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Safety Function Manual
for Collaborative Robot
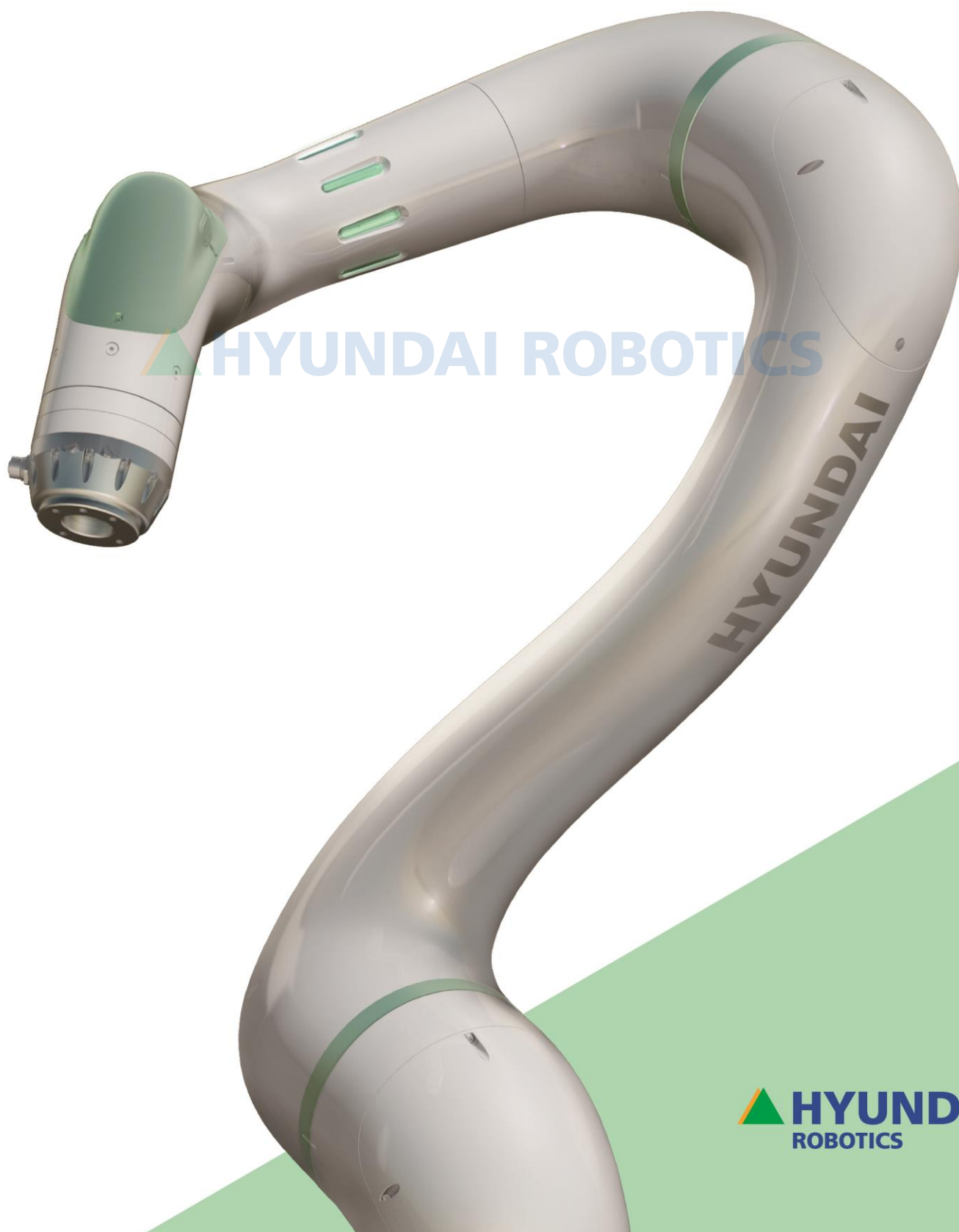
HYUNDAI ROBOTICS

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About this manual

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

Before using the product, read and fully understand the content of this manual. In addition, keep this manual at a handy 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 a material for internal training programs.

As this manual has been prepared based on standard specifications, it may not apply equally to all models that you purchase. 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 responsibilities 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 document to third parties not explicitly permitted by Hyundai Robotics are strictly prohibited.

Notation rules

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

■ Description by figures

Figures are used for easy 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:

■ GUI (Graphical User Interface)

In regard to GUI, any menu name or a button name will be in brackets ([ ]), and in the **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 the automatic mode, click the **[Menu]** button.

- Multiple menus: In the initial screen of the manual mode, click the **[Setting]** button 〉 **[5: Reset 〉 7: Unit Setting]** menu.

■ Manipulation key notation method

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

- For details of making changes in date and time information, see "**4.5 Date and time setting**."

■ References

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

Remarks	Blinking of the 🅴 icon in the status bar indicates the engineer mode.

Safety precautions

For ensuring proper product use, user safety, and for preventing property damages, make sure to read and fully understand the following precautions before using the product.

■ Danger

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

- Carry out 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 robot integrated system have different risk levels, prepare safety devices based on the device of 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, immediately stop using the product, and contact our Customer Support Team.

■ Warning

⚠ 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 take 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. Lose bolts may lead to damage of the robot due to falling from the installation position.

- Pay attention to the product connections (power and cables)so that no conducting substances such as liquid, dust, and metal particles 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 device types. In particular, 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 operation. It may lead to electric shocks, fires, faults, and injuries.

- Long-time use of the product may generate overheating and lead to injuries such as burns. In the event it is necessary to touch the product, sufficiently cool down the product by powering it off and leaving it for at least one hour.

- Never arbitrarily install, modify, disassemble or repair the product. It may lead to faults and accidents. Hyundai Robotics will not take responsibilities for product damages caused by such arbitrary actions.

HYUNDAI ROBOTICS

■ Caution

⚠ 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 the product 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 having much dust or dirt. Dust of foreign matters may lead to product faults or malfunction.

- Do not install or use the product at a place of magnetism, or a place which is affected by magnetism, or a place of electromagnetic interferences. Magnetism may lead to product damages or malfunction.

- In operating the product, do not wear loose outfit or accessories. If you wear long hair, tie it at the back of the head so that it is not entangled between joints and the like of the robot.

- While the product is in operation, do not enter its operating range or touch the robot. It may lead to injuries.

- Transport the product as it is packaged for preventing 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 due to moisture infiltration.

- Store the product at a place clean, cool, dry, and free from high variation in temperature and humidity.

- The product should be moved by two or more persons, maintaining the correct posture. If not, the persons may be subject to physical injuries in the waist, arms, legs and the like.

- In moving the product by means of 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 responsibilities for product damages caused by customer's product transportation.

HYUNDAI ROBOTICS

Contents

HYUNDAI ROBOTICS

1. Safety functions of the collaborative robot

1.1 Description of terms

■ Robot restriction parameters

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

• TCP position monitoring

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

• TCP direction monitoring

This monitors whether the tool direction is out of the specified range. If 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. If 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. If the specified value is exceeded, the safety stop set by the user will be actuated.

• Power monitoring

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

• Momentum monitoring

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

• Collision detection

If the allowable value is exceeded due to 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. If the specified value is exceeded, **Stop0** will be actuated. If a stop condition is met in the automatic mode, this function will be actuated automatically.

■ Joint restriction parameters

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

- Joint angle monitoring

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

■ Safety layout

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

- Safety area

  This refers to the working space and the safeguarded 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 is out of the working space, the safe stop function will be actuated.

- Safeguarded space

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

- Safety tool modeling

  The tool attached to the robot is modeled in spheres and cones for the monitoring of TCP position and direction.

- Safety robot modeling

  The robot's elbow is modeled in spheres for monitoring its distance from the safety area.

■ Safe stop

This is the function for stopping the robot to ensure safety if any safety conditions are violated. There are three methods for safe stop. For more details of the methods, see ISO 13850 or IEC 60204-1.

- Stop0

  The power of the motors of all the joint modules will be immediately disconnected and the motors will be stopped (uncontrolled stop).

- Stop1

  The motors of all the joint modules will be decelerated and stopped, and the power of the motors will be disconnected (controlled stop) The robot will be decelerated while it continues moving the programmed path, and be stopped. Then, as soon as the robot is stopped, its power will be disconnected.

- Stop2

  The motors of all the joint modules will be decelerated, 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 is stopped due to the safety function, the error can be cleared, and the robot can be positioned in the safe space in the recovery mode. However, if the safety board is in the FAULT state, the error cannot be cleared in the recovery mode, and the system should be rebooted.

■ Direct teaching

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

1.2 Collaborative operation mode

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

1.2.1 Safe rating monitored stop

When a person enters the operating space, the robot operation will be stopped. Install an external monitoring device, and use it as connected to the safety control module (SCM).

- If an external device is connected to the safety input, the stop modes (Stop0, Stop1, and Stop2) should be set in the safety I/O signal setting.

- When a safeguard and an external emergency stop device are connected, stop modes that 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 of the setting of safety I/O signals, see "**1.8Safety I/O signals**."

- For more details of the setting of safe stop functions, see "**1.9Safe stop functions**."

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.

In directly moving the robot's manipulator in the manual mode, you can use free motion and specific restricted motion by direct teaching with an external switch. For more details of direct teaching, see "**1** 오류! 책갈피가 자신을 참조하고 있습니다.."

1.2.3 Speed and position monitoring

The robot operates within a specified distance and speed.

In the speed and position 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 a deceleration mode with regard to the inputs of the external sensors that detect distance.

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

- For more details of the setting of the robot's safety condition level 0 (deceleration mode), see "**1.6 Robot safety conditions**."

- For more details of the setting of safety I/O signals, see "**1.8Safety I/O signals**."

1.2.4 Power and force restriction

This restricts the impact applied on human body in case of collision accidents. Through the collision detection function and the TCP force restriction function, it can restrict the impact applied on the operator in case of collisions between the operator and the robot.

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

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

1.3 Safety functions

The safety functions of the collaborative robot are for reducing impact applied to the operator in case of collisions between the operator and the robot during collaborative operation.

The safety functions include the "axis restriction function" that restricts the motion of the robot's joints, and the "robot restriction function" that restricts the robot's motion in the safety area space. These functions can be configured in the setting menu, and are used as measures for responding to the risks selected in the risk assessment conducted by the operator.

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

- Safety area: Set the operating space and the safeguarded space for restricting the robot's motion.

- Tool modeling: This is used for monitoring the tool position to check whether the robot's tool position intrudes or exceeds specific spaces.

- Robot modeling: This is used for monitoring the elbow position to check whether the robot's elbow position intrudes or exceeds specific spaces.

- Safety restriction conditions: Set monitoring criteria value for the safety functions.

One safety condition can be configured for each safety area; if not configured, Level1 (default setting mode) will be set as the default condition. You can add up to five restriction conditions, up to 16 tools, and up to 12 safety areas. 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 restriction functions

The robot restriction functions, which restrict the robot's motion in the safety area, 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 direction: This restricts the direction of the robot's end effector and the tool from deviating from a set direction.

- TCP speed: This restricts the robot's speed to a low speed so that the operator can escape from collision with the robot (the robot moves at the maximum speed of 250 ㎜/sec in the manual mode and the direct teaching mode).

- TCP force, power, and collision detection: Limit the force and pressure in cases of collisions between the robot and the operator.

- Momentum: Limit the energy and impact load in cases of collisions between the robot and the operator.

1.3.2 Axis restriction functions

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

- Joint position: Limit the robot's joint positions so that its axes can move only within specified ranges.

- Joint speed: Limit the robot's momentum so that its axes cannot move beyond set speeds.

