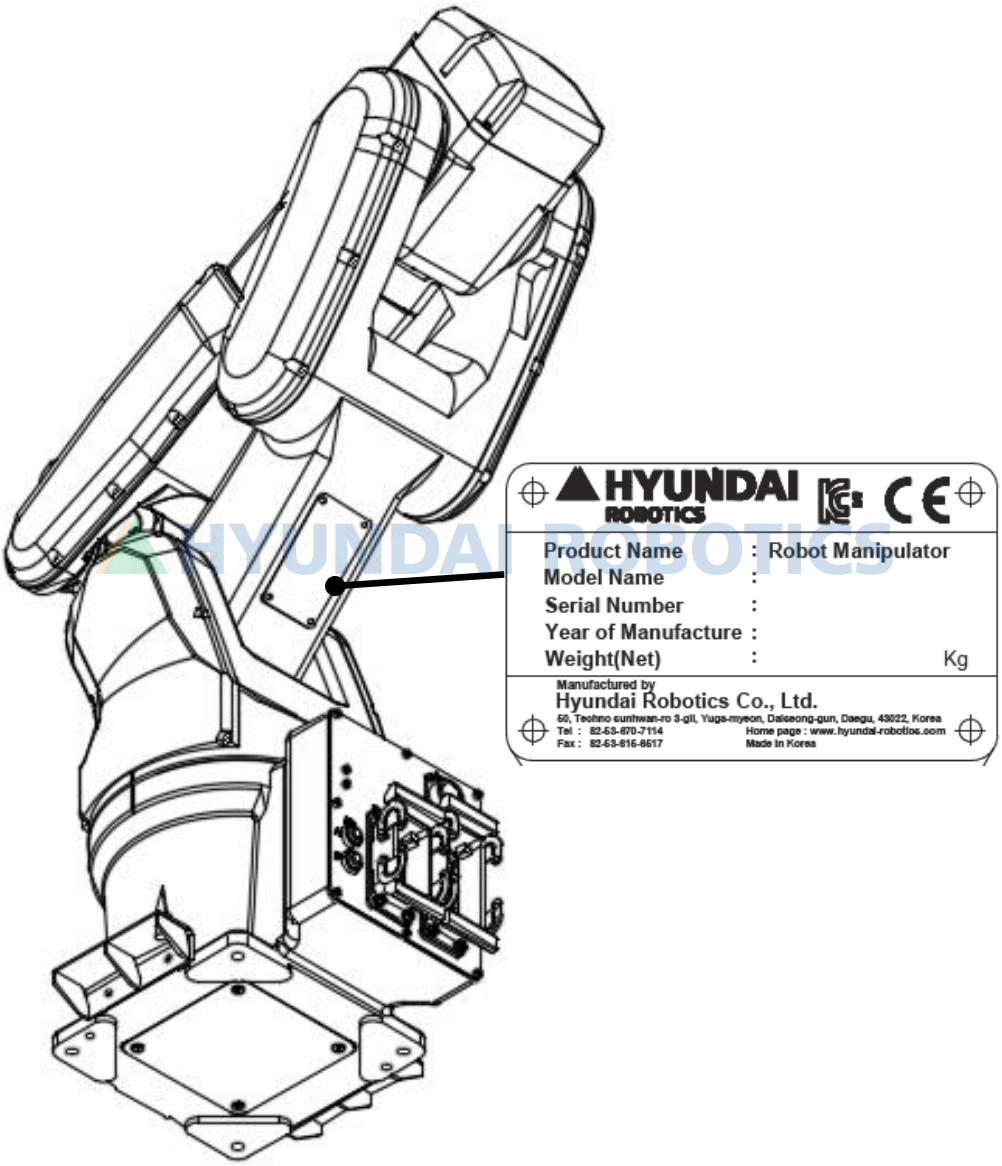


Figure 2.2 The location of identification plate [HH007C]

2.3. Basic Specifications

Table 2-1 Specifications for Models

Item				Specification
Robot Model				**HH007C-09**
Structure				Articulated
Degree of freedom				6
Drive system				AC servo type
Maximum operating area				905 mm
Max. Working envelope	**Arm**	**S**	**Swivel**	±2.967 rad (±170°)
		H	**Horizontal**	+2.967 ~ -0.785 rad (+170° ~ -45°)
		V	**Vertical**	+3.316 ~ -1.134 rad (+190 ~ -65°)
	Wrist	**R2**	**Rotation 2**	±3.316 rad (±190°)
		B	**Bending**	±2.094 rad (±120°)
		R1	**Rotation 1**	±6.283 rad (±360°)
Maximum speed	**Arm**	**S**	**Swivel**	5.76 rad/s (330°/s)
		H	**Horizontal**	5.06 rad/s (290°/s)
		V	**Vertical**	7.16 rad/s (410°/s)
	Wrist	**R2**	**Rotation 2**	8.48 rad/s (486°/s)
		B	**Bending**	9.60 rad/s (550°/s)
		R1	**Rotation 1**	14.50 rad/s (970°/s)
Load Capacity				68.6 N (7kg)
Wrist torque		**R2**	**Rotation 2**	16.6 N·m (1.69 kgf·m)
		B	**Bending**	
		R1	**Rotation 1**	9.4 N·m (0.96 kgf·m)
Accuracy of position repeatability				±0.03 mm

Item	Specification
Robot Model	**HH007C-09**
Ambient Temperature	0~45℃ (273 ~ 318 K)
Relative humidity	20 ~ 85 %RH
Robot's Weight	42.5 kg

2.4. Robot Dimension and Working Envelope

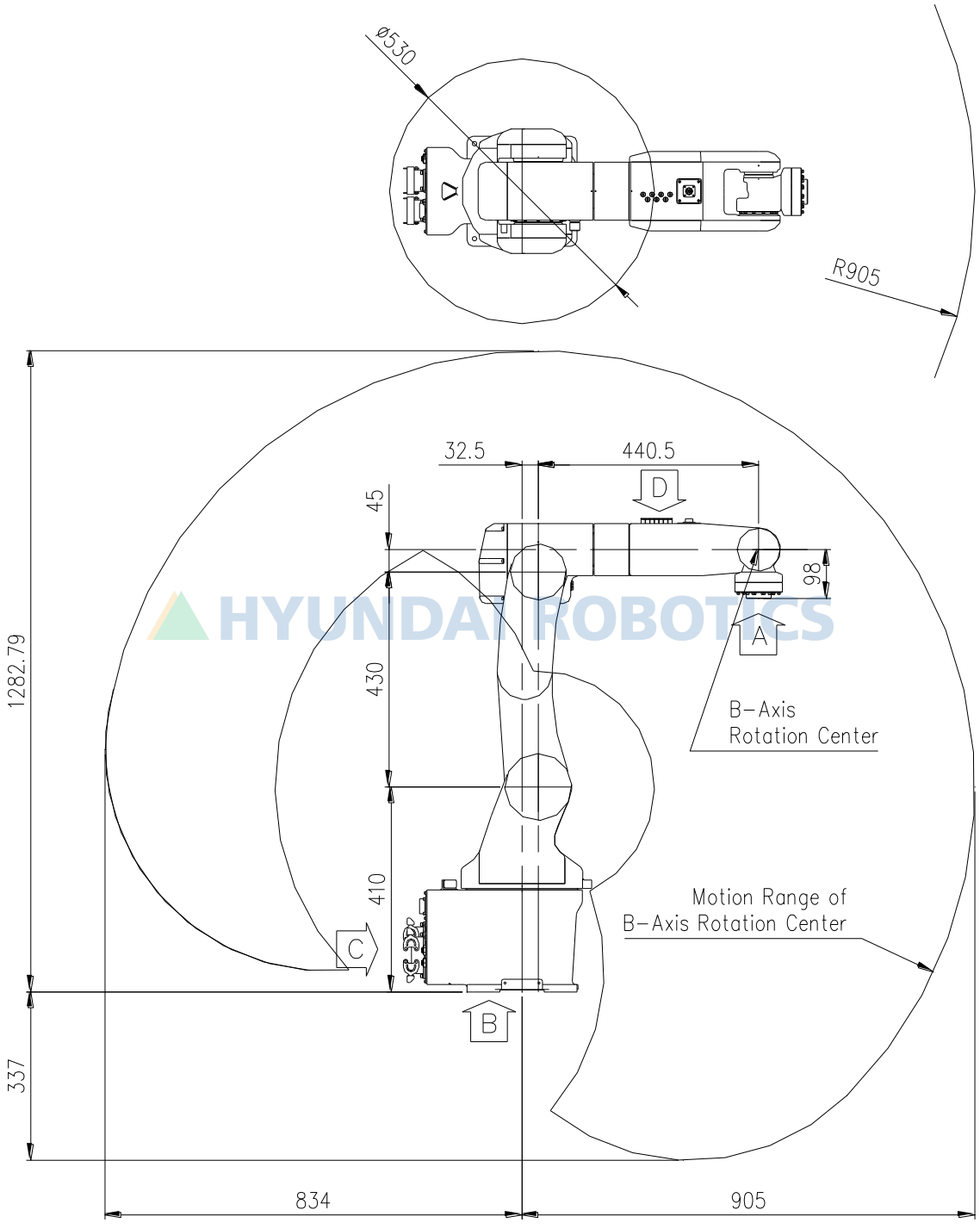


Figure 2.3 Robot Dimension and Working Envelope: [HH007C]

2.5. Axis Identification

Table 2-2 Axis Motion

Axis Name	Operation	Teach Pendant Button	
S	Arm Swivel	X+(S+)	X-(S-)
H	Arm Forward and Backward	Y+(H+)	Y-(H-)
V	Arm Upward and Downward	Z+(V+)	Z-(V-)
R2	Wrist Rotation 2	RX+(R2+)	RX-(R2-)
B	Bending	RY+(B+)	RY-(B-)
R1	Wrist Rotation 1	RZ+(R1+)	RZ-(R1-)

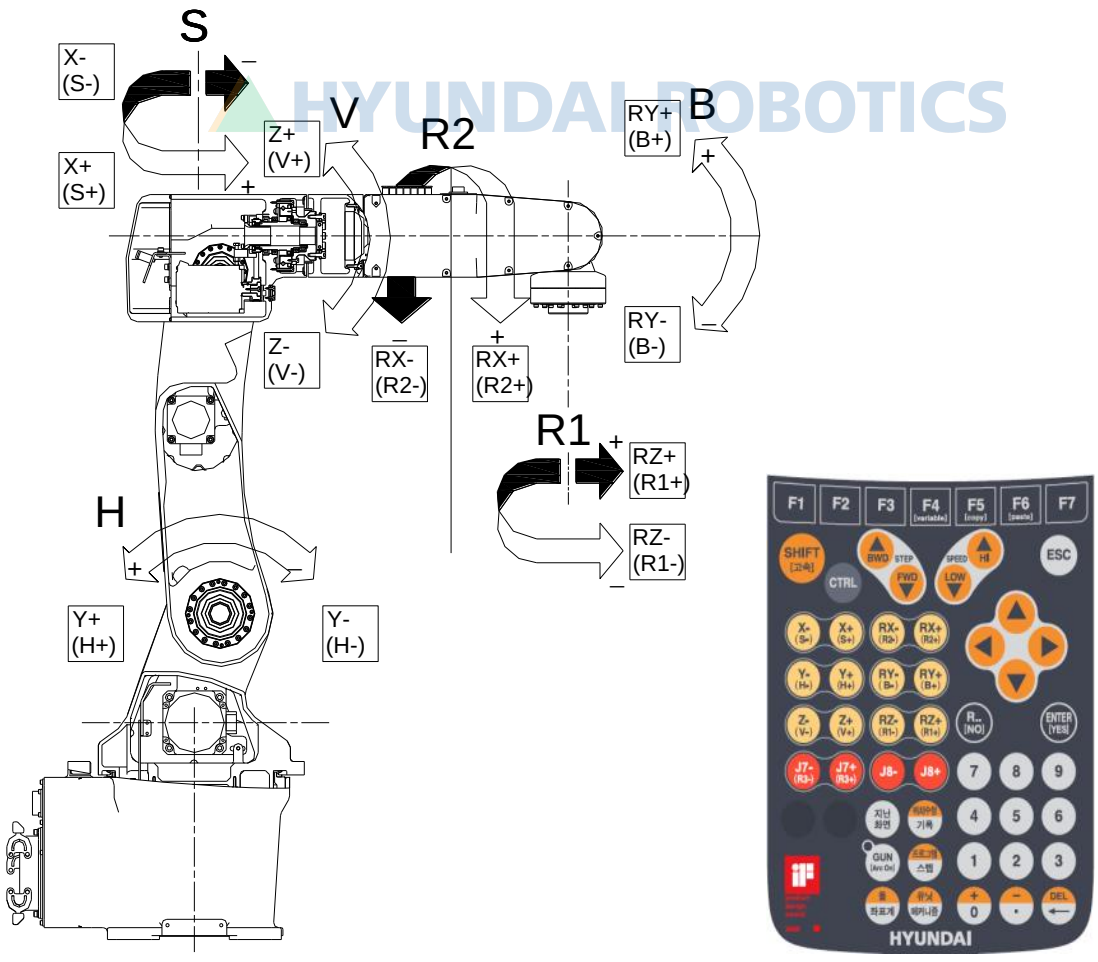


Figure 2.4 Robot Dimension and Axis

2.6. Details of Wrist Axis Attachment Surface

When attaching the work tool on the flange of the wrist end, use the bolt of the applicable model.

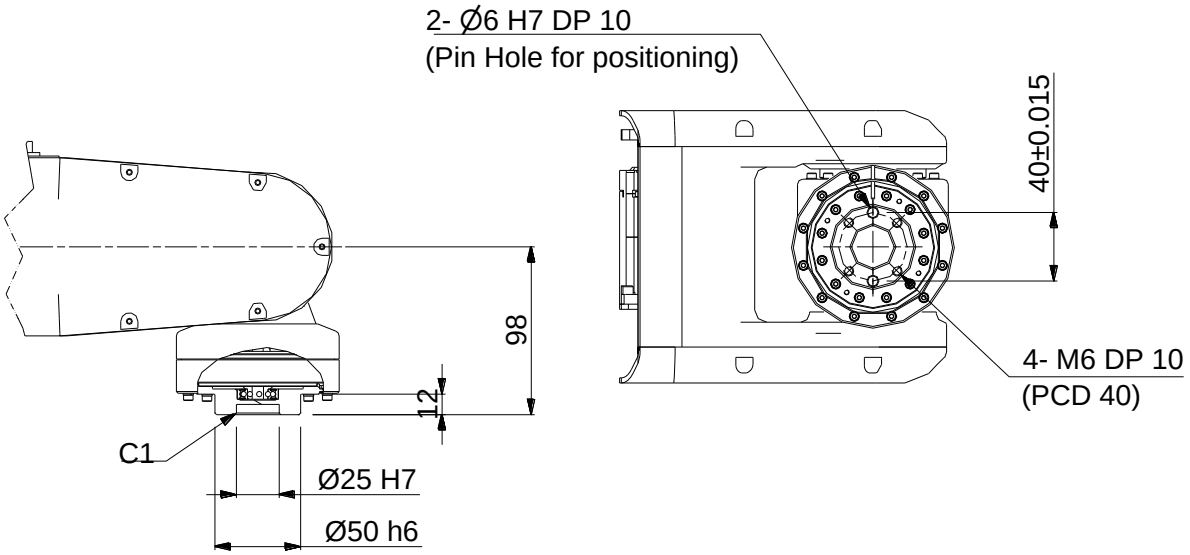


Figure 2.5 Details of Wrist Axis Attachment Surface

2.7. Wiring and Piping Drawings for Application

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

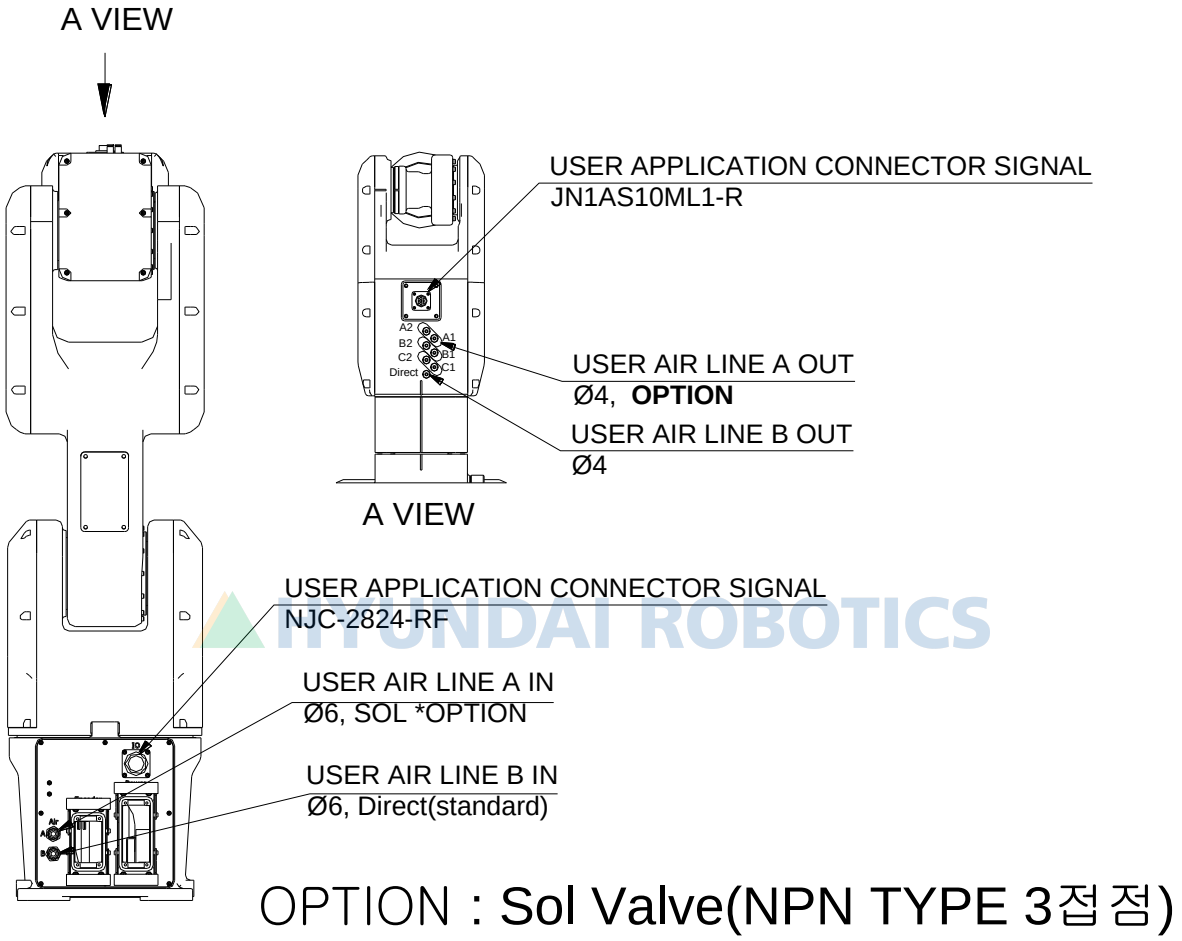


Figure 2.6 Wiring and piping drawings for application: [HH007C]

2.8. Operating range limit

When installing the robot, consider the fact that you can adjust the operating range freely within the full operating area.

The operating range limit is effective in the following environment.

- ✓ When you want to limit the operating area while the robot is operating
- ✓ When the robot can collide with the surrounding devices
- ✓ When the length of applied cable or hose is limited

There are 3 methods to limit the operating area of the robot.

- ✓ Software limit (Apply base axis)
- ✓ Limit switch (1~3 axes : Apply option)
- ✓ Mechanical stopper (1~3 axes)

[Caution]
Mechanical stopper is a physical device. The robot cannot exceed the mechanical stopper. The mechanical stoppers of 1~3 axes are fixed. For 4~6 axes, only the software limit can be applied.

When the mechanical stopper collides with the robot, it is deformed and the strength cannot be guaranteed. Therefore, you must replace the mechanical stopper in this case.

3 Instructions

3.1. Robot Component Name

Name of each part of the main body is as shown in [Fig. 3.1], [Fig. 3.2].

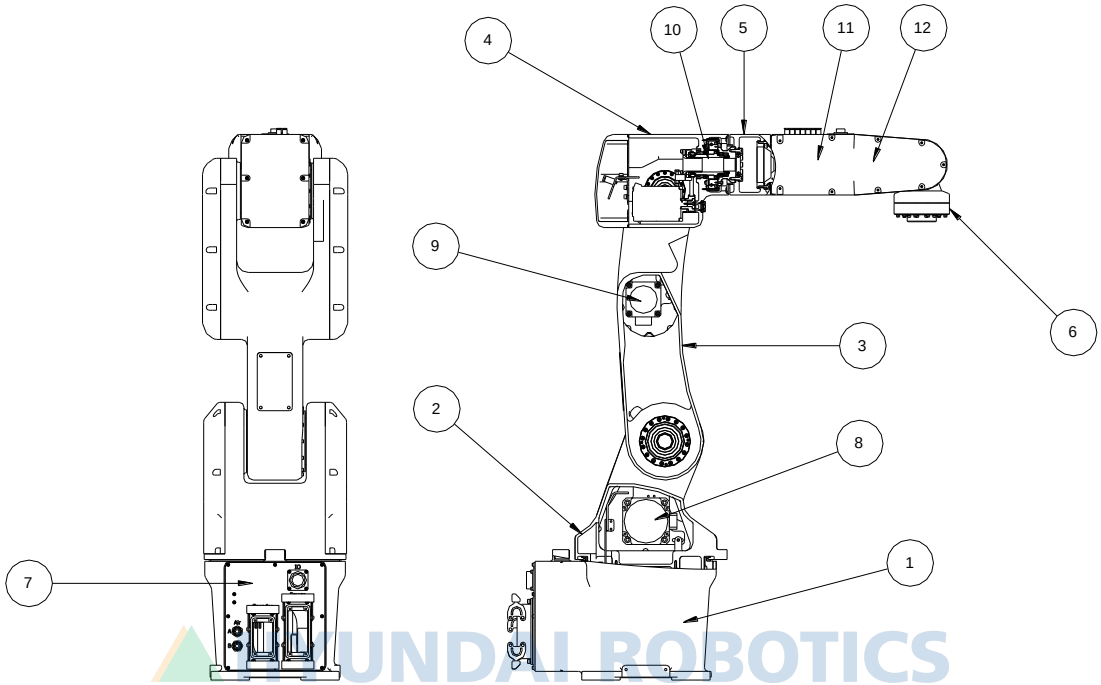


Figure 3.1 Name of Robot Components [HH007C]

Table 3-1 Name of Robot Components [HH007C]

No.	Name of each part	No.	Name of each part
1	BASE BODY	**9**	V axis motor
2	LOWER FRAME	**10**	R2 axis motor
3	UPPER FRAME	**11**	B axis motor
4	ARM FRAME	**12**	R1 axis motor
5	ARM PIPE		
6	WRIST BODY		
7	S axis motor		
8	H axis motor		

3.2. Location of Safety Nameplate

In order to prevent any accidents, safety marking plates such as [Figure 3.2] are attached to the robot. Do not remove or replace it unnecessarily.

