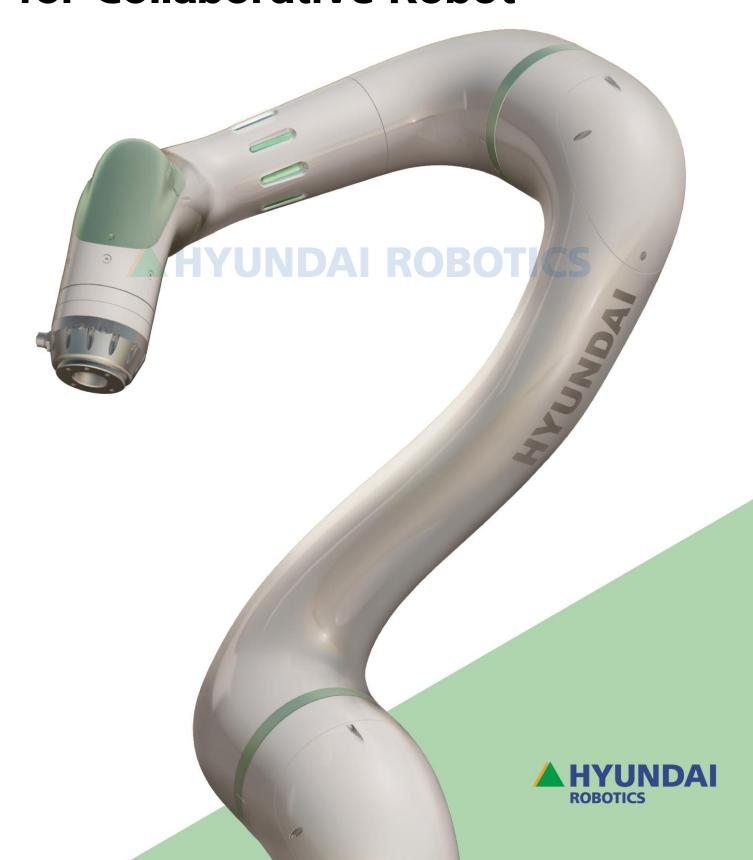


Safety Function Manual for Collaborative Robot





About this manual

This manual describes the safety functions of Hyundai Robotics collaborative robots.

Before using the product, read and fully understand the contents of this manual. In addition, keep this manual in an accessible place so that it can be read any time when necessary.

This manual may be provided to customers who purchase products of Hyundai Robotics or may be used as material for internal training programs.

As this manual has been prepared based on standard specifications, it may not apply equally to all models. In addition, the details and specifications of this manual are subject to changes for improving product performance without notice, and Hyundai Robotics will not take responsibility for any consequences of incorrect details, typos, or omissions of this manual. For detailed information on revisions, please visit our website (www.hyundai-robotics.com).

Copyright

All the programs, files, and contents relating to this product and manual are protected by the Copyright Act and a confidentiality agreement. Any use, reproduction, and disclosure or distribution of this manual to third parties not explicitly permitted by Hyundai Robotics are strictly prohibited.

Copyright © 2020 HYUNDAI ROBOTICS. All rights reserved.

Notation rules

This manual utilizes the following expression rules and safety directions for easy understanding.

Description by figures

Figures are used for a better understanding of how to operate the product and for describing screens. When a description is made by a figure, the pertaining part is marked with the figure number that describes the part, as shown in the following figure:



GUI (Graphical User Interface)

Regarding GUI, any menu name or button name will be in brackets ([]) and in **bold type**. When multiple menus need to be selected in the listed order, the menu names will be separated by the symbol ().

- Menu having a title: On the initial screen of the manual or automatic mode, click the [Menu] button.
- Multiple menus: In the initial screen of the manual mode, select the [Setting] button > [5: Reset > 7: Unit Setting] menu.

Manipulation key notation method

Any key to be pressed in the functional manipulation space of the teach pendant will be in angle brackets (〈 〉) and in **bold type**.

Pressing the (Start) key will initiate the automatic execution of the sequence programmed into the robot.

Cross-references

This provides the shortcut to the related information in the manual. Cross-references will be in quotation marks and in **bold type**.

For details on making changes in date and time information, see "4.5 Date and time setting." of "Operation
Manual for Hi6 Controller"

References

Useful or additional information on using the product will be provided as follows:

Remarks

The blinking of the circon in the status bar indicates the engineer mode.



Safety precautions

To ensure proper product use and user safety and to prevent property damages, make sure to read and fully understand the following precautions before using the product.

Danger



Impending risk: If not conformed to, operator deaths or severe injuries may occur.

- Perform a risk assessment on the entire system, not the individual devices. Connecting other devices to
 the product may increase the risk level of the product or create new risks. If the devices of the integrated
 robot system have different risk levels, prepare safety devices based on the device with the highest risk
 level in preparedness for risks.
- In installing the robot product and other devices, make sure to read, fully understand, and conform to the product installation instructions described in the manual.
- In case of any issues of the product, such as faults and damages, stop using the product immediately and contact our Customer Support Team.

Warning



Potential risk: If not conformed to, operator injuries or property damages, including serious product damages, may occur.

- Take adequate safety measures according to the result of risk assessment, and accurately assign the safe range of robot installation. During the robot operation, product damages or user injuries may occur.
- Persons who manufacture robot application systems or use the robot must read and fully understand the manual and undergo training in robot operation.
- For the safety of operators and users, prepare adequate safety facilities such as safety fences before
 installing the product.
- Secure sufficient space so that the robot arm can move freely. During the robot operation, product damages or user injuries may occur.
- Fasten locking bolts to the specified torque according to the specification sheet. Loose bolts may lead to damages of the robot because of falling from the installation position.
- Pay attention to the product connections (power and cables) so that no conductive substances, such as liquid, dust, and metal particles, could infiltrate. Do not poke the connection with sharp objects, or apply excessive force during cable connection. Corrosion or temporary short circuits of connectors may lead to product explosion or fires.
- Check the wiring specification and connect devices with terminals that are suitable for the device types.
 Make sure to connect safety devices to dedicated terminals because connecting them to general terminals does not guarantee safety functions.
- Never use damaged cables and do not disconnect cables while the product is in use. Doing so may lead to electric shocks, fires, faults, and injuries.
- Long-time use of the product may lead to overheating and cause injuries such as burns. In the event it is
 necessary to touch the product, cool down the product sufficiently by powering it off and leaving it for at
 least one hour.
- Never arbitrarily install, modify, disassemble, or repair the product. This may lead to faults and accidents. Hyundai Robotics will not take responsibility for product damages caused by such arbitrary actions.

Caution



Minor risk: If not conformed to, minor operator injuries or property damages, including product damages, may occur.

- Do not arbitrarily install, modify, disassemble, or repair the product. It is prohibited for persons other than
 experts from Hyundai Robotics to modify or attach parts to the product. Product faults caused by it will
 void free-of-charge services and warranty services.
- In the event it is necessary to install or repair the product, contact our Customer Support Team to consign the work to experts.
- Do not install or use the product at a place filled with dust or dirt. Dust or foreign matters may lead to product faults or malfunctions.
- Do not install or use the product at a place of magnetism, a place which is affected by magnetism, or a place of electromagnetic interferences. Magnetism may lead to product damages or malfunctions.
- In operating the product, do not wear loose clothes or accessories. If you have long hair, you should tie it at the back of your head so that it will not entangle between joints and the like of the robot.
- While the product is in operation, do not enter its operating range or touch the robot. Doing so may lead to injuries.
- Transport the product as it is packaged to prevent product damages and store it at a dry and low-humidity place. Storing it at a humid place may lead to product damages or faults caused by moisture infiltration.
- Store the product in a place that is clean, cool, dry, and free from high variation in temperature and humidity.
- The product should be moved by two or more persons, and the correct posture should be maintained. If not, the persons may be subject to physical injuries in the waist, arms, legs, and the like.
- In moving the product using lifting equipment, conform to the local and national safety regulations and the instructions for equipment use.
- Before moving the product, read and conform to the moving instructions specified in the manual. Hyundai Robotics will not take responsibility for product damages caused during transportation by the customer.

Contents

2. Direct teaching

1.2.4 Power and force limiting 1.3 Safety functions 1.3 I Robot limit functions 1.3.1 Robot limit functions 1.3.2 Joint limit functions 1.4 Matters to be checked upon replacing safety devices 1.5 Matters to be checked before using the safety functions 1.5.1 Encoder offset 1.5.2 Checking the torque sensor 1.5.3 Setting of tool data 1.5.4 Password setting 1.6.1 Robot limiting parameters 1.6.2 Joint limiting parameters 1.6.3 Safety space setting 1.7.1 Safety layout 1.7.3 Safety layout 29 1.7.4 Safety space setting 1.7.5 Safety loot modeling 1.7.6 Safety Stop Function 1.7.7 Safety loot modeling 1.7.8 Safety robot modeling 1.7.9 Safety conditions 1.8 Safety I/O signals 1.9 Safety Stop Function 1.10 Robot limiting parameter monitoring 1.102 Joint limiting parameter monitoring 1.103 SCM board status monitoring 1.103 SCM board status monitoring 1.103 SCM board status monitoring 1.104 Matters to be checked upon replacing safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety attachment The Rules on the Criteria for Occupational Safety at the leath, and the Public Notice of Safety attachment The Rules on the Criteria for Occupations Health, and the Publ	Copy	right tion rules	3 3 3	 2.1 Direct teaching switch assignment 2.2 Driving the robot by direct teaching 2.3 Direct teaching mode setting 2.4 Constraint motion 55 58 59
1.1 Description of terms 8 1.2 Collaborative operation mode 11 1.2 Safety-rated monitored stop 11 1.2.3 Speed and separation monitoring 11 1.2.4 Power and force limiting 11 1.2.5 Speed and separation monitoring 11 1.2.6 Power and force limiting 11 1.2.7 Power and force limiting 11 1.2.8 Safety functions 12 1.3.1 Robot limit functions 12 1.3.2 Joint limit functions 12 1.4 Matters to be checked upon replacing safety devices 14 1.5 Matters to be checked upon replacing safety functions 15 1.5.1 Encoder offset 15 1.5.2 Checking the torque sensor 16 1.5.3 Setting of tool data 21 1.5.4 Password setting 22 1.6 Robot safety conditions 24 1.6.1 Robot limiting parameters 26 1.6.2 Joint limiting parameters 27 1.7 Safety layout 29 1.7.1 Safety space setting 29 1.7.2 Safety tool modeling 34 1.7.3 Safety robot modeling 37 1.7.4 WorkCell 3D 38 1.8 Safety I/O signals 40 1.9 Safety Stop Function 42 1.10.1 Robot limiting parameter monitoring 45 1.10.2 Joint limiting parameter monitoring 45 1.10.3 SCM board status monitoring 47	1. Saf		orative	3.1 I/O map 60
122 Hand guiding 11 123 Speed and separation monitoring 11 124 Power and force limiting 11 13 Safety functions 12 13.1 Robot limit functions 12 13.2 Joint limit functions 12 14. Matters to be checked upon replacing safety devices 14 15 Matters to be checked before using the safety functions 15 15.1 Encoder offset 15 15.2 Checking the torque sensor 16 15.3 Setting of tool data 21 15.4 Password setting 22 16.6 Robot safety conditions 24 1.6.1 Robot limiting parameters 26 1.6.2 Joint limiting parameters 27 1.7 Safety layout 29 1.7.1 Safety space setting 29 1.7.2 Safety tool modeling 37 1.7.4 WorkCell 3D 38 1.8 Safety I/O signals 40 1.9 Safety condition monitoring 44 1.10.1 Robot limiting parameter monitoring 44 1.10.1 Robot limiting parameter monitoring 45 1.10.2 Joint limiting parameter monitoring 46 1.10.3 SCM board status monitoring 47				3.2.1 Default specifications of the tool I/O 61
1.3.1 Robot limit functions 1.3.2 Joint limit functions 1.3.2 Joint limit functions 1.3.3 Joint limit functions 1.3.4 Matters to be checked upon replacing safety devices 1.5 Matters to be checked before using the safety functions 1.5.1 Encoder offset 1.5.2 Checking the torque sensor 1.5.3 Setting of tool data 1.5.4 Password setting 1.5.4 Password setting 1.5.6 Robot safety conditions 1.6.1 Robot limiting parameters 1.6.2 Joint limiting parameters 1.6.3 Safety layout 1.7.1 Safety space setting 1.7.2 Safety tool modeling 1.7.3 Safety robot modeling 1.7.4 WorkCell 3D 1.8 Safety I/O signals 1.8 Safety I/O signals 1.9 Safety condition monitoring 1.10.1 Robot limiting parameter monitoring 1.10.2 Joint limiting parameter monitoring 1.10.1 Robot limiting parameter monitoring 1.10.2 Joint limiting function monitoring 1.10.3 SCM board status monitoring 1.10.3 SCM board status monitoring 1.2 Adttachment 1.3 The Rules on the Criteria for Occupational Safety and Health, and the Public Notice of Safety and Health, and the Public Not		1.2.2 Hand guiding1.2.3 Speed and separation monitoring	11 11	3.3.1 Default specifications of the analog I/O 64
1.3.2 Joint limit functions 12 1.4 Matters to be checked upon replacing safety devices 14 1.5 Matters to be checked before using the safety functions 15 1.5.1 Encoder offset 1.5.2 Checking the torque sensor 16 1.5.3 Setting of tool data 1.5.4 Password setting 22 1.6 Robot safety conditions 24 1.6.1 Robot limiting parameters 26 1.6.2 Joint limiting parameters 27 1.7 Safety layout 29 1.7.1 Safety space setting 29 1.7.2 Safety tool modeling 37 1.7.4 WorkCell 3D 1.8 Safety I/O signals 40 1.9 Safety Stop Function 42 1.10.1 Robot limiting parameter monitoring 45 1.10.2 Joint limiting parameter monitoring 45 1.10.3 SCM board status monitoring 47	1.3	•		_
devices 14 1.5 Matters to be checked before using the safety functions 15 1.5.1 Encoder offset 15 1.5.2 Checking the torque sensor 16 1.5.3 Setting of tool data 21 1.5.4 Password setting 22 1.6 Robot safety conditions 24 1.6.1 Robot limiting parameters 26 1.6.2 Joint limiting parameters 27 1.7 Safety layout 29 1.7.1 Safety space setting 34 1.7.2 Safety tool modeling 34 1.7.3 Safety robot modeling 37 1.7.4 WorkCell 3D 38 1.8 Safety I/O signals 40 1.9 Safety Stop Function 42 1.10.1 Robot limiting parameter monitoring 45 1.10.2 Joint limiting parameter monitoring 45 1.10.3 SCM board status monitoring 47				The Rules on the Criteria for Occupational Safety and
1.5.2 Checking the torque sensor 16 1.5.3 Setting of tool data 21 1.5.4 Password setting 22 1.6 Robot safety conditions 24 1.6.1 Robot limiting parameters 26 1.6.2 Joint limiting parameters 27 1.7 Safety layout 29 1.7.1 Safety space setting 29 1.7.2 Safety tool modeling 34 1.7.3 Safety robot modeling 37 1.7.4 WorkCell 3D 38 1.8 Safety I/O signals 40 1.9 Safety Stop Function 42 1.10 Safety condition monitoring 45 1.10.1 Robot limiting parameter monitoring 45 1.10.2 Joint limiting parameter monitoring 46 1.10.3 SCM board status monitoring 47		devices Matters to be checked before using the	14 e safety	Inspections 92
1.6.1 Robot limiting parameters 26 1.6.2 Joint limiting parameters 27 1.7 Safety layout 29 1.7.1 Safety space setting 29 1.7.2 Safety tool modeling 34 1.7.3 Safety robot modeling 37 1.7.4 WorkCell 3D 38 1.8 Safety I/O signals 40 1.9 Safety Stop Function 42 1.10 Safety condition monitoring 44 1.10.1 Robot limiting parameter monitoring 45 1.10.2 Joint limiting function monitoring 46 1.10.3 SCM board status monitoring 47		1.5.2 Checking the torque sensor1.5.3 Setting of tool data	16 21	
1.6.2 Joint limiting parameters 27 1.7 Safety layout 29 1.7.1 Safety space setting 29 1.7.2 Safety tool modeling 34 1.7.3 Safety robot modeling 37 1.7.4 WorkCell 3D 38 1.8 Safety I/O signals 40 1.9 Safety Stop Function 42 1.10 Safety condition monitoring 44 1.10.1 Robot limiting parameter monitoring 45 1.10.2 Joint limiting function monitoring 46 1.10.3 SCM board status monitoring 47	1.6	Robot safety conditions	24	
1.7.1 Safety space setting 29 1.7.2 Safety tool modeling 34 1.7.3 Safety robot modeling 37 1.7.4 WorkCell 3D 38 1.8 Safety I/O signals 40 1.9 Safety Stop Function 42 1.10 Safety condition monitoring 44 1.10.1 Robot limiting parameter monitoring 45 1.10.2 Joint limiting function monitoring 46 1.10.3 SCM board status monitoring 47		3.		
1.7.2 Safety tool modeling 34 1.7.3 Safety robot modeling 37 1.7.4 WorkCell 3D 38 1.8 Safety I/O signals 40 1.9 Safety Stop Function 42 1.10 Safety condition monitoring 44 1.10.1 Robot limiting parameter monitoring 45 1.10.2 Joint limiting function monitoring 46 1.10.3 SCM board status monitoring 47	1.7	Safety layout	29	
1.9 Safety Stop Function 42 1.10 Safety condition monitoring 44 1.10.1 Robot limiting parameter monitoring 45 1.10.2 Joint limiting function monitoring 46 1.10.3 SCM board status monitoring 47		1.7.2 Safety tool modeling1.7.3 Safety robot modeling	34 37	
 1.10 Safety condition monitoring 1.10.1 Robot limiting parameter monitoring 1.10.2 Joint limiting function monitoring 1.10.3 SCM board status monitoring 47 				
1.10.2 Joint limiting function monitoring1.10.3 SCM board status monitoring4647				
1.10.4 Sarety I/O status monitoring 48 1.10.5 Recovery mode 49 1.11 Collaborative robot collision detection mode	1.11	1.10.2 Joint limiting function monitoring1.10.3 SCM board status monitoring1.10.4 Safety I/O status monitoring1.10.5 Recovery mode	46 47 48 49	

1. Safety functions of the collaborative robot

1.1 Description of terms

Robot limiting parameters

These are the parameters that constitute the criteria for monitoring the speed, force, and momentum of the robot.

Tool center point (TCP) position monitoring

This monitors whether the safety tool model violates the safety space. In cases when the safety space is intruded into, the safety stop set by the user will be actuated.

TCP orientation monitoring

This monitors whether the tool orientation is out of the specified range. In cases when the specified value is exceeded, the safety stop set by the user will be actuated.

TCP speed monitoring

This monitors the speed of the tool tip. In cases when the specified value is exceeded, the safety stop set by the user will be actuated.