- Joint torque: Limit the robot's power and force by restricting torques of the axes for limiting the force and pressure applied on the operator in case of collisions with the robot.

⚠ Caution	For ensuring the safety of personnel and equipment around the robot, operators and users should conduct 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 that the settings are correct before running the robot. • Check that all the safety functions are configured and that 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 the driving of the collaborative robot is replaced, you should check the existing settings, and modify the settings, 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 options • Reconfiguration of torque sensor offsets	• 1.5.1 Encoder options • 1.5.2 Torque sensor offsets
Main controller (microcomputer)	• System resetting • Reconfiguration of all the safety-related functions	User manual
Working tools	• Checking of tool data • Checking of safety tool modeling • Checking of axial load weights • Checking of tool I/O setting	• 1.5.3 Setting of tool data • 1.7.2 Safety tool modeling • User manual • 3.1 Tool I/O
External input devices	Checking of safety I/O setting	1.8 Safety I/O signals

⚠ **Caution** Check that the settings are correct before running the robot.

1.5   Setting to be made before using the safety functions

1.5.1   Encoder options

The accuracy of encoder data is important because the safety functions of the collaborative robot diagnose the robot's position and speed based on the data collected from the encoders mounted on the axes. Although encoder offsets were set before the robot is delivered, you should set the encoder offsets if the existing offset values are not correct.

1.   Check the zero mark of each axis of the robot, and move the axes.

2.   Click **[Configure] 〉 [3: Robot parameters 〉 4: Encoder offset]** menu.

3.   Check the position of each axis, set encoder offsets, and save them by clicking the **[OK]** button.
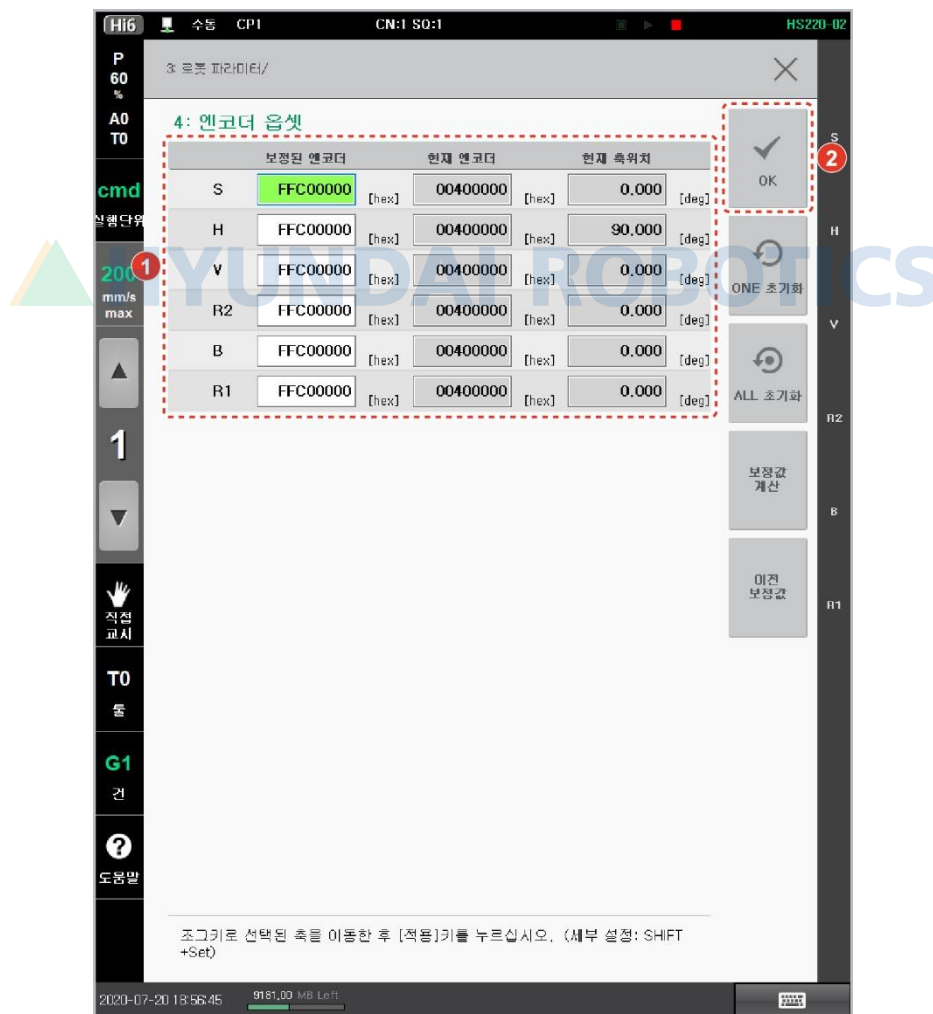
- •   To set encoder offset of an axis, click the **[Initialize ONE]** button.

- •   To set encoder offsets of all the axes, click the **[Initialize ALL]** button.

- •   To correct the encoder offset of a selected axis, click the **[Calculate correction value]** button.

- •   To call the pre-correction encoder offset of the selected axis, click the **[Previous correction value]** button.

4. Check that the current axis position of the robot is indicated at the reference posture (**0, 90, 0, 0, 0, 0** [deg]).

5. Reboot the system.

▲HYUNDAI ROBOTICS

1.5.2   Torque sensor offsets

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

1. Move the axes to a posture where the axes are not influenced by gravity (**0, 90 -90, 90, 0, 0** [deg]).

2. Click **[Configure] ⟩ [3: Robot parameters ⟩ 8: Torque sensor offset]** menu.

3. Check the position of each axis, set torque sensor offsets, and save them by clicking the **[OK]** button.


- To set torque sensor offset of an axis, click the **[Reset]** button.

- To set torque sensor offsets of all the axes, click the **[Reset all]** button.

4. Check that the corrected torque sensor data is close to **0**.

5. Reboot the system.

1.5.3 Setting of tool data

The safety functions of the collaborative robot monitors the entire robot system including a 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 base on the flange coordinate system, and input the information on the weight, center of gravity, and inertia of the tool in the applicable units.

6. Set the operating mode at the manual mode.

7. Disconnect the power of the motor by pressing the emergency stop button.

8. Click [Configure] > [3: Robot parameters > 1: Tool data] menu.

9. 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.
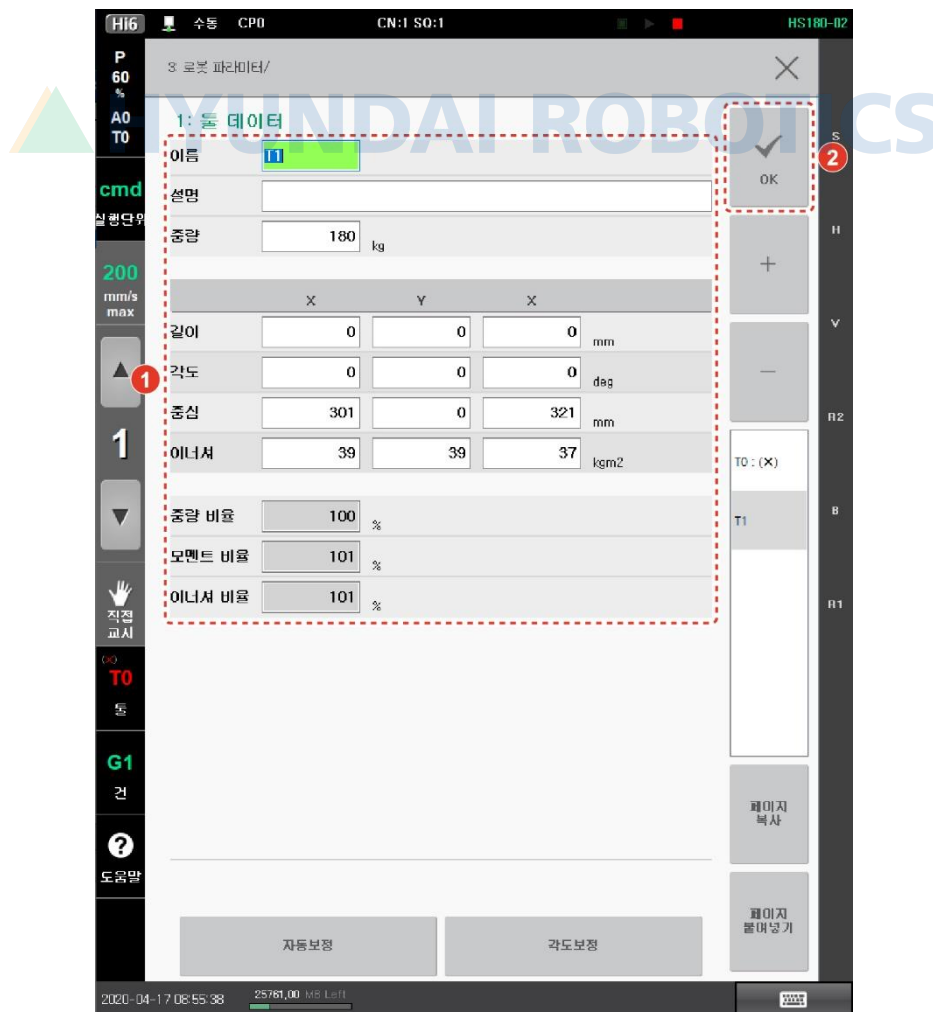
- To create a new tool data from the scratch, or easily by utilizing the existing program, click the [Automatic correction] button.

- Too correct the tool angle, click the **[Correct angle]** button.

- To add a new user coordinate system, or delete one, use the **[+]/[−]** buttons.

- To view and edit the detailed information of a tool data, select a tool data name to be viewed and edited.

- To copy the information on a tool data and paste it to that of another, **[Copy page]/[Paste page]** button.

Reference	• If there is no information on the weight and center of gravity of a tool, you can estimate the values by using the load estimation function. For more details, see "**Operation Manual for Hi6 Controllers**." • For more details of tool data setting, see "**Operation Manual for Hi6 Controllers**."

1.5.4   Password setting

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

1. Click **[Configure]** button 〉 **[5: Initialize 〉 11: Set system password]** menu. The password setting window will appear.

2. Enter the password, and click the **[Confirm]** button.
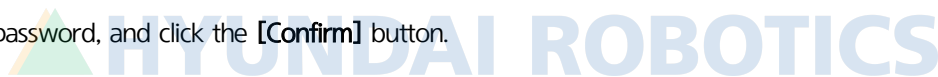
- In setting the parameters of the safety functions, the system setting password must be input for saving changes.
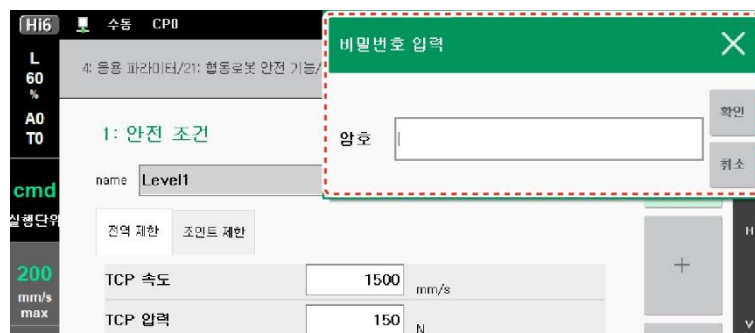
1.6   Robot safety conditions

The robot safety conditions, which are the limit values for monitoring the safety functions, comprise the robot restriction parameters and the joint restriction parameters.

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

The method for setting safety conditions is as follows:

1. Click **[Configure]** button 〉**[4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 1: Safety conditions]** menu. The safety condition setting window will appear.