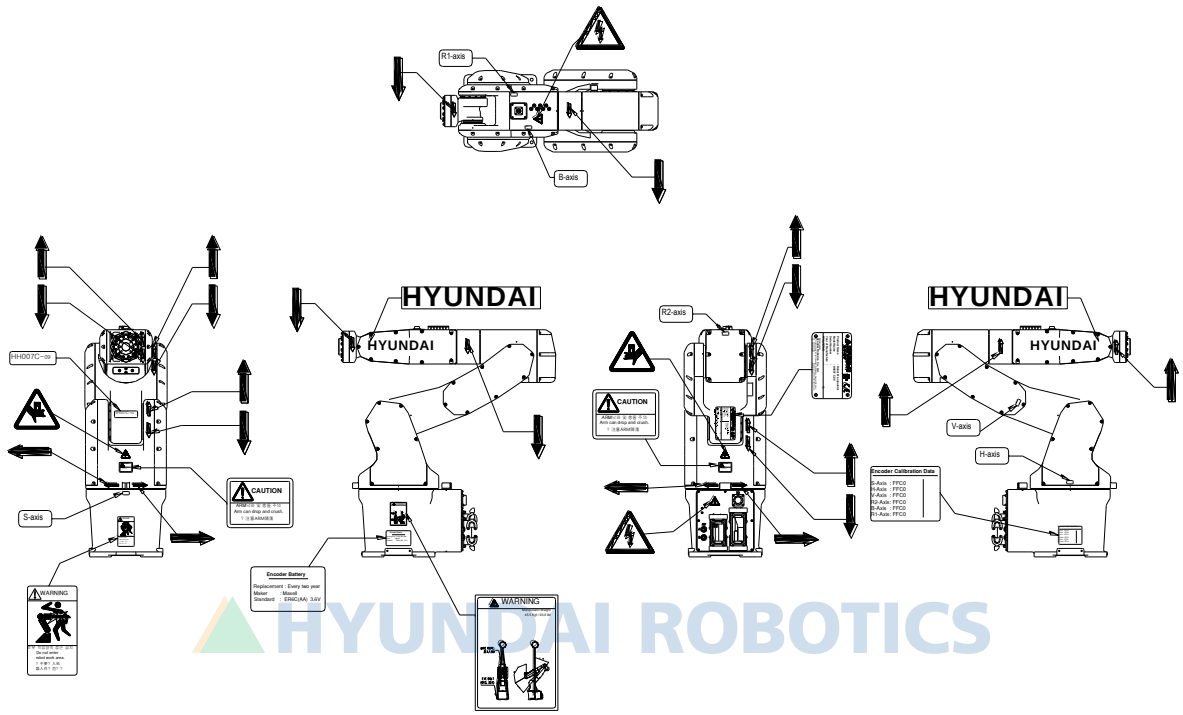


Figure 3.2 Location of Safety Nameplate [HH007C]

3.3. Transportation method

3.3.1. Using crane

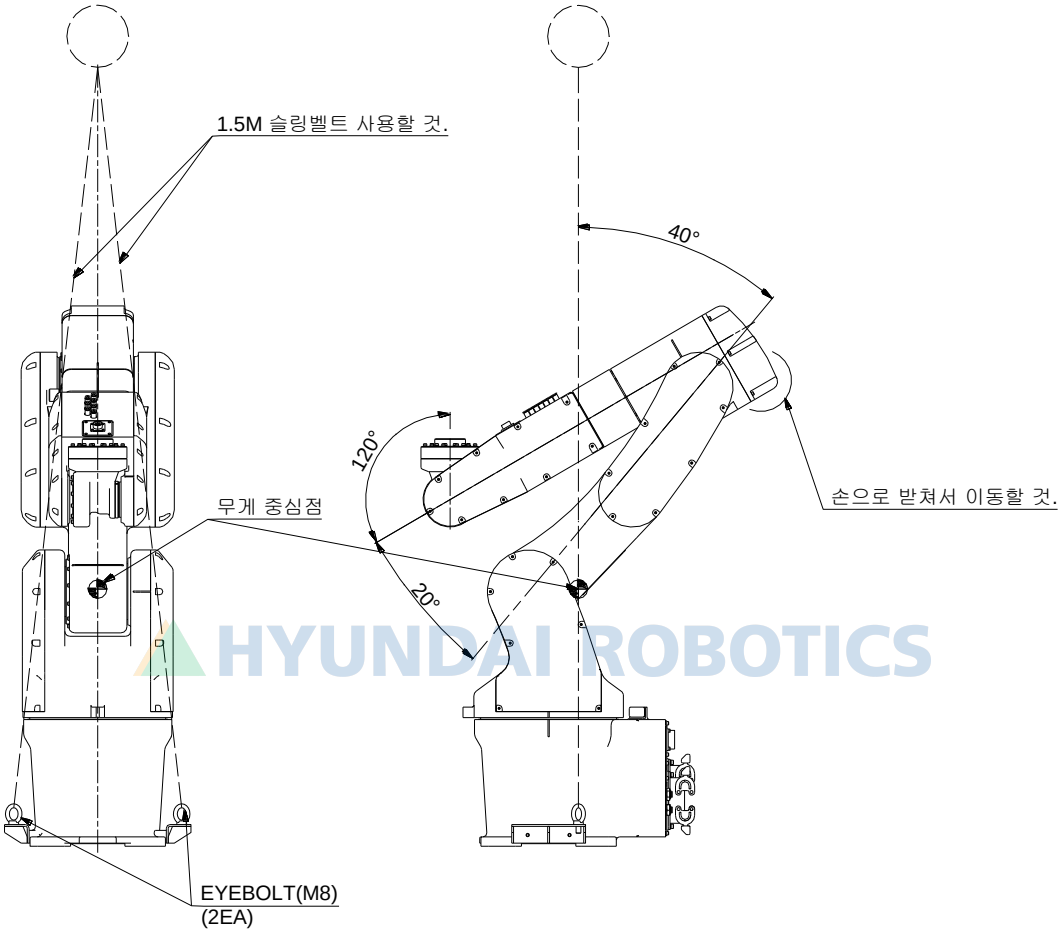


Figure 3.3 How to Transport: Using crane [HH007C]

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.
- In moving the robot, place a hand against the back of the upper frame so that the robot does not fall backward.
- Install the M8 eye bolt.
- Connect a wire rope to the EYE BOLTS.
- Attach the protective hose (50cm) to prevent the damage to the main body of the robot.
- Keep the safety regulations during lifting process.
- Weight of manipulator : 42.5kg
- Minimum crane capacity : 0.2 tons

3.3.2. Use of forklift

When transporting the main body of the robot, you can use the forklift.

Follow the below procedure for safety purposes.

- Refer to the figure and take the basic pose for each model.
- Fixate the robot to the pallet and insert the fork of the forklift to transport the robot. The pallet must be able to sufficiently withstand the strength.
- Transport in low speed.
- Follow the safety regulations.

Caution

- Do not lean on the main body of the robot during the transportation work.
- When loading/unloading the main body of the robot, make sure that the robot does not collide with the floor.
- Follow the safety rules when operating the forklift.

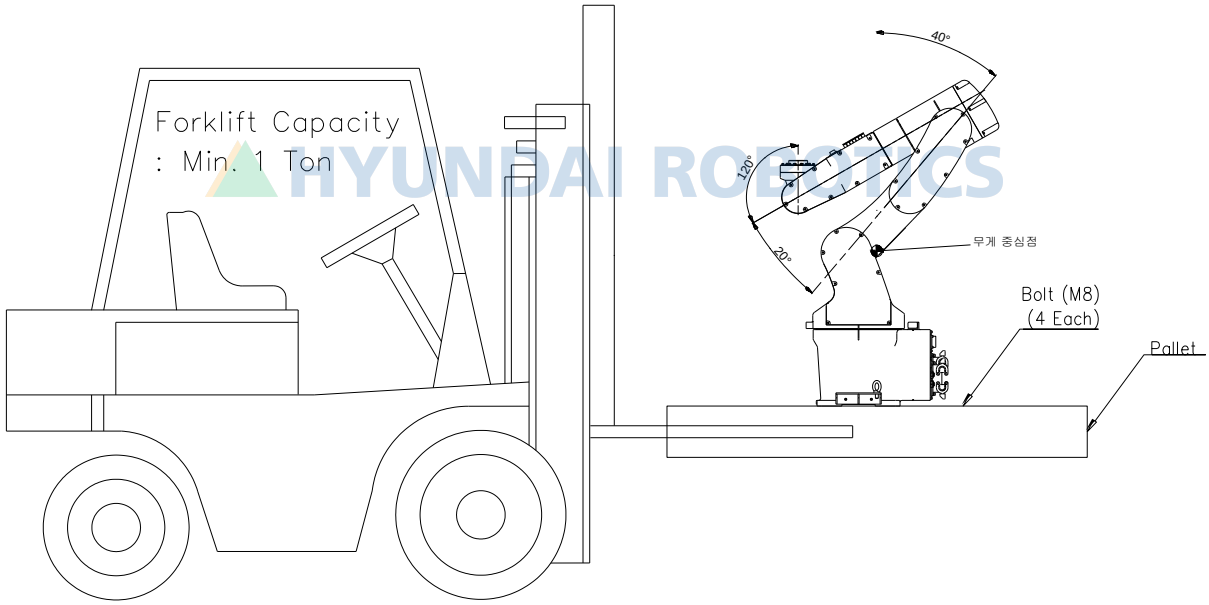


Figure 3.4 Transportation method: Use of forklift [HH007C]

3.4. Robot storage

When storing the robot without installing the robot, keep the robot in the following position as shown in [Fig. 3.3]

[Caution]
If you store the robot in a different position, the robot can fall over. When storing the robot for a long period of time, take safety measures so that the robot does not fall over.

3.5. 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.

3.5.1. Operating Conditions

(1) Ambient temperature should range from 0℃ to 45℃.
(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℃~ and 40℃.

3.5.2. Installation the Robot Manipulator

The main body of the robot must be fixated firmly with 4ea M16 bolts. All 4 bolts must be used.

- Bolt : M8(12.9) SOCKET HEAD BOLT
- Washer : Spring washer, plain washer
- Connection torque : 340Nm

The base floor where the robot will be installed must be designed to have hardness to minimize the dynamic effect of the robot.

When installing the robot on the concrete floor with thickness of 200mm or more, repair any uneven areas or cracks and fixate the mounting plate with M20 anchor bolts. And when installing the robot on the concrete floor with thickness of less than 200mm, make sure to review prior to the installation as it requires base construction.

3.5.3. Dimension of Installation Surface

Assemble the main body of the robot on the common base, Refer to the following dimensions.

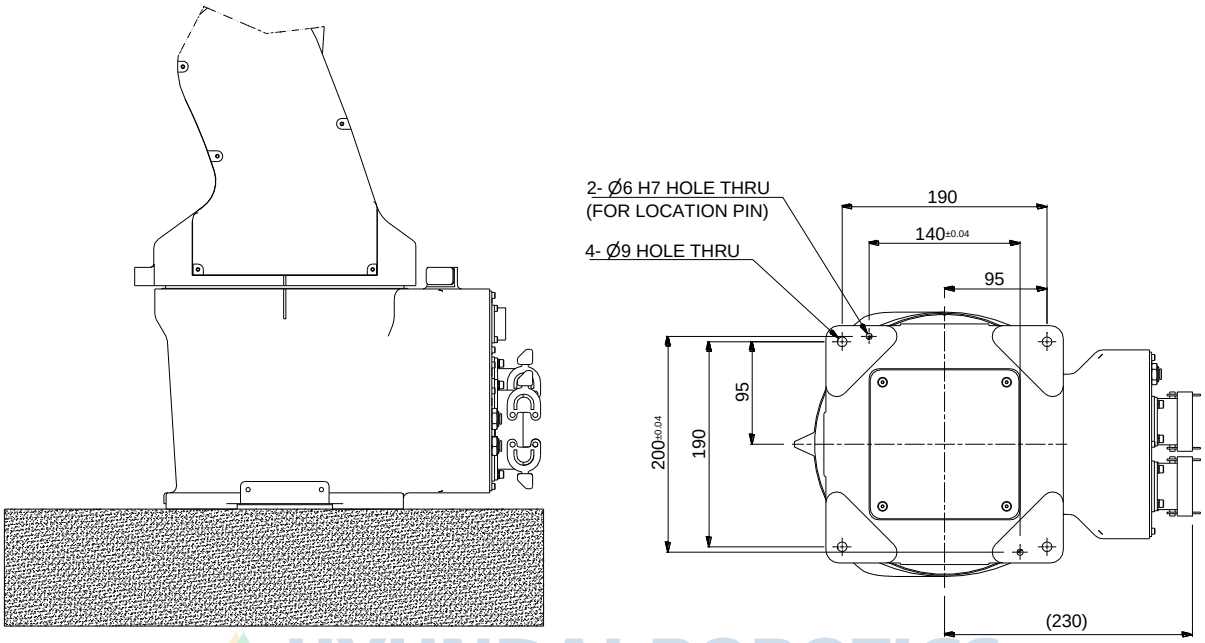


Figure 3.5 Robot installation surface dimension [HH007C]

3.5.4. 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 ±2mm.

- Cautions

  ① The flatness of the 4 mounting plates must be within 1.0 mm.
  ② The flatness of the 4 areas of the plate for assembly must be within 1.0 mm (±0.5 mm).

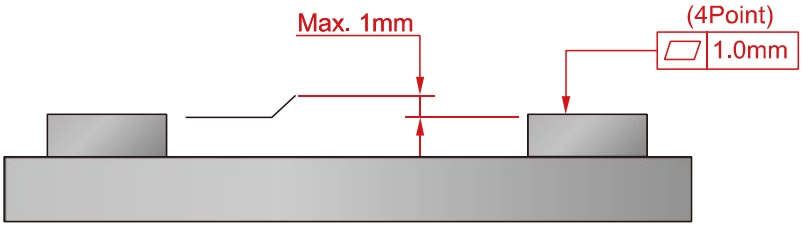


Figure 3.6 Robot installation surface accuracy

3.5.5. Emergency Stop time & Distance

The following items are the response time and distance for an emergency stop during the max speed operation of each axis (S, H, and V) with the standard load.

- HH007C
  Max Time: 0.27 seconds
  Max Moving Distance: 18.4 Inch / 46.8 cm

3.6. Allowable Load of Wrist Axis

3.6.1. 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. The direction of coordinate system used to calculate the load torque and inertia moment is the same with the direction of robot base coordinate system. Axis R2 is reviewed in the same manner with the axis B.

- 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
  Distance calculation from the axis B and R1 to the center of gravity

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

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

- Step 3
  Calculate the load torque from the calculated distance.

$$T_B = MgL_B \qquad T_{R1} = MgL_{R1}$$

  T_B: Load torque in the rotational center of axis B
  T_{R1}: Load torque in the rotational center of axis R1
  M: Mass of load
  g: Acceleration of gravity

- Step 4
  Check if the load torque calculated in the step 3 is the same with or smaller than the limit value, on the basis of allowed load torque table.

- Note: If the load mass is similar to the mass on the torque curve below, the torque can be alternatively validated by checking if the distance calculated in the step 2 is distributed in the torque curve, instead of the step 3 and 4. If it is in the torque curve, the calculated load torque is smaller than the allowed load torque but if it is out of the torque curve, the calculated load torque is bigger than the allowed load torque

Allowable load torque

Table 3-2 Allowable load torque

Robot model	Allowable load torque		
	R2 axis rotation	B axis rotation	R1 axis rotation
HH007C	16.6 Nm (1.692 kgf·m) or less		9.4 N·m (0.958 kgf·m) or less

3.6.2. Permitted inertia moment estimation

Loads must be kept below maximum conditions shown in [Table 3-3 ~ 3-5].

- 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 whether the inertia moment value is within the limit based on the allowed inertia moment table

Allowable Moment of Inertia

Table 3-3 Allowable Moment of Inertia

Robot Model	Allowable Moment of Inertia		
	R2 Axis Rotation	B Axis Rotation	R1 Axis Rotation
HH007C	0.47 kgm²		0.15 kgm²

3.6.3. Example of permitted torque and inertia moment calculation (HS180 Case)

(1) Case #1 Simple 2-D model

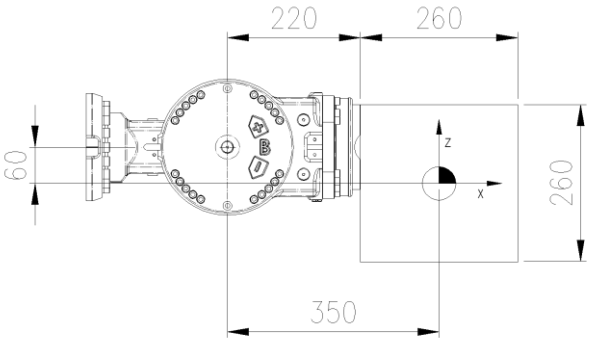


Figure 3.7 2-D load model

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 260mm and thickness of 260mm (Mass 138.15kg)

① Weight limitation
Load weight: $138.15 \leq 180$ kg

② Permitted torque limit
Location of B axis weight center L_X = 350mm, L_Y = 0mm, L_Z = -60mm
The distance from the axis B and R1 to the center of gravity can be calculated as follows.
B axis based length $L_B = \sqrt{0.35^2 + 0.06^2} = 0.355$ m
R1 axis based length $L_{R1} = 0.06$ m
Load torque of axis B $T_B = MgL_B = 49.04$ kgfm ≤ 110 kgfm
Load torque of axis R1 $T_{R1} = MgL_{R1} = 8.29$ kgfm ≤ 58 kgfm

③ Permitted inertia moment limit
Inertia moment of load from the weight J_{xx}= 1.56kgm^2, J_{yy}= 1.56 kgm^2, J_{zz}= 1.56 kgm^2
B axis inertia moment (Ja5)
$J_{a5} = ML_B^2 + J_{yy} = 138.15 \times 0.355^2 + 1.56 = 18.97 \leq 106$ kgm^2
R1 axis inertia moment (Ja6)
$J_{a6} = ML_{R1}^2 + J_{xx} = 138.15 \times 0.06^2 + 1.56 = 2.06 \leq 56$ kgm^2

④ Conclusion
It is safe because the weight, torque and inertia moment all satisfy the limited condition.

(2) Case #2 Complicated 3-D model

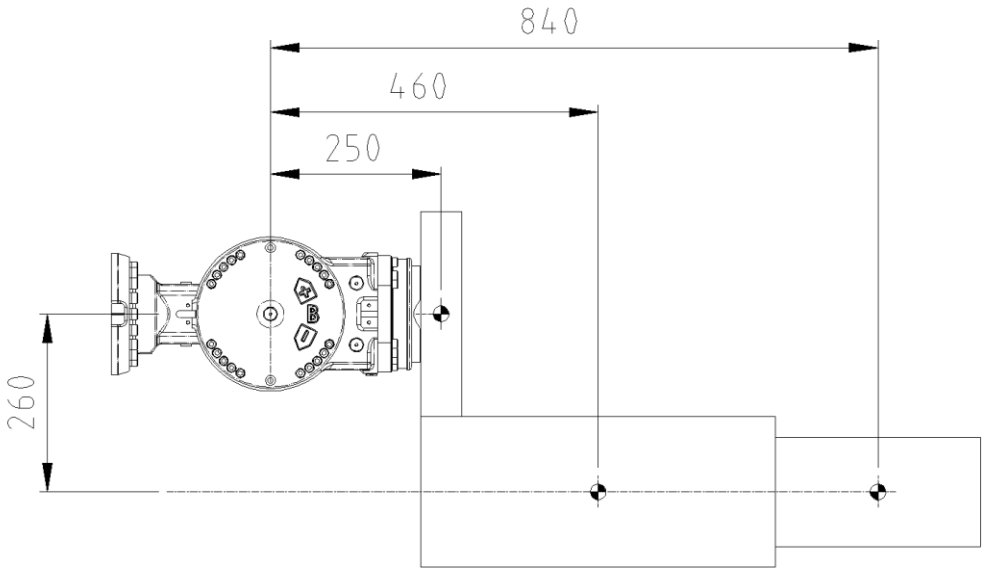


Figure 3.8 3-D load model 2-D shape

Aluminum block shape combination
(σ=0.0027 g/mm^3 : 176.3 kg)
m1 (60×300×300) 14.6kg
m2 (480×440×220) 125.4kg
m3 (280×300×160) 36.3kg

mi - 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 Weight limitation
Load weight: $176.3 \leq 180$ kg

② Permitted torque limit

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

$$L_x = \frac{\sum_i m_i L_{xi}}{\sum_i m_i} = \frac{14.6 \times 250 + 125.4 \times 460 + 36.3 \times 840}{176.3} = 520.85 \text{ mm}$$

$L_y = 0$ mm (Symmetric to Y axis)

$$L_z = \frac{\sum_i m_i L_{zi}}{\sum_i m_i} = \frac{14.6 \times 0 + 125.4 \times 260 + 36.3 \times 260}{176.3} = 238.47 \text{ mm}$$

The weight center location for the total load from the B axis rotation center Lx = 520.85mm, Ly = 0mm, LZ = -238.47mm

Distance from the axis B to center of gravity $L_B = \sqrt{0.521^2 + 0.238^2} = 0.573$ m
Distance from the axis R1 to center of gravity $L_{R1} = \sqrt{0.238^2 + 0.0^2} = 0.238$ m

Load torque of axis B $T_B = MgL_B = 101.02 \text{ kgfm} \leq 110 \text{ kgfm}$
Load torque of axis R1 $T_{R1} = MgL_{R1} = 41.96 \text{ kgfm} \leq 58 \text{ kgfm}$

x1 y1 z1 – x, y and z direction length of block m1
x2 y2 z2 – x, y and z direction length of block m2
x3 y3 z3 – x, y and z direction length of block m3

L_{X1}, L_{Y1}, L_{Z1} – Weight center location of block m1 from B axis rotation center
L_{X2}, L_{Y2}, L_{Z2} - Weight center location of block m2 from B axis rotation center
L_{X3}, L_{Y3}, L_{Z3} - Weight center location of block m3 from B axis rotation center

Jxx1, Jyy1, Jzz1 – Inertia moment by x, y and z axis from the weight center of block m1
Jxx2, Jyy2, Jzz2 – Inertia moment by x, y and z axis from the weight center of block m2
Jxx3, Jyy3, Jzz3 – Inertia moment by x, y and z axis from the weight center of block m3

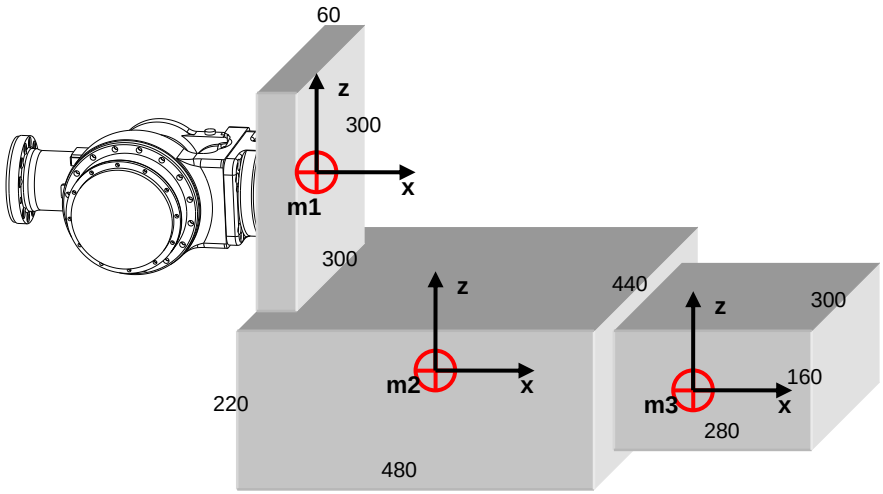


Figure 3.9 3-D load model 3-D shape

③ Permitted inertia moment limit

Table 3-4 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 (14.6)	(0.25, 0, 0)	0.219 kgm^2	0.114 kgm^2	0.114 kgm^2
m_2 (125.4)	(0.48, 0, -0.26)	2.530 kgm^2	2.915 kgm^2	4.433 kgm^2
m_3 (36.3)	(0.89, 0, -0.26)	0.350 kgm^2	0.314 kgm^2	0.509 kgm^2

B axis inertia moment (J_{a5})

$$J_{a5} = \sum_i \left[m_i(L_{xi}^2 + L_{zi}^2) + J_{yyi}\right]$$

$$= [14.6 \times (0.25^2) + 0.114] + [125.4 \times (0.46^2 + 0.26^2) + 2.915] + [36.3 \times (0.85^2 + 0.26^2) + 0.314] = 67.95 \leq 106\ \text{kg}m^2$$

R1 axis inertia moment (J_{a6})

$$J_{a6} = \sum_i \left[m_i(L_{yi}^2 + L_{zi}^2) + J_{xxi}\right]$$

$$= [14.6 \times (0^2) + 0.219] + [125.4 \times (0.26^2) + 2.530] + [36.3 \times (0.26^2) + 0.350] = 14.03 \leq 56\ \text{kg}m^2$$

④ Conclusion
It is safe because the weight, torque and inertia moment all satisfy the limited condition.