TCP force monitoring

This monitors the force of the tool tip. In cases when the specified value is exceeded, the safety stop set by the user will be actuated.

Power monitoring

This monitors the power of the robot. In cases when the specified value is exceeded, the safety stop set by the user will be actuated.

Momentum monitoring

This monitors the momentum of the robot. In cases when the specified value is exceeded, the safety stop set by the user will be actuated.

Collision detection

In cases when the allowable value is exceeded because of an external force applied to the robot, the safety stop set by the user will be actuated.

Safe operating stop (SOS) monitoring

This monitors whether the robot stops without any slips. In cases when the specified value is exceeded, **Stop0** will be actuated. Meanwhile, when a stop condition is met while the robot is in the automatic mode, this function will be actuated automatically.

Joint limiting parameters

These are the parameters that form the reference for monitoring the position, speed, and torque of each robot joint.

Joint angle monitoring

This monitors the position of each axial joint. In cases when the specified value is exceeded, the safety stop set by the user will be actuated.

Joint speed monitoring

This monitors the speed of each axial joint. In cases when the specified value is exceeded, the safety stop set by the user will be actuated.

Joint torque monitoring

This monitors the torque of each axial joint. In cases when the specified value is exceeded, the safety stop set by the user will be actuated.

Safety layout

These are the parameters for the safe space and the tool space that form the criteria for monitoring the TCP position and orientation.

Safety space

This refers to the working space and the protected space of the tool.

Working space

This refers to the space in which the robot carries out work. If the tool or the robot's elbow model goes out of the working space, the safety stop function will be actuated.

Protected space

This refers to the space where the operator should be safeguarded from the robot. If the tool or the robot's elbow model goes out of the protected space, the safety stop function will be actuated.

Safety tool modeling

The tool attached to the robot is modeled in spheres and cones to monitor the TCP position and orientation.

Safety robot modeling

The robot's elbow is modeled in spheres to monitor its distance from the safety space.

Safety stop

This is the function that stops the robot if any safety conditions are violated. There are three methods for the safety stop. For more details on the methods, refer to ISO 13850 or IEC 60204-1.

Stop0

The power of the motors of all the joint modules will disconnect immediately, and the motors will stop (uncontrolled stop).

Stop1

The motors of all the joint modules will decelerate and stop, and the power of the motors will disconnect (controlled stop). The robot will decelerate as it continues to move along the programmed path, and then it will stop. As soon as the robot stops, its power will be disconnected.

Stop2

The motors of all the joint modules will decelerate, and the safe operating stop (SOS) will take effect. The power supply status of all the motors will be retained.

Recovery mode

When the robot stops because of the safety function, you can clear the error and position the robot in the safe space while it is in recovery mode. However, when the safety board is in the FAULT state, the error cannot be cleared in recovery mode, and the system should be rebooted.

Direct teaching

This is a method in which teaching is performed by moving the robot directly. This function is actuated by a switch that is mounted on the robot.



1.2 Collaborative operation mode

ISO 10218-1 and ISO/TS 15066 describe four operating modes so that operators can practice work safety without being exposed to risks. The collaborative operation should meet a least one of these requirements, and a visual display should show that the system is in collaborative operation when it is in operation.

1.2.1 Safety-rated monitored stop

When a person enters the working space, the robot operation will stop. Install an external monitoring device, and use it while connected to the safety control module (SCM).

- When an external device is connected to the safety input, the stop modes (Stop0, Stop1, and Stop2) should be set in the safety input/output (I/O) signal setting.
- When a safeguard and an external emergency stop device are connected, the stop modes must meet the requirements of the international or local regulations.

The reference information on the setting of the related functions is as follows:

- For more details on the setting of safety I/O signals, see "1.8 Safety I/O signals."
- For more details on the setting of safety stop functions, see "1.9 Safety Stop Function."

1.2.2 Hand guiding

This is a method in which the operator holds and directly controls the robot's manipulator. This method is available in the automatic operation mode.

To move the robot's manipulator directly in the manual mode, you can use free motion and specific constraint motion by direct teaching with an external switch. For more details on direct teaching, see "2. Direct teaching."

1.2.3 Speed and separation monitoring

The robot operates within a specified distance and speed.

In the speed and separation monitoring mode, the driving speed of the robot is controlled in proportion to the distance and the relative speed between the robot and the operator, utilizing sensors that can detect the operator's position and speed. You can use the deceleration mode for the inputs of the external sensors that detect distance.

The reference information on the use of the speed and separation monitoring mode is as follows:

- For more details on the setting of the robot's safety condition level 0 (deceleration mode), see "1.6 Robot safety conditions."
- For more details on the setting of safety I/O signals, see "1.8 Safety I/O signals."

1.2.4 Power and force limiting

This limits the impact on the human body in case of a collision. The collision detection function and the TCP force limiting function can limit the impact on the operator in case of a collision between the operator and the robot.

The collision detection function detects collisions according to the set sensitivity (%), while the TCP force limiting function restricts external force (N) applied to the TCP. You can also restrict the robot's driving power by setting the electric power (W) and momentum (kg·m/s).

For more details on the setting of the robot's safety conditions, see "1.6 Robot safety conditions."

1.3 Safety functions

The purpose of the safety functions of the collaborative robot is to reduce the impact on the operator in the case of a collision between the operator and the robot during collaborative operation.

The safety functions include the "axis limiting function," which restricts the motion of the robot's joints, and the "robot limiting function," which restricts the robot's motion in the safety space. These functions can be configured in the setting menu and are used as measures to respond to the risks selected in the risk assessment performed by the operator.

In executing the safety functions, the following items should be configured:

- Safety space: Set the working space and the protected space to restrict the robot's motion.
- Tool modeling: This is used to check whether the robot's tool position intrudes or exceeds specific spaces.
- Robot modeling: This is used to check whether the robot's elbow position intrudes or exceeds specific spaces.
- Safety limiting conditions: Set monitoring criteria value for the safety functions.

One safety condition can be configured for each safety space; if not configured, Level1 (default setting mode) will be set as the default condition. You can add up to 5 limiting conditions, 16 tools, and 12 safety spaces. You can set, modify, or enable the parameters relating to the safety function only when the motors are turned off in the manual mode.

1.3.1 Robot limit functions

The robot limiting functions, which restrict the robot's motion in the safety space, include the following:

- TCP position: This restricts the tool or the elbow shapes of the robot modeled in spheres from intruding or exceeding a set space.
- TCP orientation: This restricts the orientation of the robot's end effector and the tool from deviating from a set orientation.
- TCP speed: This restricts the robot's speed to a low speed so that the operator can escape in case of a collision
 with the robot (the robot moves at a maximum speed of 250 mm/s in the manual mode and the direct
 teaching mode).
- TCP force, power, and collision detection: This limits the force and pressure in case of a collision between the robot and the operator.
- Momentum: This limits the energy and impact load in case of a collision between the robot and the operator.

1.3.2 Joint limit functions

The joint limiting functions, which restrict the robot's motion in the joint space, include the following:

- Joint position: This limits the robot's joint positions so that its axes can move only within the specified ranges.
- Joint speed: This limits the robot's momentum so that its axes cannot move beyond the specified speeds.
- Joint torque: This limits the robot's power and force by restricting the torques of the axes to reduce the force and pressure applied on the operator in case of a collision with the robot.



To ensure the safety of personnel and equipment around the robot, operators and users should perform a risk assessment before configuring the robot's safety function and set the following details according to the assessment result:

 Set passwords and the like so that the safety configuration cannot be modified by unauthorized persons.

- Set safety-related functions and interfaces.
- Check if the settings are correct before running the robot.
- Check if all the safety functions are configured and if the settings conform to the result of the risk assessment.



1.4 Matters to be checked upon replacing safety devices

When the robot, controller, working tool, or an external device used for operating the collaborative robot is replaced, you should check the current settings and modify them as necessary. The safety functions that must be checked upon the replacement of a device include the following:

Device	Matters to be checked	Reference	
All the axial modules of the robot (motors, encoders, and torque sensors)	Reconfiguration of encoder optionsReconfiguration of torque sensor offsets	1.5.1 Encoder offset1.5.2 Checking the torque sensor	
Main controller (microcomputer)	System resettingReconfiguration of all safety-related functions	User manual	
Working tools	Checking of tool dataChecking of safety tool modelingChecking of axial load weightsChecking of tool I/O setting	 1.5.3 Setting of tool data 1.7.2 Safety tool modeling User manual 3.2 Tool I/O 	
External input devices	Checking of safety I/O setting	1.8 Safety I/O signals	



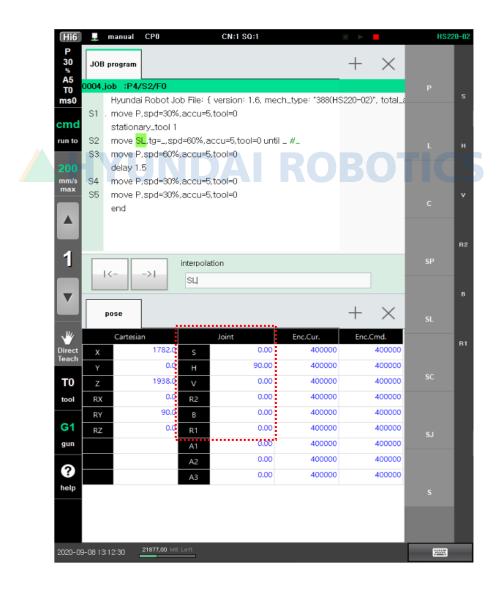
Check if the settings are correct before running the robot.

1.5 Matters to be checked before using the safety functions

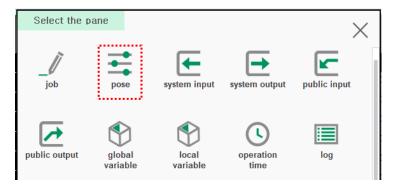
1.5.1 Encoder offset

The accuracy of encoder data is important because the safety functions of the collaborative robot detect the robot's position and speed based on the data transmitted by the encoders attached to the axes. Therefore, before using the safety functions, check whether the encoder values match the actual values.

- Check the zero mark of each axis of the robot and move the axes.
 In recovery mode, move each axis with the jog if a stop occurs because of a safety function violation. For more details on recovery mode, see "1.10.5 Recovery mode."
- 2. In the pose information window on the workspace, check whether the axial coordinate values of the robot are displayed at the reference pose (0, 90 0, 0, 0, 0 [deg]).



• Click the [+] button at the top right part of the panel stack if the pose information window does not appear on the workspace. Then, click [Pose] in the panel selection window.



- 3. Proceed to the next step if the difference of the angular value is no larger than 0.01. Otherwise, carry out the encoder offset if it is larger than 0.01.
- 4. Reboot the system.

Note For more details on the encoder offset, see "7.4.4 Encoder offsets" of the "Operation Manual for Hi6 Controllers."

1.5.2 Checking the torque sensor

You must set torque sensor offsets because the diagnosis of force/power, among the safety functions of the collaborative robot, is conducted based on the torque sensors attached to the axes. Although torque sensor offsets were set before the robot is delivered, you should set the torque sensor offsets if the current offset values are not correct.

- 1. After recording and modifying the step positions, run the program, and move the robot axes to a position that does not allow them to be affected by gravity (0, 90 -90, 90, 0, 0 [deg]).
 - The position unaffected by gravity varies depending on installation angles.

The position unaffected by gravity is (0, 90, -90, 90, 0, 0 [deg]) if the robot is installed flat on the ground. Modify the angle of axis 1 if the installation angle is sloped so that the lower frame matches the direction of the slope.

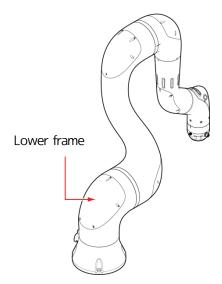


Figure 1 Robot position when installed flat on the ground (0, 90, -90, 90, 0, 0 [deg])

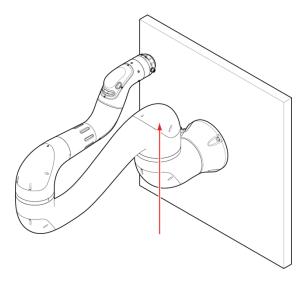


Figure 2 Robot position when it is wall-mounted (90, 90, -90, 90, 0, 0 [deg])

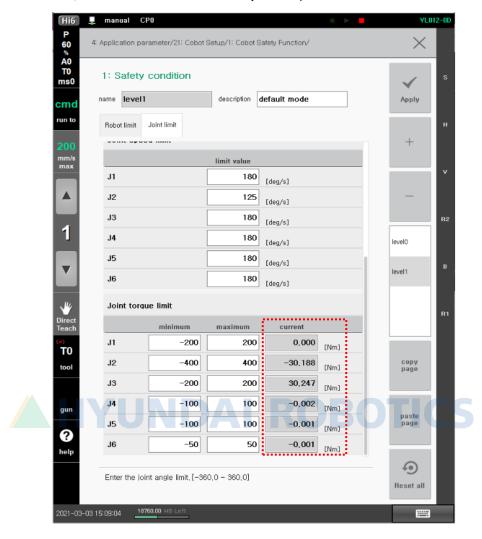
• In recovery mode, move each axis with the jog if a stop occurs because of a safety function violation. For more details on recovery mode, see "1.10.5 Recovery mode."

Note

For more details on step position recording and modification, see "2.3.2 Step position recording and modification" of the "Operation Manual for Hi6 Controllers."



2. In the [Joint limit] tab of [Set up > 4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 1: Safety condition] menu, check the current value of the joint torque limit.



3. Close the menu if the current torque sensor data value is smaller than 1 in the absolute value. Otherwise, carry out torque sensor offset if it is larger than 1.

1.5.2.1 Torque sensor offset

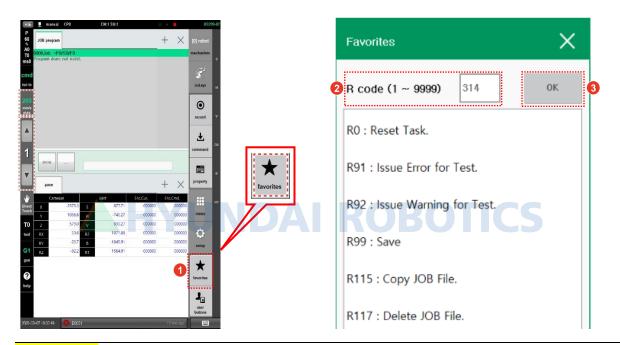
1. After recording and modifying the step positions, run the program, and move the robot axes to a position that does not allow them to be affected by gravity.

In recovery mode, move each axis with the jog if a stop occurs because of a safety function violation. For more details on recovery mode, see "1.10.5 Recovery mode."

Note

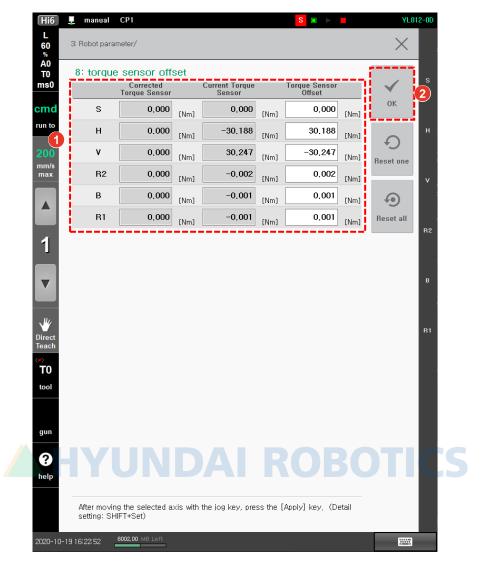
For more details on step position recording and modification, see "2.3.2 Step position recording and modification" of the "Operation Manual for Hi6 Controllers."

2. Click the **[Favorites]** button on the bottom right part of the Hi6 teach pendant window, enter "**314**" in the input box of the favorites window, and click the **[OK]** button.





- In Engineer Mode, the engineer mode icon (e) will blink on the status bar.
- Be careful as a wrong setting in Engineer Mode may lead to a severe problem in the robot system.
- 3. Click the [Set up] button > [3: Robot parameter > 8: Torque sensor offset] menu.
- 4. Check the position of each axis, click the [Reset one] or [Reset all] button, and observe whether the torque sensor offset value has been changed.

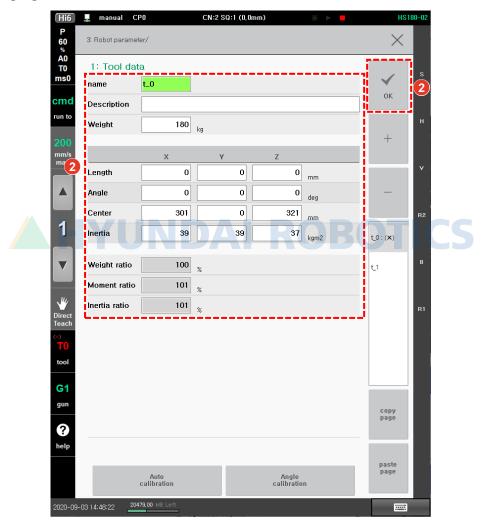


- To set the torque sensor offset of an axis, click the [Reset one] button.
- To set the torque sensor offsets of all the axes, click the [Reset all] button.
- 5. Check if the corrected torque sensor data value is close to 0, and save it by clicking the **[OK]** button.
- 6. Reboot the system.

1.5.3 Setting of tool data

The safety functions of the collaborative robot monitor the entire robot system including the tool attached to the robot's tool flange. Therefore, the smaller the difference between the tool data and its actual value, the more accurately the safety functions will work. Set the length and angle of the tool based on the flange coordinate system and input the information on the weight, center of gravity, and inertia of the tool in the applicable units.

- 1. Set the operating mode to the manual mode.
- 2. Disconnect the power of the motor by pressing the emergency stop button.
- 3. Select the [Configure] > [3: Robot parameter > 1: Tool data] menu.
- 4. Check the data of each axis, set the weight, center of gravity, and inertia of the tool, and save the values by clicking the **[OK]** button.



- To easily create new tool data from scratch utilizing the current program, click the [Auto calibration] button.
- To correct the tool angle, click the [Angle calibration] button.
- To add a new user coordinate system or delete one, use the [+] or [-] buttons, respectively.
- To view and edit the detailed information of tool data, select a tool data name to be viewed and edited.
- To copy the information on tool data and paste it to that of another, use the [Copy page] and [Paste page] buttons, respectively.

Reference

• When there is no information on the weight and center of gravity of a tool, you can estimate

the values using the load estimation function. For more details, see "Operation Manual for Hi6 Controllers."

For more details on tool data setting, see "Operation Manual for Hi6 Controllers."

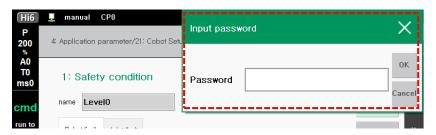
1.5.4 Password setting

The parameters for the safety functions of the collaborative robot must be set and managed by a designated person. A user designated as the administrator will be given the administrator authority and password for system setting. The password for system setting should be input when setting the parameters for the safety functions. When a wrong password is input, the administrator cannot modify or set the parameters.