2. Check and set the parameters values of the safety conditions.

No.	Description
❶	This is the details of the safety condition. You can view and set the condition name and the parameter values.

No.	Description
	• **[Name]/[Description]**: These are the name and description of the safety condition. • **[Global restriction]**: This is the setting information on the robot restriction parameters of the safety condition. For more details, see "**1.6.1 Robot restriction parameters**." • **[Joint restriction]**: This is the setting information on the joint restriction parameters of the safety condition. For more details, see "**1.6.2 Joint restriction parameters**."
❷	• **[OK]**: 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. • **[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]** button. • **[Initialize ALL]**: This initializes all the safety conditions.

1.6.1 Robot restriction parameters

These parameters are the limit values for the monitoring of the safety functions relating to the robot's driving in the safety area. If a robot restriction 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, Stop2, and Reaction) will be actuated immediately.

You can set parameter values in the **[Global restriction]** tab of **[Setting 〉 4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 1: Safety conditions]** menu.

Figure 1 Window for setting robot restriction parameters

Parameter	Description	Default setting value
TCP speed restriction	This is the TCP speed restriction value in the robot's coordinate system (1 – 5,000 (mm/sec))	1,500 mm/s
TCP force restriction	The force restriction value applied to the tool center point (TCP)(50 – 1,000 (N))	150 N
Power restriction	The mechanical power restriction value of the robot (80 – 1,000 (W))	350 N
Momentum restriction	The momentum restriction value of the robot (excluding payload) (50 – 1,000 (kg·m/sec))	50 kg·m/sec
Collision detection	The sensitivity of the collision detection function (0 – 200 (%))	100%
Deceleration ratio	The deceleration ratio of the speeds (TCP and joint speeds) set in the deceleration mode (Condition0)	20%

⚠ Caution	• In configuring a speed limit, you must consider the STO reaction time, and put a cover on the target for preventing collisions and injuries.
	• Because the speed increase in proportion to kinetic energy, and because a high payload may

increase the robot's impact momentum, collision of the robot into an external object may generate a significant impact. In the collaborative operation space, operate the robot while maintaining a safe speed and payload.

1.6.2   Joint restriction parameters

These parameters are the limit values for the monitoring of the safety functions relating to space in which the robot's joints move. If a joint restriction 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, Stop2, and Reaction) will be actuated immediately.
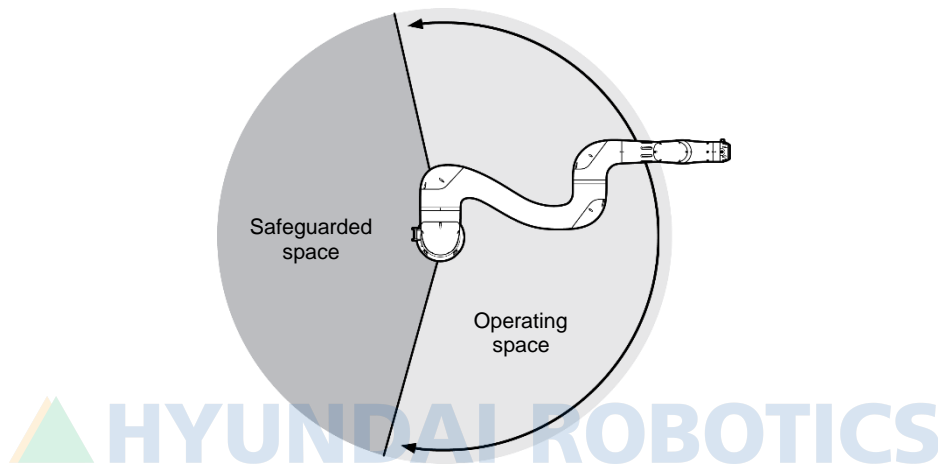

Figure 2 An example of joint restriction setting (S-axis)

You can set parameter values in the [Joint restriction] tab of [Setting 〉 4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 1: Safety conditions] menu.
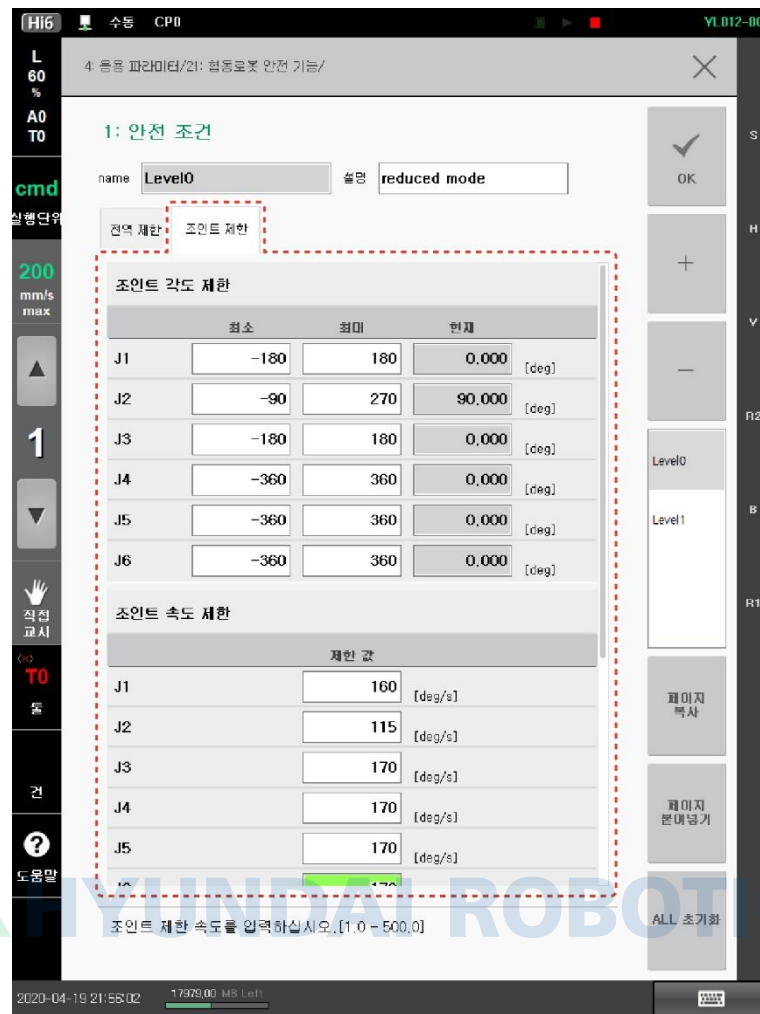
Figure 3 Window for setting joint restriction parameters

Parameter	Description	Default setting value
Joint angle restriction	The angle limit value of a joint (-360.0 - 360.0 (deg))	It is identical to a robot soft limit.
Joint speed restriction	The angular speed limit value of a joint (1.0 - 500.0 (deg))	It is identical to the highest speed of the axis.
Joint torque restriction	The torque limit value of a joint (-500.0 - 500.0 (Nm))	It is identical to the highest torque of the axis.

⚠ Caution | In configuring a speed limit, you must consider the STO reaction time, and put a cover on the target for preventing collisions and injuries.

1.7 Safety layout

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

1.7.1 Safety area setting

The safety area is an operating space or a safeguarded space in which the range of the tool or the robot elbow is monitored. The operating space is a limited space in which the monitoring target can move freely but which it cannot exceed. Unlike this, the safeguarded space is a limited space in which the monitoring target cannot move when it intrude into the space. If the safety area is an operating space, you can enable it by assigning a safety condition number. In the operating space, if the monitoring target moves exceeding the limit value of a safety condition, a functional safe stop will be actuated.
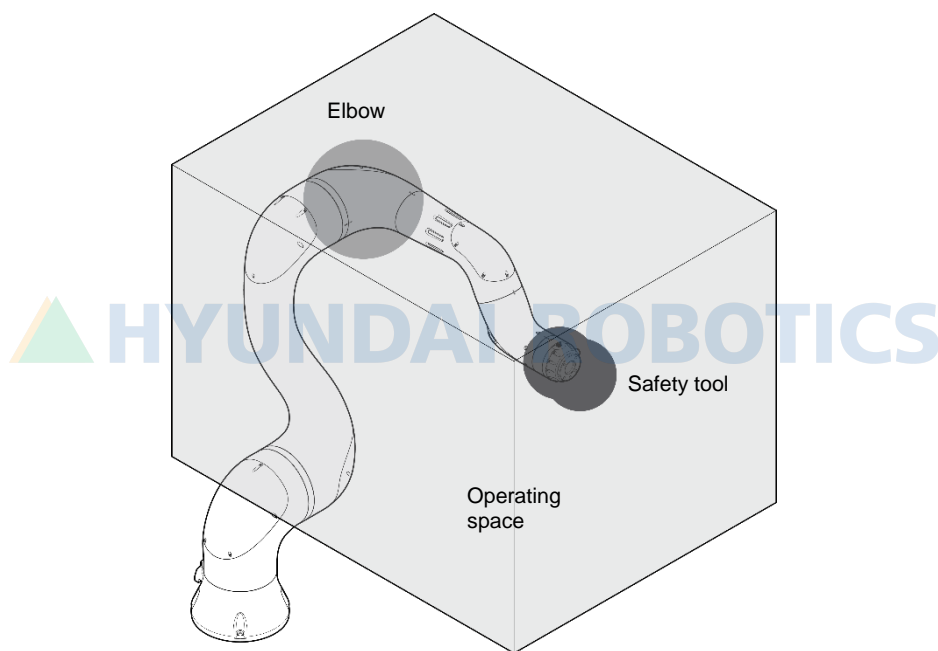

Figure 4 Safety area: Operating space
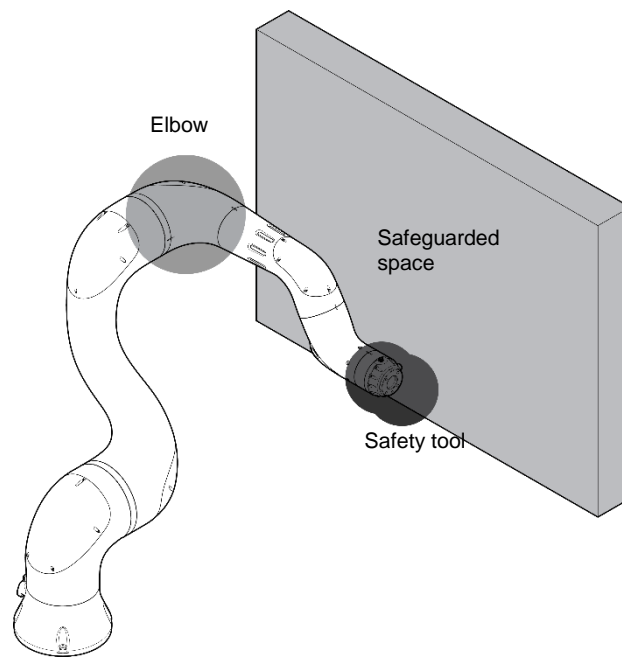
Figure 5 Safety area: Safeguarded space

A safety area 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 areas, each of a cuboid shape. The safety area are enabled by parameter setting or safety I/O signals.