HYUNDAI ROBOTICS

4
Inspection

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

4.1. Inspection Schedule

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].
If you have difficulty in understanding the inspection and adjustment methods, please contact the Hyundai Robotics A/S Center (Customer Support).

Table 4-1 Inspection Schedule

Daily Inspection	Daily	MANIPULATOR, MOTOR, REDUCER
Regular Inspection	3months	WIRING, BOLTS, REDUCER
	1 year	LIMIT SWITCH / Dog, Brake

4.2. Inspection Item and Period

Table 4-2 Inspection Items and Periods

No.	Inspection Intervals			Inspection Items	Inspection method	Standards	Remark
	Daily	3months	1year				
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, paint marking with naked eyes · Examine any cable cover damages with naked eyes		
3		○		Main bolts	Examine paint marking with naked eyes		
4	○			Motor	Check the abnormal heating Check the abnormal sound		
5			○	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							
6	○			Reducer	Check the abnormal sound Check the shaking(vibrating)		
Axis R2, B, R1							
7		○		Reducer	Check the abnormal sound Check the shaking(vibrating)		
8		○		End Effect tightening bolts	Examine paint marking with naked eyes		
9		○		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 [Figure 4.1].
- Check the abnormal noise in an automatic or teaching mode in order to ensure the condition of power transmission (such as motor, reducer, etc).

4.3. Inspection of Main External Bolts

The recommended bolt torque is shown in [Figure 4.1]
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 [HH007C]

No.	Inspection parts	No.	Inspection parts
1	Attachment bolts for the basic axis reducer	**4**	For 1st arm assembly
2	Attachment bolts for the basic axis reducer	**5**	For B, R1 axis motor assembly
3	Attachment bolts for the basic axis motor	**6**	For End Effector assembly

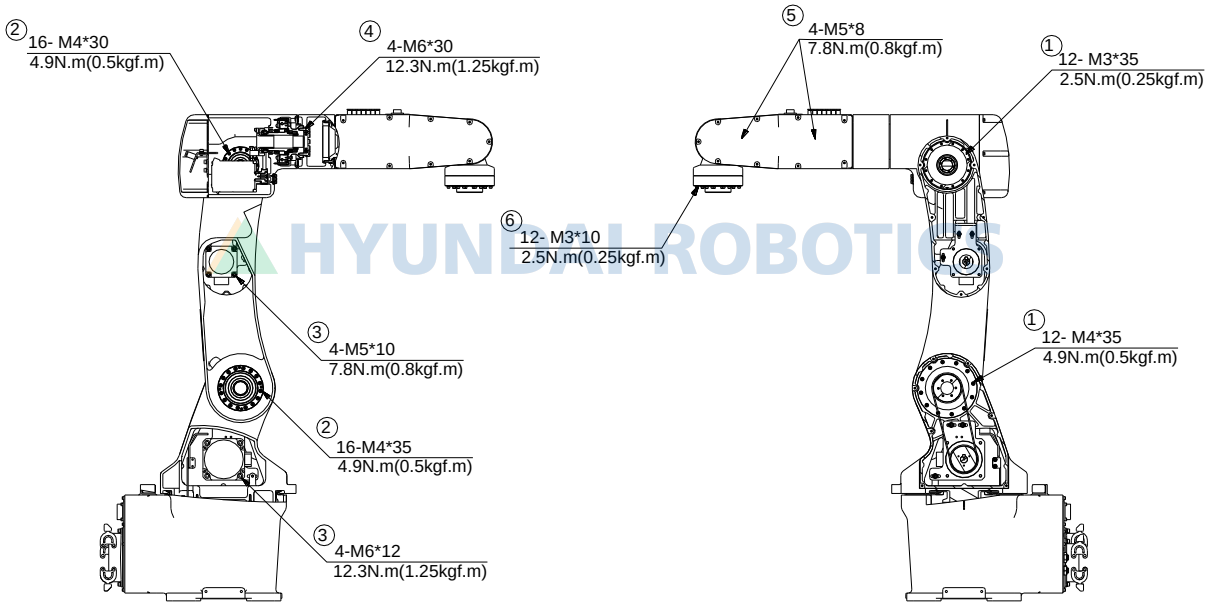


Figure 4.1 Inspection part for main bolts [HH007C]

4.4. Checking wiring in the manipulator

Although internal wiring of robot manipulator is resistant to bending, be sure to inspect everyday, because robot movement may be problematic in the case of disconnection or short circuit caused by damaged wiring and breakage. Then, prior inspection is required when work is done in the operation scope based on the following conditions of safety inspection.

4.4.1. Condition of safety inspection

When users do work such as teaching robot (excluding the case where driving source of industrial robot is blocked) in the operation scope of industrial robot, be sure to check the following items before work. If any abnormality is found, correct immediately and take other necessary actions.

- Check whether outer sheath and cable is damaged or not.
- Check whether robot manipulator works abnormally or not.
- Check the function of emergency stop

4.4.2. Inspection part

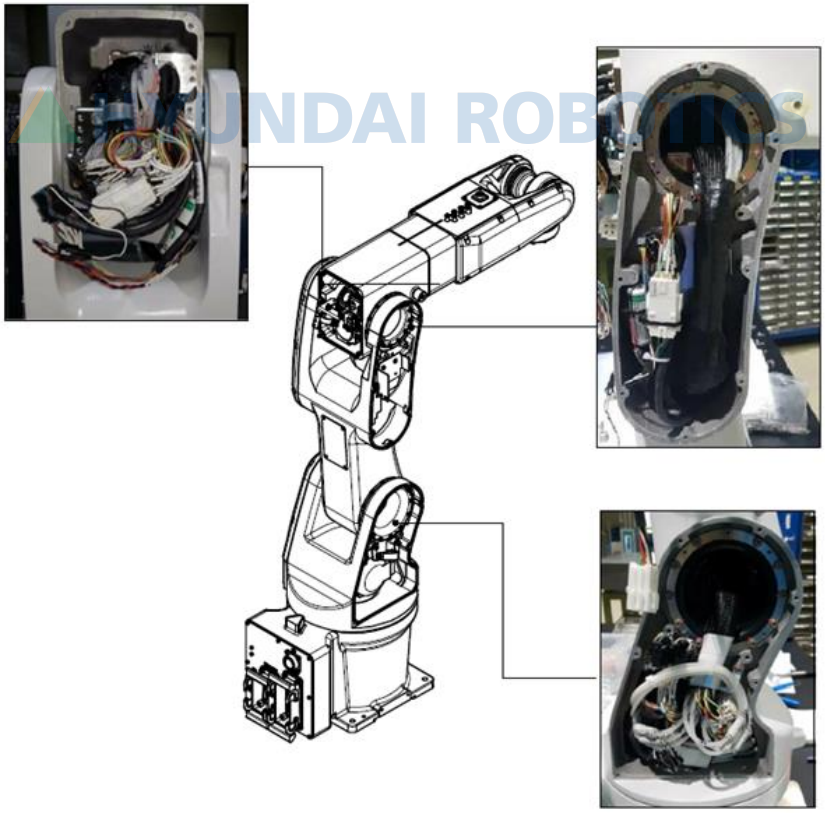


Figure 4.2 Cable inspection part [HH007C]

4.5. Checking the timing belt

The driving part of all the axes, except for the S axis, has a timing belt.
For the operating assembly of the timing belt, check the tension of the belt after every 1,500 hours and when there is vibration/noise on the belt. If the tension of the timing belt is not appropriate, it may have a severely negative effect on the performance of the robot.

- Check the timing belt
  ① Turn off the power.
  ② Take off the arm pipe cover.
  ③ Press the center of the timing belt with the given force (F=0.2kgf).
  ④ Check the pressed length.
  ⑤ If the pressed length is not appropriate (3.4mm), loosen the motor flange bolt slightly.
  ⑥ Set the tension of the timing belt.
  ⑦ Tighten the motor flange bolt.
  ⑧ Assemble the arm pipe cover.
  ⑨ Turn on the power.

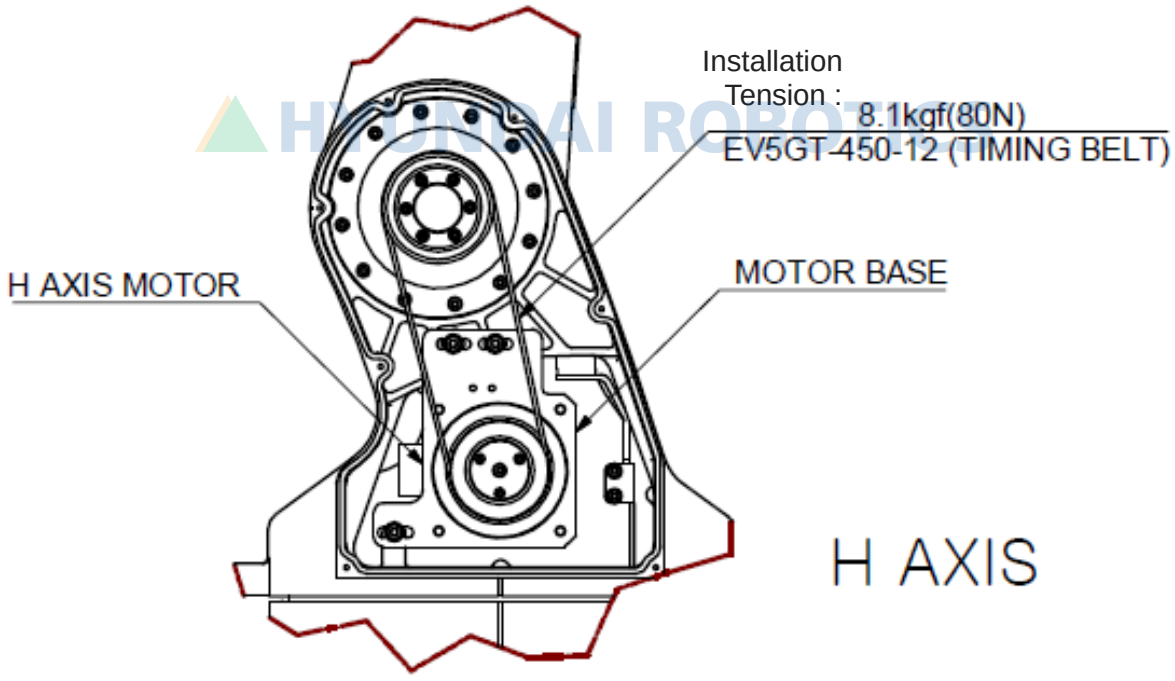


Figure 4.3 Location to check the tension of H axis timing belt [HH007C]

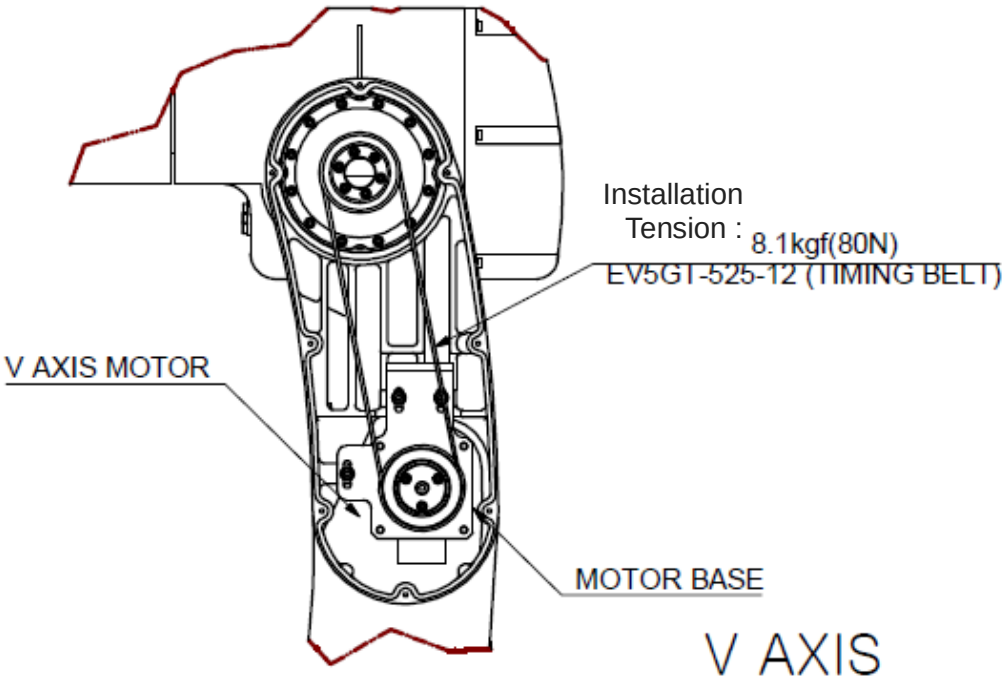


Figure 4.4 Location to check the tension of V axis timing belt [HH007C]

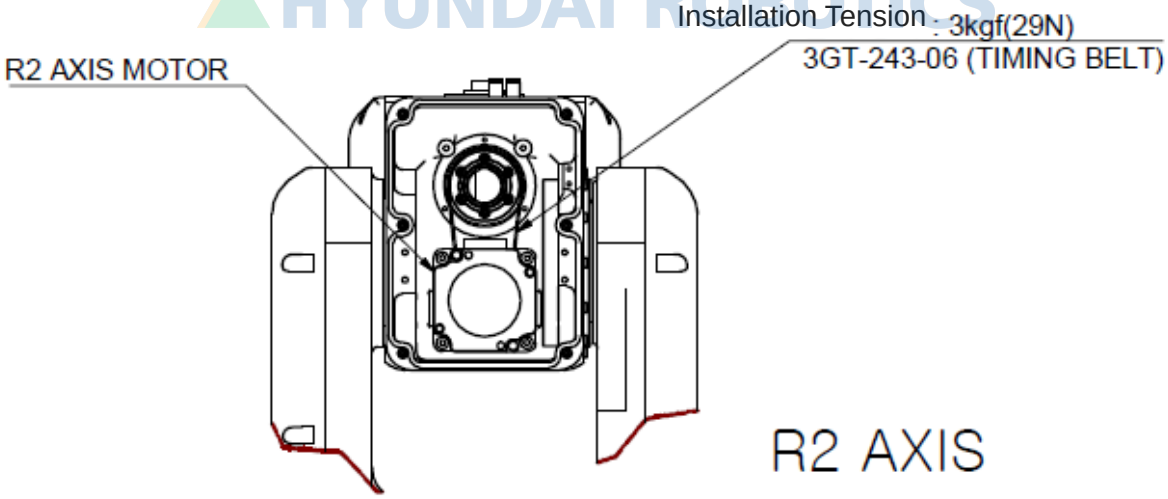


Figure 4.5 Location to check the tension of V axis timing belt [HH007C]

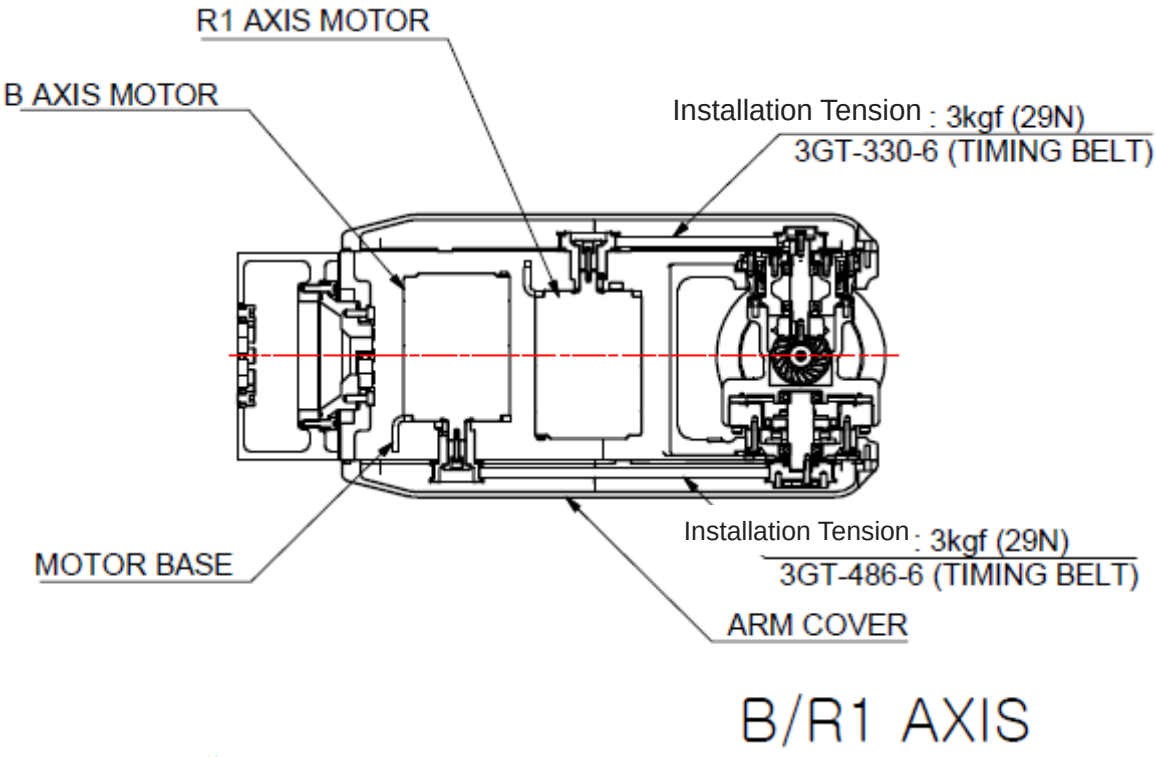


Figure 4.6 Location to check the tension of V axis timing belt [HH007C]

HYUNDAI ROBOTICS

5 Maintenance

5.1. 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) With the power of the control in on condition, press the emergency stop button.

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) Separate the cover of the battery location by each axis.

(3) Remove the old battery.

(4) Insert the new battery. Pay attention to the direction.

- ✓ **Battery specification: ER6C(AA) 3.6V**
- ✓ **Maker: Maxell**

(5) Install the cover to its original location.

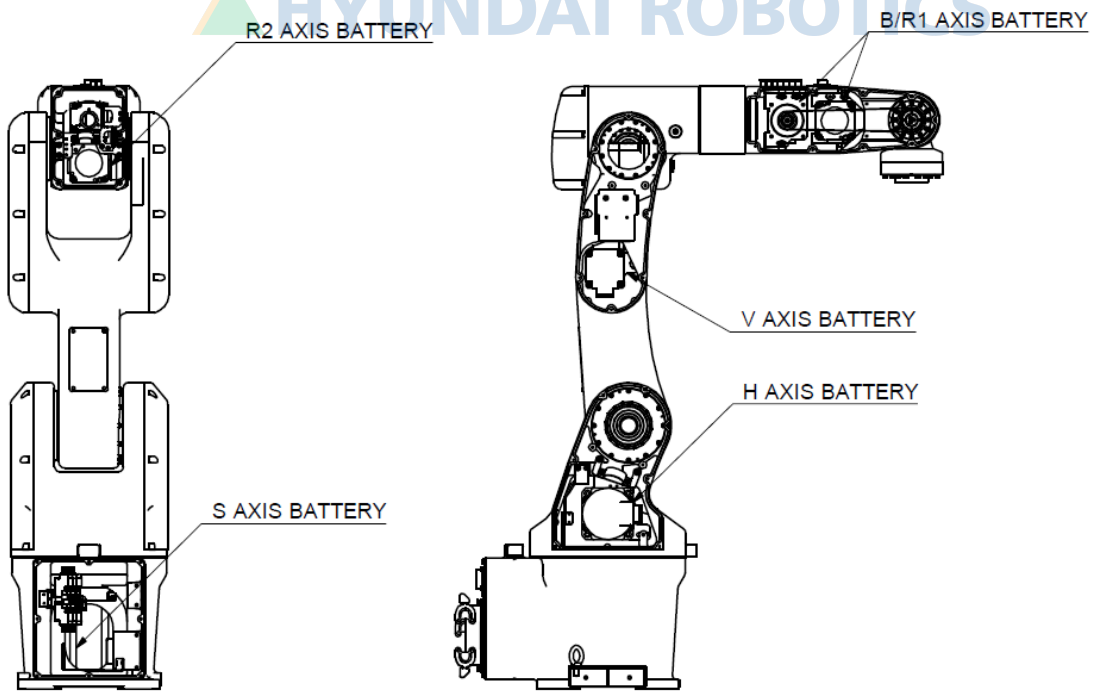


Figure 5.1 Battery replacement location [HH007C]

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 circuit the +/- of the battery.
- ✓ Do not expose batteries to high temperature or flame.

5.1.1. 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±15℃) and at relative humidity of less than 70%.

(3) Check the battery storage every six months, and manage them with first-in-first-out.

5.2. 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.

6
Troubleshooting

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

Defect parts / Trouble phenomenon	Reducer	Brake	Motor	Encoder	Backlash	Grease
Overload [Note 1]	○	○	○			
Displacement	○		○	○		
Abnormal sound occurrence	○	○	○			○ [Note 5]
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.
[Note 5] If there is noise from the greased part of reducer at reduced-speed operation, check the state closely for 1-2 days during operation. Generally, the noise will go away.
(The noise will go away if you run the axis at a high speed for 5-10 minutes).

The noise may be caused by following reasons.

1. Operation after greasing or replacing the reducer
2. Operation after long-term storage
3. Operation at a low speed
4. Operation at a low temperature

6.3. Diagnostics and Resolutions for Major Parts Failure

6.3.1. Reducer

Vibration and abnormal sound will be occurred when a reducer 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 Apply force to the 1st and the 2nd arms to investigate whether the bearings have any gap.
  (When a chain block is to be used, maintain the 1st and the 2nd arms in their positions and check whether the bearings have any gap while not applying any load on the reducer.)
  ② Check if peripheral equipment has been contacted with the robot before the abnormality.

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

- Resolution
  ① Replace the reducer.
  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 reducer replacement)

6.3.2. Brake

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.

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

- Diagnostics
  Check for overheating and abnormal sound.

- Resolution
  Replace the motor.

6.3.4. 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(BD542) 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(BD542), replace the servo amp board.

6.4. Motor and reducer replacement

Caution:

This robot has a brake installed on the motor to maintain the position of the arm and when the motor is disassembled, the arm will fall. To prevent this, hang the arm with the crane or insert a fixating pin to keep the 1st and 2nd arms fixed.

When touching the motor immediately after the robot stops, check the temperature of the motor. The weights of the motor and reducer are as follows. When transporting the motor, be careful.

Please note that entry of dust into the reducer must be prevented and the bolts on the reducer must be tightened to the specified torque when replacing the reducer. Grease must be topped up in the same amount discharged grease.