- 1. Select the **[Configure]** button > **[5: Initialize > 11: system password setting]** menu. The password setting window will appear.
- 2. Enter the password, and click the [OK] button.



• In setting the parameters of the safety functions, the system setting password must be input for saving changes.





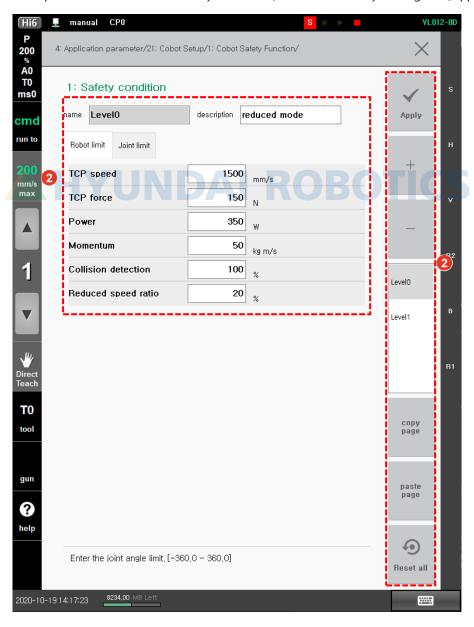
1.6 Robot safety conditions

The robot safety conditions, which are the limit values for monitoring the safety functions, consist of the robot limiting parameters and the joint limiting parameters.

You can enable the desired safety conditions for each safe space. In a space for which no specific conditions are designated or a space that is not enabled, the monitoring will be done based on Condition1 (default setting mode). When the deceleration mode is enabled, the monitoring will be done based on Condition0.

The method for setting safety conditions is as follows:

- 1. Select the [Configure] button > [4: Application parameter > 21: Cobot setup > 1: Cobot Safety function > 1: Safety condition] menu. The safety condition setting window will appear.
- 2. Check and set the parameter values of the safety conditions, and save them by clicking the [Apply] button.



No.	Description
2	These are the details of the safety condition. You can view and set the condition name and the

No.	Description				
	parameter values.				
	• [Name]/[Description]: These are the name and description of the safety condition.				
	• [Robot limit]: This is the setting information on the robot limiting parameters of the safety condition. For more details, see "1.6.1 Robot limiting parameters"				
	• [Joint limit]: This is the setting information on the joint limiting parameters of the safety condition. For more details, see "1.6.2 Joint limiting parameters."				
	• [Apply]: This saves changes.				
	• [+]/[-]: "+" adds a new safety condition, and "-" deletes an existing safety condition. You can add up to five safety conditions.				
	• This is the list of safety conditions. If you select a condition name, you can view and modify its details.				
2	• [Copy page]/[Paste page]: "Copy page" copies the information on a safety condition, and "Paste page" pastes it to another.				
	In the list of safety conditions, select the name of a condition, click the [Copy page] button, select				
	the name of another condition to which the condition will be applied, and click the [Paste page]				
	• [Reset all]: This initializes all the safety conditions.				

3. After checking the parameter values, finish the setting by clicking the [X] button or by clicking the \(\le \sc \rangle \) key of the teach pendant.

1.6.1 Robot limiting parameters

These parameters are the limit values for monitoring the safety functions relating to the robot's driving in the safety space. If a robot limiting parameter is enabled in a Cartesian space, monitoring will be done at all times, and if the deceleration mode is enabled, monitoring will be done based on Condition 0. If a monitoring violation occurs, safety stops (Stop 0, Stop 1, and Stop 2) will be actuated immediately.

You can set parameter values in the [Robot limit] tab of the [Set up > 4: Application parameter > 21: Cobot setup > 1: Cobot Safety Function > 1: Safety condition] menu.

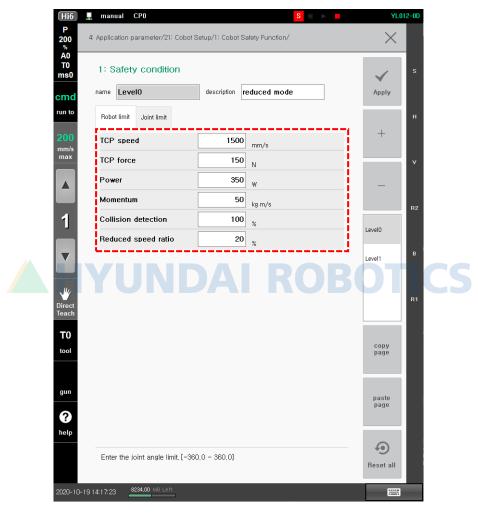


Figure 3 Window for setting robot limiting parameters

Parameter	Description	Default setting value
TCP speed	TCP speed The TCP speed limiting value in the robot's coordinate system (1–5,000 mm/s)	
TCP force	The force limiting value applied to the TCP (50-1,000 N)	150 N
Power	The mechanical power limiting value of the robot (80–1,000 W)	350 W
Momentum	The momentum limiting value of the robot (excluding payload) (50–1,000 kg·m/s)	50 kg·m/s
Collision detection	The sensitivity of the collision detection function (0%-200%)	100%
Reduced speed ratio	The reduced speed ratio of the speeds (TCP and joint speeds) set in	20%

Parameter	Description	Default setting value
	the deceleration mode (Condition0)	



- In configuring a speed limit, you must consider the stop reaction time and put a cover on the target to prevent collisions and injuries.
- Because the speed increases in proportion to kinetic energy and a high payload may increase
 the robot's momentum, the collision of the robot with an external object may generate
 significant impact. In the collaborative operation space, operate the robot while maintaining a
 safe speed and payload.

1.6.2 Joint limiting parameters

These parameters are the limit values for monitoring the safety functions relating to the space in which the robot's joints move. If a joint limiting parameter is enabled in a Cartesian space, monitoring will be done at all times, and if the deceleration mode is enabled, monitoring will be done based on Condition0. If a monitoring violation occurs, safety stops (Stop0, Stop1, and Stop2) will be actuated immediately.

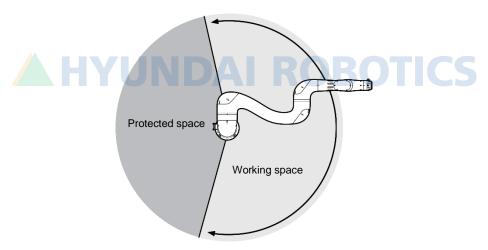


Figure 4 An example of joint limiting setting (S-axis)

You can set the parameter values in the [Joint limit] tab of the [Set up > 4: Application parameter > 21: Cobot setup > 1: Cobot Safety Function > 1: Safety condition] menu.

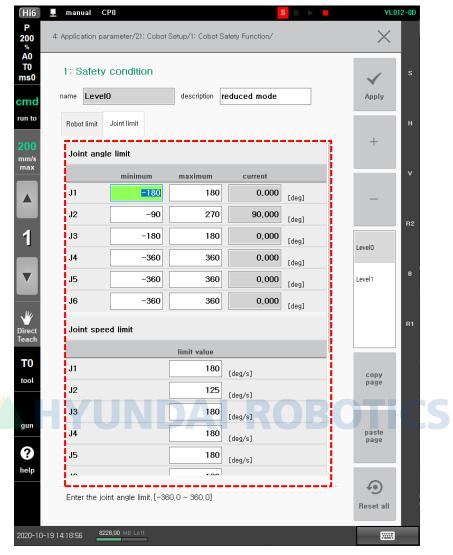


Figure 5 Window for setting joint limiting parameters

Parameter	Description	Default setting value
Joint angle limit	The angle limit value of a joint (-360.0° $-$ 360.0°)	It is identical to a robot soft limit.
Joint speed limit	The angular speed limit value of a joint (1.0 $^{\circ}$ –500.0 $^{\circ}$)	It is identical to the highest speed of the axis.
Joint torque limit	The torque limit value of a joint (-500.0-500.0 Nm)	It is identical to the highest torque of the axis.

In configuring a speed limit, you must consider the STOP reaction time and put a cover on the

target to prevent collisions and injuries.

1.7 Safety layout

This sets the safety space, safety tools, and safety robot elbow.

1.7.1 Safety space setting

The safety space is a working space or a protected space in which the range of the tool or the robot elbow is monitored. The working space is a limited space where the monitoring target can move freely but cannot exceed. In contrast, the protected space is a limited space in which the monitoring target cannot move when it intrudes into the space. If the safety space is a working space, you can enable it by assigning a safety condition number. In the working space, if the monitoring target moves and exceeds the limit value of a safety condition, a functional safety stop will be actuated.

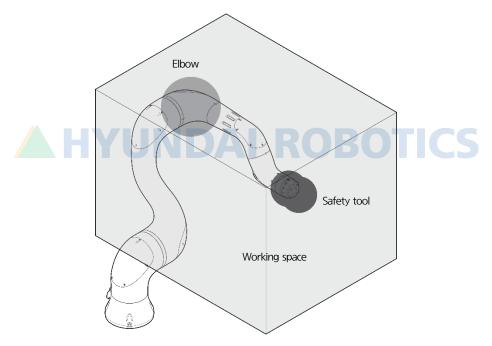


Figure 6 Safety space: Working space

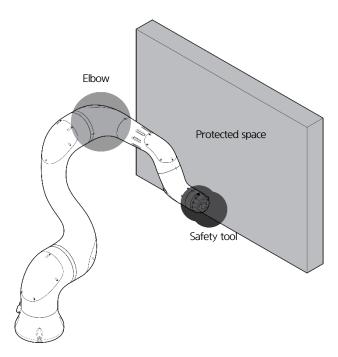


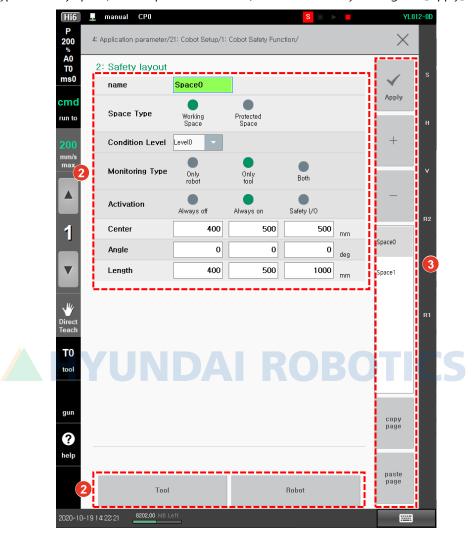
Figure 7 Safety space: Protected space

A safety space should be configured by setting the position and length of the zero point based on the robot coordinate system, including a stopping distance. You can add up to 12 spaces, each of a cuboid shape. The safety space is enabled by setting parameters or safety I/O signals.



The method for setting safety spaces is as follows:

- 1. Click the [Configure] button > [4: Application parameter > 21: Cobot setup > 1: Cobot Safety Function > 2: Safety layout] menu.
- 2. Select the type of safety space, set the parameter values, and save them by clicking the [Apply] button.



No.	Description
2	These are the details of the safety space. You can view and set the space name and the parameter values. For more details on the setting, see "1.7.1.1 Setting information on safety space parameters."
2	 [Tool]: This sets the parameter values of the tool used for safety space monitoring. For more details, see "1.7.2 Safety tool modeling." [Robot]: This sets the parameter values of the robot model used for safety space monitoring. For more details, see "1.7.3 Safety robot modeling."
3	 [Apply]: This saves changes. [+]/[-]: "+" adds a new safety space, and "-" deletes an existing safety space. You can add up to 12 safety spaces. This is the list of safety spaces. If you select a space name, you can view and modify its details. [Copy page]/[Paste page]: "Copy page" copies the information on a safety space, and "Paste page" pastes it to another. In the list of safety spaces, select the name of an space, click the [Copy page] button, select the name of another space to which the values will be applied, and click the [Paste page] button.

3. After checking the parameter values, finish the setting by clicking the [X] button or by clicking the [esc] key of the teach pendant.

1.7.1.1 Setting information on safety space parameters

Parameter		Description	Default setting value
Name		The name of the selected safety space (name character string, 24 characters at maximum, not modifiable)	CobotSpace n
Space t	ype	Type of safety space (0 = working space, 1 = protected space)	0
Condition	ı level	Condition for actuating safety functions in the space (0-4)	1
Monitorin	g type	Monitoring target (0-2: 0 = tool, 1 = robot (elbow), 2 = tool and robot)	0
Actuation		Actuation condition (On/Off: $0 = \text{always off}$, $1 = \text{always on}$, $2 = \text{safety}$ I/O)	0
	X		
Center	Υ	Zero point of the space (-30,000–300,000 mm)	0
	Z		
	RX		
Angle	RY	Direction of the zero point (RX/RZ: -180° -180° , RY: -90° -90°)	0
	RZ		
	LX		
Length	LY	Length in the X, Y, and Z directions (0–60,000 mm)	0
	LZ	HYUNDAI ROBOTICS	



- The robot monitoring function is carried out based on the configured spaces and modeled tools. The spaces and tools should include all the components including distance.
- Put a cover on the robot to prevent collisions and injuries.

1.7.2 Safety tool modeling

Safety space monitoring detects whether the tool modeled in spheres intrudes into the safety spaces or exceeds the working space. You can set up to 16 safety tools and model a safety tool with a maximum of 6 spheres.

Because a safety tool is enabled by a number that is set on the teach pendant, you should model a safety tool based on the tool data set in the [Setting > 3: Robot parameter > 1: Tool data] menu. Refer to the TCP position information displayed at the top of the tool data setting window.

Each sphere used for safety tool modeling is set by its center and radius. Set the center position of the sphere for the modeling based on the robot flange coordinate system (Xf, Yf, and Zf), and set the radius of the sphere, including the tool size and the stopping distance, at the maximum TCP speed.

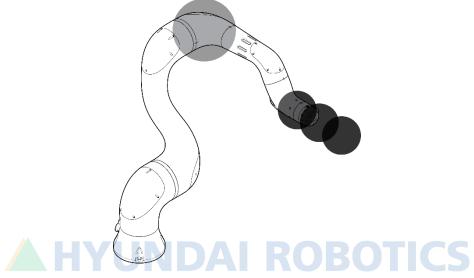


Figure 8 Tool modeling

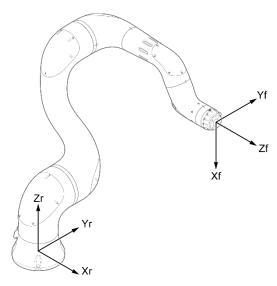


Figure 9 Robot flange coordinate system

To use the TCP orientation limiting function in safety tool modeling, you can set cones for monitoring by setting rotation and deviation angles in creating the reference vector.

You can model a cone (2) that is formed with generator lines spread by the deviation angle (4) from the reference vector (3), which is set by the rotation of the Z-direction vector of the robot coordinate system (2) at a specified angle. The vertex (5) of the cone is located at the TCP, and if the Z-direction vector (6) of the TCP exceeds the monitoring cone, a violation error of the TCP position limiting function will occur.

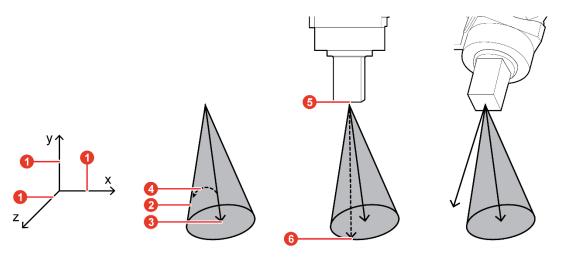


Figure 10 TCP orientation limiting function

You can set parameter values by clicking the **[Tool]** button in the **[Set up > 4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 2: Safety layout]** menu.



Figure 11 Safety tool modeling setting window

Parameter			Description	Default setting value
Name			The name of the selected safety tool (name character string, not modifiable)	CobotTool n
TCP X Y Z		Υ	The tool data set in the [Configure > 3: Robot parameter > 1: Tool data] menu	0
	Or	n/Off	Whether to enable monitoring (Off = no monitoring, On = monitoring)	Sphere1: On / Spheres 2–6: Off
Sphere	Center	X Y Z	The XYZ coordinate value of the center of the sphere in the flange coordinate system (-10,000-10,000 mm)	0
	Radius		Radius of the sphere (0-10,000 mm)	1,000 mm
	On/Off		Whether to enable monitoring (Off = no monitoring, On = monitoring)	Off
	Cone	RX The di	The direction of the reference vector that forms the center of the cone (based on the robot coordinate system, 0.0° -180.0°)	0
Cone		RY		0
		RZ		0
	Deviation angle		The orientation limit value of the safety tool (cone angle/2, 0.0° -180.0°)	0

Reference

If you use the **[Copy TCP]** button, the rotational angle values that can be set as the Z-direction vector of the current TCP will be applied to the reference vector, which facilitates the setting of the reference vector.



- Before changing a tool data, check if the parameters set in the tool modeling are correct. The
 tool data number and the safety tool modeling number of a tool should be equal to each
 other.
- Because the definition of a robot layout setting applies to the elbow, the other parts of the robot may intrude into a safety space even if a safety space is set.

1.7.3 Safety robot modeling

This is the robot model used for safety space monitoring. There is only one safety robot model, and the model consists of a sphere.

The sphere used for safety robot modeling is specified by its center and radius. The sphere center of the model is the position of the robot's elbow (axis 3: V axis), and the radius should be large enough to include the current size of the elbow and its stopping distance at the maximum TCP speed.

To set the parameter values, click the [Robot] button in the [Configure > 4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 2: Safety layout] menu.