The method for setting safety areas is as follows:

1. Click [Configure] button 〉 [4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 2: Safety layout] menu.

2. Select a type of the safety area, and set the parameter values.

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

1.7.1.1 Setting information on safety area parameters

Parameter		Description	Default setting value
Name		The name of the selected safety area (name character string, 24 characters at the maximum, not modifiable)	CobotSpace n
Description		The characteristics of each space (description character string)	-
Area type		Type of safety area (0 = operating space, 1 = safeguarded space)	0
Condition level		Condition for actuating safety functions in the space (0 – 4)	1
Monitoring type		Monitoring target (0 – 2: 0 = tool, 1 = robot (elbow), 2 = tool and robot)	0
Actuation		Actuation condition (On/Off: 0 = always off, 1 = always on, 2 = safety I/O)	0
Center	X	Zero point of the space (-30,000 – 300,000 (mm))	0
	Y		
	Z		
Angle	RX	Direction of the zero point (RX/RZ: -180 – 180˚, RY: -90 – 90˚)	0
	RY		
	RZ		
Length	LX	Length in the X, Y, and Z direction (0 – 60,000 (mm))	0
	LY		
	LZ		

⚠ Caution	• 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

In the safety area monitoring, it is monitored whether the tool modeled in spheres intrudes into the safety areas or exceeding the operating space. You can set up to 16 safety tools, and model a safety tool with a maximum of six spheres.

Because a safety tool is enabled by a number set on the teach pendant, you should model a safety tool based on the tool data set in [Setting > 3: Robot parameters > 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.
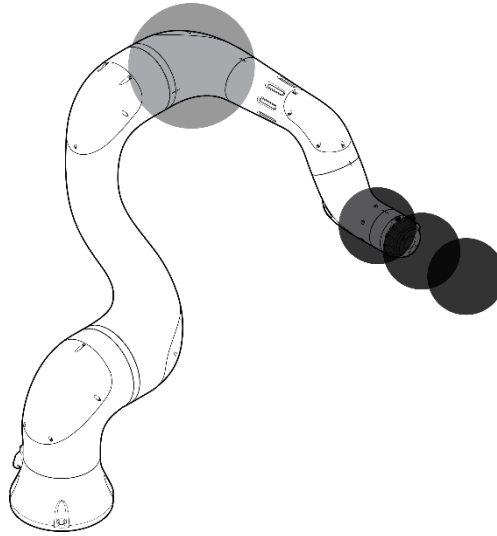

Figure Tool modeling
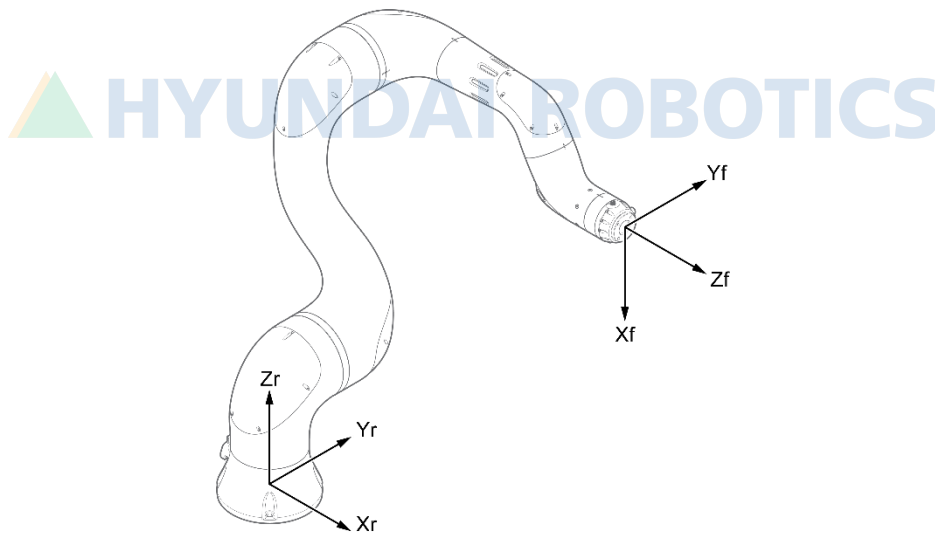
Figure 6 Robot flange coordinate system

In the safety tool modeling, to use the TCP direction restriction function, you can set cones for monitoring by setting rotation angles 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 (**1**) 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, an error of violation the TCP position restriction function will occur.

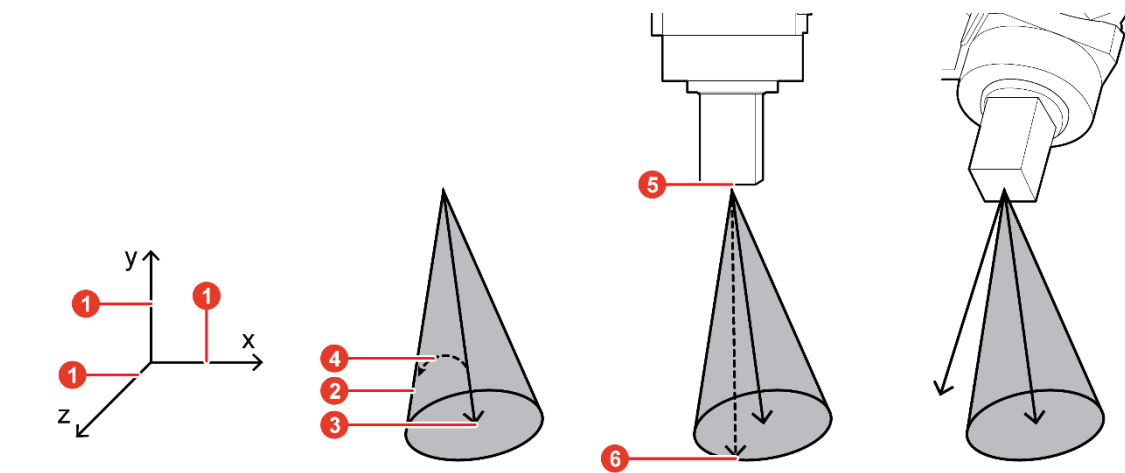Figure 7 TCP direction restriction function

You can set parameter values by clicking the [Tool] button in[Setting 〉 4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 1: Safety conditions] menu.
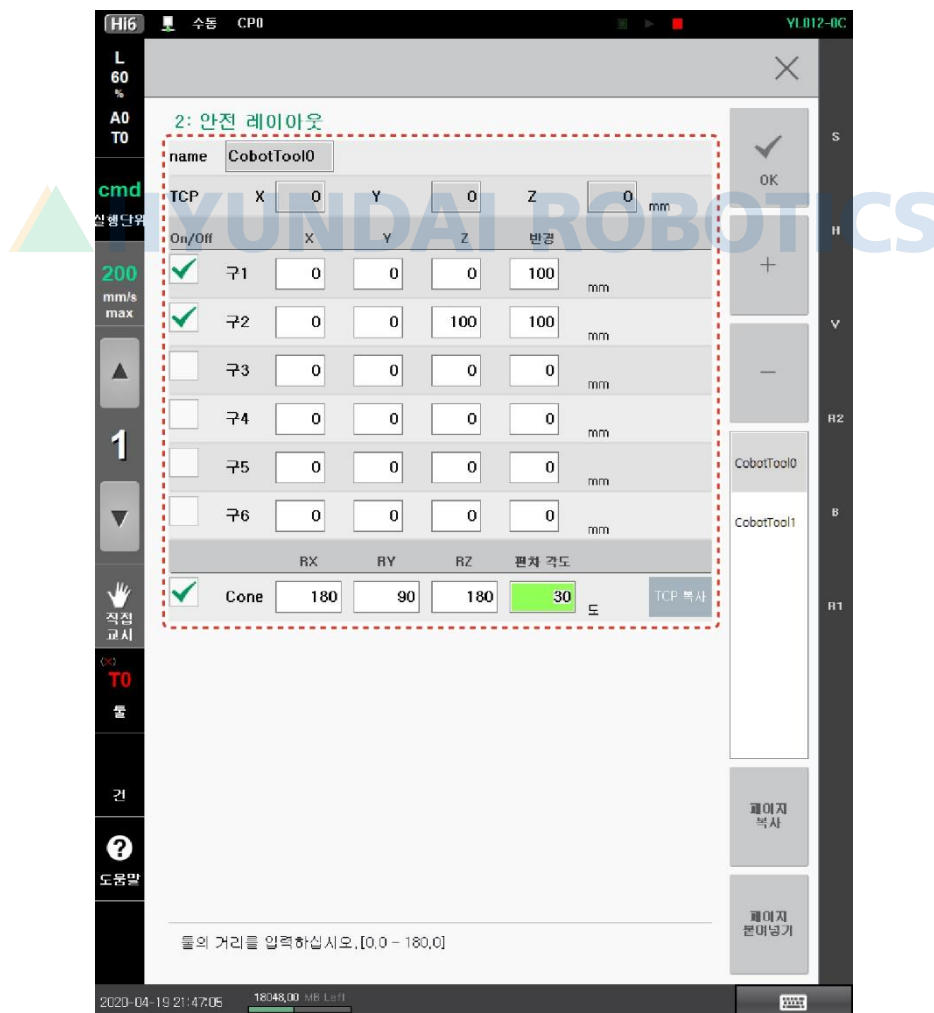

Figure 8 Safety tool modeling setting window

Parameter	Description	Default setting value

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

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.

⚠ Caution	• Before changing a tool data, make sure to re-check that 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 area even if a safety area is set.

1.7.3   Safety robot modeling

This is the robot model used for safety area monitoring. There is only one safety robot model, and the model comprises a sphere.

The sphere used for safety robot modeling is set 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 [Configure 〉 4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 2: Safety layout] menu.

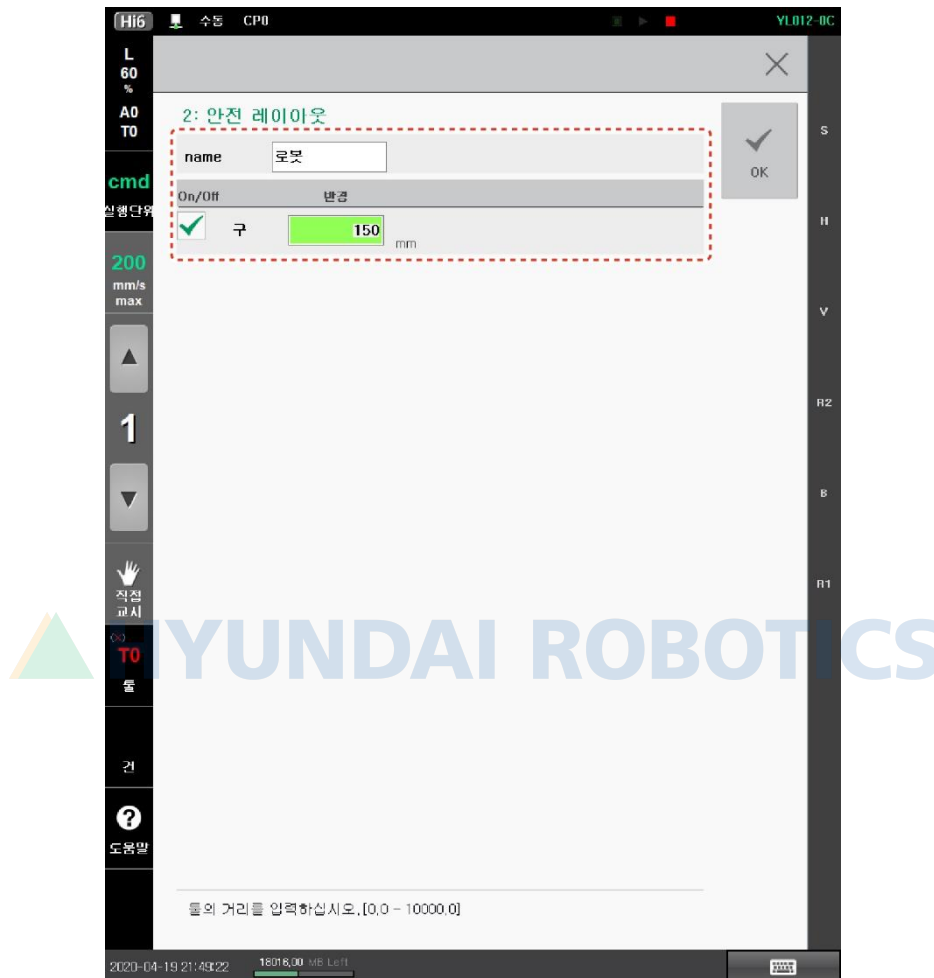Figure 9 Safety robot modeling setting window

| 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)	On
Radius	Radius of the sphere (0 – 10,000 (mm))	1,000 mm

1.7.4 WorkCell 3D

This directly monitors the parameters set in the safety layout by using WorkCell 3D. WorkCell 3D can 3D-visualize the safety areas, tool models, and robot models set in the safety layout so that the operator can view the settings. In

addition, the robot's position is identified real-time, so that the operator can check whether the robot violates any safety areas.