Table 6-2 Weight (motor)

Axis / Model	S	H	V	R2	B	R1
HH007C	1.8kg	3.1kg	1.8kg	0.9Kg	0.9kg	0.9kg

Table 6-3 Weight (reducer)

Axis / Model	S	H	V	R2	B	R1
HH007C	1.4Kg	1.4kg	0.9kg	0.5Kg	0.4kg	0.5kg

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 performs the work quickly and carefully. An escape route should be determined before starting work.

6.4.1. Necessary Tools and Parts

Table 6-4 Necessary Tools (motor)

Tool Name	Part No.(Model)	Remark
Torque wrench (prepared by user)	M5 Torque wrench M4 Torque wrench M3 Torque wrench	Use torque wrench and extension on the market

Table 6-5 Necessary Tools (reducer)

Tool Name	Part No.(Model)	Remark
Torque wrench (prepared by user)	M6 Torque wrench M5 Torque wrench M4 Torque wrench M3 Torque wrench	Use torque wrench and extension on the market

Table 6-6 Required part and how to set the zero point by axis

Model	Required part	S	H	V	R2	B	R1
HH007C	Location setting scale						
	Location setting V-groove	○	○	○	○	○	○

(When overhauling the robot, you can use the leveler to set the zero point precisely. If you need to calibrate the zero point precisely, please consult with Hyundai Robotics.)

6.4.2. How to Replace Motor

(1) Set the controller to teaching mode and set the robot to standby [ON] condition. If the robot is not in standby [ON] condition, check whether the arm is sufficiently fixated to avoid it from dropping. And then proceed to (4).

(2) The axis requiring motor replacement takes basic posture.

(3) For the S axis: [Figure 6.1]; for the H axis: [Figure 6.2 / 6.3];
for the V axis: [Figure 6.4 / 6.5]; for the R2 axis: [Figure 6.6];
for the B axis: [Figure 6.7]l and for the R1 axis: [Figure 6.8]
Set the origin point of each axis by using the groove made on the frame.

(4) Turn the main power [OFF] with the controller power [OFF].

(5) Disconnect the connector from the motor.

(6) Upon disconnecting the motor wire, remove the motor bolts to detach the motor from the robot body.

(7) Detach the gear from the motor shaft.
Be careful to avoid excessive impact to the motor.

(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 moderate amount of grease to the teeth of gear.

(10) Connect the connector to the motor.

(11) 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.

(12) Perform the encoder calibration about the axis whose motor is replaced. Refer to the chapter [Encoder Calibration] in the controller operating manual.

(13) Confirm that there is no error in robot's motion.

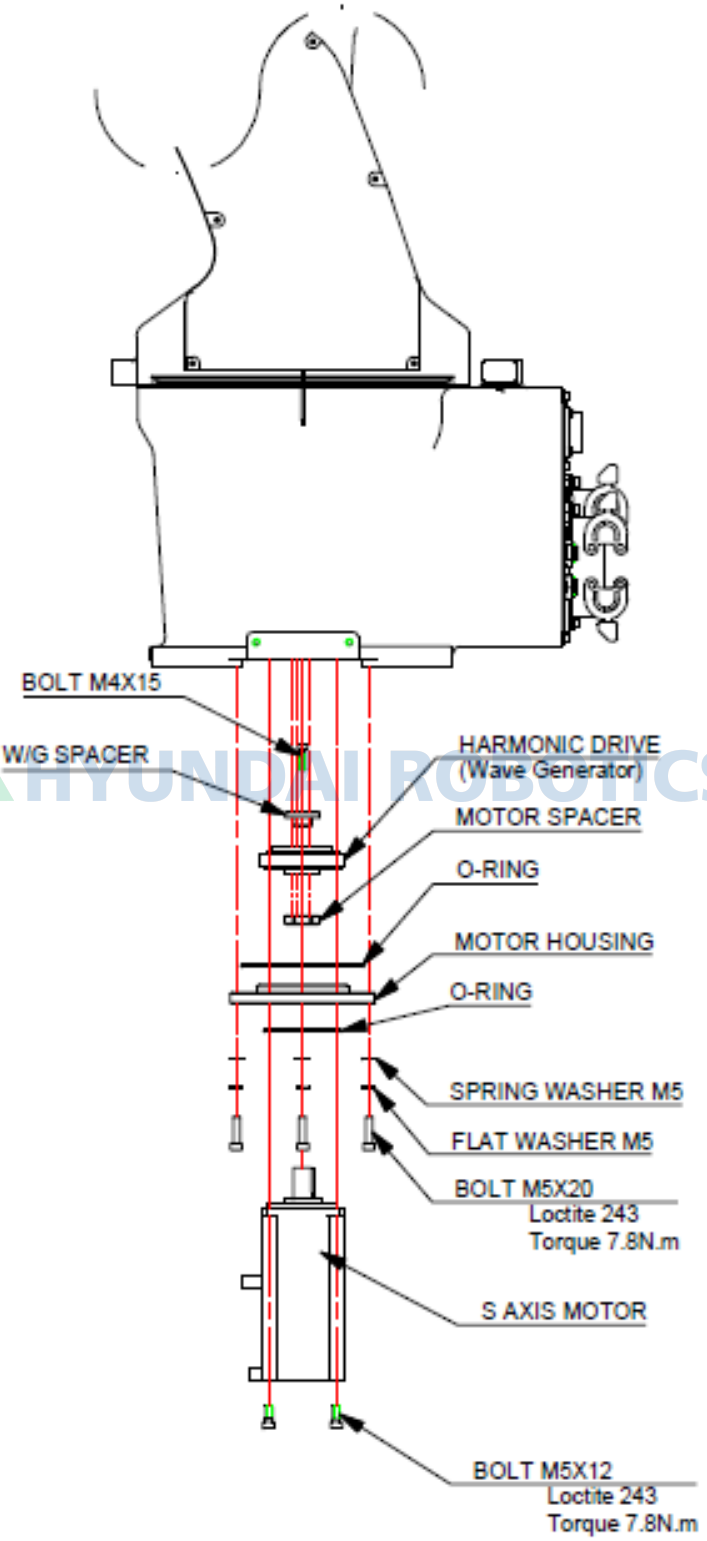


Figure 6.1 S axis motor replacement [HH007C]

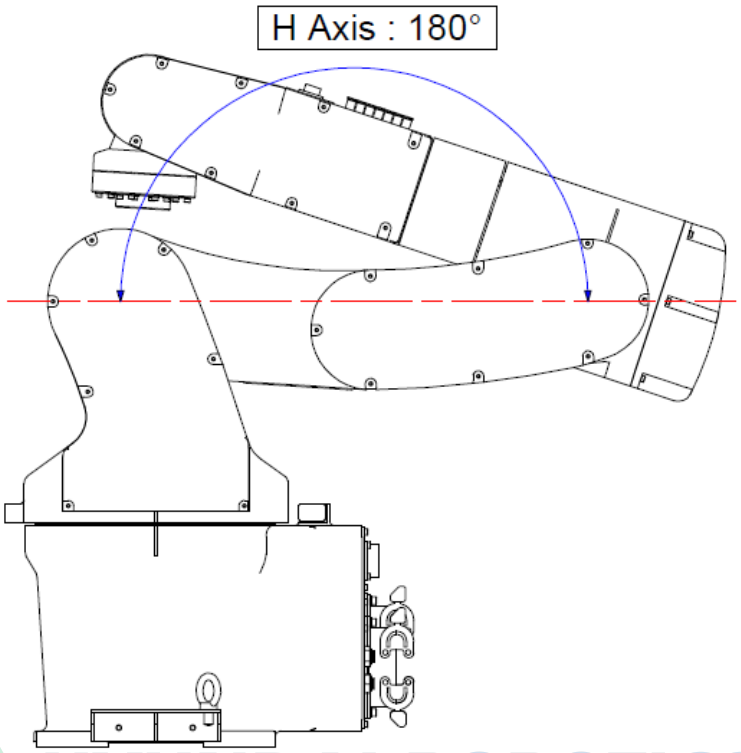


Figure 6.2 Robot position when replacing the H axis motor [HH007C]

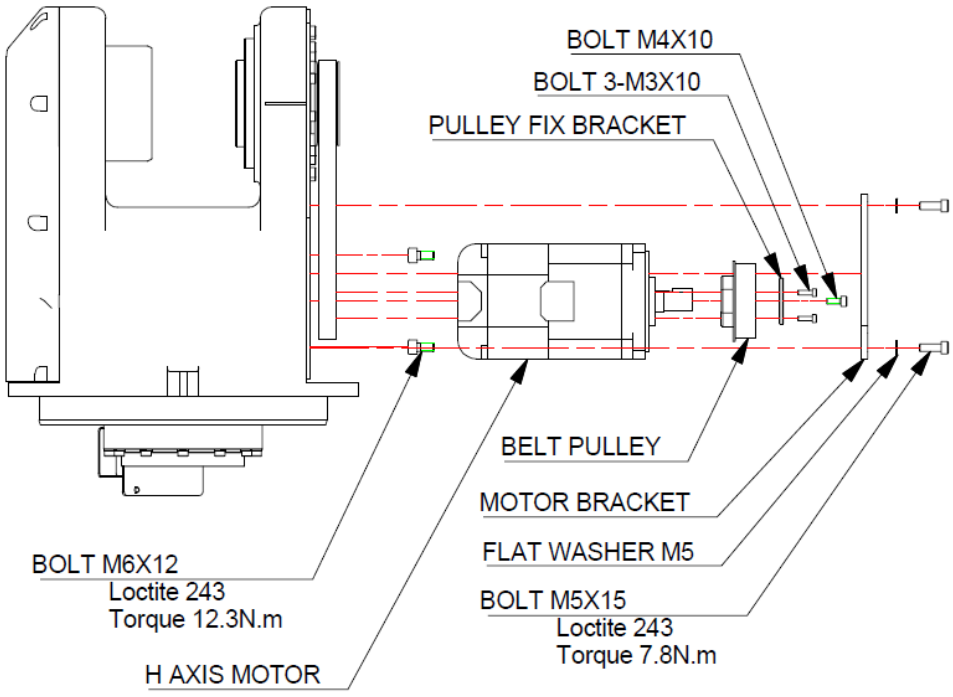


Figure 6.3 H axis motor replacement [HH007C]

Caution

When replacing the V axis motor, the upper arm must accurately be aligned to the direction of gravity to the mechanical stopper so that the upper arm does not rotate.

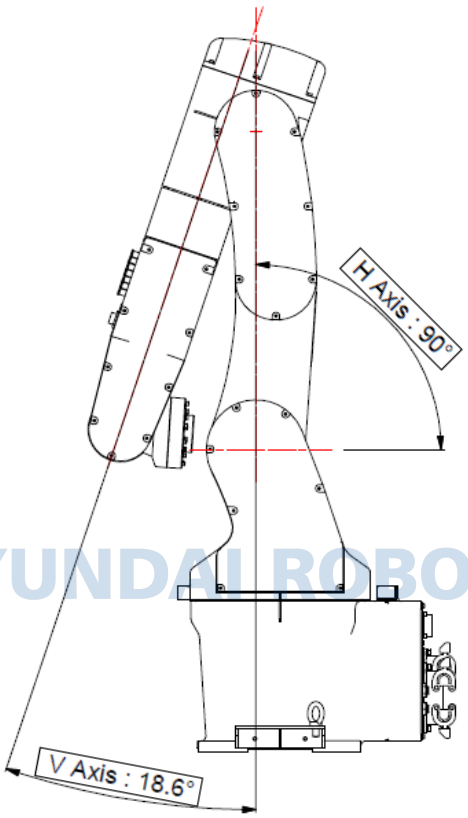


Figure 6.4 Robot position when replacing the V axis motor [HH007C]

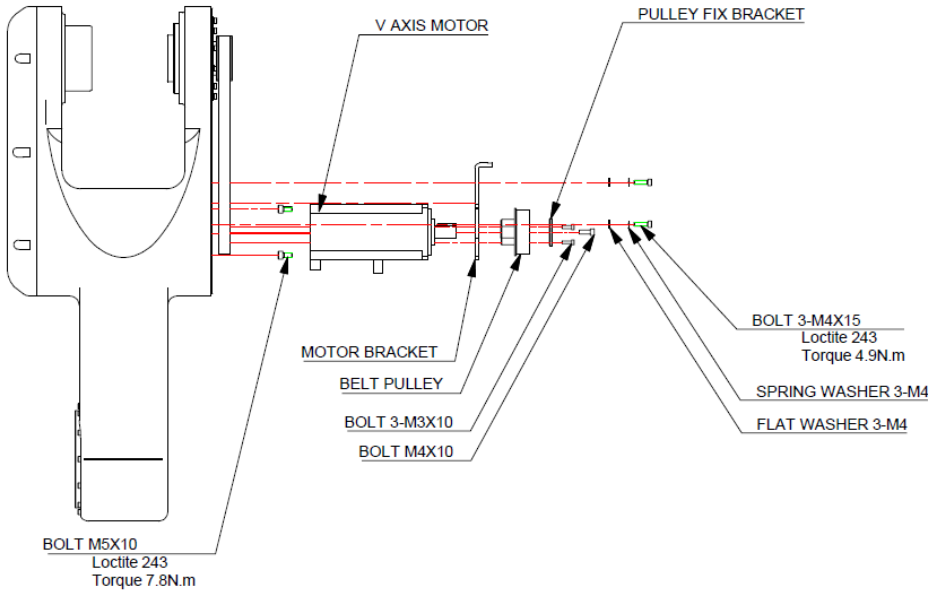


Figure 6.5 V axis motor replacement [HH007C]

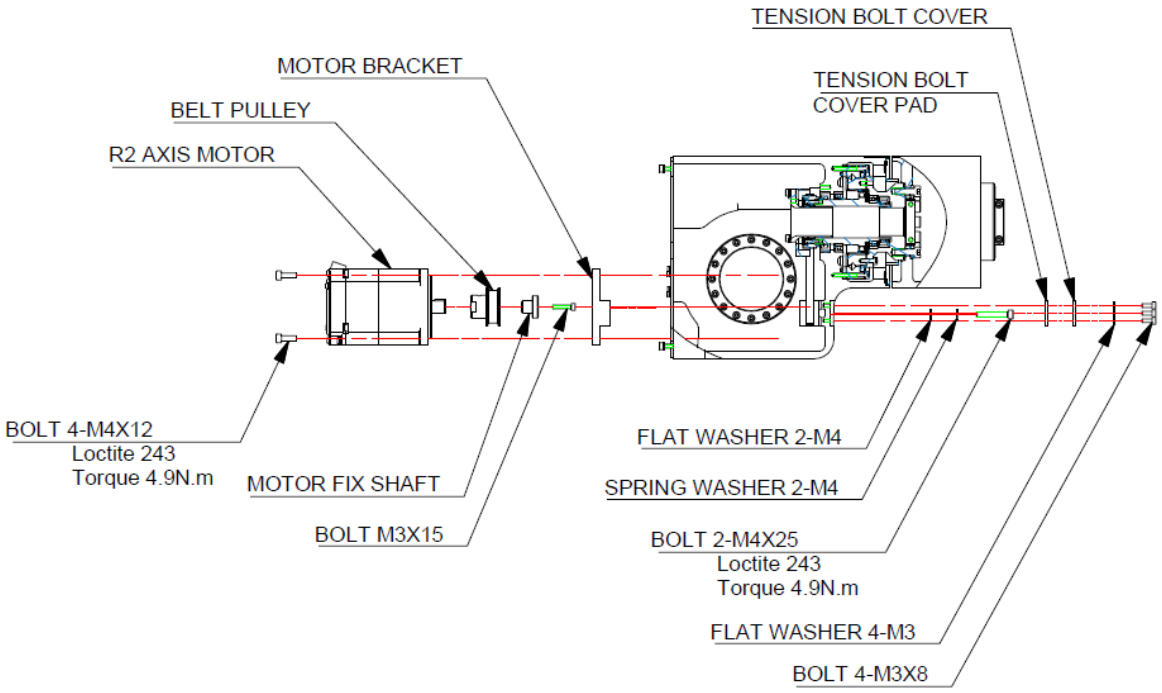


Figure 6.6 R2 axis motor replacement [HH007C]

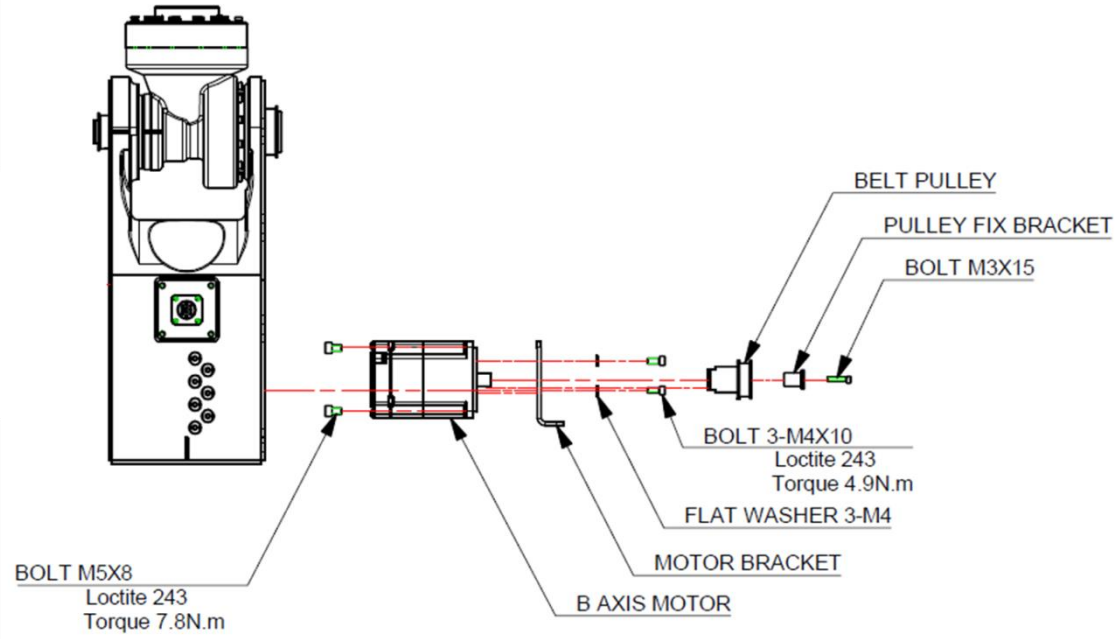


Figure 6.7 B axis motor replacement [HH007C]

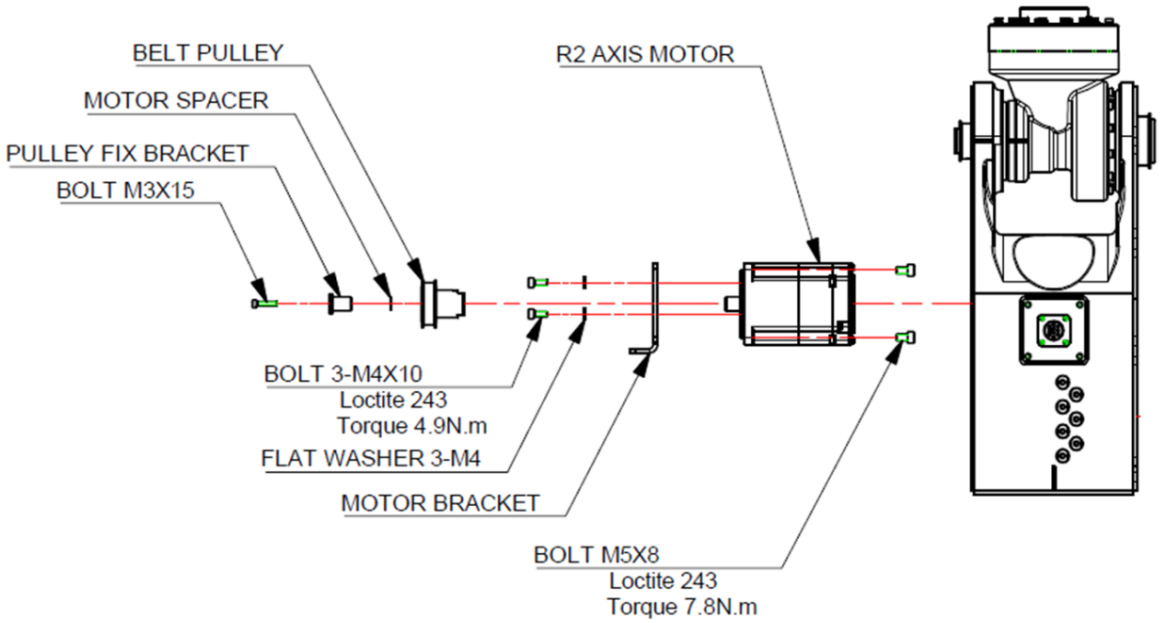


Figure 6.8 R1 axis motor replacement [HH007C]

6.4.3. Replacing Axis-S Reducer [HH007C]

(1) Set the controller to teaching mode and set the robot to standby [ON] condition. If the robot is not in standby [ON] condition, check whether the arm is sufficiently fixated to avoid it from dropping. And then proceed to (4).

(2) Turn the main power [OFF] with the controller power [OFF].

(3) Disconnect the motor wiring of the S axis, remove the bolts from the motor-mounting part, and remove the motor assembly from the body of the robot.

(4) Referring to [Figure 6.13], remove the bolts from the locking part of the S-axis reducer.

(5) Pull out the lower frame.

(6) Remove the bolts from the output part of the S-axis reducer.

(7) Before mounting the new reducer, apply Threebond to the part marked in red.

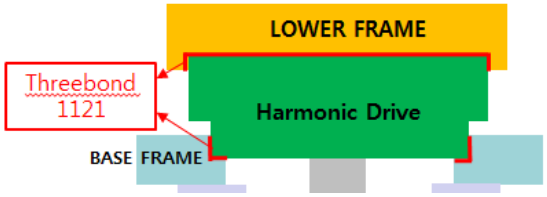


Figure 6.9 S-axis reduction gear Three Bond coating detail [HH007C]

(8) Apply 42 g of the grease (SK-1A) to the inside of the reducer in a thickness that matches the ball diameter of the wave generator.

(9) Mount the new reducer, and fasten the bolts at the output part of the lower frame.

(10) Fasten the bolts at the locking part of the S-axis reducer to the base body.

(11) Mount a new wave generator to the motor assembly that has been detached in (3).
(Apply a thin layer of grease to the outer diameter and the ball of the wave generator.)

(12) Referring to [6.4.2], mount the motor and connect the motor cables.