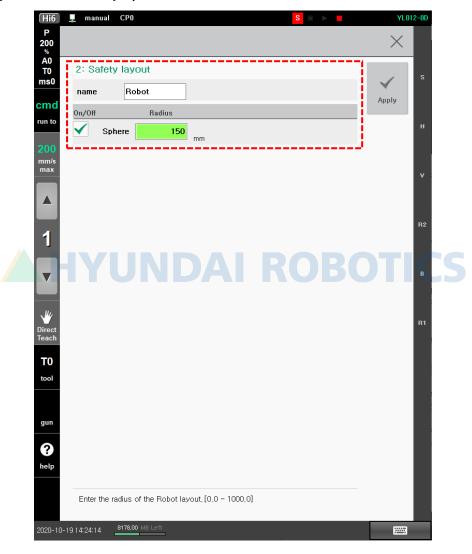


Figure 12 Safety robot modeling setting window

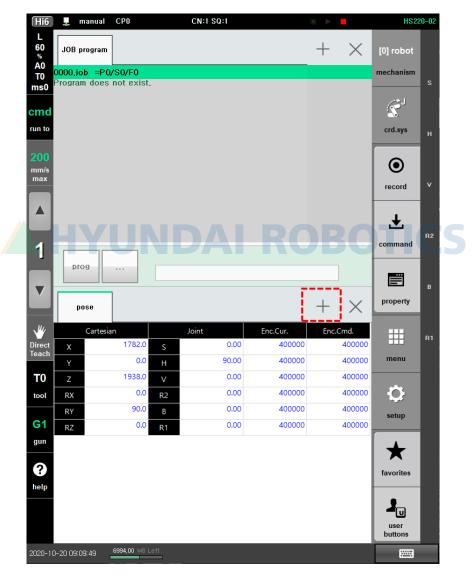
Parameter	Description	Default setting value
Name	The name of the selected safety robot model (name character string, not modifiable)	Robot
On/Off	Whether to enable monitoring (Off = no monitoring, On = monitoring)	Off
Radius	Radius of the sphere (0-10,000 mm)	0 mm

1.7.4 WorkCell 3D

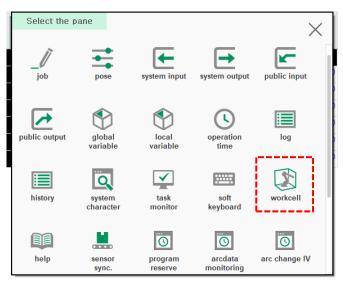
This directly monitors the parameters specified in the safety layout by using WorkCell 3D. WorkCell 3D can 3D visualize the safety spaces, tool models, and robot models specified in the safety layout so that the operator can view the settings. In addition, the robot's position is identified in real time so that the operator can check whether the robot violates any safety spaces.

You can enable the WorkCell 3D function on the panel selection window of the operation program for the working space.

1. Click the [+] button that is at the top-right part of the panel stack of the working space.

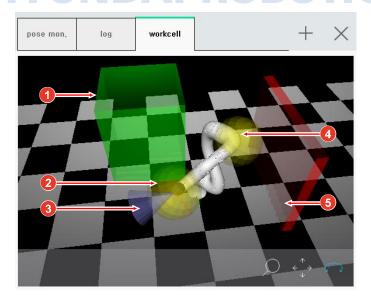


2. On the panel selection window, select [WorkCell]. Then, the robot's current posture will appear on the 3D window.



Reference

- On the panel selection window, all the items that can be monitored will appear.
- The items that can be monitored will vary depending on controller settings.
- 3. Check the settings of the working space (1), tool space (2), tool orientation limiting (3), robot elbow space (4), and limiting space (5).



- To adjust the camera, select the **[Expand/Shrink]** icon (**[**), the **[Move]** icon (**[**), or the **[Rotate]** icon (**[**), and drag the screen.
- To modify the setting and apply the set values, close and reopen the WorkCell window.

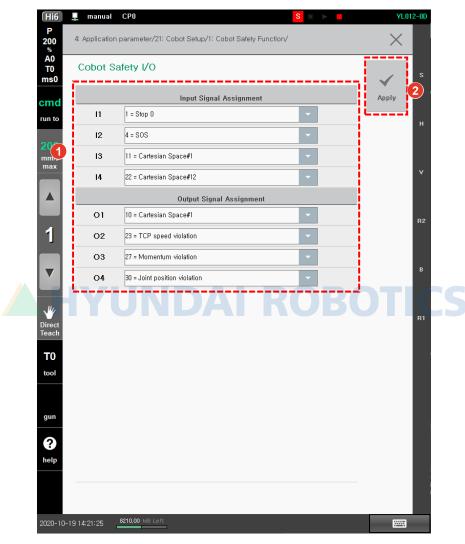


Compare the robot's WorkCell simulation position and its actual position, and identify any adjacent obstacles in operating the robot safely.

1.8 Safety I/O signals

This assigns safety I/Os in using the collaborative robot. Each safety I/O is of a dual channel. You can set up to four signals each for input and output.

- 1. Select the [Configure] button > [4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 3: Cobot Safety I/O] menu.
- 2. Click the drop-down menu, configure I/O signals, and click the [Apply] button.



Parameter		Description		
Input signal assignment	INO-IN3	 Activation signal assignment 0 = None 1 = Stop 0 2 = Stop 1 3 = Stop 2 	 (up to 4 signals, 0-22) 4 = SOS 5 = Reduced mode 7 = Motor on 11-22 = Safety spaces #1 - #12 	
Output	OUT0-	Monitoring signal assignment (up to 4 signals, 0–43)		

Param	neter	Description		
signal assignment	OUT3	 0 = None 1 = STO activation status 2 = SOS activation status 3 = Reduced mode activation status 4 = Not reduced mode 5 = Robot moving 7 = Mode switch - manual 8 = Mode switch - auto 9 = Mode switch - remote 10-21 = Safety spaces #1 - #12 	 22 = Violation alarm 23 = TCP speed violation 24 = TCP orientation violation 25 = TCP force violation 26 = Collision detection 27 = Momentum violation 28 = Power violation 29 = SOS violation 30 = Joint position violation 31 = Joint speed violation 32 = Joint torque violation 	
			• 33-43 = Safety space violation #1 - #12	

3. After checking the parameter values, finish the setting by clicking the [X] button or by clicking the 〈esc〉 key of the teach pendant.



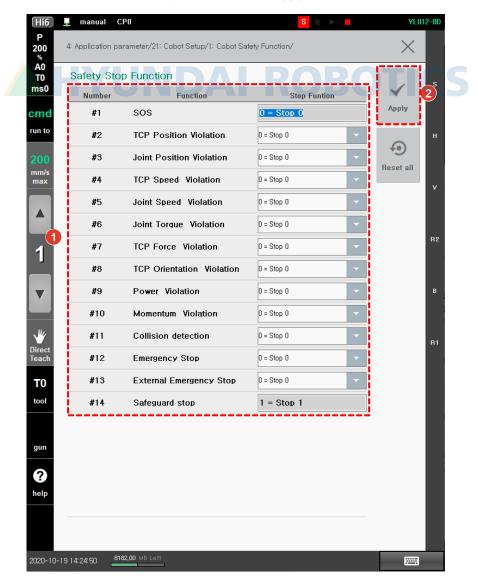
1.9 Safety Stop Function

Set an adequate safety stop type for each safety stop function. The safety stop functions, which stop the robot under a safe condition in case of a safety violation, include the following three types. All types of safety stop functions meet the requirements of Clause 4.2.2.4 of IEC 61800-5-2.

- Stop0: The power of the motors of all the joint modules will disconnect immediately, and the motors will stop.
- Stop1: The power of the motors of all the joint modules will decelerate, and the motors will stop. Then, the power of the motors will be disconnected.
- Stop2: The motors of all the joint modules will decelerate, and the safe operating stop (SOS) function will take effect. The power supply status of all the motors will be retained.

The method for setting the safety stop types of the safety functions is as follows:

- 1. Select the [Configure] button > [4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 4: Safety Stop Function] menu.
- 2. Click the drop-down menu, set the stop type, and click the [Apply] button.



No.	Safety function	Stop function	No.	Safety function	Stop function
1	SOS	Default setting value: Stop0 (fixed value)	8	TCP orientation violation	Default setting value: Stop0
2	TCP position violation (safety space violation)	(safety space Default setting value: 9 F		Power violation	Default setting value: Stop0
3	Joint position violation	Default setting value: Stop0	10	Momentum violation	Default setting value: Stop0
4	TCP speed violation	Default setting value: Stop0	11	Collision detection	Default setting value: Stop0
5	Joint speed violation	Default setting value: Stop0	12	Emergency stop	Default setting value: Stop0
6	Joint torque violation	Default setting value: Stop0	13	External emergency stop	Default setting value: Stop0
7	TCP force violation	Default setting value: Stop0	14	Safeguard stop	Default setting value: Stop1 (fixed value)

3. After checking the parameter values, finish the setting by clicking the [X] button or by clicking the \(\ext{esc} \) key of the teach pendant.

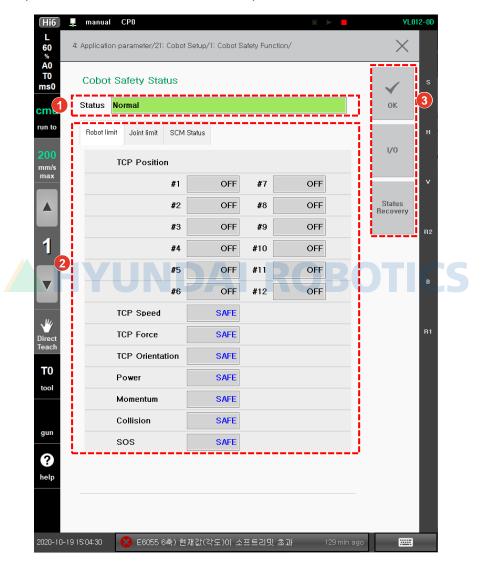


You should set an adequate stopping method for each function based on the result of the risk assessment.

1.10 Safety condition monitoring

This monitors safety function violations and the status of the SCM board. You can view the statuses of the robot limiting functions, joint limiting functions, and the SCM board.

- 1. Select the [Configure] button > [4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 5: Cobot Safety Status] menu.
- 2. Check the safety conditions and the statuses of the safety functions of the collaborative robot.



No.	Description				
1	View the safety conditions of the collaborative robot.				
	Select the Safety Functions tab, and view the statuses of the safety functions.				
2	OFF: Safety space disabled / SAFE: Safety function observed / UNSAFE: Safety function violated / ERROR: SCM status error				
3	• [I/O]: You can view the statuses of the safety I/Os.				
	• [Status Recovery]: In case of safety violations during monitoring, you can clear errors and recover				

No.	Description
	the status.

1.10.1 Robot limiting parameter monitoring

Select the [Robot limit] tab of [Configure > 4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 5: Cobot Safety Status] to view the statuses of the robot limiting functions.

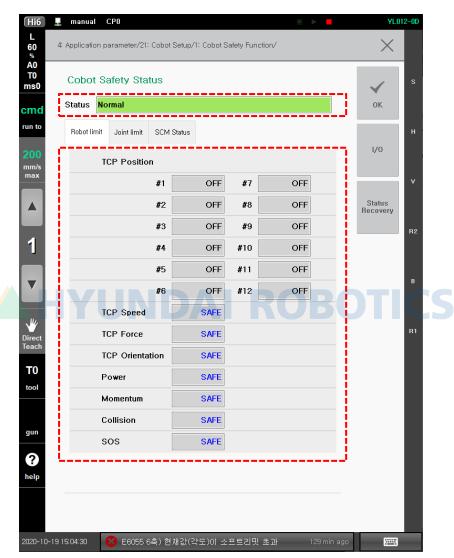


Figure 13 Safety conditions of the collaborative robot: Robot limiting

• [Status]: You can view the safety conditions.

You can monitor the statuses of the safety functions of the collaborative robot. In a normal condition, **Normal** will be displayed. If an error or violation of a safety function occurs, the pertaining error code will be displayed.

- You can view the statuses of the robot limiting functions.
 - **[TCP position]**: This indicates the statuses of the Cartesian spaces (nos. 1–12) and whether a TCP position violation has occurred during the monitoring.
 - [TCP speed]: This indicates whether a TCP speed violation has occurred during the monitoring.
 - **[TCP force]**: This indicates whether a TCP force violation has occurred during the monitoring.
 - [TCP orientation]: This indicates whether a TCP orientation violation has occurred during the monitoring.
 - [Power]: This indicates whether a power violation has occurred during the monitoring.
 - [Momentum]: This indicates whether a momentum violation has occurred during the monitoring.

- [Collision]: This indicates whether a collision has been detected during the monitoring.
- [SOS] (Safe operating stop monitoring): This indicates whether an SOS violation has occurred during the monitoring.

1.10.2 Joint limiting function monitoring

Select the [Joint limit] tab of [Configure > 4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 5: Cobot Safety Status] to view the statuses of the joint limiting functions.

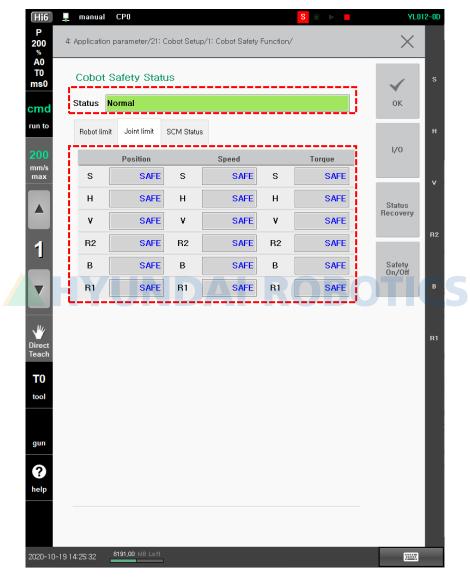


Figure 14 Safety conditions of the collaborative robot: Joint limiting

[Status]: You can view the safety conditions.

You can monitor the statuses of the safety functions of the collaborative robot. In a normal condition, **Normal** will be displayed. If an error or violation of a safety function occurs, the pertaining error code will be displayed.

- You can view the statuses of the joint limiting functions.
 - [Position]: This indicates whether an axial joint position violation has occurred during the monitoring.
 - [Speed]: This indicates whether an axial joint speed violation has occurred during the monitoring.
 - [Torque]: This indicates whether an axial joint torque violation has occurred during the monitoring.

1.10.3 SCM board status monitoring

Select the [SCM Status] tab of [Configure > 4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 5: Cobot Safety Status] to view the status of the SCM board.

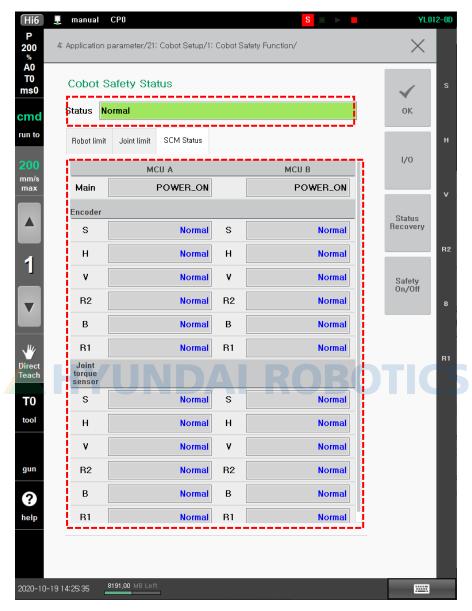


Figure 15 Safety conditions of the collaborative robot: SCM status

• [Status]: You can view the safety conditions.

You can monitor the statuses of the safety functions of the collaborative robot. In a normal condition, **Normal** will be displayed. If an error or violation of a safety function occurs, the pertaining error code will be displayed.

- You can view the status of the SCM board.
 - [Main]: This is a status display of the dual MCUs (MCU A, MCU B).

 POWER_ON, INIT_STATE, WAIT_KIENMATICS_INFO, WAIT_DYNAMICS_INFO, WAIT_SAFE_PARAMETER,
 INITIAL_MONITORING, NORMAL_OPERATION, , STO_STATE_BY_PARAM, STO_STATE_BY_SI, SS1_STATE,
 SS2_STATE, SOS_STATE, FAULT_STATE
 - **[Encoder]**: This is a status display of the axial dual encoders (Normal, Error, Off).
 - [Joint torque sensor]: This is a status display of the axial dual JTSs (Normal, Error, Off).

1.10.4 Safety I/O status monitoring

Select the [I/O] button at the right side of the window of [Configure > 4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 5: Cobot Safety Status] to view the statuses of the safety I/Os.

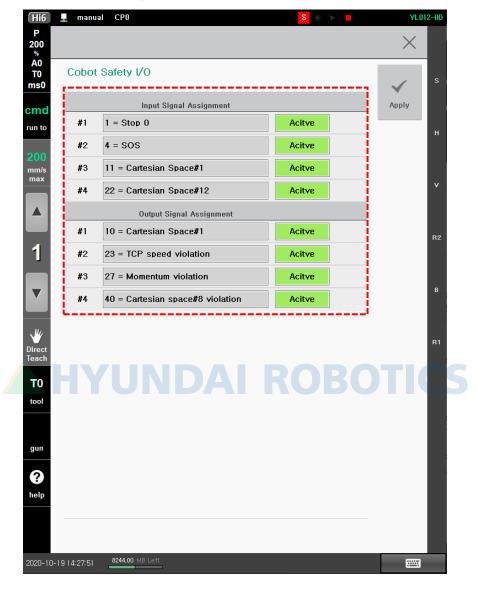


Figure 16 Safety conditions of the collaborative robot: Safety I/O

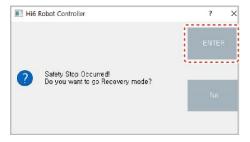
- **[Input signal assignment]**: This displays the statuses of assignment and activation (On/Off) of the input signals (nos. 11–14)
- **[Output signal assignment]**: This displays the statuses of assignment and activation (On/Off) of the output signals (nos. 11–14)

1.10.5 Recovery mode

In recovery mode, you can clear errors that occur because of the safety function violations during monitoring. Because position detection is temporarily disabled in recovery mode, you can drive the robot and adjust its angle and position without violating the safety functions.

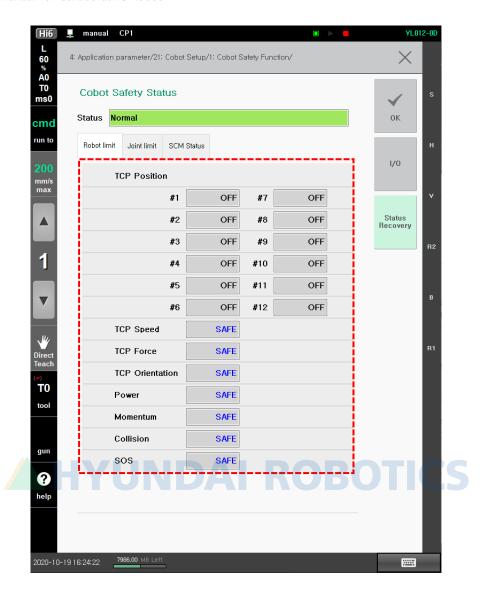
If a safety function monitoring is violated, the robot will activate a safety stop immediately and stop moving. In addition, the safety stop notice window will appear on the operating program window.

- Set the operating mode to the manual mode.
- On the safety stop notice window, click the [ENTER] button. Then, the safety condition monitoring window will appear.



- 3. Click the [Status Recovery] button. Then, the [Status Recovery] button will turn green, and the system will enter recovery mode.
- 4. In recovery mode, adjust the robot's angle and position to clear errors.





- 5. After the recovery is completed, click the [Status Recovery] button. Then, the [Status Recovery] will turn into the previous color, and the recovery mode will be cleared.
 - You can also clear the recovery mode by clicking the [X] button at the upper-right corner of the safety condition monitoring window.



After clearing the recovery mode, recheck the safety layout setting and the teaching position of the operating program.

1.10.5.1 Recovery in case of robot position violations

Robot position violations are situations in which the robot's position exceeds a safety space, and these include TCP position, TCP orientation, and joint monitoring violations. When a robot position violation occurs, you can only clear the error by moving the robot's physical position.