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

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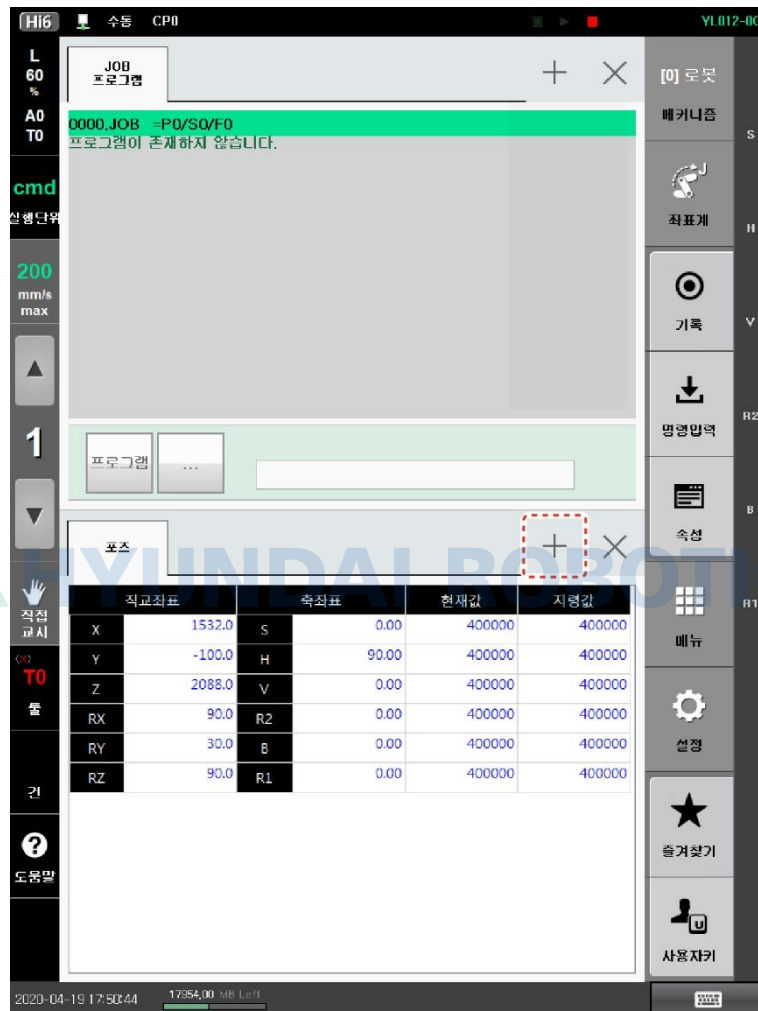

2. On the panel selection window, click **[WorkCell]**. Then, the robot's current posture will appear on the 3D window.

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 operating space (**1**), tool space (**2**), tool direction restriction (**3**), robot elbow space (**4**), and restriction space (**5**).
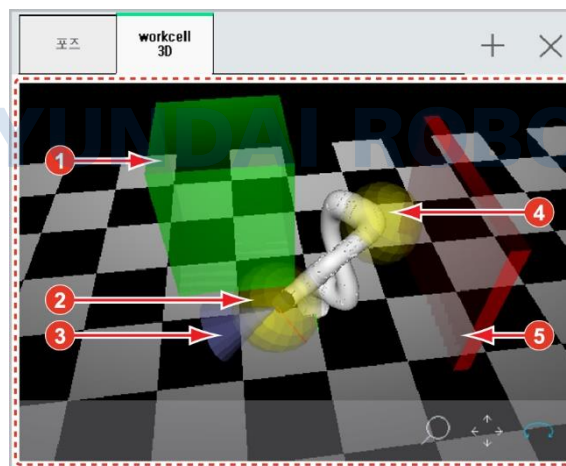
- To adjust the camera, select the **[Expand/Shrink]** icon (⊙), the **[Move]** icon(✥), or the **[Rotate]** icon(↻), and drag the screen.

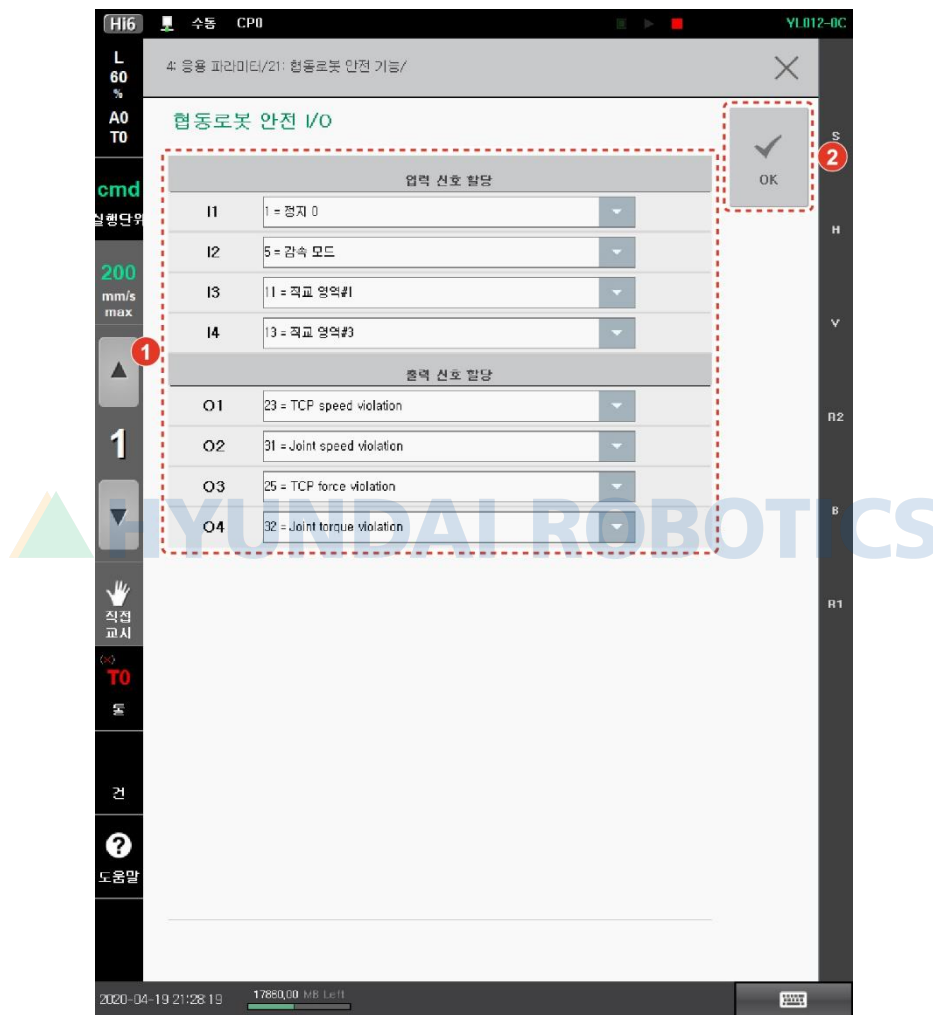- To modify the setting, ad apply the set values, close and re-open the WorkCell window.

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

1.8   Safety I/O signals

This assigns safety I/Os for 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.   Click [Configure] button 〉[4: Application parameters 〉1: Safety functions 〉3: Safety I/O of collaborative robot] menu.

2.   Click the drop-down menu, configure I/O signals, and click the [OK] button.

Parameter		Description
Input signal assignment	IN0 – IN3	Activation signal assignment (up to 4 signals, 0 – 22) • 0 = none • 6 = Enable SW • 1 = Stop 0 • 7 = Motor on • 2 = Stop 1 • 8 = Mode switch-manual • 3 = Stop 2 • 9 = Mode switch-auto • 4 = SOS • 10 = Mode switch-remote • 5 = Reduced mode • 11– 22 = Cartesian space #1 – #12
Output	OUT0 –	Monitoring signal assignment (up to 4 signals, 0 – 43)

Parameter		Description	
signal assignment	OUT3	• 0 = none	• 22 = Violation alarm
		• 1 = STO activation status	• 23 = TCP speed violation
		• 2 = SOS activation status	• 24 = TCP orientation violation
		• 3 = Reduced mode activation status	• 25 = TCP force violation
		• 4 = Not reduced mode	• 26 = Collision detection
		• 5 = Robot moving	• 27 = Momentum violation
		• 6 = Robot not stopping	• 28 = Power violation
		• 7 = Mode switch-manual	• 29 = SOS violation
		• 8 = Mode switch-auto	• 30 = Joint position violation
		• 9 = Mode switch-remote	• 31 = Joint speed violation
		• 10 – 21 = Cartesian space status #1 – #12	• 32 – 42 = Cartesian space violation #1 – #12

HYUNDAI ROBOTICS

1.9 Safe stop functions

Set adequate safety stop type for each safe stop function. The safe stop functions, which stop the robot for a safe condition in case of safety violation, include the following three types: All the types of safe 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 be immediately disconnected and the motors will be stopped.

- Stop1: The power of the motors of all the joint modules will be decelerated and the motors will be stopped. Then, the power of the motors will be disconnected.