(13) Confirm that there is no error in robot's motion

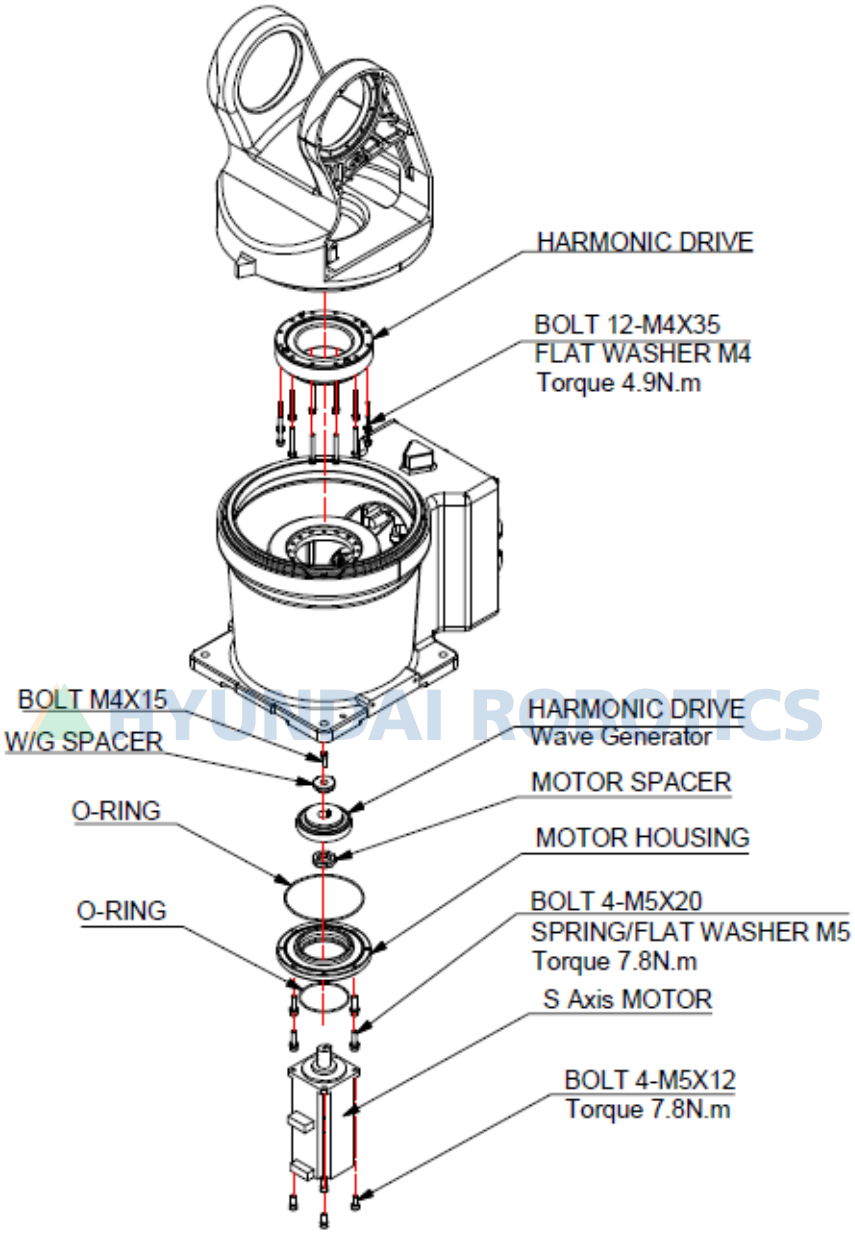


Figure 6.10 Axis-S Reducer Disassembly Diagram [HH007C]

6.4.4. Replacing Axis-H Reducer [HH007C]

(1) Set the controller to teaching mode and set the robot to standby [ON] condition. If the robot is not in standby [ON] condition, check whether the arm is sufficiently fixated to avoid it from dropping. And then proceed to (4).

(2) Turn off the power of the controller and the primary power supply.

(3) By removing the bolts from the H-axis motor bracket, remove the timing belt.

(4) Remove the bolts from the locking/output part of the H-axis reducer.

(5) Mount a new H-axis reducer, and fasten the bolts at the locking/output part.

(6) Adjust the tension of the timing belt..
(Belt: EV5GT / Width: 12 mm / Belt's unit mass: 4 / Span length: 141 mm / Tension: 98 N)

(7) With reference to [6.4.2], assemble the motor and connect the motor wire.

(8) Confirm that there is no error in robot's motion.

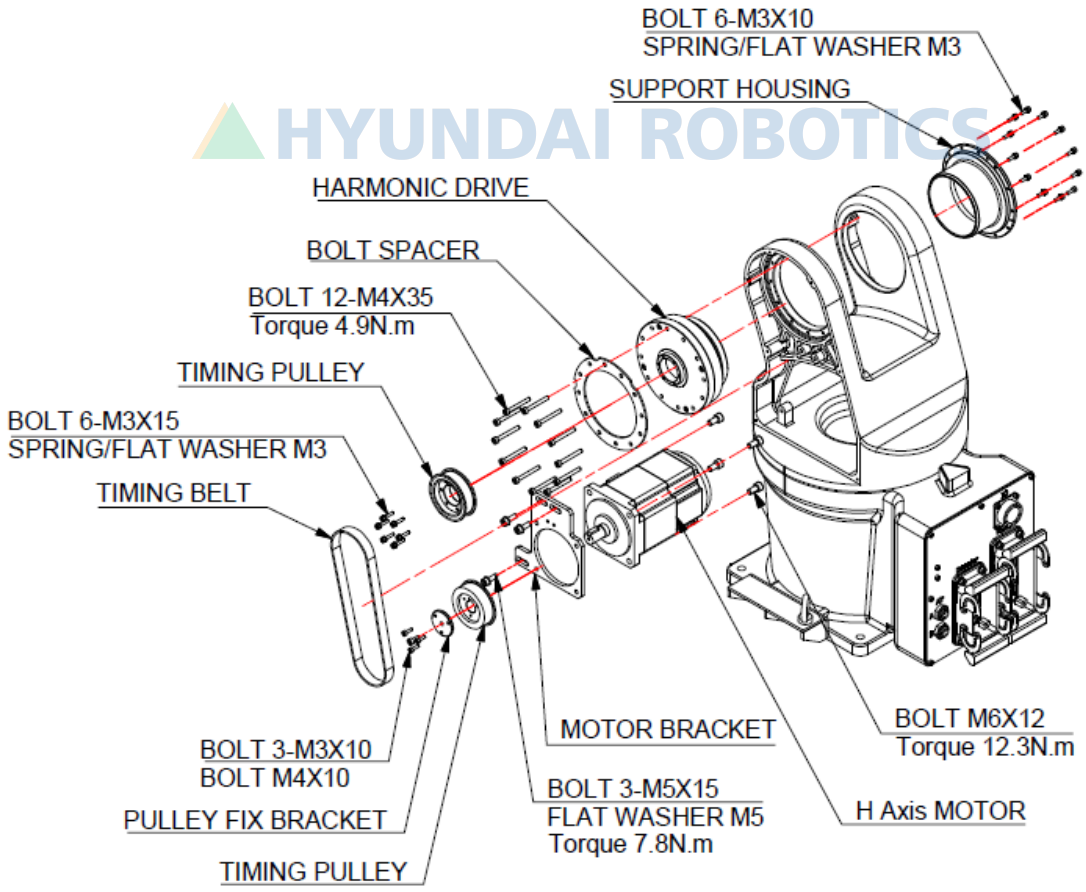


Figure 6.11 Axis-H Reducer Disassembly Diagram [HH007C]

6.4.5. Replacing Axis-V Reducer [HA006L]

(1) Set the controller to teaching mode and set the robot to standby [ON] condition. If the robot is not in standby [ON] condition, check whether the arm is sufficiently fixated to avoid it from dropping. And then proceed to (3).

(2) Turn the main power [OFF] with the controller power [OFF].

(3) By removing the bolts from the V-axis motor bracket, remove the timing belt.

(4) Remove the R2-axis motor wiring of the arm frame, and remove the R2 motor.

(5) Remove the bolts from the locking/output part of the V-axis reducer..

(6) Mount a new V-axis reducer, and fasten the bolts at the locking/output part.

(7) Referring to [6.4.2], reassemble the R2-axis motor, and adjust the tension of the timing belt.
(Belt: 3GT / Width: 6 mm / Belt's unit mass: 2.5 / Span length: 66 mm / Tension: 29 N)

(8) Adjust the tension of the V-axis timing belt..
(Belt: EV5GT / Width: 12 mm / Belt's unit mass: 4 / Span length: 190 mm / Tension: 98 N)

(9) Referring to [6.4.2], connect the R2-axis motor cables of the arm frame, and put the cables in order..

(10) Confirm that there is no error in robot's motion.

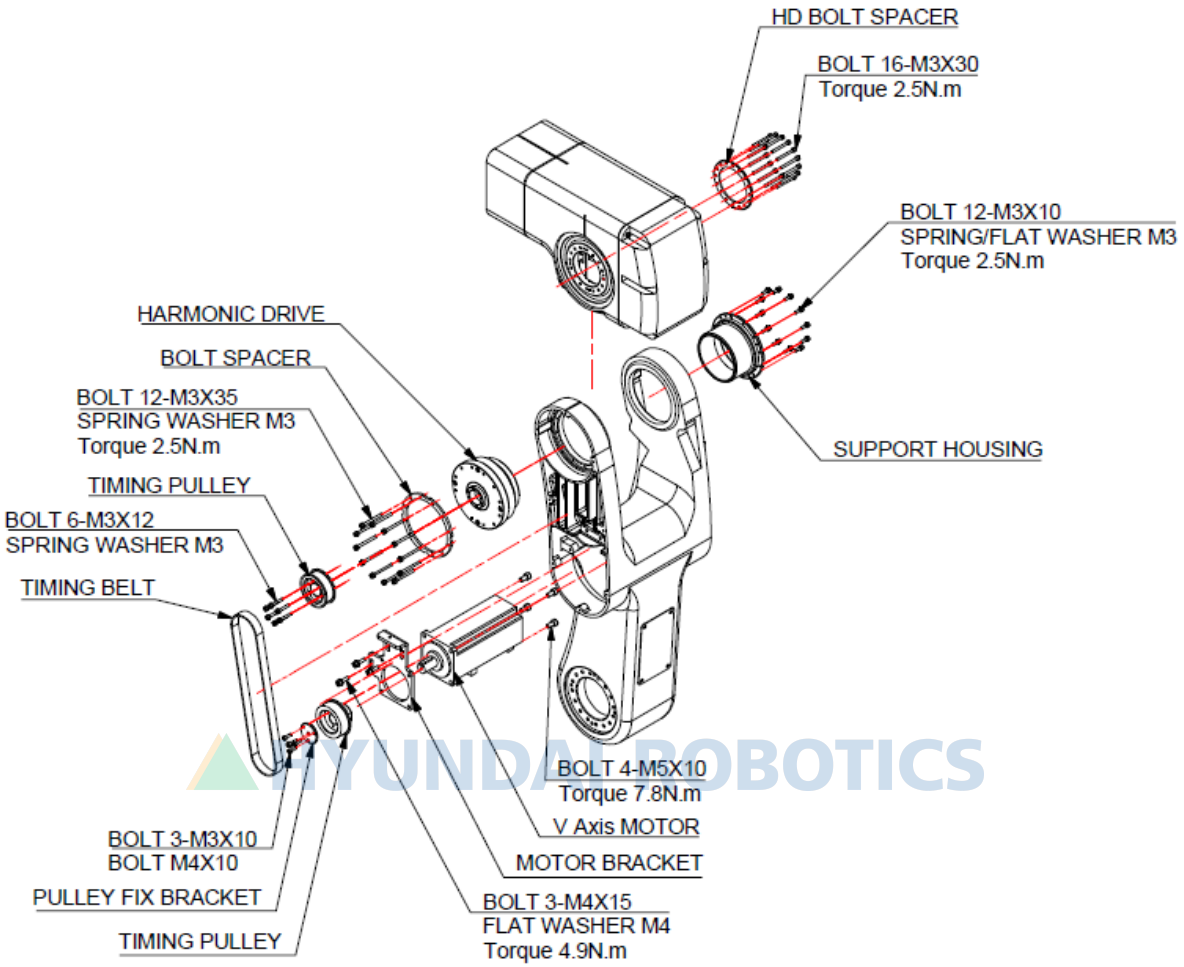


Figure 6.12 Axis-V Reducer Disassembly Diagram [HH007C]

6.4.6. Replacing Axis-R2 Reducer [HH007C]

(1) Set the controller to teaching mode and set the robot to standby [ON] condition. If the robot is not in standby [ON] condition, check whether the arm is sufficiently fixated to avoid it from dropping. And then proceed to (3).

(2) Turn the main power [OFF] with the controller power [OFF].

(3) Remove the R2-axis motor wiring of the arm frame, and remove the R2 motor.

(4) Remove the internal parts of the arm frame, including the cable guides, timing pulley, and timing belt.

(5) Remove the frontal parts of the reducer, including the frame spacer and front housing..

(6) Fasten the bolts at the locking part of the R2-axis reducer.

(7) Apply 13 g of grease (SK-1A) to the inside of the reducer in a thickness that matches the ball diameter of the wave generator .

(8) Mount a new R2-axis reducer and fasten the bolts at the locking part.

(9) Apply Threebond to the outer and inner wheels of the bearing, as shown in the following figure, and insert the bearing into the wave generator (replaced).

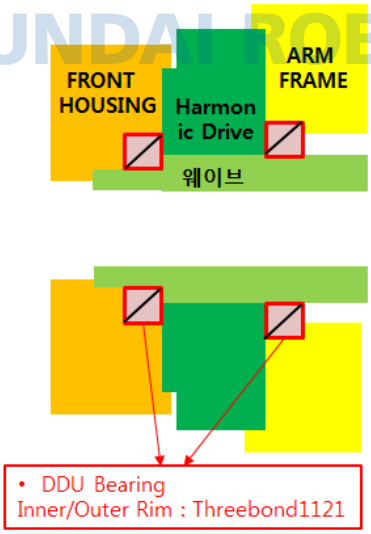


Figure 6.13 R2-axis reduction gear Three Bond coating detail [HH007C]

(10) Apply a thin layer of grease to the outer diameter and the ball of the wave generator. Then, insert the wave generator.

(11) Reassemble the parts in (3)–(5).

(12) Reassemble the R2-axis motor, and adjust the tension of the timing belt.
(Belt: 3GT / Width: 6 mm / Belt's unit mass: 2.5 / Span length: 66 mm / Tension: 29 N)

(13) Connect the R2-axis motor cables of the arm frame, and put the cables in order.

(14) Confirm that there is no error in robot's motion

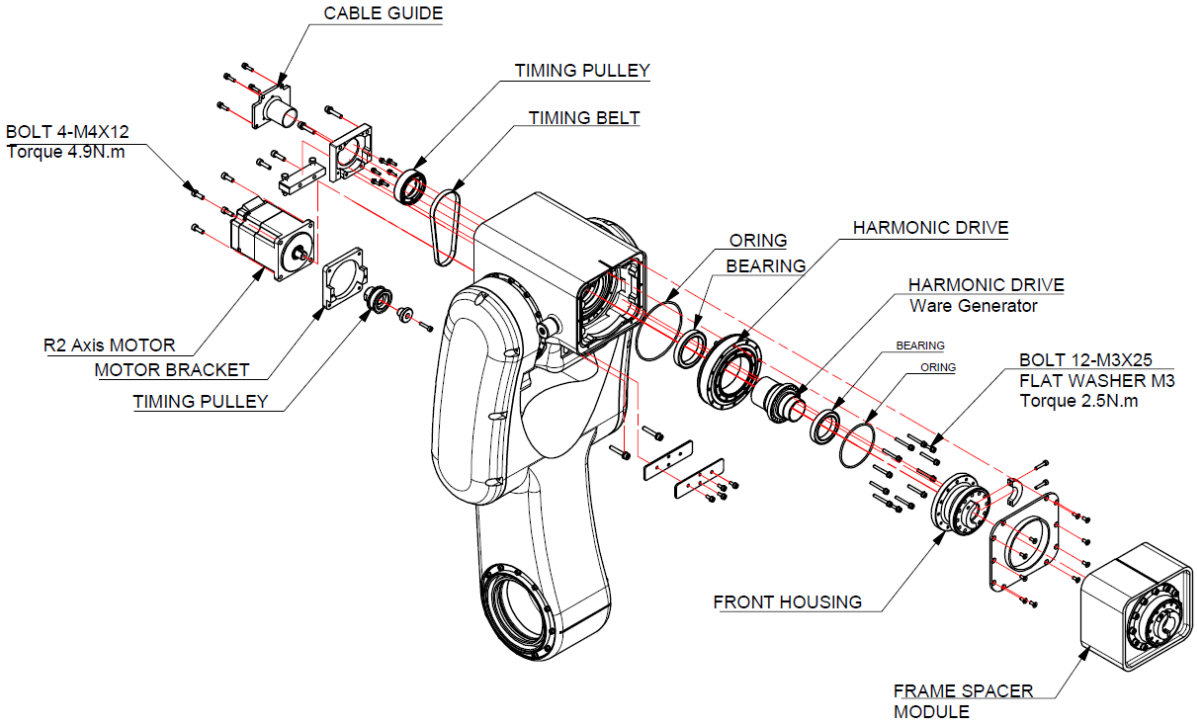


Figure 6.14 Axis-R2 Reducer Disassembly Diagram [HA006L]

6.4.7. Replacing Axis-B Reducer [HH007C]

(1) Set the controller to teaching mode and set the robot to standby [ON] condition. If the robot is not in standby [ON] condition, check whether the arm is sufficiently fixated to avoid it from dropping. And then proceed to (3).

(2) Turn the main power [OFF] with the controller power [OFF].

(3) By removing the bolts from the B-axis and R1-axis motor brackets, remove the timing belts.

(4) Remove the H/D housing, as shown in [Figure 6.13], and remove the wave generator.

(5) Remove the bearing support housing and the bearing housing as shown in [Figure 6.14].

(6) Remove the wrist body, and remove the bolts from the locking part of the B-axis reducer.

(7) Apply 9 g of grease (SK-1A) to the inside of the reducer in a thickness that matches the ball diameter of the wave generator..

(8) Mount a new B-axis reducer, and fasten the bolts at the locking part.

(9) Apply Threebond to the outer and inner wheels of the bearing as shown in the following figure, and insert the bearing into the axis of the wave generator..

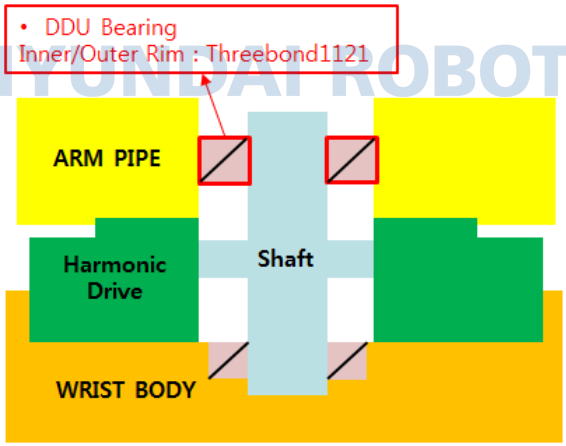


Figure 6.15 B-axis reduction gear Three Bond coating detail [HH007C]

(10) Connect the wave generator (replaced) to the axis, and insert it.

(11) Insert the wrist body into the arm pipe.

(12) By fastening the bolts of B-axis and R1-axis motor brackets, adjust the tension of the timing belts.
(B-axis belt: 3GT / Width: 6 mm / Belt's unit mass: 2.5 / Span length: 193 mm / Tension: 29 N)
(R1-axis belt: 3GT / Width: 6 mm / Belt's unit mass: 2.5 / Span length: 119 mm / Tension: 29 N)

(13) Confirm that there is no error in robot's motion.

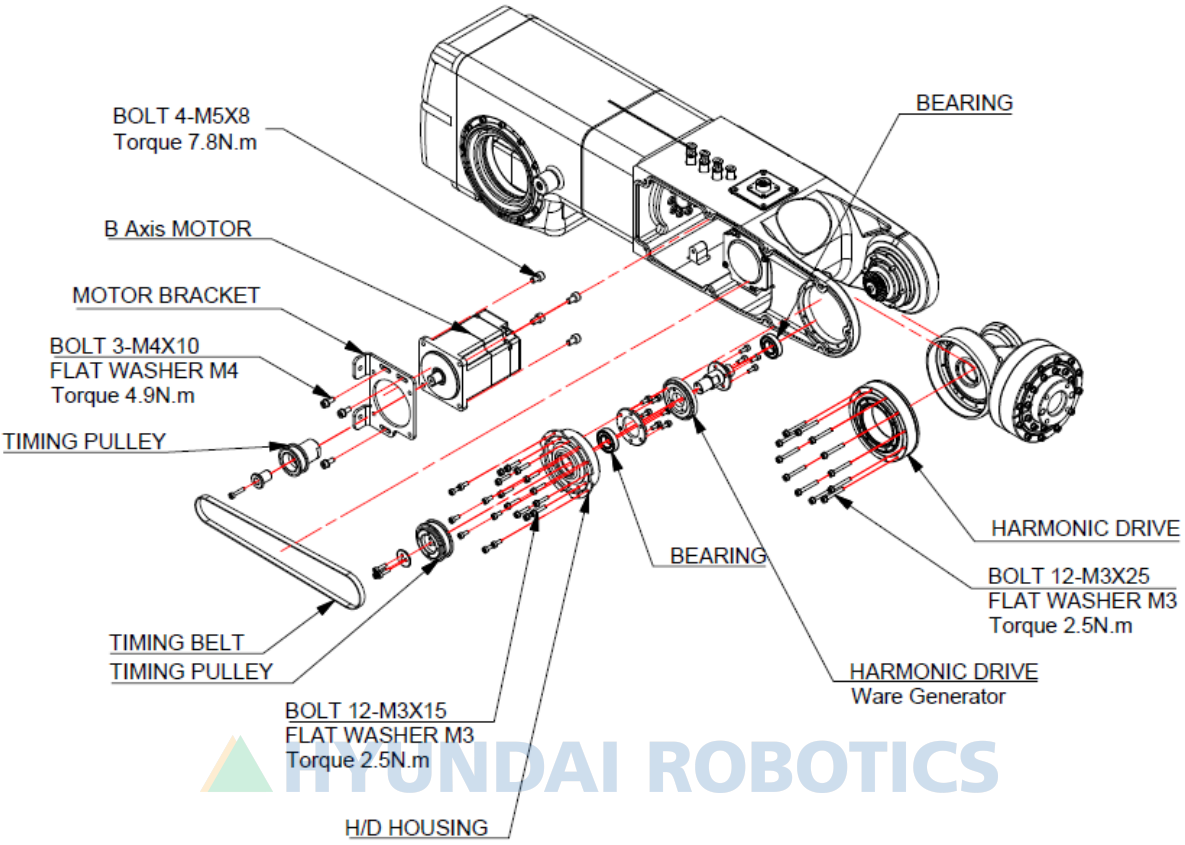


Figure 6.16 Axis-B Reducer Disassembly Diagram [HH007C]

6.4.8. Replacing Axis-R1 Reducer [HH007C]

(1) Set the controller to teaching mode and set the robot to standby [ON] condition. If the robot is not in standby [ON] condition, check whether the arm is sufficiently fixated to avoid it from dropping. And then proceed to (3).

(2) Turn the main power [OFF] with the controller power [OFF].

(3) Remove the bolts from the output part of the R1-axis reducer..

(4) Remove the wave generator.

(5) Remove the bolts from the locking part of the R1-axis reducer..

(6) Apply 13 g of grease (SK-1A) to the inside of the reducer in a thickness that matches the ball diameter of the wave generator.

(7) Apply Threebond to the outer and inner wheels of the bearing, as shown in the following figure, and insert the bearing into the axis of the wave generator.

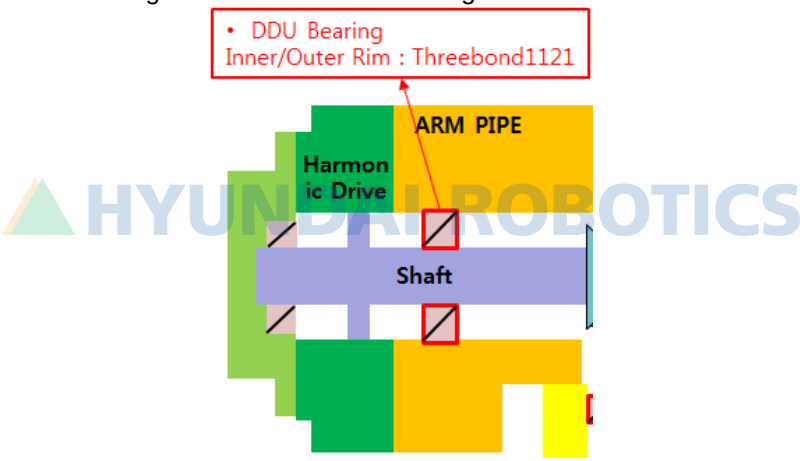


Figure 6.17 R1-axis reduction gear Three Bond coating detail [HH007C]

(8) Connect the wave generator (replaced), and insert it..