- 1. On the safety condition monitoring window, click the [Status Recovery] button to enter recovery mode.
- 2. Turn on the motor by using the enabling switch on the teach pendant.
- 3. Use the teaching device to move the robot back to a safety space.
- 4. On the safety condition monitoring window, check if the status of each space is displayed as SAFE.
- 5. After the recovery is completed, click the [Status Recovery] button to clear the recovery mode.



After clearing the recovery mode, recheck the safety layout setting and the teaching position of the operating program.

1.10.5.2 Recovery in case of robot speed violations

Robot speed violations are situations in which the robot's speed exceeds a safety limit, and these include TCP speed, joint speed, power, and momentum monitoring violations. Because the robot detects the instantaneous speed in the case of robot speed violations, you can clear the error without moving the robot's position.

- 1. On the safety condition monitoring window, click the [Status Recovery] button to enter recovery mode.
- 2. On the safety condition monitoring window, check if the status of each space is displayed as SAFE.
- 3. After the recovery is completed, click the [Status Recovery] button to clear the recovery mode.



- After clearing the error, make sure to recheck all speed-related safety parameters and the speed displayed on the operating program.
- After clearing the recovery mode, recheck the safety layout setting and the teaching position of the operating program.

1.10.5.3 Recovery in case of robot force violations

Robot force violations are situations in which external force is applied on the robot or in which the amount of the force used by the robot internally exceeds a safety limit, and these include TCP force, collision detection, joint torque, power, and momentum monitoring violations. You can clear errors depending on the causes of the violations.

- Violation caused by external force applied on the robot
- 1. Remove the external factor that is applying force on the robot.
- 2. On the safety condition monitoring window, click the [Status Recovery] button to enter recovery mode.
- 3. On the safety condition monitoring window, check if the status of each space is displayed as SAFE.
- 4. After the recovery is completed, click the [Status Recovery] button to clear the recovery mode.



After clearing the recovery mode, recheck the safety layout setting and the teaching position of the operating program.

- Violation caused by the amount of force used by the robot internally exceeding a safety limit
- 1. On the safety condition monitoring window, click the [Status Recovery] button to enter recovery mode.
- 2. Turn on the motor using the enabling switch on the teach pendant.
- 3. Use the teaching device to move the robot to a low-load posture.
- 4. On the safety condition monitoring window, check if the status of each space is displayed as SAFE.
- 5. After the recovery is completed, click the [Status Recovery] button to clear the recovery mode.



- After clearing the recovery mode, recheck the robot's safety condition setting, tool data, the teaching position of the operating program, and the torque sensor offset.
- If the error is not cleared, check the tool data, tool number, safety condition setting, and torque

sensor offset, and repeat procedures 1 through 5.

1.10.5.4 Recovery in cases of safe operating stop (SOS) violations

SOS violations are situations in which the robot's motion is detected while its motor is on and is supposed to be in a stop state. Because the robot detects the instantaneous speed in the case of robot speed violations, you can clear the error without moving the robot's position.

- 1. Remove the external factor that is applying force on the robot.
- 2. On the safety condition monitoring window, click the [Status Recovery] button to enter recovery mode.
- 3. On the safety condition monitoring window, check if the status of each space is displayed as SAFE.
- 4. After the recovery is completed, click the [Status Recovery] button to clear the recovery mode.



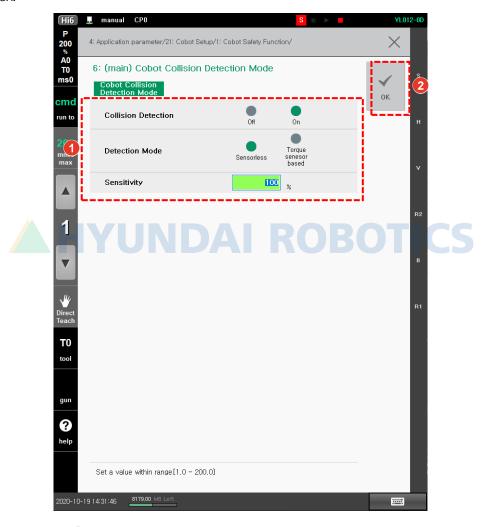
- After clearing the recovery mode, turn on the motor in the automatic mode and check if the error does not persist.
- If the same error recurs, check the driving module of the pertaining axis.



1.11 Collaborative robot collision detection mode

The collision detection function is a safety mechanism for situations in which the robot operates in an abnormal condition or malfunctions. You can adjust the level of reaction to collisions by setting the detection mode and sensitivity.

- 1. Set the operating mode to the manual mode.
- 2. Select the [Configure] button > [4: Application parameter > 21: Cobot Setup > 1: Cobot Safety Function > 6: (Main) Cobot Collision Detection Mode] menu.
- 3. Set whether to use the collaborative robot's collision detection function, configure the options, and click the **[OK]** button.



- [Collision detection]: Set whether to use the collision detection function.
- [Detection mode]: Select the detection mode for collision detection.
- **[Sensitivity]**: Set the sensitivity for collision detection. The larger the value, the higher the sensitivity to impacts.



False detection of collision may occur if the difference between the tool data and the
actual value is large. In addition, make sure to check the installation angle and gravity
direction of the robot. Then, check the encoder and torque sensor if false detection occurs
after the correct setting of the tool data.

• Setting the sensitivity value of collision detection at an overlarge value may lead to false detection. Therefore, set it at a proper value suitable for ensuring worker safety.



2. Direct teaching

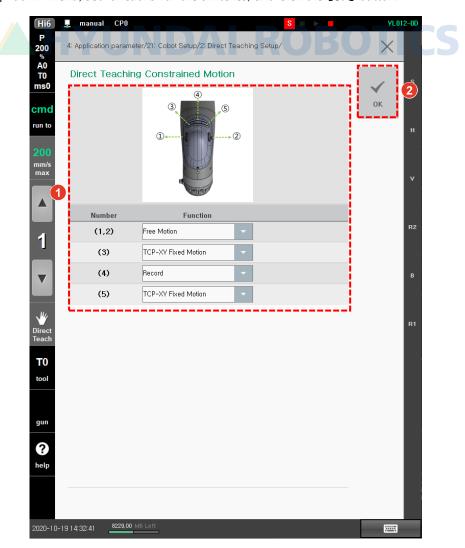
Direct teaching is a method of teaching the collaborative robot in which the teaching device attached to the manipulator is used for moving the robot directly. Because direct teaching specifies the robot's position by moving it directly, you can teach the robot in an intuitive manner without specialized knowledge.

Direct teaching methods include the free motion method, where all axes of the robot can be moved freely, and the constraint motion method, where the axes of the robot can be moved only in specific directions. The axial movement direction of the constraint motion method can be used by assigning it to the teaching switch of the robot manipulator.

2.1 Direct teaching switch assignment

The method for setting the switches of the teaching device attached to the robot manipulator is as follows:

- 1. Select the [Configure] button > [4: Application parameter > 21: Cobot Setup > 2: Direct Teaching Setup > 1: Direct Teaching Constrained Motion] menu.
- 2. Click the drop-down menu, set functions for the switches, and click the [OK] button.



Hyundai Robotics Direct teaching_55

• The functions that can be assigned to the direct teaching switches are as follows:

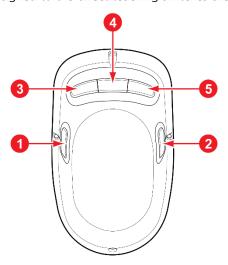


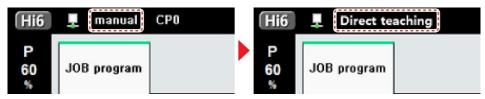
Figure 17 Direct teaching switches

No.	Function					
1/2	Free motion: The axes move in all directions (fixed).					
3/4	Constraint motion: The axes move only in the assigned directions. X and Y directions based on the tool coordinate system (XY plane) Z direction on the tool coordinate system Angles fixed based on the tool coordinate system: Motion in all directions (RX, RY, and RZ angles are restricted.) Points (positions) fixed based on the tool coordinate system: Only angles can be changed.					
4	Record positions (fixed).					

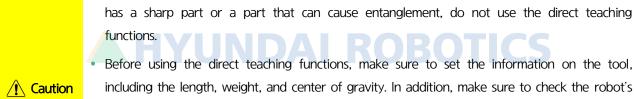
56_Direct teachingHyundai Robotics

2.2 Driving the robot by direct teaching

- 1. Set the operating mode to the manual mode.
- 2. Press the (Motor) key on the teach pendant to supply servo power to the motor. The motor lamp will blink.
- Press a direct teaching switch (1, 2, 3, or 5). The motor's break will be released, and the direct teaching function will turn on. In the status display line of the operating program window, the operating method will be displayed as "Direct teaching."



- 4. While the direct teaching switch (1, 2, 3, or 5) is pressed, hold and move the robot to teach it the desired position.
 - To move all the axes of the robot freely, press a direct teaching switch (1 or 2).
 - To move all the axes of the robot in assigned directions only, press a direct teaching switch (3 or 5).
 - To record the position of the robot, press a direct teaching switch (4).



installation angle and direction of gravity.



 Set the enabling or disabling of the direct teaching functions only when the robot is at a complete stop. Changing the status of a direct teaching function while the robot is moving may cause the robot to malfunction.

• Use the direct teaching functions in a safe environment only. If the tool or a nearby structure

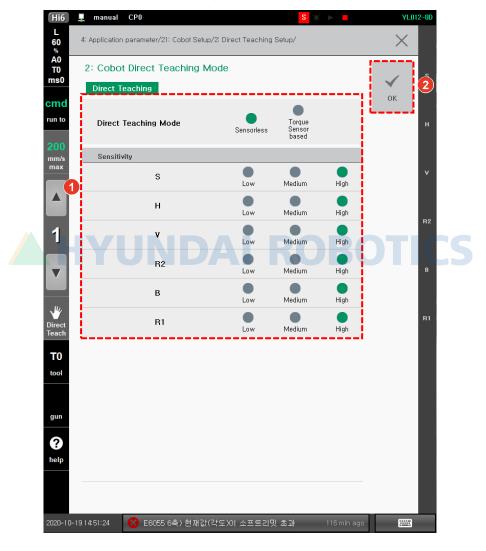
Hyundai Robotics Direct teaching_57

2.3 Direct teaching mode setting

Direct teaching supports the sensorless mode and the torque sensor-based mode.

You can select the desired direct teaching mode and set the sensitivity of each axis. The higher the sensitivity, the smaller the force required to move the robot.

- 1. Set the operating mode to the manual mode.
- 2. Select the [Configure] button > 4: Application parameter > 21: Cobot Setup > 2: Direct Teaching Setup> 2: Cobot Direct Teaching Mode] menu.
- 3. Select the direct teaching mode, set the sensitivity of each axis, and click the [OK] button.



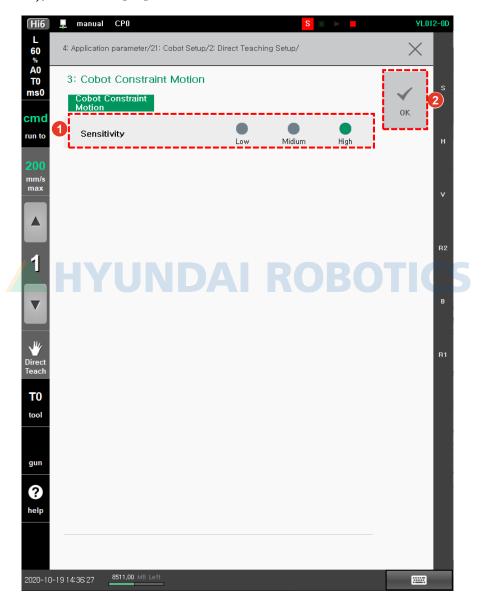
58_Direct teaching

Hyundai Robotics

2.4 Constraint motion

When you conduct direct teaching through the constraint motion method, you can set the sensitivity of constraint motion. The higher the sensitivity, the smaller the force required to move the robot.

- 1. Set the operating mode to the manual mode.
- 2. Select the [Configure] button > [4: Application parameter > 21: Cobot Setup > 2: Direct Teaching Setup > 3: Cobot Constraint Motion] menu.
- 3. Select a sensitivity, and click the **[OK]** button.



Hyundai Robotics Direct teaching_59

3. I/O setting

3.1 I/O map

The mapping between the safety control modules (SCMs) of the collaborative robot and the tool I/O of the system is as follows. Write the program by referring to this information.

Input					Output		
Byte	Bit		Usage	Byte	Bit		Usage
SIB24			Robot parameter violation status	SOB24			-
SIB25			TCP speed violation status	SOB25			-
SIB26			TCP force violation status	SOB26			-
SIB27			TCP orientation violation status	SOB27			-
SIB28		HY	Power violation status	SOB28	OB	OTIC	S -
SIB29			Momentum violation status	SOB29			-
SIB30			SOS violation status	SOB30			-
SIB31		SCM	Collision detection status	SOB31		SCM	-
SIB32		2 2	Analog input	SOB32			Analog output
SIB33			channel 0	SOB33			channel 0
SIB34			Analog input	SOB34			Analog output
SIB35			channel 1	SOB35			channel 1
	SI288		Digital input 0		SO288		Digital output 0
	SI289		Digital input 1		SO289		Digital output 1
	SI290		Digital input 2		SO290		Digital output 2
SIB36	SI291		Digital input 3	SOB36	SO291		Digital output 3
)ICOIC	SI292		Digital input 4	30030	SO292		Digital output 4
	SI293		Digital input 5		SO293		Digital output 5
	SI294		Digital input 6		SO294		Digital output 6
	SI295		Digital input 7		SO295		Digital output 7

60_I/O setting Hyundai Robotics

	Input					Output	
Byte	Bit		Usage	Byte	Bit	Usage	
	SI296		Digital input 0		SO296		Digital output 0
	SI297		Digital input 1		SO297		Digital output 1
	SI298		Digital input 2		SO298	T. 1110	Digital output 2
CIDOZ	SI299		Digital input 3		SO299		Digital output 3
SIB37	SI300		-	SOB37	SO300		-
	SI301	T1.1/O	-		SO301		-
	SI302	Tool I/O	-		SO302	Tool I/O	-
	SI303		-		SO303		-
SIB38			Analog input	SOB38			-
SIB39			channel 0	SOB39			-
SIB40			Analog input	SOB40			-
SIB41			channel 1	SOB41			-

3.2 Tool 1/0 HYUNDAI ROBOTICS

The tool I/O, which is a module mounted at the robot tip, supplies communication and power so that the robot can be connected to external devices.

3.2.1 Default specifications of the tool I/O

■ Digital I/O

Division	Input Output		
No. of channels	4		
	• SMT-IO06-48PP-HD01: PNP	• SMT-IO06-48PP-HD01: PNP	
1/0 1	• SMT-IO06-48NN-HD01: NPN	• SMT-IO06-48NN-HD01: NPN	
I/O type	• SMT-IO06-48PN-HD01: PNP	• SMT-IO06-48PN-HD01: NPN	
	• SMT-IO06-48NP-HD01: NPN	• SMT-IO06-48NP-HD01: PNP	
Rated voltage	12 or 24 V		
Rated current	1 mA	1 A/Output, 1.5 A/Common	
Voltage at On	4 V DC max.		
Voltage at Off	3 V DC max.		
Delay in On	1 ms max.		

Hyundai Robotics I/O setting_61

Delay in Off	1 ms max.		
Leakage current	- 0.1 mA max.		
Absolute maximum output	-0.5-+26 V		

Analog input

Division	Voltage	Current	
No. of channels	2	2	
Input range	0-10 V	0-20 mA	
AD/DA conversion data	0-1,000	0-2,000	
Input impedance 1 MQ		250 Ω	
Precision	±1.0% FS (±100 mV)	±1.0% FS (±200 uA)	
Ambient temperature	0° C-	:-55° C	
Absolute maximum input	-0.5-+26 V	-2.5-+25 mA	

■ I/O voltage

Division		Information	
	Supply voltage mode	0, 12, or 24 V DC output (±5%)	
Output voltage	Rated supply current	1.5 A	
	Absolute supply current	1.6 A max.	
Input voltage	Input voltage range	+48 V DC (±10%)	
" pac voluge	Current consumption	800 mA max.	

General specifications

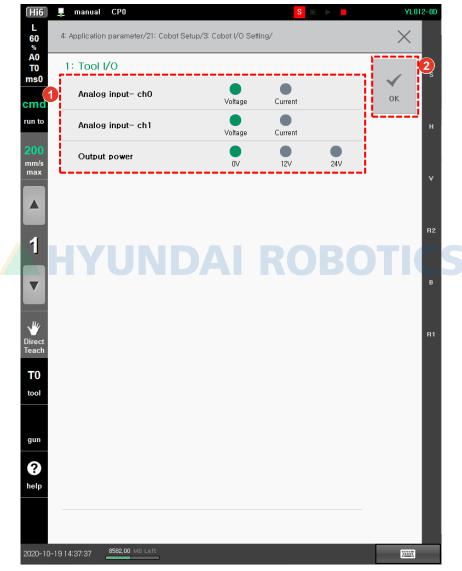
Division		Description
Communication interface	Protocol	EtherCAT
communication interface	Connector	Hirose connector \times 2 (EtherCAT input and output)
Product	Weight 30 g max.	
rroduct	Diameter	70 Ø
Environment	Operating temperature	0° C-50° C
LIVII OTITICITO	Storage	-20° C-60° C / ≤90% RH (noncondensing)

62_I/O setting Hyundai Robotics

temperature/humidity	

3.2.2 Tool I/O setting

- 1. Select the [Configure] button > [4: Application parameter > 21: Cobot Setup > 3: Cobot I/O Setting > 1: Tool I/O] menu.
- 2. Set the I/O voltage and current, and click the [OK] button.



- [Analog input]: Select the voltage input and the current input of the two channels.
- **[Output power]**: Select one among 0 V (off), 12 V, and 24 V. The set values will be retained after the power is turned off and on.

Hyundai Robotics I/O setting_63

3.3 Analog I/O

The analog I/O module, which is mounted on BD6F1 inside the controller, provides the I/O of analog voltage and current.