- Stop2: The motors of all the joint modules will be decelerated, 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 safe stop types of the safety functions is as follows:

1. Click [Configure] button 〉 [4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 5: Safe stop functions] menu.

2. Click the drop-down menu, set the stop type, and click the [OK] button.

No.	Safety function	Stop function	No.	Safety function	Stop function
#1	SOS	Default value: Stop0 (fixed value)	#8	TCP direction violation	Default setting value: Stop0
#2	TCP position violation (Cartesian space violation)	Default setting value: Stop0	#9	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

No.	Safety function	Stop function	No.	Safety function	Stop function
#7	TCP pressure violation	Default setting value: Stop0	#14	Safeguard stop	Default setting value: Stop1 (fixed value)

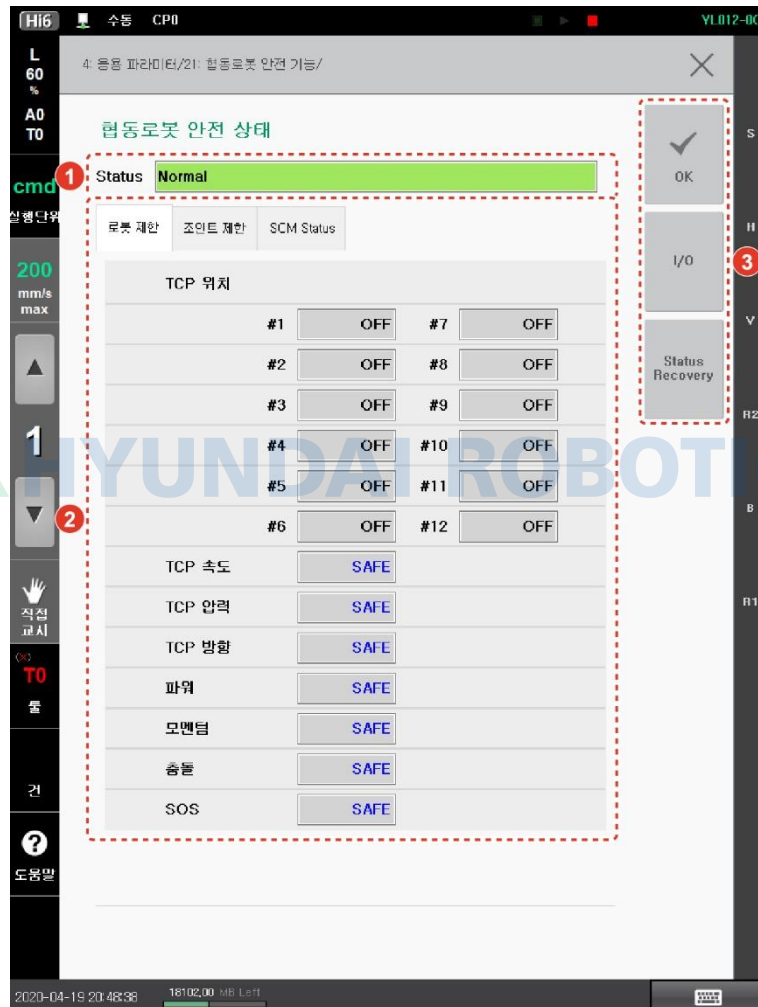| ⚠ Caution	You should set an adequate stopping method for each function based on the result of risk assessment.

HYUNDAI ROBOTICS

1.10 Safety condition monitoring

This monitors safety function violation and the status of the SCM (Safety Control Module) board. You can view the statuses of the robot restriction functions, joint restriction functions, and the SCM board.

1. Click **[Configure]** button 〉 **[4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 6: Safety Conditions of collaborative robot]** menu.

2. Check the safety conditions and the statuses of the safety functions of the collaborative robot.

No.	Description
❶	View the safety conditions of the collaborative robot.
❷	Click the Safety Functions tab, and view the statuses of the safety functions. **OFF**: Safety area disabled / **SAFE**: Safety function observed / **UNSAFE**: Safety function violated / **ERROR**: SCM status error
❸	• **[I/O]**: You can view the statuses of the safety I/Os.

No.	Description
	• **[Status Recovery]**: In case of safety violations during monitoring, you can clear errors and recover the status.

1.10.1 Robot restriction parameter monitoring

Click the **[Robot restriction]** tab of **[Configure 〉 4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 6: Safety conditions of collaborative robot]** for viewing the statuses of the robot restriction functions.
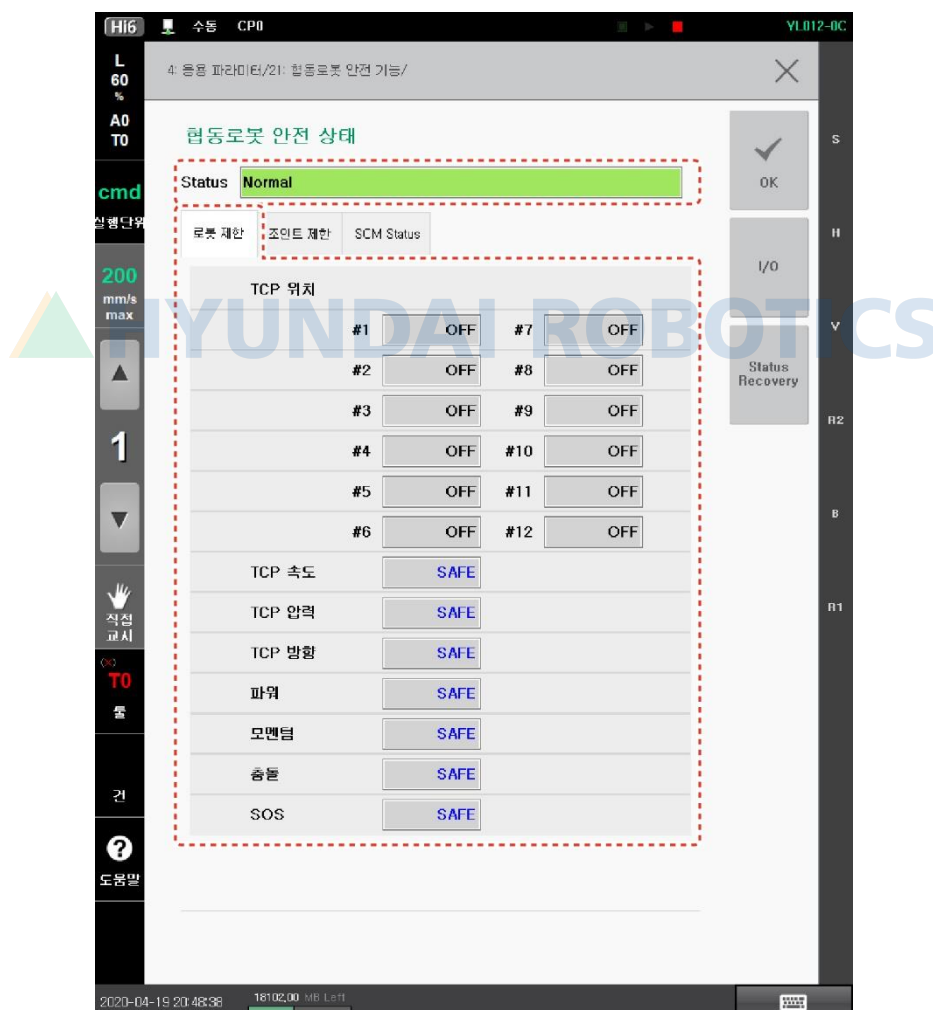

Figure 10 Safety conditions of collaborative robot: Robot restriction

• **[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 restriction functions.

- **[TCP position]**: The statuses of the Cartesian spaces (#1 – #12), and whether TCP position violation has occurred during the monitoring

- **[TCP speed]**: Whether TCP speed violation has occurred during the monitoring

- **[TCP force]**: Whether TCP force violation has occurred during the monitoring

- **[TCP direction]**: Whether TCP direction violation has occurred during the monitoring

- **[Power]**: Whether power violation has occurred during the monitoring

- **[Momentum]**: Whether momentum violation has occurred during the monitoring

- **[Collision detection]**: Whether collision has been detected during the monitoring

- **[SOS]**: (Safe stop monitoring) Whether SOS violation has occurred during the monitoring

1.10.2   Joint restriction function monitoring

Click the **[Joint restriction]** tab of **[Configure 〉 4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 6: Safety conditions of collaborative robot]** for viewing the statuses of the joint restriction functions.

Figure 11 Safety conditions of collaborative robot: Joint restriction

- **[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 restriction functions.

  - **[Position]**: Whether axial joint position violation has occurred during the monitoring

  - **[Speed]**: Whether axial joint speed violation has occurred during the monitoring

  - **[Torque]**: Whether axial joint torque violation has occurred during the monitoring

1.10.3 SCM board status monitoring

Click the [SCM Status] tab of [Configure 〉 4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 6: Safety conditions of collaborative robot] for viewing the status of the SCM board.
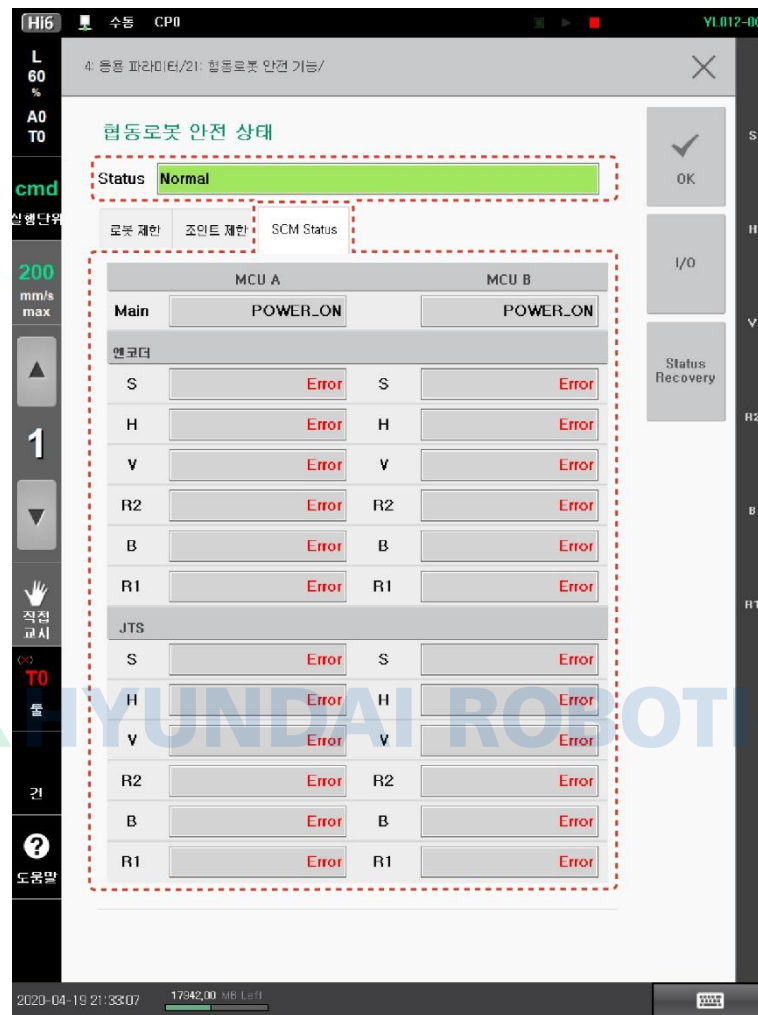

Figure 12 Safety conditions of collaborative robot: SCM status

- [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]: 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]: Status display of the axial dual encoders (Normal, Error, Off)

  - [JST]: Status display of the axial dual JTSs (Normal, Error, Off)