(9) Fasten the bolts at the output part of the R1-axis reducer.

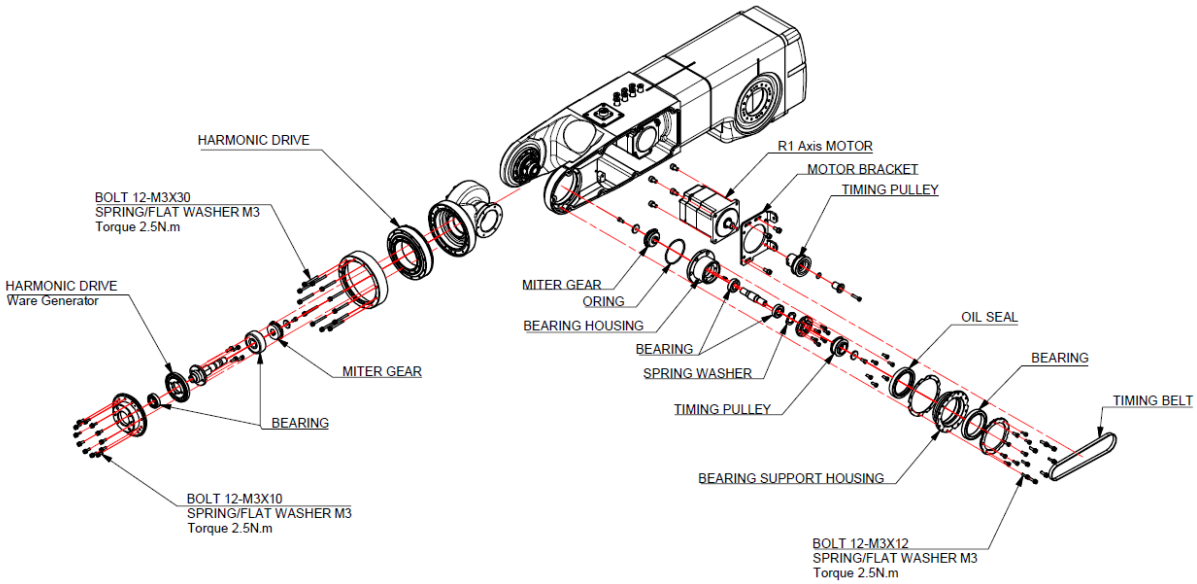


Figure 6.18 Axis-R1 Reducer Disassembly Diagram [HH007C]

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.

A scale or V-groove is used to determine the standard posture position for each axis of the robot. When the motor is replaced by the user, set the encoder using the scale or V-groove to have each axis at its original point.

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) Set the controller to teaching mode and set the robot to standby [ON] condition.
If the robot cannot be set to standby [ON] condition due to issues, use the brake cancel switch to set the reference location of the robot.

(2) Move each axis to the basic posture to align it with the scale or V-groove.

(3) Reset the Encoder. Refer to 『6.5.2 Encoder Reset』 for the method of encoder reset.

(4) Correct the encoder. Refer to 『Controller Operation Manual』.

(5) Confirm that there is no problem in robot motion.

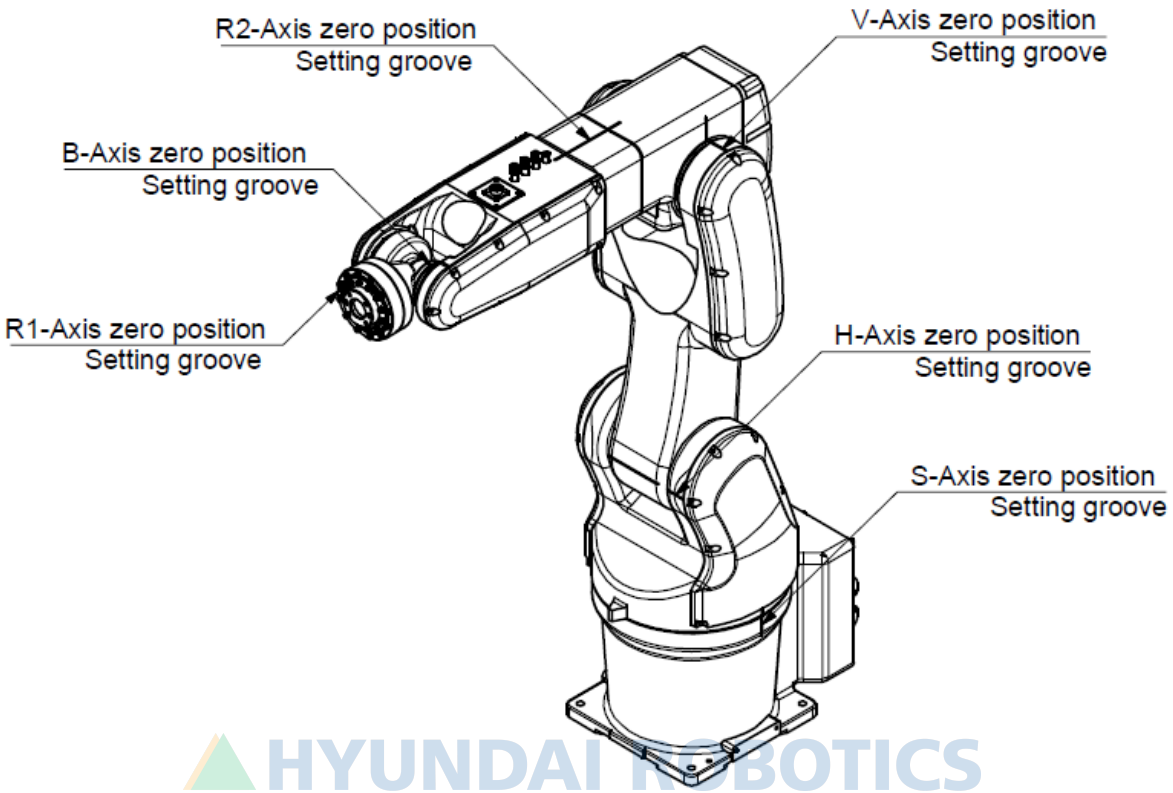
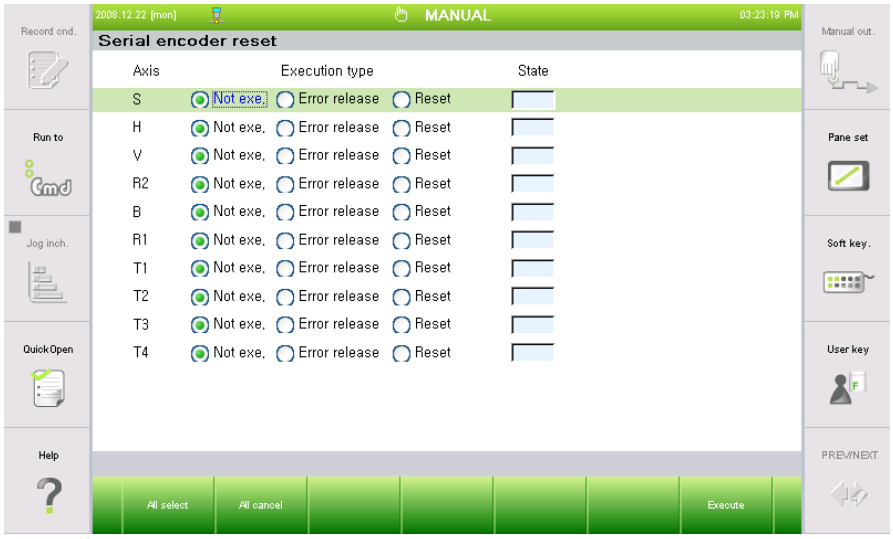


Figure 6.19 Zero point setting method [HH007C]

6.5.2. Encoder Reset

(1) Turn off the motor.

(2) Open the serial encoder reset window. (『[F2]: System』 → 『5: Initialize』 → 『4: Serial encoder reset』)



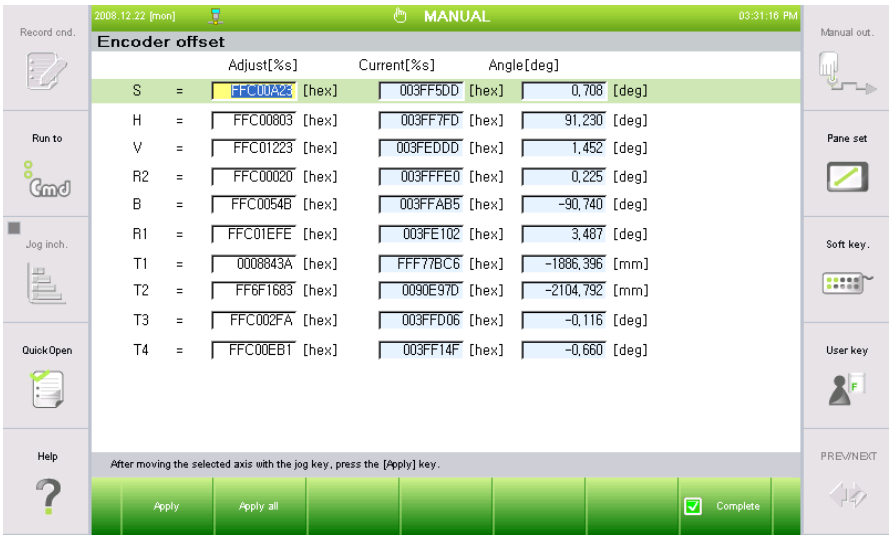
(3) Use keys like [↓], [↑], [SHIFT] + [←][→] to move to a desirable axis, then press the [Execute] key.

(4) After the encoder is reset, please make sure the controller power is turned on.

6.5.3. Encoder offset and Selection

- It is necessary to compensate encoder data for the basic position of each axis.
- Refer to 『Encoder offset』in the Controller Manual for details.

[Encoder offset Screen]



(1) Select the axis, move the axis to a standard position using the [Axis operation] key, and press the 『[F1]: Apply』 key.

(2) Place the robot's entire axis as the standard position using the [Axis operation] key and press the 『[F2]: Apply all』 key to carry out encoder offset correction for the entire axis.

(3) To save the set data, press the 『[F7]: Complete』 key. The [ESC] key will prevent the changes being saved.

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

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 [HH007C]

Category	Part Name	Manufacturer	Per Unit		Application
		Specification	Use	Rec.	
A	Grease	Hyundai Robotics SK-1A		2.5kg/CAN	S,R2,B,R1 Harmonic reducer
A	Encoder Battery	Hyundai Robotics ER6C(AA)3.6V	6EA	6EA	Replace every 2 years irrelevant from operating time
B	AC servo motor	Hyundai Robotics	1EA	1EA	S-Axis
B	AC servo motor	Hyundai Robotics	1EA	1EA	V-Axis
B	AC servo motor	Hyundai Robotics	1EA	1EA	H-Axis
B	AC servo motor	Hyundai Robotics	1EA	1EA	R2-Axis
B	AC servo motor	Hyundai Robotics	1EA	1EA	B-Axis
B	AC servo motor	Hyundai Robotics	1EA	1EA	R1-Axis

Category	Part Name	Manufacturer	Per Unit		Application
		Specification	Use	Rec.	
C	Harmonic drive	Hyundai Robotics	1EA	1EA	S-Axis
C	Harmonic drive	Hyundai Robotics	1EA	1EA	H-Axis
C	Harmonic drive	Hyundai Robotics	1EA	1EA	V-Axis
C	Harmonic drive	Hyundai Robotics	1EA	1EA	R2-Axis
C	Harmonic drive	Hyundai Robotics	1EA	1EA	B-Axis
C	Harmonic drive	Hyundai Robotics	1EA	1EA	R1-Axis
C	CABLE ASS'Y	Hyundai Robotics	1Set	1Set	HH007C
D	V SEAL	Hyundai Robotics VL-200	1EA	1EA	S-Axis
D	OIL SEAL	NOK AE 3733 E0	1EA	1EA	H-Axis

Category	Part Name	Manufacturer	Per Unit		Application
		Specification	Use	Rec.	
D	OIL SEAL	NOK AE 2048 K0	1EA	1EA	V-Axis
D	OIL SEAL	NOK AE 3513 E0	1EA	1EA	R2-Axis
D	OIL SEAL	NOK AE 1538 E5	1EA	1EA	B-Axis
D	OIL SEAL	NOK AE 2343 E0	1EA	1EA	R1-Axis
D	O RING	Hyundai Robotics ID86.7 D1.78(NBR)	1EA	1EA	S-Axis
D	O RING	Hyundai Robotics AS568-34	1EA	1EA	S-Axis
D	O RING	Hyundai Robotics AS568-40	1EA	1EA	R2-Axis
D	O RING	Hyundai Robotics AS568-37	1EA	1EA	R2-Axis
D	O RING	Hyundai Robotics AS568-34	1EA	1EA	R2-Axis
D	O RING	Hyundai Robotics AS568-30	1EA	1EA	B-Axis

Category	Part Name	Manufacturer	Per Unit		Application
		Specification	Use	Rec.	
D	BALL BEARING	NSK 6816ZZ	1EA	1EA	V-Axis
D	BALL BEARING	NSK 6814ZZ	1EA	1EA	R2
D	BALL BEARING	NSK 6807DD	1EA	1EA	R2
D	BALL BEARING	NSK 6806DD	1EA	1EA	R2
D	BALL BEARING	NSK 6901DDU	1EA	1EA	R2
D	BALL BEARING	NSK 6808ZZ	1EA	1EA	B-Axis
D	BALL BEARING	NSK 6900DD	1EA	1EA	B-Axis
D	BALL BEARING	NSK 6901DDU	1EA	1EA	B-Axis
D	BALL BEARING	NSK 6301DDU	1EA	1EA	R1-Axis
D	Timing belt	Hyundai Robotics EV5GT-L450-12	1EA	1EA	H-Axis

Category	Part Name	Manufacturer	Per Unit		Application
		Specification	Use	Rec.	
D	Timing belt	Hyundai Robotics EV5GT-L525-12	1EA	1EA	V-Axis
D	Timing belt	Hyundai Robotics 3GT-L243-6	1EA	1EA	R2-Axis
D	Timing belt	Hyundai Robotics 3GT-486-6	1EA	1EA	B-Axis
D	Timing belt	Hyundai Robotics 3GT-330-6	1EA	1EA	R1-Axis

8
Decommission

8. Decommission

The robot is made up of several materials as shown in [Table 8-1]. Some of them should be properly arranged and sealed up to eliminate any bad influence on the human body or environment.

Table 8-1 Materials of each part

Parts	Materials
Battery	NiCad or Lithium
Wiring, Motor	Copper
Brakes, Motors	Samarium Cobalt(or Neodymium)
Wiring, Connectors	Plastic / Rubber
Reducers, Bearings	Oil / Grease
1st Arm, Wrist Cover etc.	Aluminum alloy cast

9

Internal Wiring Diagram

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

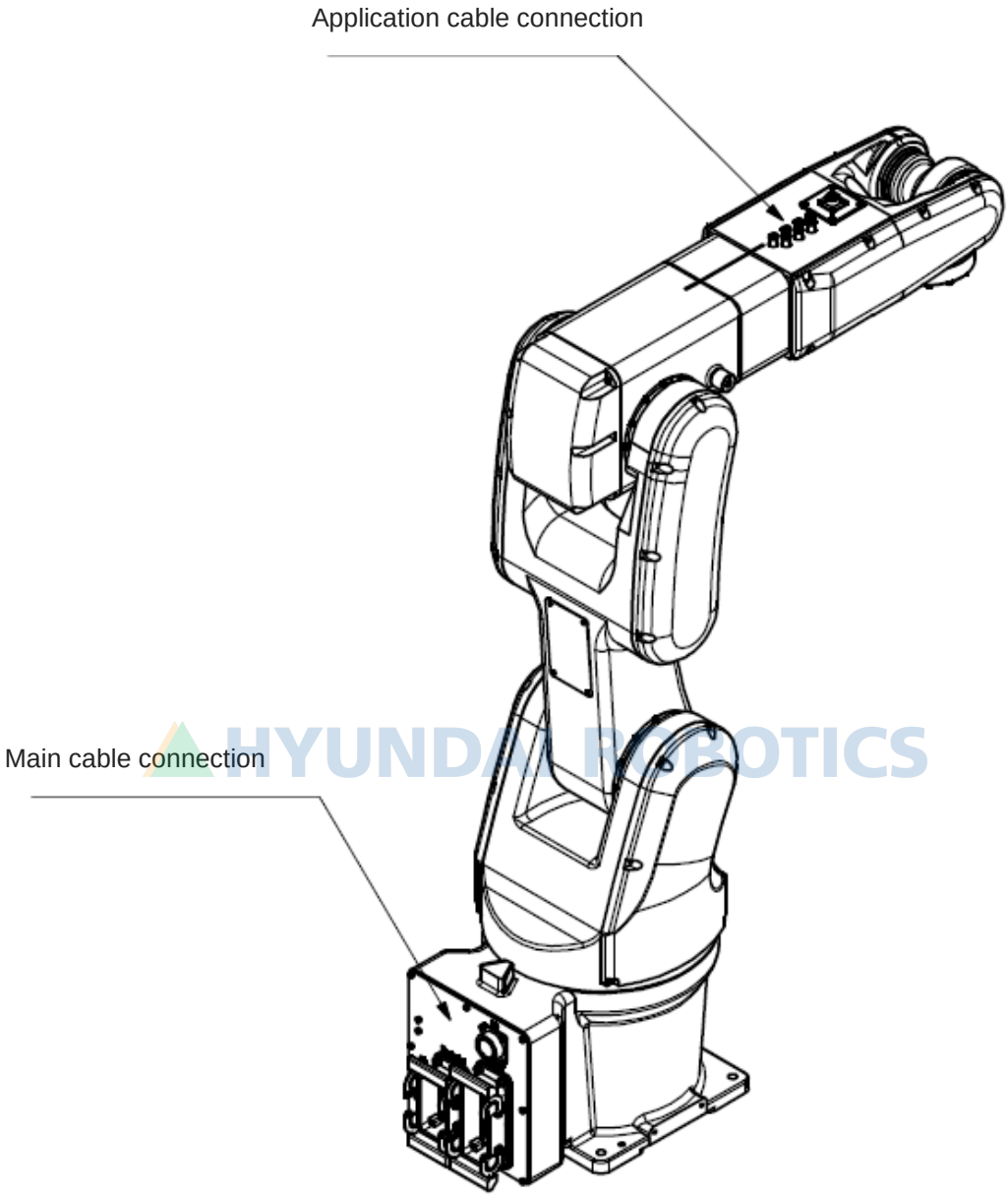


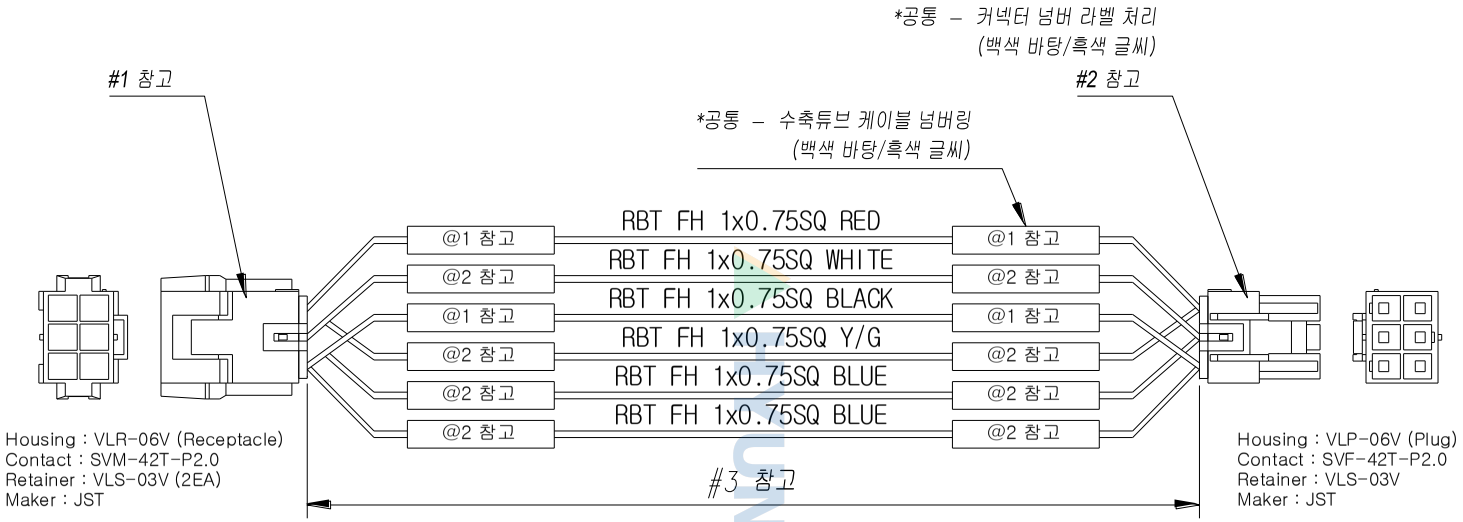
Figure 9.1 Manipulator Configuration [HH007C]

HH007C 로봇 기내 배선도

PAGE NO	CONTENTS
1	3 SEC PW,BK CABLE(900mm)
2	1,2 SEC USER CABLE
3	4 SEC USER CABLE
4	3 SEC ENC CABLE(900mm)
5	1 SEC BATTERY
6	1,2 SEC PW,BK CABLE
7	3 SEC USER CABLE(900mm)
8	1,2 SEC USER CABLE
9	1,2 SEC ENC CABLE
10	1,2 SEC ENC CABLE
11	1,2 SEC PW,BK CABLE
12	1 SEC SOL CABLE

HYUNDAI ROBOTICS

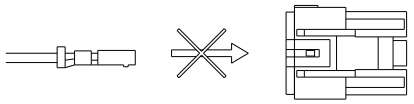
A3 (420x297mm)



CABLE LIST					
No	#1	#2	#3	수량	비고
1	CNP5A	CNP5B	628 mm	1	
2	CNP6A	CNP6B	628 mm	1	
3					
4					
5					
6					

NUMBERING							
No	@1	@2	@3	@4	@5	@6	비고
1	U_5	V_5	W_5	FG_5	BK+_5	BK-_5	
2	U_6	V_6	W_6	FG_6	BK+_6	BK-_6	
3							
4							
5							
6							

* CNP5B, CNP6B 측 커넥터 하우징은
조립되지 않은 상태로 납품
(핀작업만 실시, 하우징 동봉하여 납품)