3.3.1 Default specifications of the analog I/O

Analog input

Division	Voltage	Current	
No. of channels	2		
Input range	User-configured	4–20 mA	
ii ipat range	(0–5 V, 0–10 V, -5–5 V, -10–10 V)	4 20 IIIA	
AD/DA conversion data	Expressed in the mV unit	Expressed in the uA unit	
Precision	±5.0% FS		
Ambient temperature	-40° C-125° C		

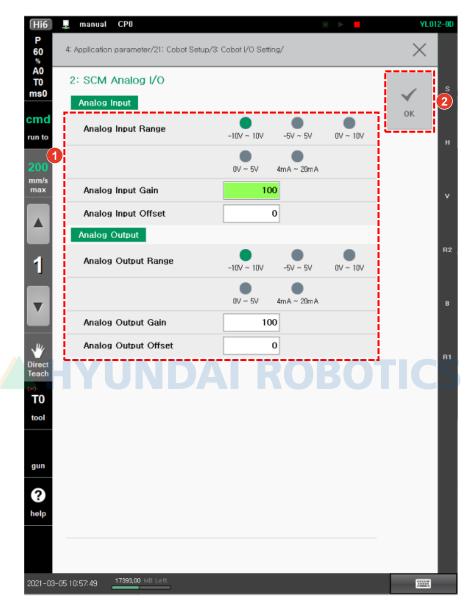
Analog output

Division	Voltage	Current	
No. of channels		2	
Input range	User-configured (0–5 V, 0–10 V, -5–5 V, -10–10 V)	4–20 mA	
AD/DA conversion data	Expressed in the mV unit	Expressed in the uA unit	
Precision	±5.0% FS		
Ambient temperature	-40° C-125° C		

64_I/O setting Hyundai Robotics

3.3.2 Analog I/O setting

1. Select the [Configure] button > [4: Application parameter > 21: Cobot Setup > 3: Cobot I/O setting > 2: SCM Analog I/O] .



- 2. Set the I/O voltage, current, gain, and offset, and click the [OK] button.
 - [Analog I/O range]: Select the voltage or current range of the analog I/O channel.
 - [Analog I/O gain]: Set the analog I/O gain (unit: %).
 - [Analog I/O offset]: Set the analog I/O offset (unit: mV or uA).

Reference The specified values of voltage and current will apply to the system after the controller is rebooted.

Hyundai Robotics I/O setting_65

4. Error messages

The safety function error messages of the collaborative robot are as follows:

Code	Message	Cause	Solutions
E7001	Error in the initialization of the safety controller	Error in communication between the safety controller and the mainboard	 Reboot the controller. Check the communication cable between the safety controller and the mainboard. If the error persists, replace the safety controller board.
E7002	Failure in the initialization of the robot's statics data	Data transmission to the safety controller failed because of a failure in motion initialization.	Reboot the controller.If the error persists, consult with Hyundai Robotics.
E7003	Failure in the initialization of the robot's dynamics data	Data transmission to the safety controller failed because of a failure in motion initialization.	Reboot the controller.If the error persists, consult with Hyundai Robotics.
E7004	Failure in the initialization of the safety function parameters	Data transmission to the safety controller failed because of a failure in motion initialization.	Reboot the controller.If the error persists, consult with Hyundai Robotics.
E7005	Failure in the transmission of the safety function parameters	Error in communication between the safety controller and the mainboard	 Reboot the controller. Check the communication cable between the safety controller and the mainboard. If the error persists, replace the safety controller board.
E7010	Error in the central processing unit (CPU) diagnosis in the safety controller	Error in the CPU eFuse	Reboot the controller.If the error persists, replace the safety controller board.
E7011	Error in the CPU diagnosis in the safety controller	Error in the CPU ECC module	Reboot the controller.If the error persists, replace the safety controller board.
E7012	Error in the CPU diagnosis in the safety controller	Error in the CPU POSCON diagnosis	Reboot the controller.If the error persists, replace the safety controller board.

66_Error messages Hyundai Robotics

Error messages

Code	Message	Cause	Solutions
E7013	Error in the CPU diagnosis in the safety controller	Error in the CPU POSCON diagnosis	Reboot the controller.If the error persists, replace the safety controller board.
E7014	Error in the CPU diagnosis in the safety controller	Error in the CPU POSCON diagnosis	Reboot the controller.If the error persists, replace the safety controller board.
E7015	Error in the CPU diagnosis in the safety controller	Error in the CPU POSCON diagnosis	Reboot the controller.If the error persists, replace the safety controller board.
E7016	Error in the CPU diagnosis in the safety controller	Error in the CPU POSCON diagnosis	Reboot the controller.If the error persists, replace the safety controller board.
E7017	Error in the CPU diagnosis in the safety controller	Error in the CPU POSCON diagnosis	Reboot the controller.If the error persists, replace the safety controller board.
E7018	Error in the CPU diagnosis in the safety controller	Error of invalid memory access by the CPU	Reboot the controller.If the error persists, replace the safety controller board.
E7019	Error in the CPU diagnosis in the safety controller	Error of invalid peripheral access by the CPU	Reboot the controller.If the error persists, replace the safety controller board.
E7020	Error in the CPU diagnosis in the safety controller	Error of invalid peripheral access by the CPU	Reboot the controller.If the error persists, replace the safety controller board.
E7021	Error in the CPU diagnosis in the safety controller	Error of invalid peripheral access by the CPU	Reboot the controller.If the error persists, replace the safety controller board.
E7022	Error in the CPU diagnosis in the safety controller	Error of invalid peripheral access by the CPU	Reboot the controller.If the error persists, replace the safety controller board.
E7022	Error in the CPU diagnosis in the safety controller	Error of invalid peripheral access by the CPU	Reboot the controller.If the error persists, replace the safety controller board.

Hyundai Robotics Error messages_67

Code	Message	Cause	Solutions
E7023	Error in the CPU diagnosis in the safety controller	Error of invalid peripheral access by the CPU	Reboot the controller.If the error persists, replace the safety controller board.
E7024	Error in the CPU diagnosis in the safety controller	Error of invalid peripheral access by the CPU	Reboot the controller.If the error persists, replace the safety controller board.
E7025	Error in the CPU diagnosis in the safety controller	Error of invalid peripheral access by the CPU	Reboot the controller.If the error persists, replace the safety controller board.
E7026	Error in the CPU diagnosis in the safety controller	CPU REG1 ADC RAM parity error	Reboot the controller.If the error persists, replace the safety controller board.
E7027	Error in the CPU diagnosis in the safety controller	CPU REG2 ADC RAM parity error	Reboot the controller.If the error persists, replace the safety controller board.
E7028	Error in the CPU diagnosis in the safety controller	CPU SPI1 MIBSPI analog loopback test error	Reboot the controller.If the error persists, replace the safety controller board.
E7029	Error in the CPU diagnosis in the safety controller	CPU SPI1 MIBSPI ECC_TEST_MODE_1BIT error	Reboot the controller.If the error persists, replace the safety controller board.
E7030	Error in the CPU diagnosis in the safety controller	CPU SPI1 MIBSPI ECC_TEST_MODE_1BIT error	Reboot the controller.If the error persists, replace the safety controller board.
E7031	Error in the CPU diagnosis in the safety controller	ERR_SPI1_MIBSPI_ECC_TEST _MODE_1BIT_FAULT_INJECT	Reboot the controller.If the error persists, replace the safety controller board.
E7032	Error in the CPU diagnosis in the safety controller	ERR_SPI1_MIBSPI_ECC_TEST _MODE_2BIT_FAULT_INJECT	Reboot the controller.If the error persists, replace the safety controller board.
E7033	Error in the CPU diagnosis in the safety controller	ERR_VIM_SOFTWARE_TEST	Reboot the controller.If the error persists, replace the safety controller board.

68_Error messages Hyundai Robotics

Code	Message	Cause	Solutions
E7034	Error in the CPU diagnosis in the safety controller	ERR_DCAN1_ECC_TEST_MODE_ 1BIT	Reboot the controller.If the error persists, replace the safety controller board.
E7035	Error in the CPU diagnosis in the safety controller	ERR_DCAN2_ECC_TEST_MODE _1BIT	Reboot the controller.If the error persists, replace the safety controller board.
E7036	Error in the CPU diagnosis in the safety controller	ERR_DCAN1_ECC_TEST_MODE_ 2BIT	Reboot the controller.If the error persists, replace the safety controller board.
E7037	Error in the CPU diagnosis in the safety controller	ERR_DCAN2_ECC_TEST_MODE _2BIT	Reboot the controller.If the error persists, replace the safety controller board.
E7038	Error in the CPU diagnosis in the safety controller	ERR_DCAN1_ECC_TEST_MODE _1BIT_FAULT_INJECT	Reboot the controller.If the error persists, replace the safety controller board.
E7039	Error in the CPU diagnosis in the safety controller	ERR_DCAN1_ECC_TEST_MODE _2BIT_FAULT_INJECT	Reboot the controller.If the error persists, replace the safety controller board.
E7040	Error in the CPU diagnosis in the safety controller	ERR_DCAN2_ECC_TEST_MODE _1BIT_FAULT_INJECT	Reboot the controller.If the error persists, replace the safety controller board.
E7041	Error in the CPU diagnosis in the safety controller	ERR_DCAN2_ECC_TEST_MODE _2BIT_FAULT_INJECT	Reboot the controller.If the error persists, replace the safety controller board.
E7042	Error in the CPU diagnosis in the safety controller	ERR_FLASH_ECC_TEST_MODE_ 1BIT	Reboot the controller.If the error persists, replace the safety controller board.
E7043	Error in the CPU diagnosis in the safety controller	ERR_FLASH_ECC_TEST_MODE_ 2BIT	Reboot the controller.If the error persists, replace the safety controller board.
E7044	Error in the CPU diagnosis in the safety controller	ERR_SRAM_ECC_ERROR_FORCI NG_1BIT	Reboot the controller.If the error persists, replace the safety controller board.

Hyundai Robotics Error messages_69

Code	Message	Cause	Solutions
E7045	Error in the CPU diagnosis in the safety controller	ERR_SRAM_ECC_ERROR_FORCI NG_2BIT	Reboot the controller.If the error persists, replace the safety controller board.
E7046	Error in the CPU diagnosis in the safety controller	ERR_ALL1PORTMEM_PBIST_EX ECUTE	Reboot the controller.If the error persists, replace the safety controller board.
E7047	Error in the CPU diagnosis in the safety controller	ERR_ALL2PORTMEM_PBIST_EX ECUTE	Reboot the controller.If the error persists, replace the safety controller board.
E7048	Error in the CPU diagnosis in the safety controller	ERR_ALLROMMEM_PBIST_EXE CUTE	Reboot the controller.If the error persists, replace the safety controller board.
E7049	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_CPUCOMP_SELF_ TEST	Reboot the controller.If the error persists, replace the safety controller board.
E7050	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_CPUCOMP_SELF _TEST_ERROR_FORCING	Reboot the controller.If the error persists, replace the safety controller board.
E7051	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_CPUCOMP _ERROR_FORCING_TEST	Reboot the controller.If the error persists, replace the safety controller board.
E7052	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_VIMCOMP_SELF_ TEST	Reboot the controller.If the error persists, replace the safety controller board.
E7053	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_VIMCOMP _SELF_TEST_ERROR_FORCING	Reboot the controller.If the error persists, replace the safety controller board.
E7054	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_VIMCOMP _ERROR_FORCING_TEST	Reboot the controller.If the error persists, replace the safety controller board.
E7055	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_PDCOMP_SELF_T EST	Reboot the controller.If the error persists, replace the safety controller board.

70_Error messages Hyundai Robotics

Code	Message	Cause	Solutions
E7056	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_PDCOMP _SELF_TEST_ERROR_FORCING	Reboot the controller.If the error persists, replace the safety controller board.
E7057	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_PDCOMP _ERROR_FORCING_TEST	Reboot the controller.If the error persists, replace the safety controller board.
E7058	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_INMCOMP_SELF_ TEST	Reboot the controller.If the error persists, replace the safety controller board.
E7059	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_INMCOMP _SELF_TEST_ERROR_FORCING	Reboot the controller.If the error persists, replace the safety controller board.
E7060	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_INMCOMP _ERROR_FORCING_TEST	 Reboot the controller. If the error persists, replace the safety controller board.
E7061	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_CPUCOMP_ERRO R _FORCING_TEST_FAULT_INJEC T	Reboot the controller.If the error persists, replace the safety controller board.
E7062	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_VIMCOMP_ERRO R _FORCING_TEST_FAULT_INJEC T	Reboot the controller.If the error persists, replace the safety controller board.
E7063	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_PDCOMP_ERROR _FORCING_TEST_FAULT_INJEC T	Reboot the controller.If the error persists, replace the safety controller board.
E7064	Error in the CPU diagnosis in the safety controller	ERR_CCMR5F_INMCOMP_ERRO R _FORCING_TEST_FAULT_INJEC T	Reboot the controller.If the error persists, replace the safety controller board.
E7065	Error in the CPU diagnosis in the safety controller	Error in the RAM diagnosis (ERR_RAM_MARCH_TEST)	Reboot the controller.If the error persists, replace the safety controller board.
E7066	Error in the CPU diagnosis in the safety controller	The program code of the flash area does not match the CRC (ERR_CRC_TEST).	Reboot the controller.If the error persists, replace the

Hyundai Robotics Error messages_71

Code	Message	Cause	Solutions
			safety controller board.
E7101	Error in the safety CPU (CH0) watchdog in the safety controller	Watchdog timeout of the safety CPU (CH0)	Reboot the controller.If the error persists, replace the safety controller board.
E7102	Error in the safety CPU (CH1) watchdog in the safety controller	Watchdog timeout of the safety CPU (CH1)	Reboot the controller.If the error persists, replace the safety controller board.
E7103	Error in the axis 1 encoder diagnosis by the safety controller	An error occurred during the axis 1 encoder diagnosis.	 Check the CAN communication cable between the safety controller and the encoder. Reboot the controller.
E7104	Error in the axis 2 encoder diagnosis by the safety controller	An error occurred during the axis 2 encoder diagnosis.	 Check the CAN communication cable between the safety controller and the encoder. Reboot the controller.
E7105	Error in the axis 3 encoder diagnosis by the safety controller	An error occurred during the axis 3 encoder diagnosis.	 Check the CAN communication cable between the safety controller and the encoder. Reboot the controller.
E7106	Error in the axis 4 encoder diagnosis by the safety controller	An error occurred during the axis 4 encoder diagnosis.	 Check the CAN communication cable between the safety controller and the encoder. Reboot the controller.
E7107	Error in the axis 5 encoder diagnosis by the safety controller	An error occurred during the axis 5 encoder diagnosis.	 Check the CAN communication cable between the safety controller and the encoder. Reboot the controller.
E7108	Error in the axis 6 encoder diagnosis by the safety controller	An error occurred during the axis 6 encoder diagnosis.	 Check the CAN communication cable between the safety controller and the encoder. Reboot the controller.
E7109	Error in the axis 1 torque sensor diagnosis by the safety controller	An error occurred during the axis 1 torque sensor diagnosis.	Check the CAN communication cable between the safety controller and the torque sensor.

72_Error messages Hyundai Robotics

Code	Message	Cause	Solutions
			 Check the torque sensor of the pertaining axis. Reboot the controller.
E7110	Error in the axis 2 torque sensor diagnosis by the safety controller	An error occurred during the axis 2 torque sensor diagnosis.	 Check the CAN communication cable between the safety controller and the torque sensor. Check the torque sensor of the pertaining axis. Reboot the controller.
E7111	Error in the axis 3 torque sensor diagnosis by the safety controller	An error occurred during the axis 3 torque sensor diagnosis.	 Check the CAN communication cable between the safety controller and the torque sensor. Check the torque sensor of the pertaining axis. Reboot the controller.
E7112	Error in the axis 4 torque sensor diagnosis by the safety controller	An error occurred during the axis 4 torque sensor diagnosis.	 Check the CAN communication cable between the safety controller and the torque sensor. Check the torque sensor of the pertaining axis. Reboot the controller.
E7113	Error in the axis 5 torque sensor diagnosis by the safety controller	An error occurred during the axis 5 torque sensor diagnosis.	 Check the CAN communication cable between the safety controller and the torque sensor. Check the torque sensor of the pertaining axis. Reboot the controller.
E7114	Error in the axis 6 torque sensor diagnosis by the safety controller	An error occurred during the axis 6 torque sensor diagnosis.	 Check the CAN communication cable between the safety controller and the torque sensor. Check the torque sensor of the pertaining axis. Reboot the controller.
E7115	Error (2) in the axis 1 torque sensor diagnosis by	An error occurred during the axis 1 torque sensor diagnosis.	Check if the tool data match the actual tool.

Code	Message	Cause	Solutions
	the safety controller		 Check the CAN communication cable between the safety controller and the torque sensor. Check the torque sensor of the pertaining axis. Reboot the controller.
E7116	Error (2) in the axis 2 torque sensor diagnosis by the safety controller	An error occurred during the axis 2 torque sensor diagnosis.	 Check if the tool data match the actual tool. Check the CAN communication cable between the safety controller and the torque sensor. Check the torque sensor of the pertaining axis. Reboot the controller.
E7117	Error (2) in the axis 3 torque sensor diagnosis by the safety controller	An error occurred during the axis 3 torque sensor diagnosis.	 Check if the tool data match the actual tool. Check the CAN communication cable between the safety controller and the torque sensor. Check the torque sensor of the pertaining axis. Reboot the controller.
E7118	Error (2) in the axis 4 torque sensor diagnosis by the safety controller	An error occurred during the axis 4 torque sensor diagnosis.	 Check if the tool data match the actual tool. Check the CAN communication cable between the safety controller and the torque sensor. Check the torque sensor of the pertaining axis. Reboot the controller.
E7119	Error (2) in the axis 5 torque sensor diagnosis by the safety controller	An error occurred during the axis 5 torque sensor diagnosis.	 Check if the tool data match the actual tool. Check the CAN communication cable between the safety controller and the torque sensor.

Code	Message	Cause	Solutions
			Check the torque sensor of the pertaining axis.Reboot the controller.
E7120	Error (2) in the axis 6 torque sensor diagnosis by the safety controller	An error occurred during the axis 6 torque sensor diagnosis.	 Check if the tool data match the actual tool. Check the CAN communication cable between the safety controller and the torque sensor. Check the torque sensor of the pertaining axis. Reboot the controller.
E7170	Low temperature error in the safety controller	Low temperature error in Temperature Sensor 1	Reboot the controller.If the error persists, replace the safety controller board.
E7171	Low temperature error in the safety controller	Low temperature error in Temperature Sensor 2	 Reboot the controller. If the error persists, replace the safety controller board.
E7172	Low temperature error in the safety controller	Low temperature error in Temperature Sensor 3	Reboot the controller.If the error persists, replace the safety controller board.
E7173	High temperature error in the safety controller	High temperature error in Temperature Sensor 1	Reboot the controller.If the error persists, replace the safety controller board.
E7174	High temperature error in the safety controller	High temperature error in Temperature Sensor 2	Reboot the controller.If the error persists, replace the safety controller board.
E7175	High temperature error in the safety controller	High temperature error in Temperature Sensor 3	Reboot the controller.If the error persists, replace the safety controller board.
E7176	Error in the 1.2 V power in the safety controller	The 1.2 V power of Channel 0 is below the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7177	Error in the 3.3 V power in the safety controller	The 3.3 V power of Channel 0 is below the specified value.	Reboot the controller.