1.10.4 Safety I/O status monitoring

Click the **[I/O]** button at the right of window of **[Configure 〉 4: Application parameters 〉 21: Collaborative robot 〉 1: Safety functions 〉 6: Safety conditions of collaborative robot]** menu for viewing the statuses of the safety I/Os.
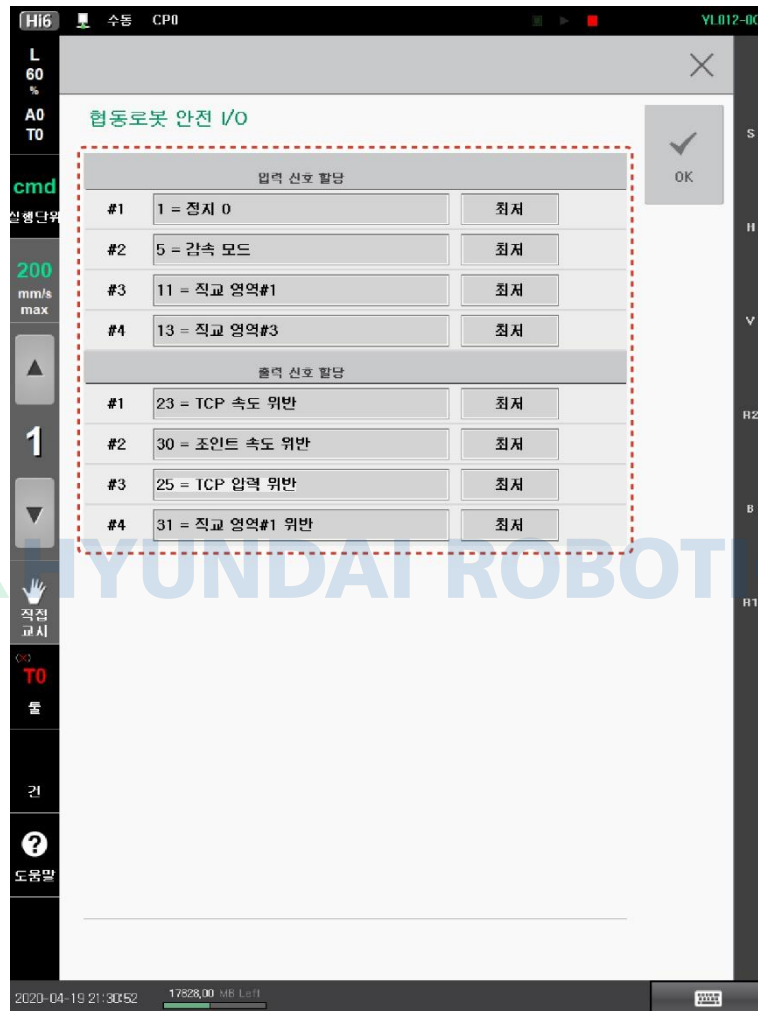

Figure 13 Safety conditions of collaborative robot: Safety I/O

- **[Input signal assignment]**: Display of the statuses of assignment and activation (On/Off) of the input signals (#11 – #14)

- **[Output signal assignment]**: Display of the statuses of assignment and activation (On/Off) of the output signals (#11 – #14)
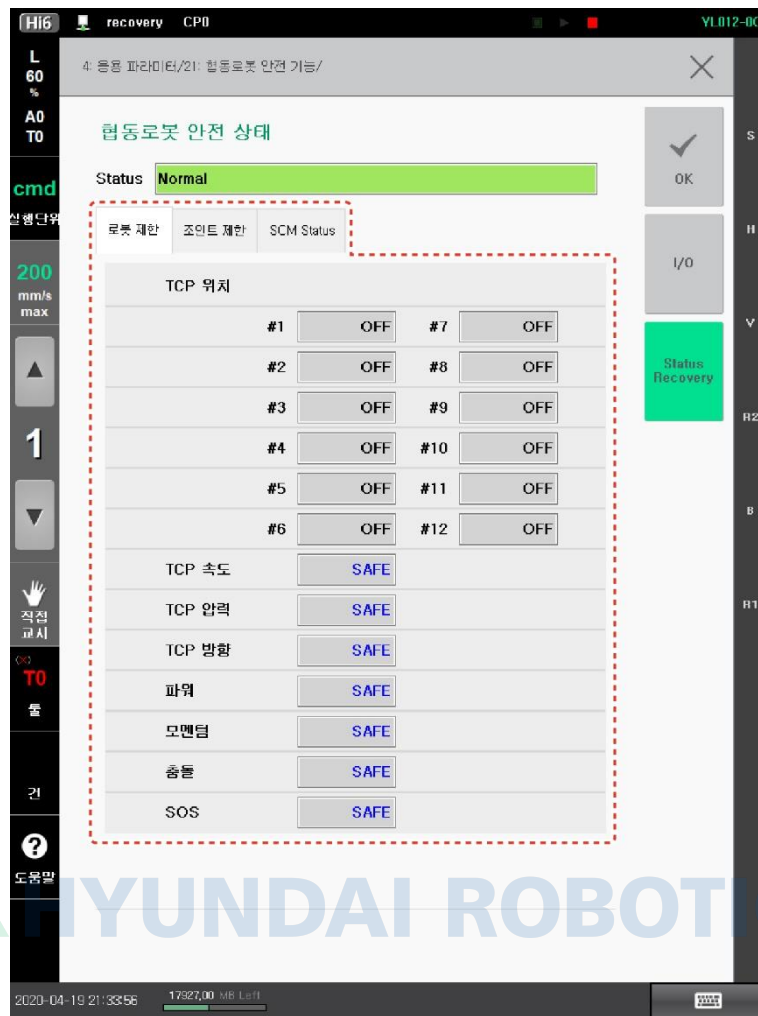
1.10.5 Recovery mode

In the recovery mode, you can clear errors that occur due to safety function violations during monitoring. Because the position detection is temporarily disabled in the 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 safe stop immediately, and stop moving. In addition, the safe stop notice window will appear on the operating program window.

1. Set the operating mode at the manual mode.

2. On the safe 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 to green, and the system will enter the recovery mode.

4. In the 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 to the previous color, and the recovery mode will be cleared.

- You can also clear the recovery mode by clicking the **[X]** button at the top right side of the safety condition monitoring window.

⚠ Caution	After clearing the recovery mode, re-check 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 area, and include TCP position, TCP direction, and joint monitoring violations. When a robot position violation occurs, you can clear the error only by moving the robot's physical position.

6. On the safety condition monitoring window, click the **[Status Recovery]** button to enter the recovery model.

7. Turn on the motor by using the enabling switch on the teach pendant.

8. By using the teaching device, move the robot back to a safety area.

9. On the safety condition monitoring window, check that the status of each area is displayed as **SAFE**.

10. After the recovery is completed, click the **[Status Recovery]** button to clear the recovery mode.

⚠ Caution	After clearing the recovery mode, re-check 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 include TCP speed, joint speed, power, and momentum monitoring violations. Because the robot detects the instantaneous speed in 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 the recovery model.

2. On the safety condition monitoring window, check that the status of each area is displayed as **SAFE**.

3. After the recovery is completed, click the **[Status Recovery]** button to clear the recovery mode.

⚠ Caution	• After clearing the error, make sure to re-check the speed-related safety parameters, and the speed displayed on the operating program. • After clearing the recovery mode, re-check 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 include TCP force, collision detection, joint torque, power, and momentum monitoring violations. You can clear errors depending on the causes of the violations.

■ Violation because external force is applied on the robot

1. Remove the external factor that applies force on the robot.

2. On the safety condition monitoring window, click the **[Status Recovery]** button to enter the recovery model.

3. On the safety condition monitoring window, check that the status of each area is displayed as **SAFE**.

4. After the recovery is completed, click the **[Status Recovery]** button to clear the recovery mode.

⚠ Caution	After clearing the recovery mode, re-check the safety layout setting and the teaching position of the operating program.

■ Violation because the amount of the force used by the robot internally exceeds a safety limit

5. On the safety condition monitoring window, click the [Status Recovery] button to enter the recovery model.

6. Turn on the motor by using the enabling switch on the teach pendant.

7. By using the teaching device, move the robot to a low-load posture.

8. On the safety condition monitoring window, check that the status of each area is displayed as SAFE.

9. After the recovery is completed, click the [Status Recovery] button to clear the recovery mode.

⚠ Caution	• After clearing the recovery mode, re-check the robot's safety condition setting, tool data, the teaching position of the operating program, and torque sensor offset. • If the error is not cleared, check the tool data, tool number, safety condition setting, and torque sensor offset, and repeat the 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 it is supposed to be in a stop state. Because the robot detects the instantaneous speed in case of robot speed violations, you can clear the error without moving the robot's position.

1. Remove the external factor that applies force on the robot.

2. On the safety condition monitoring window, click the [Status Recovery] button to enter the recovery model.

3. On the safety condition monitoring window, check that the status of each area is displayed as SAFE.

4. After the recovery is completed, click the [Status Recovery] button to clear the recovery mode.

| ⚠ Caution	• After clearing the recovery mode, turn on the motor in the automatic mode, and check that 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 at the manual mode.

2.   Click [Configure] button 〉 [4: Application parameters 〉 21: Collaborative robot collision detection mode] menu.

3.   Set whether to use the collaborative robot's collision detection function, configure the options, and click the [OK] button.
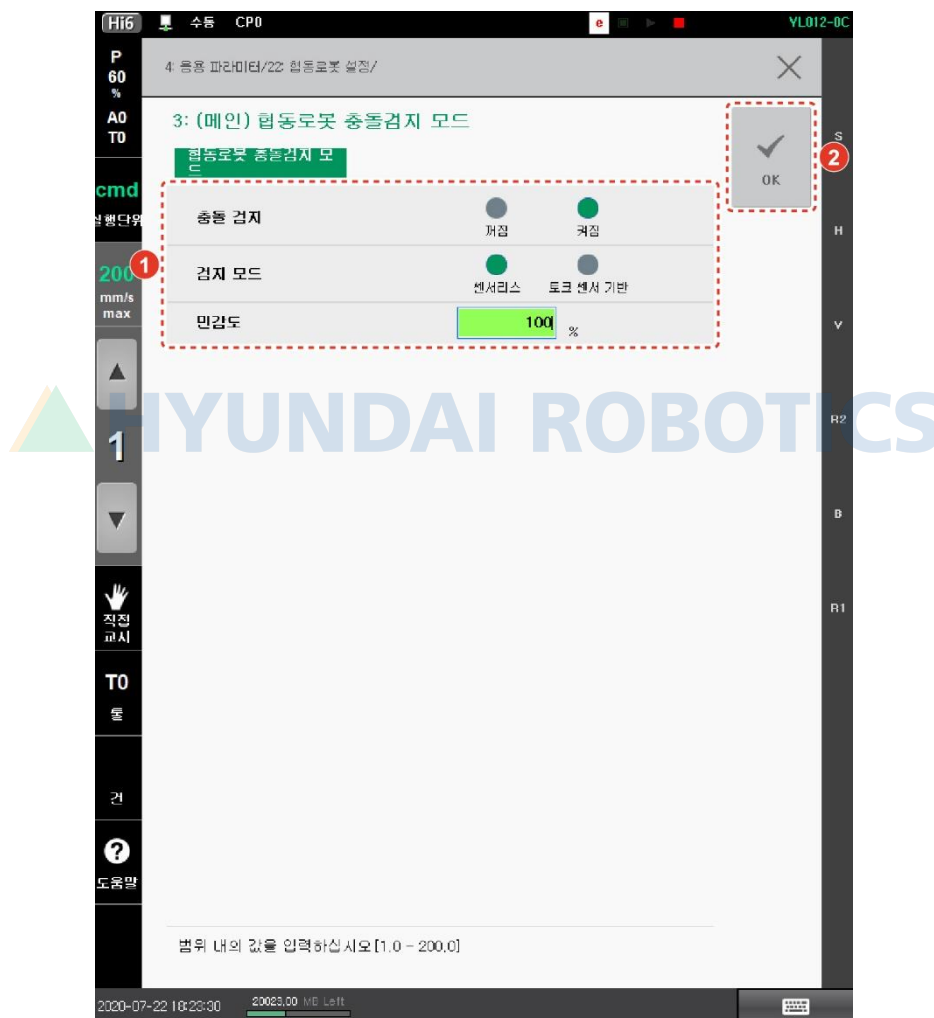
- •   [Collision detection]: Set whether to use the collision detection function.

- •   [Detection mode]: Select the detection mode for collision detection.