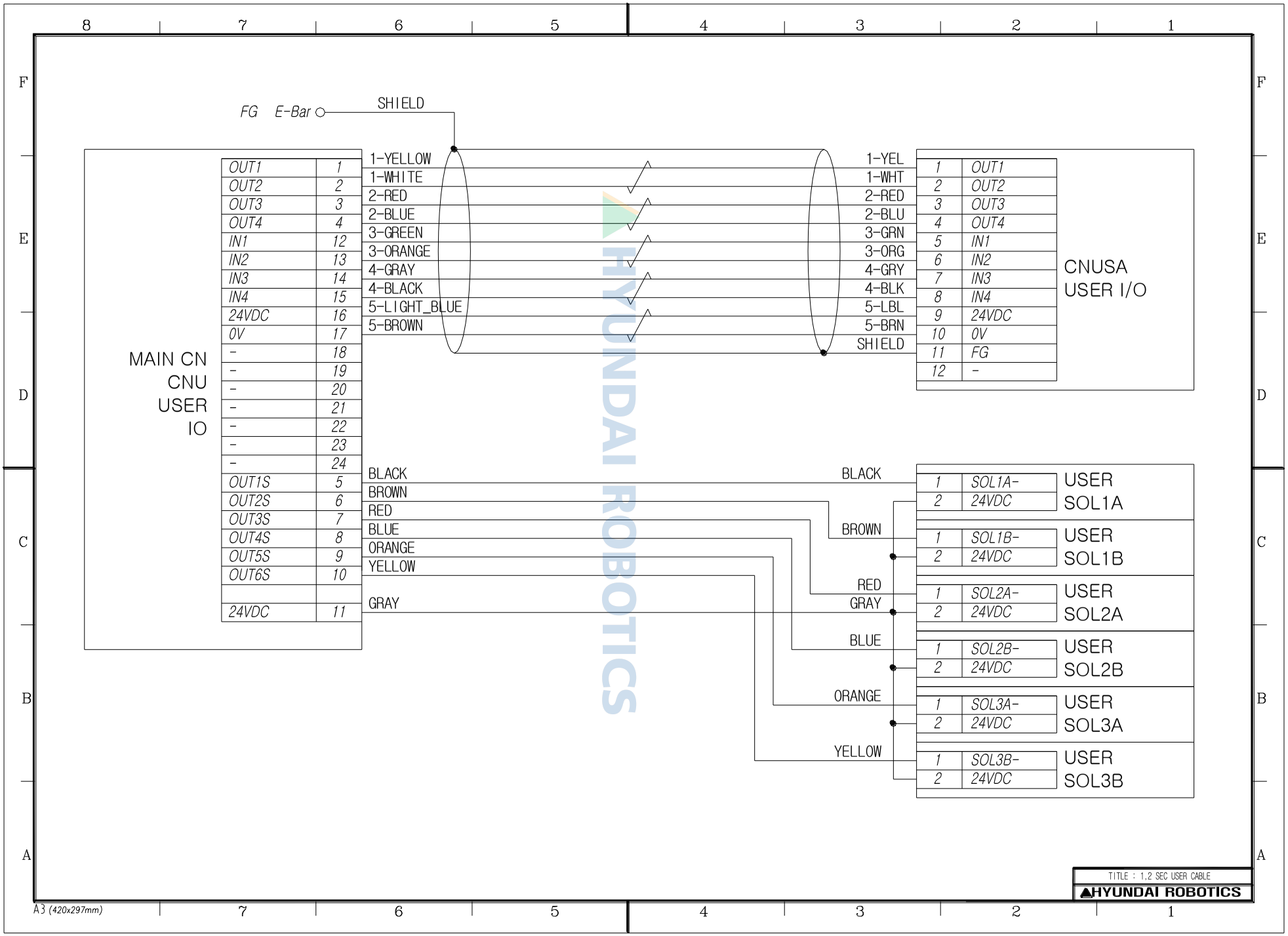


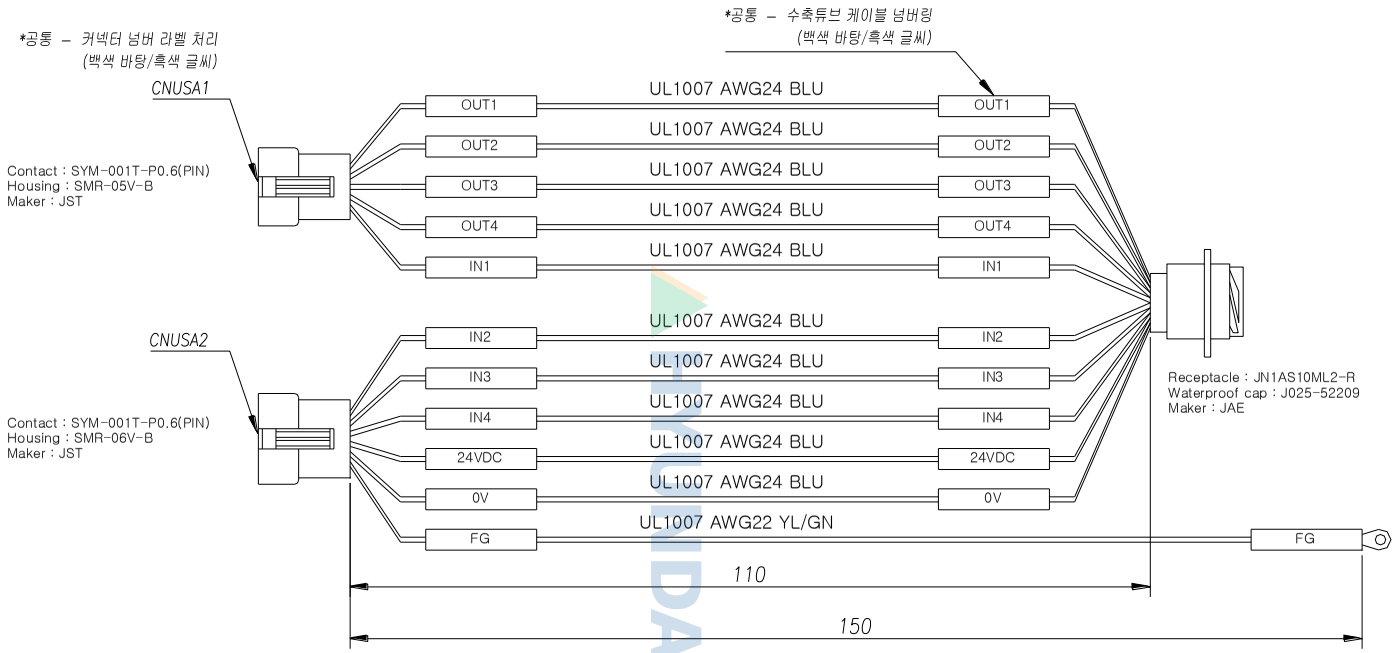
* 확인 사항
1. 표기 되지 않은 케이블 : Hitachi Cable 적용
2. 표시되지 않은 터미널 : O형, 1.5-M4
3. 케이블 라벨 : 백색 바탕/흑색 글씨, 투명수축 튜브 마감 처리
4. 케이블 넘버링 : 수축타입 적용 / 길이 26mm

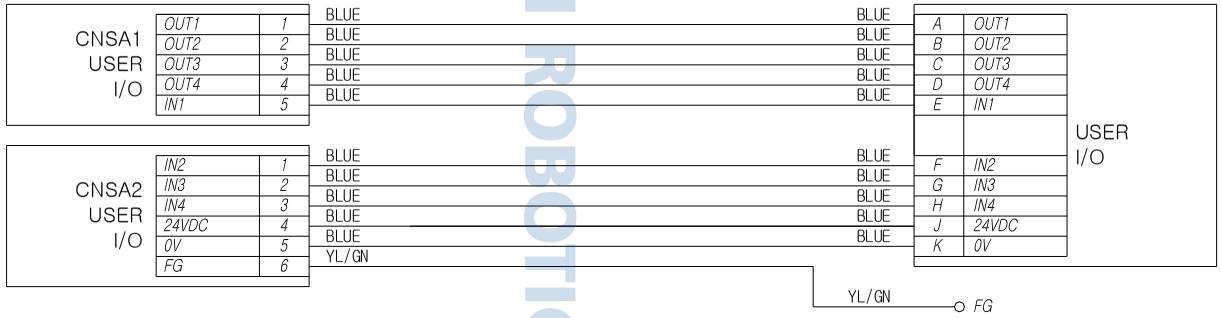
TITLE : 3 SEC PW,BK CABLE(900mm)

HYUNDAI ROBOTICS

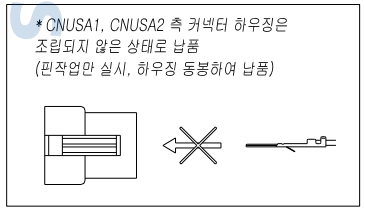
A3 (420x297mm)


FG
E-Bar
SHIELD
MAIN CN
CNU
USER
IO
OUT1 1
OUT2 2
OUT3 3
OUT4 4
IN1 12
IN2 13
IN3 14
IN4 15
24VDC 16
0V 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
OUT1S 5
OUT2S 6
OUT3S 7
OUT4S 8
OUT5S 9
OUT6S 10
24VDC 11
1-YELLOW
1-WHITE
2-RED
2-BLUE
3-GREEN
3-ORANGE
4-GRAY
4-BLACK
5-LIGHT_BLUE
5-BROWN
BLACK
BROWN
RED
BLUE
ORANGE
YELLOW
GRAY
1-YEL
1-WHT
2-RED
2-BLU
3-GRN
3-ORG
4-GRY
4-BLK
5-LBL
5-BRN
SHIELD
1 OUT1
2 OUT2
3 OUT3
4 OUT4
5 IN1
6 IN2
7 IN3
8 IN4
9 24VDC
10 0V
11 FG
12 -
CNUSA
USER I/O
BLACK
1 SOL1A-
2 24VDC
USER
SOL1A
BROWN
1 SOL1B-
2 24VDC
USER
SOL1B
RED
GRAY
1 SOL2A-
2 24VDC
USER
SOL2A
BLUE
1 SOL2B-
2 24VDC
USER
SOL2B
ORANGE
1 SOL3A-
2 24VDC
USER
SOL3A
YELLOW
1 SOL3B-
2 24VDC
USER
SOL3B
HYUNDAI ROBOTICS
TITLE : 1,2 SEC USER CABLE
HYUNDAI ROBOTICS
A3 (420x297mm)





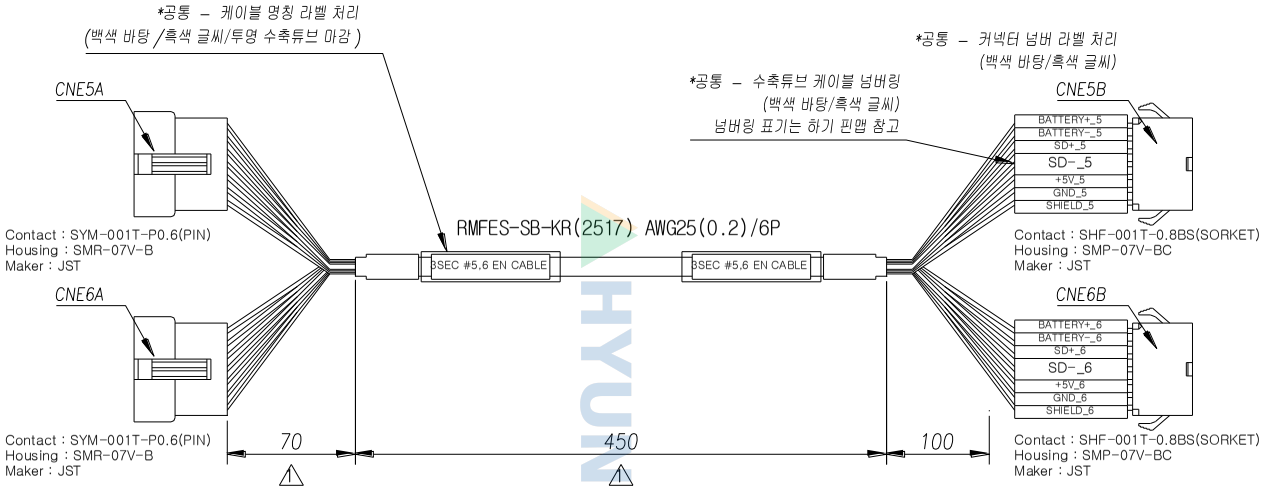
* 확인 사항
1. 표기 되지 않은 케이블 : Hitachi Cable 적용
2. 표시되지 않은 터미널 : O형, 1.5-M4
3. 케이블 라벨 : 백색 바탕/흑색 글씨, 투명수축 튜브 마감 처리
4. 케이블 넘버링 : 수축타입 적용 / 길이 26mm

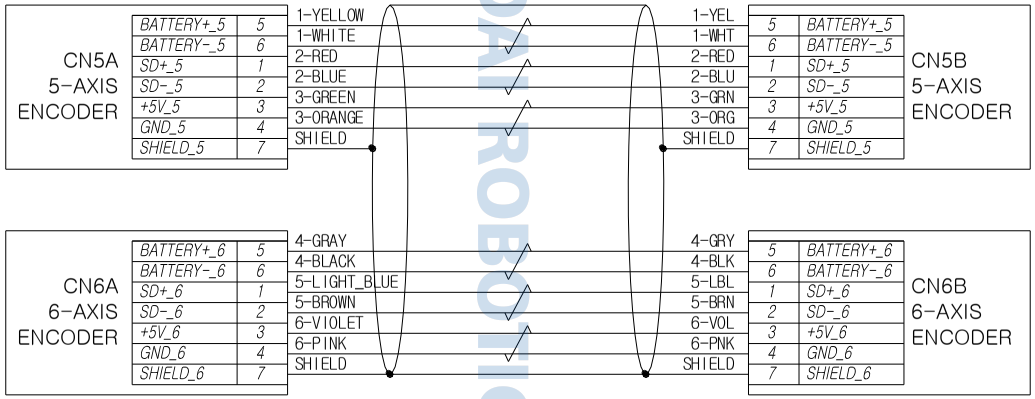


TITLE : 4 SEC USER CABLE

HYUNDAI ROBOTICS

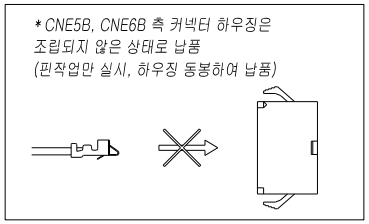
A3 (420x297mm)





* 확인 사항

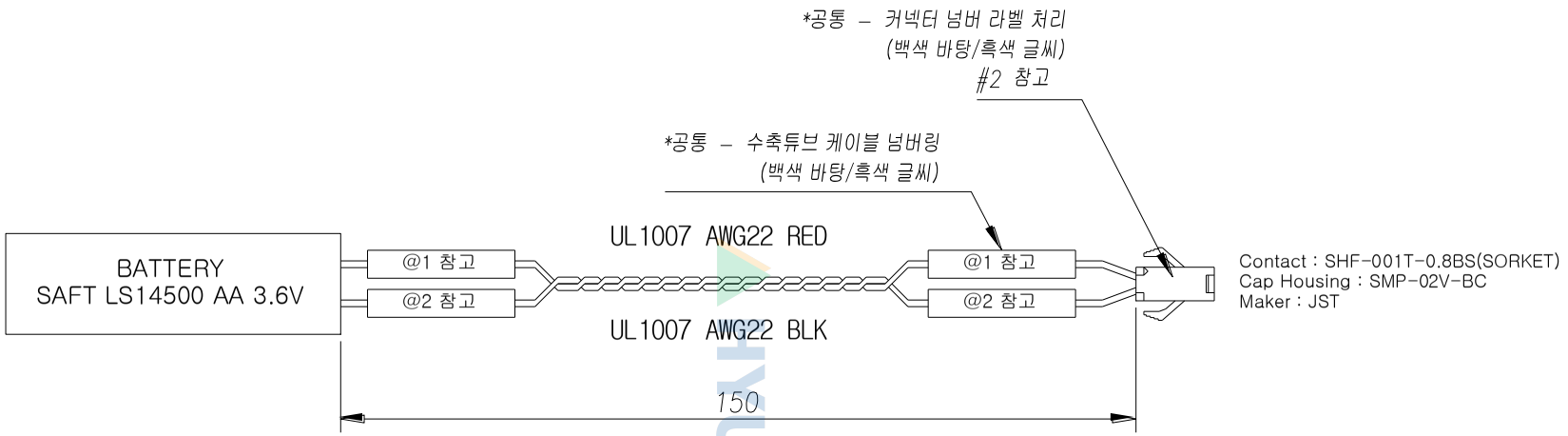
1. 표기 되지 않은 케이블 : Hitachi Cable 적용
2. 표시되지 않은 터미널 : O형, 1.5-M4
3. 케이블 라벨 : 백색 바탕/흑색 글씨, 투명수축 튜브 마감 처리
4. 케이블 넘버링 : 수축타입 적용 / 길이 26mm

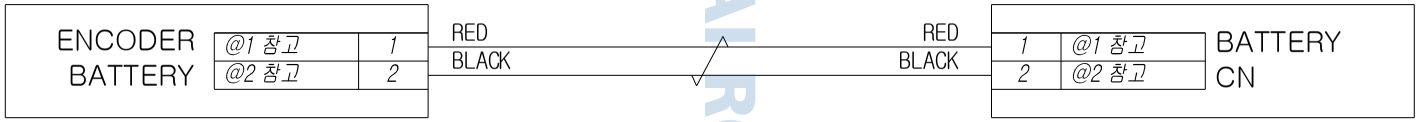


TITLE : 3 SEC ENC CABLE(900mm)

HYUNDAI ROBOTICS

A3 (420x297mm)





* 확인 사항
1. 표기 되지 않은 케이블 : Hitachi Cable 적용
2. 표시되지 않은 터미널 : O형, 1.5-M4
3. 케이블 라벨 : 백색 바탕/흑색 글씨, 투명수축 튜브 마감 처리
4. 케이블 넘버링 : 수축타입 적용 / 길이 26mm

CABLE LIST

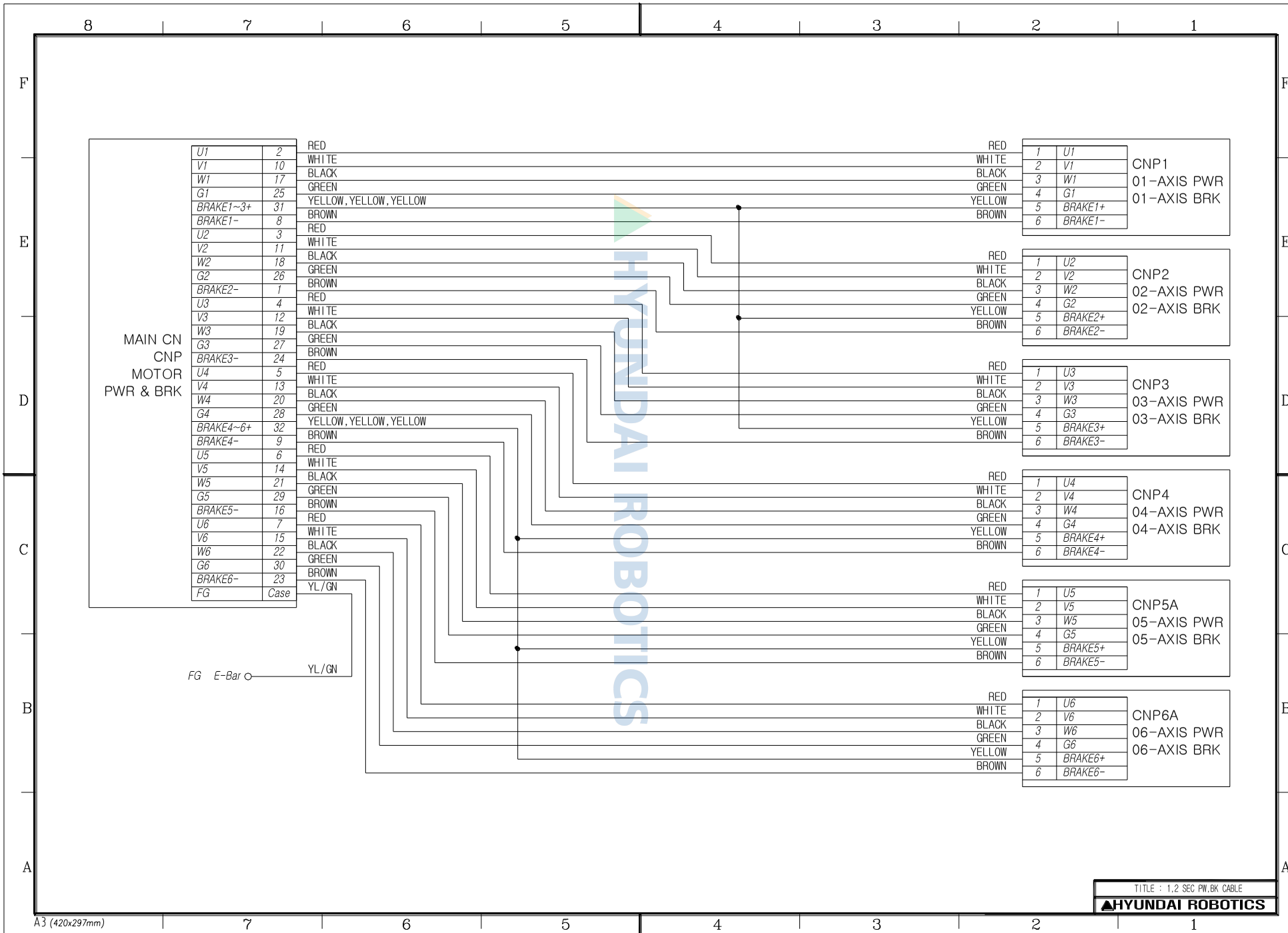
No	#1	#2	수량	비고
1	BATTERY-1	CNBAT1	1	
2	BATTERY-2	CNBAT2	1	
3	BATTERY-3	CNBAT3	1	
4	BATTERY-4	CNBAT4	1	
5	BATTERY-5	CNBAT5	1	
6	BATTERY-6	CNBAT6	1	

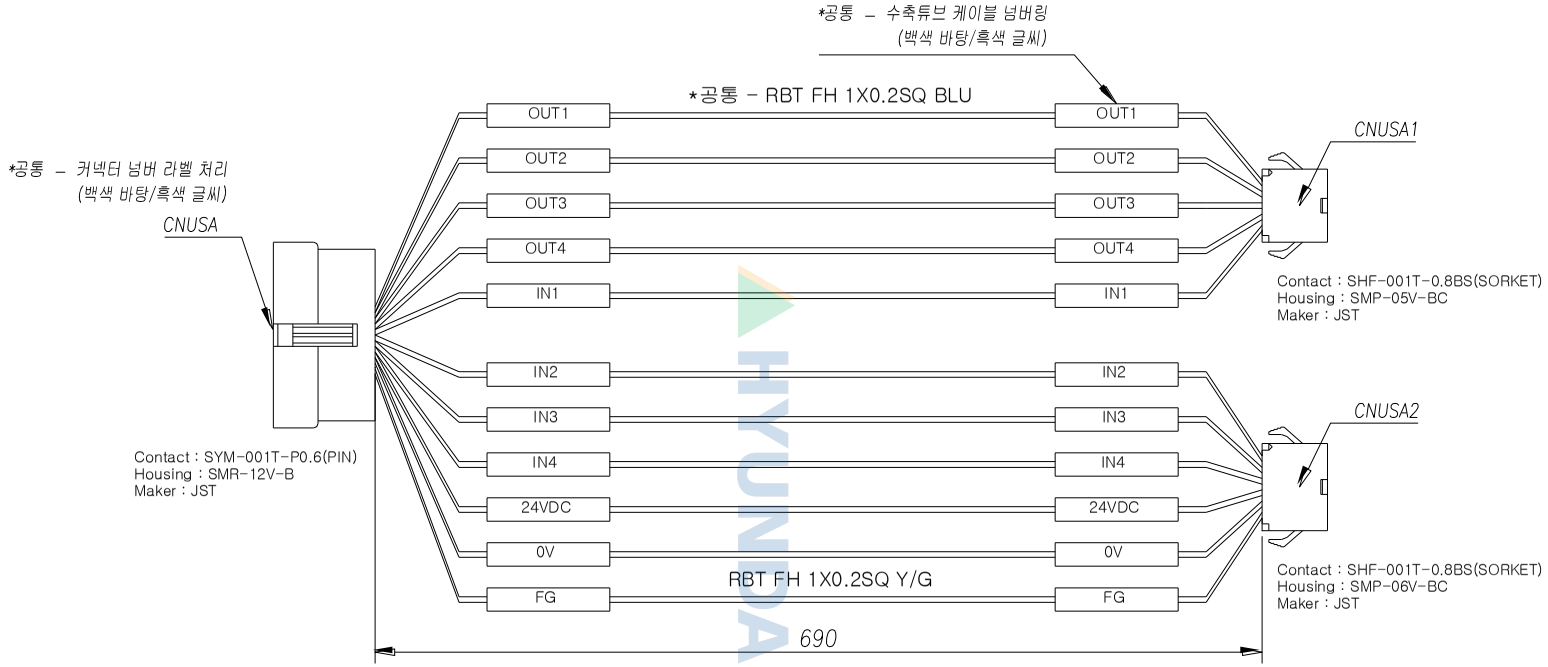
NUMBERING

No	@1	@2	비고
1	VCC_1	GND_1	
2	VCC_2	GND_2	
3	VCC_3	GND_3	
4	VCC_4	GND_4	
5	VCC_5	GND_5	
6	VCC_6	GND_6	

TITLE : 1 SEC BATTERY
HYUNDAI ROBOTICS

A3 (420x297mm)