Code	Message	Cause	Solutions
			If the error persists, replace the safety controller board.
E7178	Error in the 3.3 V power in the safety controller	The 3.3 V power of Channel 0 is below the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7179	Error in the 5 V power in the safety controller	The 5 V power of Channel 0 is below the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7180	Error in the 24 V power in the safety controller	The 24 V power of Channel 0 is below the specified value.	Reboot the controller.Check the 24 V power of the controller.
E7181	Error in the 48 V power in the safety controller	The 48 V power of Channel 0 is below the specified value.	Reboot the controller.Check the 48 V power of the controller.
E7182	Error in the 1.2 V power in the safety controller	The 1.2 V power of Channel 1 is below the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7183	Error in the 3.3 V power in the safety controller	The 3.3 V power of Channel 1 is below the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7184	Error in the 3.3 V power in the safety controller	The 3.3 V power of Channel 1 is below the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7185	Error in the 5 V power in the safety controller	The 5 V power of Channel 1 is below the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7186	Error in the 24 V power in the safety controller	The 24 V power of Channel 1 is below the specified value.	Reboot the controller.Check the 24 V power of the controller.
E7187	Error in the 48 V power in the safety controller	The 48 V power of Channel 1 is below the specified value.	Reboot the controller.Check the 48 V power of the controller.

Code	Message	Cause	Solutions
E7188	Error in the 1.2 V power in the safety controller	The 1.2 V power of Channel 0 is above the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7189	Error in the 3.3 V power in the safety controller	The 3.3 V power of Channel 0 is above the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7190	Error in the 3.3 V power in the safety controller	The 3.3 V power of Channel 0 is above the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7191	Error in the 5 V power in the safety controller	The 5 V power of Channel 0 is above the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7192	Error in the 24 V power in the safety controller	The 24 V power of Channel 0 is above the specified value.	Reboot the controller.Check the 24 V power of the controller.
E7193	Error in the 48 V power in the safety controller	The 48 V power of Channel 0 is above the specified value.	Reboot the controller.Check the 48 V power of the controller.
E7194	Error in the 1.2 V power in the safety controller	The 1.2 V power of Channel 1 is above the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7195	Error in the 3.3 V power in the safety controller	The 3.3 V power of Channel 1 is above the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7196	Error in the 3.3 V power in the safety controller	The 3.3 V power of Channel 1 is above the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7197	Error in the 5 V power in the safety controller	The 5 V power of Channel 1 is above the specified value.	Reboot the controller.If the error persists, replace the safety controller board.
E7198	Error in the 24 V power in the safety controller	The 24 V power of Channel 1 is above the specified value.	Reboot the controller.Check the 24 V power of the controller.

Code	Message	Cause	Solutions
E7199	Error in the 48 V power in the safety controller	The 48 V power of Channel 1 is above the specified value.	Reboot the controller.Check the 48 V power of the controller.
E7200	Safety controller failed to read the temperature sensor	The temperature sensor value cannot be read.	Reboot the controller.If the error persists, replace the safety controller board.
E7201	Safety controller failed to read the voltage sensor	The voltage value cannot be read.	Reboot the controller.If the error persists, replace the safety controller board.
E7202	Error in the program sequence diagnosis in the safety controller	The operating sequence of the safety program in the safety controller is abnormal.	Reboot the controller.If the error persists, replace the safety controller board.
E7203	Error in the program sequence diagnosis in the safety controller	The operating sequence of the safety program in the safety controller is abnormal.	Reboot the controller.If the error persists, replace the safety controller board.
E7204	Error in the program sequence diagnosis in the safety controller	The operating sequence of the safety program in the safety controller is abnormal.	Reboot the controller.If the error persists, replace the safety controller board.
E7205	Error in the program sequence diagnosis in the safety controller	The operating sequence of the safety program in the safety controller is abnormal.	Reboot the controller.If the error persists, replace the safety controller board.
E7206	Error in the program sequence diagnosis in the safety controller	The operating sequence of the safety program in the safety controller is abnormal.	Reboot the controller.If the error persists, replace the safety controller board.
E7207	Error in the program sequence diagnosis in the safety controller	The operating sequence of the safety program in the safety controller is abnormal.	Reboot the controller.If the error persists, replace the safety controller board.
E7210	Error in the interchannel status synchronization in the safety controller	Two channels have different statuses.	Reboot the controller.If the error persists, replace the safety controller board.
E7211	Error in the status of the safety controller	It has an undefined status.	Reboot the controller.If the error persists, replace the safety controller board.

Error messages

	ъ
	7
	,
	9
	÷

Code	Message	Cause	Solutions
E7212	Error in the channels in the safety controller	The IDs of the two channels are incorrect.	Reboot the controller.If the error persists, replace the safety controller board.
E7213	Interchannel synchronization timeout in the safety controller	Two channels cannot be synchronized with each other.	Reboot the controller.If the error persists, replace the safety controller board.
E7250	Error in the interchannel status synchronization in the safety controller	Two channels have different statuses.	Reboot the controller.If the error persists, replace the safety controller board.
E7251	Error in the status of the safety controller	It has an undefined status.	Reboot the controller.If the error persists, replace the safety controller board.
E7252	Error in the channels in the safety controller	The IDs of the two channels are incorrect.	Reboot the controller.If the error persists, replace the safety controller board.
E7253	Interchannel synchronization timeout in the safety controller	Two channels cannot be synchronized with each other.	Reboot the controller.If the error persists, replace the safety controller board.
E7761	Error in the tool number in the safety controller	An abnormal tool number has been received from the main computer.	Reboot the controller.If the error persists, replace the safety controller board.
E7301	Error in the safety communication in the safety controller	Error in the communication with the EtherCAT slave	 Reboot the controller. Check the EtherCAT communication cable between the main computer and the safety controller.
E7302	Error in the SDO subindex in the safety controller	Abnormal subindex during the initialization data extraction	Reboot the controller.If the error persists, replace the safety controller board.
E7303	Safety communication timeout in the safety controller	Error in the communication with the EtherCAT slave	 Reboot the controller. Check the EtherCAT communication cable between the main computer and the safety controller.
E7304	Error in the safety	Abnormal header information	Reboot the controller.

Code	Message	Cause	Solutions
	communication in the safety controller	on the communication frame	If the error persists, replace the safety controller board.
E7305	Safety communication CRC error in the safety controller	CRC error of the communication frame	Reboot the controller.If the error persists, replace the safety controller board.
E7306	Safety communication subindex error in the safety controller	The subindex of the communication frame exceeded the specified range.	Reboot the controller.If the error persists, replace the safety controller board.
E7307	Error in the safety communication in the safety controller	Abnormal length information on the SDO frame	Reboot the controller.If the error persists, replace the safety controller board.
E7308	Error in the safety communication in the safety controller	A wrong factor was transmitted during the communication with the EtherCAT slave.	Reboot the controller.If the error persists, replace the safety controller board.
E7309	Error in the safety communication in the safety controller	Failure in object writing in the EtherCAT slave	Reboot the controller.If the error persists, replace the safety controller board.
E7310	Error in the safety communication in the safety controller	Data of an identical serial number was received from the main computer.	Reboot the controller.If the error persists, replace the safety controller board.
E7311	Safety communication timeout in the safety controller	Cyclic communication timeout with the main computer	Reboot the controller.If the error persists, replace the safety controller board.
E7321	Parameter range exceeded in the safety controller	A condition parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7326	Parameter range exceeded in the safety controller	The Cartesian space 1 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7327	Parameter range exceeded in the safety controller	The Cartesian space 2 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7328	Parameter range exceeded in the safety controller	The Cartesian space 3 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7329	Parameter range exceeded in the safety controller	The Cartesian space 4 parameter exceeded the	Check whether the safety parameter setting is in the specified range.

Code	Message	Cause	Solutions
		specified range.	
E7330	Parameter range exceeded in the safety controller	The Cartesian space 5 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7331	Parameter range exceeded in the safety controller	The Cartesian space 6 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7332	Parameter range exceeded in the safety controller	The Cartesian space 7 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7333	Parameter range exceeded in the safety controller	The Cartesian space 8 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7334	Parameter range exceeded in the safety controller	The Cartesian space 9 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7335	Parameter range exceeded in the safety controller	The Cartesian space 10 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7336	Parameter range exceeded in the safety controller	The Cartesian space 11 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7337	Parameter range exceeded in the safety controller	The Cartesian space 12 parameter exceeded the specified range.	Check whether the safety parameter setting is in the specified range.
E7338	Failure in the parameter initialization in the safety controller	An overlapping safety parameter was received.	Reboot the controller.
E7339	Failure in the kinematics information initialization in the safety controller	Overlapping apparatus information was received from the main computer.	Reboot the controller.
E7340	Failure in the dynamic information initialization in the safety controller	Overlapping dynamic information was received from the main computer.	Reboot the controller.
E7341	Parameter range of the safety controller exceeded	Tool parameter range was exceeded.	Check that the set tool parameters are within the range.
E7342	Parameter range of the safety controller exceeded	Robot layout parameter range was exceeded.	Check that the set safety parameters are within the range.
E7343	Parameter range of the safety controller exceeded	Axial applied weight parameter range (S-axis) was exceeded.	Check that the set safety parameters are within the range.
E7344	Parameter range of the safety controller exceeded	Axial applied weight parameter range (H-axis) was exceeded.	Check that the set safety parameters are within the range.
E7345	Parameter range of the	Axial applied weight parameter	Check that the set safety parameters

Code	Message	Cause	Solutions
	safety controller exceeded	range (V-axis) was exceeded.	are within the range.
E7346	Parameter range of the safety controller exceeded	Safety I/O parameter range was exceeded.	Check that the set safety parameters are within the range.
E7347	Parameter range of the safety controller exceeded	Safety stop parameter range was exceeded.	Check that the set safety parameters are within the range.
E7348	Parameter range of the safety controller exceeded	Default parameter range was exceeded.	Check that the set safety parameters are within the range.
E7403	Failure in opening the collaborative robot configuration file	A failure occurred in opening the collaborative robot configuration file.	Set all the configurations of the collaborative robot again.
E7405	The configuration certificate file of the collaborative robot is missing.	A failure occurred in reading the certificate file of the collaborative robot configuration file.	Set all the configurations of the collaborative robot again.
E7407	The type of the configuration certificate of the collaborative robot is invalid.	The type of the certificate file is invalid. The file may have been modified arbitrarily.	Set all the configurations of the collaborative robot again.
E7409	The code of the configuration certificate of the collaborative robot does not match.	The code of the certificate file is invalid. The file may have been modified arbitrarily.	Set all the configurations of the collaborative robot again.
E7501	Error in the communication with the safety board of the collaborative robot	Communication with the safety board of the collaborative robot is not established.	Reboot the controller.
E7601	Failure in the reading of version information on the axis 1 torque sensor in the safety controller	Failure in the reading of version information on the axis 1 torque sensor in the safety controller	 Reboot the controller. Check the CAN communication cable of the robot manipulator. Check the CAN ID settings of the torque sensors of axes 1 through 6.
E7602	Failure in the reading of version information on the axis 2 torque sensor in the safety controller	Failure in the reading of version information on the axis 2 torque sensor in the safety controller	 Reboot the controller. Check the CAN communication cable of the robot manipulator. Check the CAN ID settings of the torque sensors of axes 1 through 6.
E7603	Failure in the reading of version information on the axis 3 torque sensor in the safety controller	Failure in the reading of version information on the axis 3 torque sensor in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.Check the CAN ID settings of the

Error messages

Code	Message	Cause	Solutions
			torque sensors of axes 1 through 6.
E7604	Failure in the reading of version information on the axis 4 torque sensor in the safety controller	Failure in the reading of version information on the axis 4 torque sensor in the safety controller	 Reboot the controller. Check the CAN communication cable of the robot manipulator. Check the CAN ID settings of the torque sensors of axes 1 through 6.
E7605	Failure in the reading of version information on the axis 5 torque sensor in the safety controller	Failure in the reading of version information on the axis 5 torque sensor in the safety controller	 Reboot the controller. Check the CAN communication cable of the robot manipulator. Check the CAN ID settings of the torque sensors of axes 1 through 6.
E7606	Failure in the reading of version information on the axis 6 torque sensor in the safety controller	Failure in the reading of version information on the axis 6 torque sensor in the safety controller	 Reboot the controller. Check the CAN communication cable of the robot manipulator. Check the CAN ID settings of the torque sensors of axes 1 through 6.
E7607	Failure in the reading of the version information on the axis 1 encoder in the safety controller	Failure in the reading of the version information on the axis 1 encoder in the safety controller	 Reboot the controller. Check the CAN communication cable of the robot manipulator. Check the CAN ID settings of the encoders of axes 1 through 6.
E7608	Failure in the reading of the version information on the axis 2 encoder in the safety controller	Failure in the reading of the version information on the axis 2 encoder in the safety controller	 Reboot the controller. Check the CAN communication cable of the robot manipulator. Check the CAN ID settings of the encoders of axes 1 through 6.
E7609	Failure in the reading of the version information on the axis 3 encoder in the safety controller	Failure in the reading of the version information on the axis 3 encoder in the safety controller	 Reboot the controller. Check the CAN communication cable of the robot manipulator. Check the CAN ID settings of the encoders of axes 1 through 6.
E7610	Failure in the reading of the version information on the axis 4 encoder in the safety controller	Failure in the reading of the version information on the axis 4 encoder in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.

Code	Message	Cause	Solutions
			Check the CAN ID settings of the encoders of axes 1 through 6.
E7611	Failure in the reading of the version information on the axis 5 encoder in the safety controller	Failure in the reading of the version information on the axis 5 encoder in the safety controller	 Reboot the controller. Check the CAN communication cable of the robot manipulator. Check the CAN ID settings of the encoders of axes 1 through 6.
E7612	Failure in the reading of the version information on the axis 6 encoder in the safety controller	Failure in the reading of the version information on the axis 6 encoder in the safety controller	 Reboot the controller. Check the CAN communication cable of the robot manipulator. Check the CAN ID settings of the encoders of axes 1 through 6.
E7613	Communication timeout of the axis 1 torque sensor in the safety controller	CAN communication timeout of the axis 1 torque sensor in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7614	Communication timeout of the axis 2 torque sensor in the safety controller	CAN communication timeout of the axis 2 torque sensor in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7615	Communication timeout of the axis 3 torque sensor in the safety controller	CAN communication timeout of the axis 3 torque sensor in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7616	Communication timeout of the axis 4 torque sensor in the safety controller	CAN communication timeout of the axis 4 torque sensor in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7617	Communication timeout of the axis 5 torque sensor in the safety controller	CAN communication timeout of the axis 5 torque sensor in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7618	Communication timeout of the axis 6 torque sensor in the safety controller	CAN communication timeout of the axis 6 torque sensor in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7619	Communication timeout of the axis 1 encoder in the safety controller	CAN communication timeout of the axis 1 encoder in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.

Error messages

Code	Message	Cause	Solutions
E7620	Communication timeout of the axis 2 encoder in the safety controller	CAN communication timeout of the axis 2 encoder in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7621	Communication timeout of the axis 3 encoder in the safety controller	CAN communication timeout of the axis 3 encoder in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7622	Communication timeout of the axis 4 encoder in the safety controller	CAN communication timeout of the axis 4 encoder in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7623	Communication timeout of the axis 5 encoder in the safety controller	CAN communication timeout of the axis 5 encoder in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7624	Communication timeout of the axis 6 encoder in the safety controller	CAN communication timeout of the axis 6 encoder in the safety controller	Reboot the controller.Check the CAN communication cable of the robot manipulator.
E7701	TCP speed violation (%s [mm/s])	The TCP speed violated the safety condition.	 Check the specified values in the menu for setting the conditions of the safety functions. Check the robot's TCP speed in the edited program.
E7702	TCP force violation (%s [N])	The TCP force violated the safety condition.	 Check the specified values in the menu for setting the conditions of the safety functions. Check the tool number and data.
E7703	TCP rotating angle violation (%s [deg])	The TCP rotating angle violated the safety condition.	 Check the specified values in the menu for setting the conditions of the safety functions. Check the tool's orientation in the edited program.
E7704	Robot's power factor violation (%s [N])	The robot's power factor violated the safety condition.	 Check the specified values in the menu for setting the conditions of the safety functions. Check the speeds and positions of the axes in the edited program.

Code	Message	Cause	Solutions
E7705	Robot's momentum violation (%s [kg m/s])	The robot's momentum violated the safety condition.	 Check the specified values in the menu for setting the conditions of the safety functions. Check the robot's position and TCP speed in the edited program.
E7706	Robot's safety stop violation	The robot's motion was detected in stop mode.	Check if the brakes of the axes function normally.
E7707	A collision was detected. – SCM (%s axis)	A collision with the robot was detected.	Identify the collision and remove its causes.Adjust the collision detection level.
E7708	A collision with the collaborative robot was detected. – Main	A collision occurred because of an external factor.	Identify the collision and remove its causes.Adjust the collision detection level.
E7711	TCP position violation of safety space (Cartesian space %s)	The TCP position exceeded a safety space.	 Move to the safety space status monitoring window. Select the recovery mode button to change the mode. Move the robot to a safe space.
E7731	Axis 1 violation of safety space (%s [deg])	The position of axis 1 exceeded a specified safety space.	 Move to the safety space status monitoring window. Select the recovery mode button to change the mode. Move the robot to a safe space.
E7732	Axis 2 violation of safety space (%s [deg])	The position of axis 2 exceeded a specified safety space.	 Move to the safety space status monitoring window. Select the recovery mode button to change the mode. Move the robot to a safe space.
E7733	Axis 3 violation of safety space (%s [deg])	The position of axis 3 exceeded a specified safety space.	 Move to the safety space status monitoring window. Select the recovery mode button to change the mode. Move the robot to a safe space.
E7734	Axis 4 violation of safety space (%s [deg])	The position of axis 4 exceeded a specified safety	Move to the safety space status

Error messages

Code	Message	Cause	Solutions
		space.	monitoring window.
			Select the recovery mode button to
			change the mode.
			• Move the robot to a safe space.
			Move to the safety space status
		The position of axis 5	monitoring window.
E7735	Axis 5 violation of safety space (%s [deg])	exceeded a specified safety	Select the recovery mode button to
	, , , ,	space.	change the mode.
			Move the robot to a safe space.
			• Move to the safety space status
	Axis 6 violation of safety	The position of axis 6	monitoring window.
E7736	space (%s [deg])	exceeded a specified safety space.	Select the recovery mode button to
		space.	change the mode.
			Move the robot to a safe space.
	A LIVII	NIDAL DO	• In the menu for setting the
E7741	Axis 1 violation of safe	The speed of axis 1 exceeded the specified safety condition.	conditions of the safety functions, check the speeds of the axes.
E//41	speed (%s [deg/s])		 Check the speeds in the edited
			program.
			• In the menu for setting the
	Axis 2 violation of safe speed (%s [deg/s])	The speed of axis 2 exceeded the specified safety condition.	conditions of the safety functions,
E7742			check the speeds of the axes.
			• Check the speeds in the edited
			program.
			• In the menu for setting the
	Axis 3 violation of safe	The speed of axis 3 exceeded	conditions of the safety functions,
E7743	speed (%s [deg/s])	the specified safety condition.	check the speeds of the axes.
			 Check the speeds in the edited program.
E7744	Axis 4 violation of safe speed (%s [deg/s])		 In the menu for setting the conditions of the safety functions,
		The speed of axis 4 exceeded the specified safety condition.	check the speeds of the axes.
			Check the speeds in the edited
			program.
E7745	Axis 5 violation of safe	The speed of axis 5 exceeded	• In the menu for setting the

Code	Message	Cause	Solutions
	speed (%s [deg/s])	the specified safety condition.	conditions of the safety functions, check the speeds of the axes. Check the speeds in the edited program.
E7746	Axis 6 violation of safe speed (%s [deg/s])	The speed of axis 6 exceeded the specified safety condition.	 In the menu for setting the conditions of the safety functions, check the speeds of the axes. Check the speeds in the edited program.
E7751	Axis 1 violation of torque (%s [Nm])	The torque of axis 1 exceeded the specified safety condition.	 In the menu for setting the conditions of the safety functions, check the torques of the axes. In the safety function parameters, check the current torques of the axes.
E7752	Axis 2 violation of torque (%s [Nm])	The torque of axis 2 exceeded the specified safety condition.	 In the menu for setting the conditions of the safety functions, check the torques of the axes. In the safety function parameters, check the current torques of the axes.
E7753	Axis 3 violation of torque (%s [Nm])	The torque of axis 3 exceeded the specified safety condition.	 In the menu for setting the conditions of the safety functions, check the torques of the axes. In the safety function parameters, check the current torques of the axes.
E7754	Axis 4 violation of torque (%s [Nm])	The torque of axis 4 exceeded the specified safety condition.	 In the menu for setting the conditions of the safety functions, check the torques of the axes. In the safety function parameters, check the current torques of the axes.
E7755	Axis 5 violation of torque (%s [Nm])	The torque of axis 5 exceeded the specified safety condition.	In the menu for setting the conditions of the safety functions, check the torques of the axes.