MAIN CN
CNP
MOTOR
PWR & BRK
U1 2
V1 10
W1 17
G1 25
BRAKE1~3+ 31
BRAKE1- 8
U2 3
V2 11
W2 18
G2 26
BRAKE2- 1
U3 4
V3 12
W3 19
G3 27
BRAKE3- 24
U4 5
V4 13
W4 20
G4 28
BRAKE4~6+ 32
BRAKE4- 9
U5 6
V5 14
W5 21
G5 29
BRAKE5- 16
U6 7
V6 15
W6 22
G6 30
BRAKE6- 23
FG Case
RED
WHITE
BLACK
GREEN
YELLOW,YELLOW,YELLOW
BROWN
YL/GN
FG E-Bar
CNP1
01-AXIS PWR
01-AXIS BRK
CNP2
02-AXIS PWR
02-AXIS BRK
CNP3
03-AXIS PWR
03-AXIS BRK
CNP4
04-AXIS PWR
04-AXIS BRK
CNP5A
05-AXIS PWR
05-AXIS BRK
CNP6A
06-AXIS PWR
06-AXIS BRK
U1 V1 W1 G1 BRAKE1+ BRAKE1-
U2 V2 W2 G2 BRAKE2+ BRAKE2-
U3 V3 W3 G3 BRAKE3+ BRAKE3-
U4 V4 W4 G4 BRAKE4+ BRAKE4-
U5 V5 W5 G5 BRAKE5+ BRAKE5-
U6 V6 W6 G6 BRAKE6+ BRAKE6-
HYUNDAI ROBOTICS
TITLE : 1,2 SEC PW,BK CABLE
HYUNDAI ROBOTICS
A3 (420x297mm)



CNUSA USER I/O				CNSA1 USER I/O	
OUT1	1	BLUE	BLUE	1	OUT1
OUT2	2	BLUE	BLUE	2	OUT2
OUT3	3	BLUE	BLUE	3	OUT3
OUT4	4	BLUE	BLUE	4	OUT4
IN1	5	BLUE	BLUE	5	IN1
IN2	6	BLUE	BLUE	1	IN2
IN3	7	BLUE	BLUE	2	IN3
IN4	8	BLUE	BLUE	3	IN4
24VDC	9	BLUE	BLUE	4	24VDC
0V	10	BLUE	BLUE	5	0V
FG	11	YL/GN	YL/GN	6	FG
-	12				

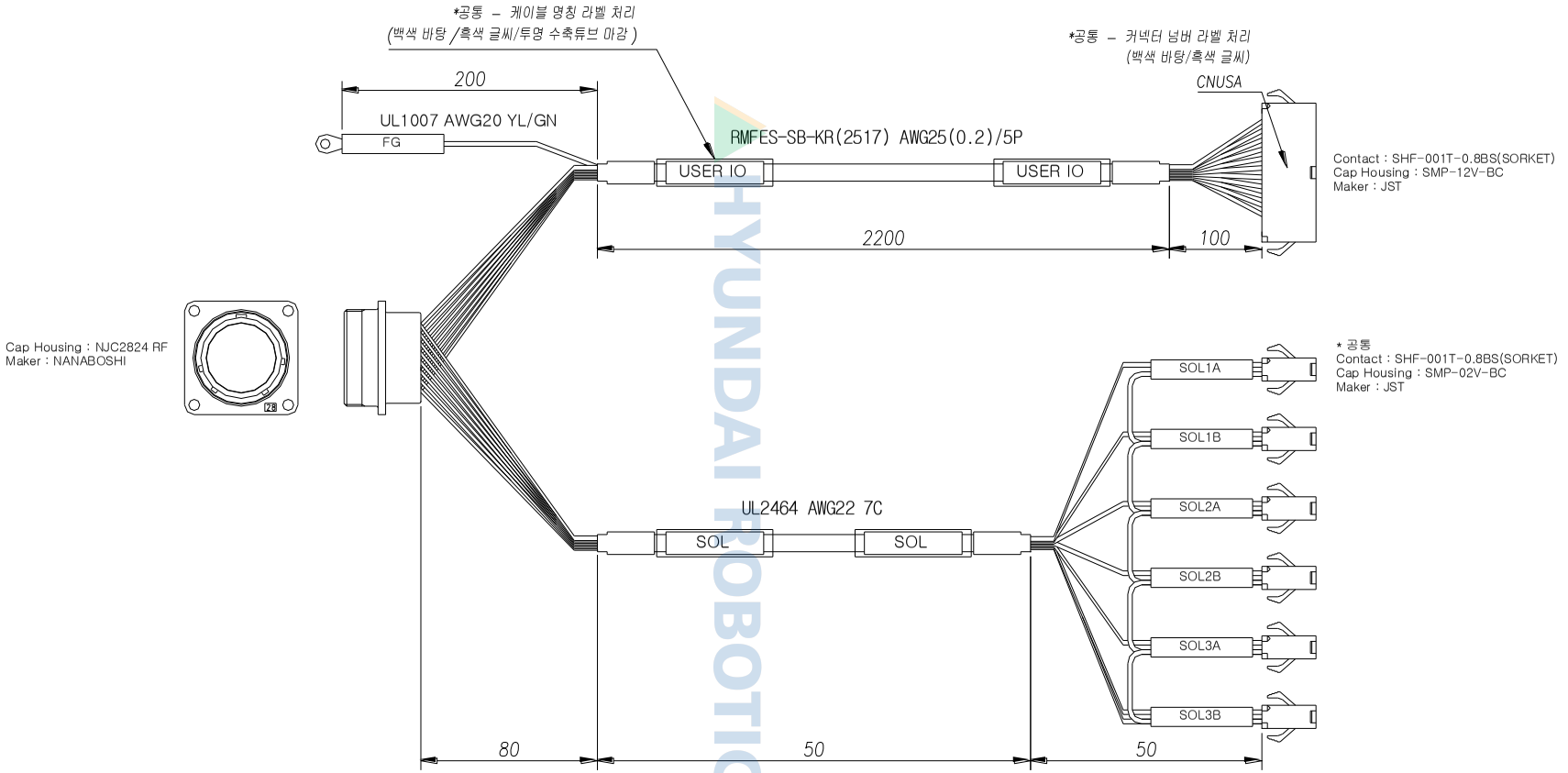
CNSA2 USER I/O

* 확인 사항
1. 표기 되지 않은 케이블 : Hitachi Cable 적용
2. 표시되지 않은 터미널 : O형, 1.5-M4
3. 케이블 라벨 : 백색 바탕/흑색 글씨, 투명수축 튜브 마감 처리
4. 케이블 넘버링 : 수축타입 적용 / 길이 26mm

TITLE : 3 SEC USER CABLE(900mm)

HYUNDAI ROBOTICS

A3 (420x297mm)

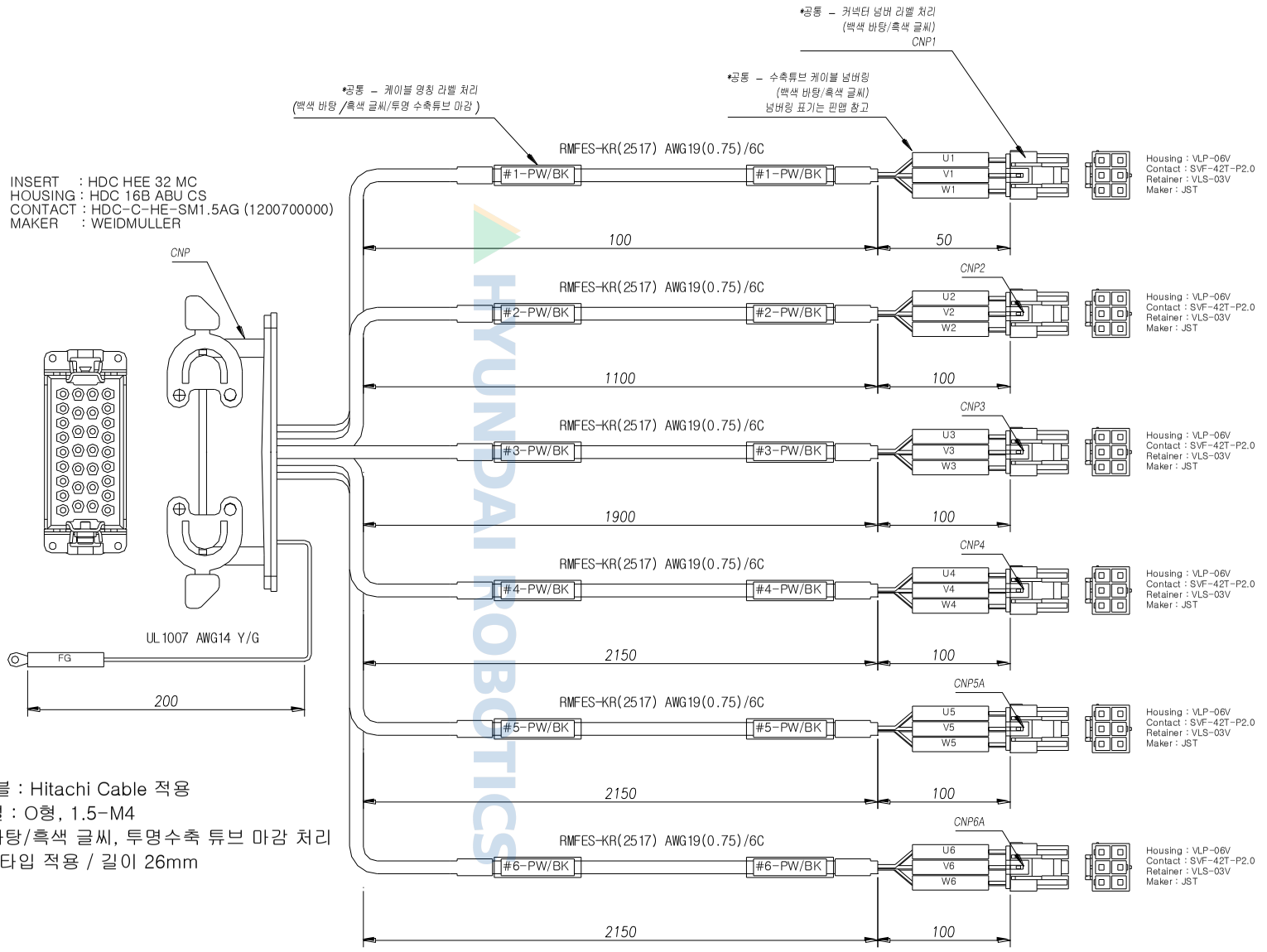


* 확인 사항
1. 표기 되지 않은 케이블 : Hitachi Cable 적용
2. 표시되지 않은 터미널 : O형, 1.5-M4
3. 케이블 라벨 : 백색 바탕/흑색 글씨, 투명수축 튜브 마감 처리
4. 케이블 넘버링 : 수축타입 적용 / 길이 26mm

TITLE : 1,2 SEC USER CABLE

HYUNDAI ROBOTICS

A3 (420x297mm)



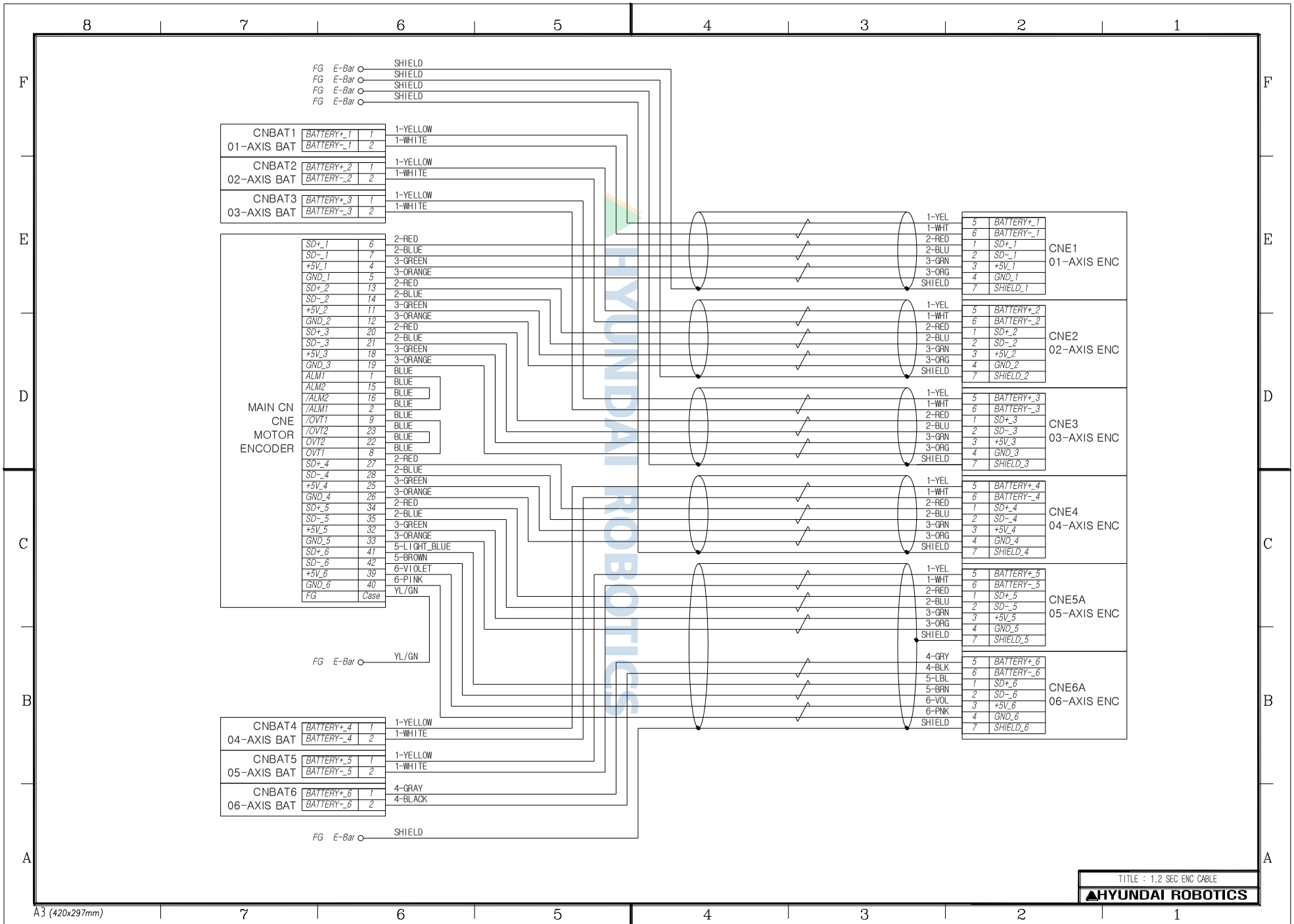
* 확인 사항

1. 표기 되지 않은 케이블 : Hitachi Cable 적용
2. 표시되지 않은 터미널 : O형, 1.5-M4
3. 케이블 라벨 : 백색 바탕/흑색 글씨, 투명수축 튜브 마감 처리
4. 케이블 넘버링 : 수축타입 적용 / 길이 26mm

TITLE : 1.2 SEC PW.BK CABLE

HYUNDAI ROBOTICS

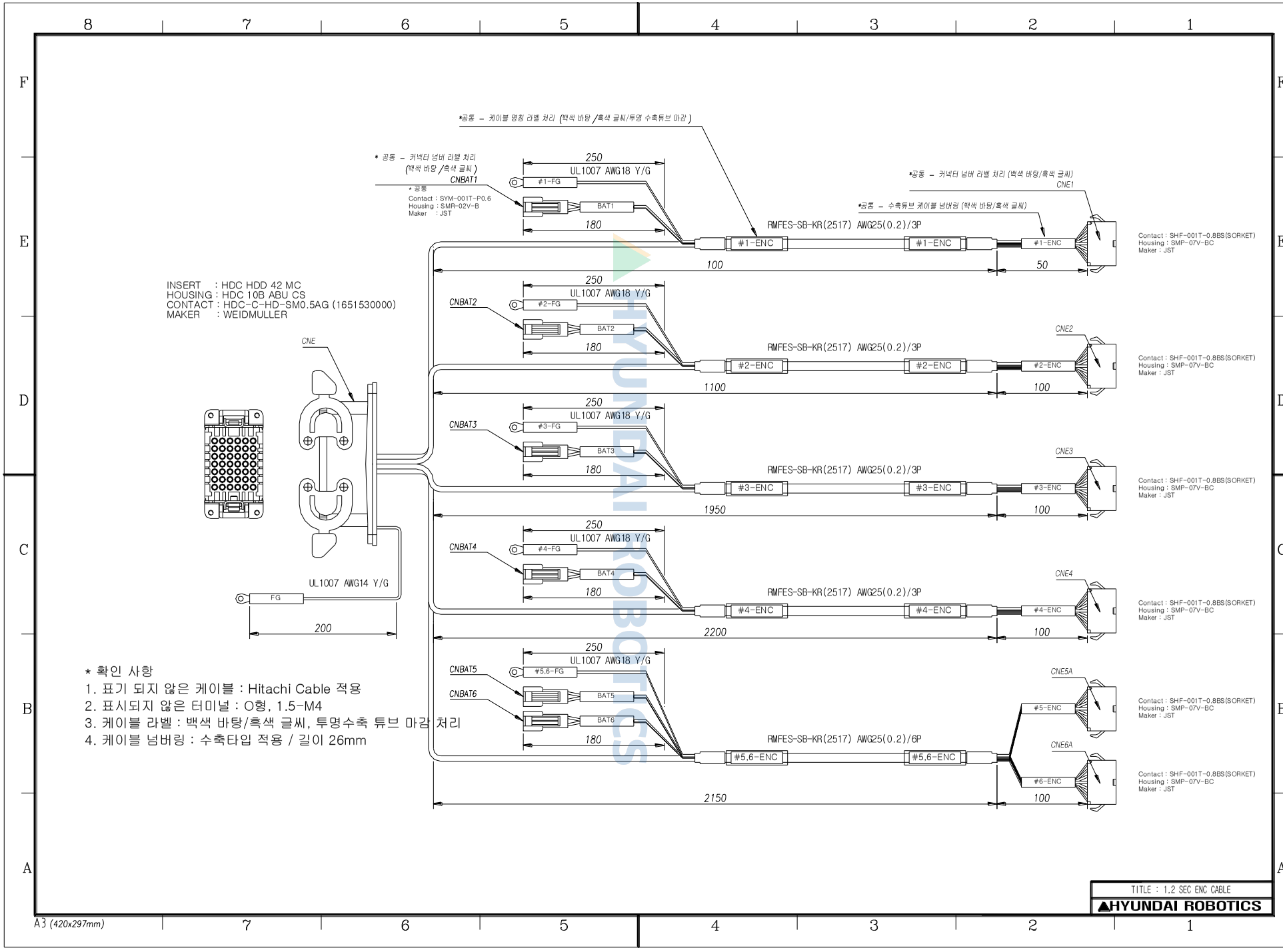
A3 (420x297mm)



TITLE : 1,2 SEC ENC CABLE

HYUNDAI ROBOTICS

A3 (420x297mm)

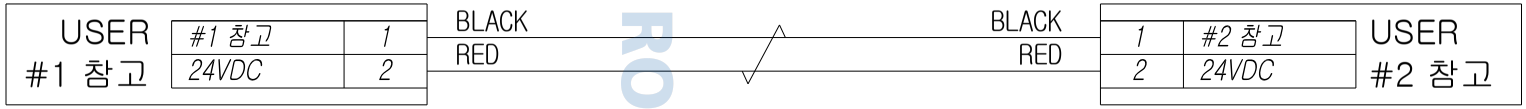

*공통 – 케이블 명칭 라벨 처리 (백색 바탕 /흑색 글씨/투명 수축튜브 마감)
* 공통 – 커넥터 넘버 라벨 처리 (백색 바탕 /흑색 글씨)
CNBAT1
* 공통
Contact : SYM-001T-P0.6
Housing : SMR-02V-B
Maker : JST
250
UL1007 AWG18 Y/G
#1-FG
BAT1
180
*공통 – 커넥터 넘버 라벨 처리 (백색 바탕/흑색 글씨)
CNE1
*공통 – 수축튜브 케이블 넘버링 (백색 바탕/흑색 글씨)
RMFES-SB-KR(2517) AWG25(0.2)/3P
#1-ENC
#1-ENC
#1-ENC
100
50
Contact : SHF-001T-0.8BS(SORKET)
Housing : SMP-07V-BC
Maker : JST
INSERT : HDC HDD 42 MC
HOUSING : HDC 10B ABU CS
CONTACT : HDC-C-HD-SM0.5AG (1651530000)
MAKER : WEIDMULLER
CNE
CNBAT2
#2-FG
BAT2
180
CNE2
#2-ENC
#2-ENC
#2-ENC
1100
100
CNBAT3
#3-FG
BAT3
180
CNE3
#3-ENC
#3-ENC
#3-ENC
1950
100
CNBAT4
#4-FG
BAT4
180
CNE4
#4-ENC
#4-ENC
#4-ENC
2200
100
UL1007 AWG14 Y/G
FG
200
CNBAT5
CNBAT6
#5,6-FG
BAT5
BAT6
180
CNE5A
CNE6A
#5-ENC
#6-ENC
RMFES-SB-KR(2517) AWG25(0.2)/6P
#5,6-ENC
#5,6-ENC
2150
100
* 확인 사항
1. 표기 되지 않은 케이블 : Hitachi Cable 적용
2. 표시되지 않은 터미널 : O형, 1.5-M4
3. 케이블 라벨 : 백색 바탕/흑색 글씨, 투명수축 튜브 마감 처리
4. 케이블 넘버링 : 수축타입 적용 / 길이 26mm
TITLE : 1.2 SEC ENC CABLE
HYUNDAI ROBOTICS
A3 (420x297mm)

Solenoid Cable
* 사급품

Housing : SMR-02V-B
Maker : JST

Contact : SYM-001T-P0.6(PIN)

#3 참고



* 확인 사항
1. 표기 되지 않은 케이블 : Hitachi Cable 적용
2. 표시되지 않은 터미널 : O형, 1.5-M4
3. 케이블 라벨 : 백색 바탕/흑색 글씨, 투명수축 튜브 마감 처리
4. 케이블 넘버링 : 수축타입 적용 / 길이 26mm

CABLE LIST

No	#1	#2	#3	수량	비고
1	SOL1A	SOL1A	150 mm	1	
2	SOL1B	SOL1B	100 mm	1	
3	SOL2A	SOL2A	150 mm	1	
4	SOL2B	SOL2B	100 mm	1	
5	SOL3A	SOL3A	150 mm	1	
6	SOL3B	SOL3B	100 mm	1	

TITLE : 1 SEC SOL CABLE
HYUNDAI ROBOTICS

A3 (420x297mm)