Error messages

Code	Message	Cause	Solutions
			 In the safety function parameters, check the current torques of the axes.
E7756	Axis 6 violation of torque (%s [Nm])	The torque of axis 6 exceeded the specified safety condition.	 In the menu for setting the conditions of the safety functions, check the torques of the axes. In the safety function parameters, check the current torques of the axes.
E7802	Error in the mode switch in the safety controller	Abnormal mode switch signal input	Check the TP cable.
E7804	Error in the interchannel communication in the safety controller	Communication error between the two safety CPUs	Reboot the controller.If the error persists, replace the safety controller.
E7805	Error in the diagnosis of the signal for servo power control by the safety controller	Error in the feedback of the STO signal for servo power control	Reboot the controller.If the error persists, replace the safety controller.
E7806	Error in the TP emergency stop signal in the safety controller	Error in the emergency stop signal of the TP	Check the TP cable.
E7807	Error in the TP enabling switch signal in the safety controller	Error in the enabling switch signal of the TP	Check the TP cable.
E7808	Error in the external safeguarding signal in the safety controller	Error in the external safeguarding signal	Check the external safeguarding signal cable.
E7809	Error in the external emergency stop signal in the safety controller	Error in the external emergency stop signal	Check the external emergency stop signal cable.
E7811	Mismatch of the TP mode switch signals in the safety controller	Mismatch between the dual signals of the TP mode switch	Check the TP cable.
E7812	Mismatch of the TP enabling switch signals in the safety controller	Mismatch between the dual signals of the TP enabling switch	Check the TP cable.
E7813	Mismatch of the external emergency stop signals in the safety controller	Mismatch between the external emergency stop dual-channel signals	Check the external emergency stop cable.
E7814	Mismatch of the external safeguarding signals in the	Mismatch between the external safeguarding dual-channel	Check the external safeguarding cable.

Code	Message	Cause	Solutions
	safety controller	signals	
E7815	Mismatch of the TP emergency stop signals in the safety controller	Mismatch between the TP emergency stop dual-channel signals	Check the TP cable.
E7816	Mismatch of the safety input signals (no. 0) in the safety controller	Mismatch between the safety input no. 0 dual-channel signals	Check the input signal cable.
E7817	Mismatch of the safety input signals (no. 1) in the safety controller	Mismatch between the safety input no.1 dual-channel signals	Check the input signal cable.
E7818	Mismatch of the safety input signals (no. 2) in the safety controller	Mismatch between the safety input no. 2 dual-channel signals	Check the input signal cable.
E7819	Mismatch of the safety input signals (no. 3) in the safety controller	Mismatch between the safety input no. 3 dual-channel signals	Check the input signal cable.
E7821	Error in the safety output signal setting in the safety controller	Abnormal usage setting of safety output signals	Check the output signal assignments of the safety parameters.
E7822	Error in the safety input signal setting in the safety controller	Mismatch of the usages of the dual safety input signals	Check the input signal assignments of the safety parameters.
E7823	Error in the safety output signal setting in the safety controller	Mismatch of the usage settings of dual safety output signals	Check the output signal assignments of the safety parameters.
E7825	Error in the TP enabling signal diagnosis in the safety controller	Failure in the 0 V diagnosis during the TP enabling signal diagnosis	Check the TP cable.
E7826	Error in the TP emergency stop signal diagnosis in the safety controller	Failure in the 0 V diagnosis during the TP emergency stop signal diagnosis	Check the TP cable.
E7827	Error in the TP enabling signal diagnosis in the safety controller	Failure in the high voltage diagnosis during the TP enabling signal diagnosis	Check the TP cable.
E7828	Error in the TP emergency stop signal diagnosis in the safety controller	Failure in the high voltage diagnosis during the TP emergency stop signal diagnosis	Check the TP cable.
E7829	Error in the safety output signal diagnosis	Error in the safety output signal feedback	Check the output signal cable.
E7830	Error in the direct teaching switch diagnosis	Mismatch between the direct teaching switch dual-channel signals	Check the direct teaching switches.Reboot the controller.

Code	Message	Cause	Solutions
			If the error persists, replace the safety controller.
E7901	Error in the communication between the safety CPUs in the safety controller	Error in the communication parameters between the safety CPUs	Reboot the controller.If the error persists, replace the safety controller.
E7902	Error in the communication between the safety CPUs in the safety controller	General error in the communication between the safety CPUs	Reboot the controller.If the error persists, replace the safety controller.
E7903	Communication timeout between the safety CPUs in the safety controller	Communication timeout between the safety CPUs in the safety controller	Reboot the controller.If the error persists, replace the safety controller.
E7904	Error in the communication between the safety CPUs in the safety controller	Error in the communication TX between the safety CPUs in the safety controller	Reboot the controller.If the error persists, replace the safety controller.
E7905	Error in the communication between the safety CPUs in the safety controller	Error in the communication TX between the safety CPUs in the safety controller	Reboot the controller.If the error persists, replace the safety controller.

Attachment

The Rules on the Criteria for Occupational Safety and Health, and the Public Notice of Safety Inspections

The applicable industrial robots shall be installed in consideration of the inspection criteria specified in the Rules on the Criteria for Occupational Safety and Health, and the Public Notice of Safety Inspections (if the robots are subject to inspection).

■ The Rules on the Criteria for Occupational Safety and Health

Article 222 (Teaching, etc.) When the project owner carries out teaching (setting, modifying, or result verification of the operating sequence, positions, and speed of the manipulator) for the applicable robot within its operating range, he/she shall take the following actions for preventing hazards due to any unexpected operation or mal-operation of the robot: However, the actions provided in Paragraphs 2 and 3 may be omitted if the work is carried out while the driving source of the robot is disconnected. 〈amended on April 7, 2016〉

- 3. Specify instructions on the details of the following items, and ensure that the work is carried out according to the instructions.
 - a. operating methods and sequence of the robot
 - b. the speed of the manipulator during the work
 - c. the signaling methods in case two or more workers carry out the work
 - d. the actions to be taken in case anomalies are found
 - e. the actions to be taken after the robot operation is stopped and resumed after anomalies are found
 - f. other actions to be taken for preventing hazards due to unexpected operation or mal-operation of the robot
- 4. The workers and their supervisors shall take actions to stop the robot operation immediately upon finding any anomalies.
- 5. During the work, take necessary actions for ensuring that any persons other than the authorizes workers cannot activate the activation switch and the like of the robot by posting signs on the activation switch and the like of the robot indicating that work is in process.

Article 223 (Hazard prevention in operation) The project owner shall, in order to prevent hazards of injuries that might occur to the workers due to the robot operation (excluding the robot operation for the teaching specified in Article 222 and the robot operation under the proviso to Article 224), install a fence of no lower than 1.8 m (the height may be adjusted in case where no hazards are posed by the height in consideration of the operating range of the robot), and install sensing-type protective devices such as safety mats or optical-electronic protective devices in partial zones where fences cannot be installed due to presence of conveyor systems and the like. However, the actions provided herein may be omitted when it is deemed by the Minister of Employment and Labor that the robot's safety conditions meet the criteria specified in the Korean Standard under Article 12 of the Industrial Standardization Act or those commonly applicable internationally.

Article 224 (Actions to be taken during work such as repairs) The project owner shall, in repairing, inspecting, adjusting (excluding those fall under the scope of teaching and the like), cleaning, lubricating, or verifying such results) within the robot's operating range, stop the robot operation, lock the activation switch of the robot by a key during the work, manage the key separately, or take necessary actions for ensuring that any persons other than the authorizes workers cannot manipulate the activation switch by posting signs on the activation switch of the

robot indicating that work is in process. However, this shall not apply to cases where it is inevitable to carry out the work while the robot is in operation and where the actions specified in Article 222 have been taken for preventing hazards due to unexpected operation or mal-operation of the robot

	[Annex Table 14] Criteria for Inspection of Industrial Robots (relating to Article 30)	
Automatic operation	 a. In the automatic operation mode, the safety devices such as the protective fences shall maintain normal functionality, and the protective stop function shall run if any persons enter the protected space. b. The protective stop or emergency stop functions shall not be reset or invalidated upon the selection of the automatic operation mode. 	
mode	c. The automatic operation mode shall be cleared when any stop signals are given.d. When the automatic mode is selected, the automatic mode shall be activated only by a separate activation action from outside the protected space.	
	e. The switching from the automatic operation mode to another operation mode shall be possible only when the driving part is stopped.	
Pendant control	f. If the pendant has a string, its length shall be sufficiently long so that the teaching worker can carry out the work safely.	
Electrical connection devices	The electrical connection devices such as electrical ports connected to the robot shall be of a type that cannot be disconnected easily.	
Robot system layout design	The layout of a robot system for arranging working space, access and buffer space shall meet the following items: a. Limiting space and working space shall be set based on the maximum reach of the robot, and buffer space shall be arranged between the robot and any obstacle such as a building column. b. Safe passages including pedestrians' passages shall be arranged. c. The access and path to the control system shall be safe. d. Safe passages shall be arranged for accessing the robot for checkup, cleaning, repair, maintenance, and the like. e. No hazard of slipping, tripping, and stumbling due to wiring or other hazard source shall exist. f. No hazard due to cable trays and the like shall exist. g. Operation controllers and auxiliary equipment (such as welding controllers, pneumatic valves) requiring access during automatic operation shall be located outside the protected space.	
Robot system stop function	 Any robot system shall have a protective stop function and a separate emergency stop function. a. Emergency stop function 1) The robot system shall have a single emergency stop function for all the related parts of the system. 2) In the case of multiple robots or multiple cells, the control range may be divided, provided that the control ranges have clear indication in characters or symbols close to the emergency stop devices. 3) When there are two or more control locations, the emergency stop device installed at each control location shall maintain its functionality at all times. 4) The emergency stop function shall have priority over all the other robot controls. Upon any emergency stop, the driving power from the robot driver shall be removed, and retained 	

[Annex Table 14] Criteria for Inspection of Industrial Robots (relating to Article 30)

- at the stopped condition until it is reset.
- 5) Resetting shall be possible only manually, and the robot operation may not be resumed immediately after resetting, but shall be activated by a separate activation action.
- 6) The performance of the emergency stop circuit shall meet the performance requirements for the safety-related control systems specified in Paragraph 4.
- b. Protective stop function
 - 1) The robot system shall have one or more protective stop circuits for being connected to external protective devices.
 - 2) The protective stop circuits shall be such that their activation stops the robot operation, removes the power to the actuator, and enables control of all the hazard sources controlled by the robot.
 - 3) The protective stop shall be actuated by manual operation or a control logic.
 - 4) At least one protective stop functions shall be of the Stop 0 or Stop 1 type.
 - Note 1) Stop 0 type: The system is stopped by an immediate disconnection of the power to the actuator.
 - Note 2) Stop 1 type: The stopping is controlled so that the power is disconnected after the system is stopped while the power to the actuator is retained.
 - 5) The performance of the protective stop circuit shall meet the performance requirements for the safety-related control systems specified in Paragraph 4.

The robot system shall meet the following items for preventing unexpected actuation.

- a. Starting and restarting shall be possible only when all the safety functions and protective measures operate normally.
- b. When the power supply is stopped and resumed, a starting interface device shall be installed for preventing dangerous operations resume automatically, and resetting shall be possible only by manual operation.
- c. Starting and restarting controls shall be operated manually outside the protected space, and they may not be activated inside the protected space.

Manual resetting, starting, and restarting

- d. The starting and restarting control devices shall be located where the operator can have a clear view of the protected space. However, if it is impracticable to secure view of the protected space, any of the following shall apply.
 - 1) Install a detection device that can detect the presence of workers inside the protected space.
 - 2) Install a means to fix the entrance door while it is opened.
 - 3) Install an additional time limiting reset device inside the protected space.
 - 4) Issue visual/audio alarm that can be clearly recognized inside the protected space, and provide sufficient time for escaping.
- e. When Item 4) of Paragraph d applies, install emergency stop devices of a sufficient number at places inside the protected space easily accessible by workers.

Protected space, fences, etc.

Protected space and fences shall meet the following paragraphs: However, partial exception may apply depending on the operating types of collaborative robots.

- a. Limiting spaces shall be located inside the protected space.
- b. The protected space shall be set by fences. However, at openings for moving in/out materials or parts, the protected space shall be set by sensing-type protective devices.

[Annex Table 14] Criteria for Inspection of Industrial Robots (relating to Article 30)

- c. The fences of a robot cell shall meet the following paragraphs:
 - 1) The fences shall be installed firmed so that they cannot be easily damaged by external force, and that they can be removed only by tools.
 - 2) When a fence has an opening for moving in/out materials or parts, physical access by workers to hazardous points under, beside, or through the opening shall be prevented. If such measures are impracticable, additional actions shall be taken such as the installation of sensing-type protective devices.
 - 3) The fences shall be no lower than 1,800 mm. However, the fences may be adjusted to no lower than 1,400 mm in case where no hazards are posed by the height in consideration of the operating range of the robot and the safety distance specified in KS B ISO 13857.
 - 4) Movable fences (entrances) shall be such that they open sideways or in the direction moving away from hazard sources, and shall not have a structure in which they are opened toward the protected space.
 - 5) Movable fences (entrances) shall have interlock devices, and the interlock devices shall be able to put hazard sources into safe conditions before workers approach them. However, in the case where it is probable that workers approach hazardous spaces before hazard sources are removed, entrance locking devices shall be installed in addition to the interlock devices.
 - 6) The locking devices of movable fences (entrances) shall be such that the robot can be actuated only when the fences (entrances) are closed and locked.



Warranty

Hyundai Robotics (hereinafter "We"), provides warranty for raw material and manufacturing defects of this product according to the details specified in the Warranty Statement to protect the benefits of the customers who purchase robot systems manufactured and sold by us or our authorized sellers. This warranty is provided only for end users (hereinafter "Customers") of our robots.

Warranty scope

The robot and its components (hereinafter the "Product") are under our warrant in terms of material and manufacturing defects.

The only responsibilities of ours and the only remedial measures relating to any of our products will be limited to the repair or replacement of products deemed to have direct defects at our discretion. We will not compensate for any collateral damages or accidental, special, or consequential damages including the loss of income, loss of use, loss of production, or damages of other products or equipment caused by the defects of our products.

Warranty period

We provide a one-year warranty for product quality beginning on the date on which our product is delivered to a site after the customer purchased the product or the date on which the customer issues a letter of acceptance after the completion of commissioning. However, if the contract date and the delivery date (installation and commissioning completion date) do not match, the delivery date will be the beginning date of the warranty. When the product is replaced with a new finished product, the warranty period will be calculated from the replacement date.

Warranty limitations and exceptions

To maintain the validity of the warranty, the customer should comply with the maintenance procedure specified by us and keep the relevant records. If it is to be decided that the following are true because the customer does not comply with the maintenance procedure, the warranty will be void.

- Product faults and damages caused by the customer's carelessness, unskillful operation, erroneous or arbitrary modification, disassembly, and repairing
- Product faults and damages caused by the installation and use of parts, consumables, software, etc. that are not authorized by us
- Product faults and damages caused by noncompliance with the instructions and precautions specified in the product manual
- Product faults and damages caused by its use for purposes other than its intended purposes
- Product faults and damages caused by the use of the product in inadequate environments or dropping or giving impact to the product
- Product faults and damages caused by arbitrary installation, repair, or maintenance carried out by persons (customers, unauthorized persons, or non-licensed maintenance workers, etc.) other than installation experts.
- When the service life of consumable parts has elapsed
- When warranty service is filed after the warranty period has expired

We do not provide warranty for product damages caused by external situations that are not under our reasonable control, such as thefts, intentional sabotages, fires, natural disasters, wars, or terroristic behaviors. In addition, we will not take responsibility for any defects of products, functionality, and performance that are beyond the scope specified in the Warranty Statement.

96_Warranty Hyundai Robotics

Customer Support

- Representative phone number: 1670-5041 | Email: robotics@hyundai-robotics.com
- Working hours: Weekdays (Monday–Friday) 09:00–18:00 | Closed on weekends and holidays

For details and queries about products or services, please contact our Customer Support Team.





A HYUNDAI ROBOTICS

Gyeonggi-do: F2, Medipark Building, Dolmaro 43, Bundang-gu, Seongnam-si, Gyeonggi-do

Daegu: 50 Technosunhwan-ro 3-gil, Yuga-eup, Dalseong-gun, Daegu-si

Ulsan: Room 201-5, Automotive and Shipbuilding Engineering Hall, Maegoksaneop-ro 21, Buk-gu, Ulsan-si

Middle Region: Song-gok-gil 161, Yeomchi-eup, Asan-si, Chungcheongnam-do

Gwangju: Room 101, Building B, Pyeongdongsandan-ro 170-3, Gwangsan-gu, Gwangju-si

ARS 1588-9997 | 1 Robot Sales, 2 Service Sales, 3 Purchasing Consultation, 4 Customer Support, 5 Investment Queries, 6

Recruitment, and Other Queries www.hyundai-robotics.com