- •   [Sensitivity]: Set the sensitivity for the collision detection. The larger the value, the higher the sensitivity to impacts.
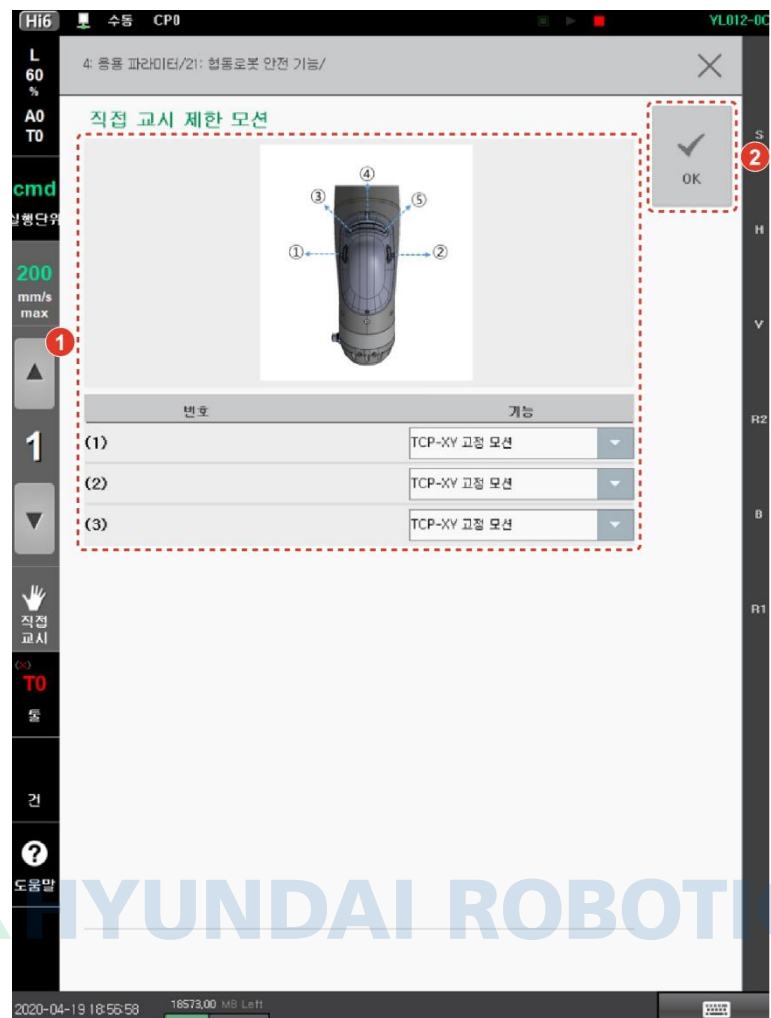
2. Direct teaching

The teaching of the collaborative robot is direct teaching 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.

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

2.1 Direct teaching switch setting

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

1. Click [Configure] button 〉 [4: Application parameters 〉 21: Collaborative robot 〉 2: Direct teaching 〉 4: Direct teaching switch setting] menu.

2. Click the drop-down menu, set functions for the switches, and click the [OK] button.

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

Figure 14 Direct teaching switches
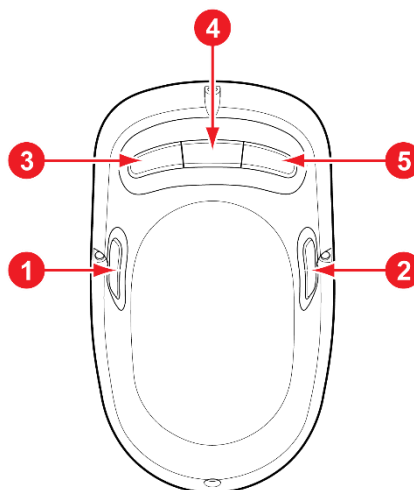
No.	Function
❶/❷	Free motion: The axes move in all directions. (fixed)
❸/❺	Restricted motion: The axes move only in the assigned directions. • X and Y direction based on the tool coordinate system (XY plane)

	• Z direction on the tool coordinate system
	• Angles fixed based on the tool coordinate system: Motion in all directions (RX, RY, and RZ angles restricted)
	• Points (positions) fixed based on the tool coordinate system: Only angles can be changed.
❹	Record positions. (fixed)

2.2 Driving the robot by direct teaching

1. Set the operating mode at the manual mode.

2. Click the 〈**Motor**〉 key on the teach pendant to supply servo power to the motor. The motor lamp will blink.

3. 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**.
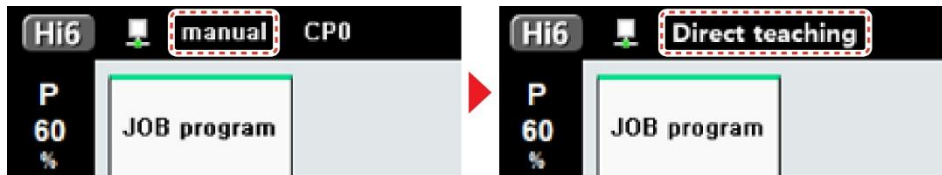
4. While the direct teaching switch (1, 2, 3 or 5) is pressed, hold and move the robot to teach it a desired position.

- 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 only in assigned directions, press a direct teaching switch (3 or 5).

- To record the position of the robot, press a direct teaching switch (4).

⚠ Caution	• Use the direct teaching functions only in a safe environment. If the tool or a nearby structure has a sharp part or a part that can cause entanglement, do not use the direct teaching functions.
	• Before using the direct teaching functions, make sure to set the information on the tool including length, weight, and center of gravity. In addition, make sure to check the robot's installation angle and direction of gravity.
	• Set the enabling or disabling of the direct teaching functions only in the state in which the robot is completely stopped. Changing the status of a direct teaching function while the robot is moving, the robot may malfunction.

2.3   Direct teaching mode setting

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

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

1.   Set the operating mode at the manual mode.

2.   Click [Configure] button 〉 [4: Click [Application parameters 〉 21: Collaborative robot 〉 2: Direct teaching 〉 1: Collaborative direct teaching mode] menu.

3.   Click the direct teaching mode, set the sensitivity of each axis, and click the [OK] button.
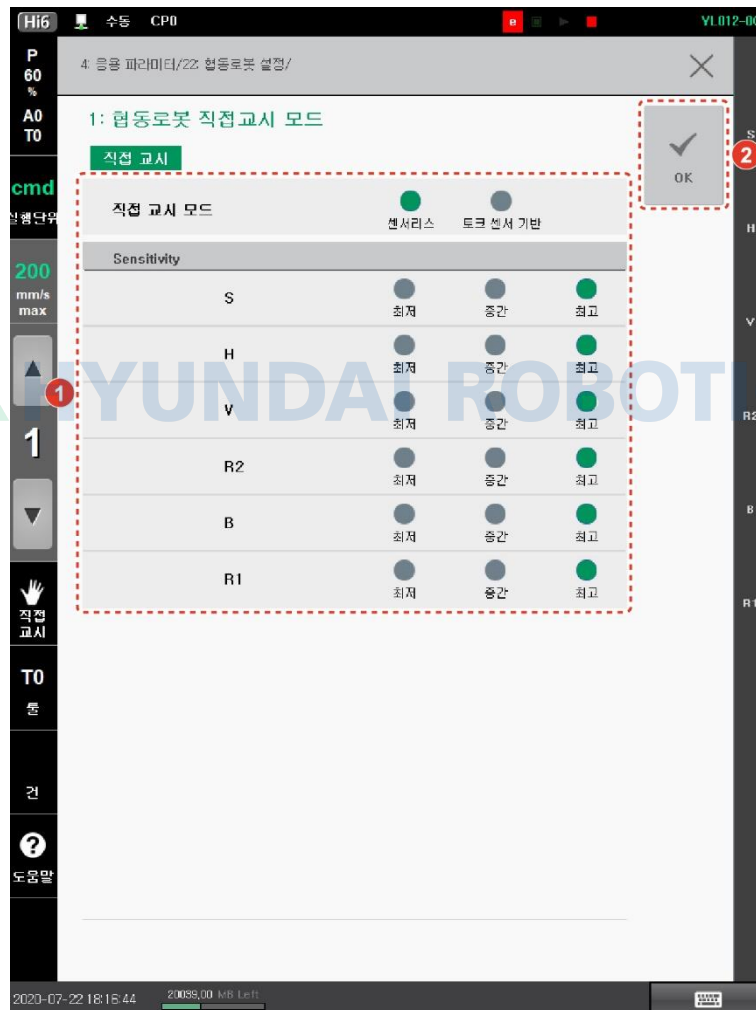
2.4   Restricted motion setting

When you conduct direct teaching by the restricted motion method, you can set the sensitivity of restricted motion. The higher the sensitivity, the smaller the force to move the robot.
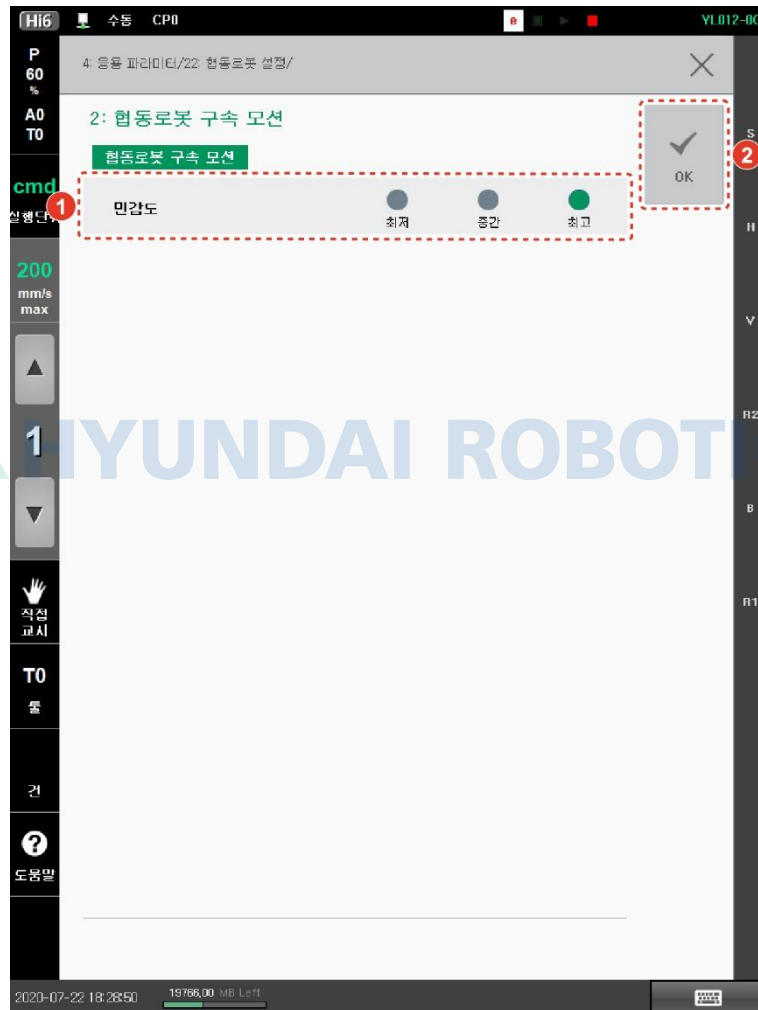
1.   Set the operating mode at the manual mode.

2.   Click [Configure] button 〉 [4: Application parameters 〉 21: Collaborative robot 〉 2: Direct teaching 〉 2: Collaborative robot restricted motion] menu.

3.   Select a sensitivity, and click the [OK] button.

3. I/O setting

3.1 Tool I/O

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.

3.1.1 Default specifications of the tool I/O

■ Digital I/O

Division	Input	Output
No. of channels	4	
I/O type	• SMT-IO06-48PP-HD01: PNP • SMT-IO06-48NN-HD01: NPN • SMT-IO06-48PN-HD01: PNP • SMT-IO06-48NP-HD01: NPN	• SMT-IO06-48PP-HD01: PNP • SMT-IO06-48NN-HD01: NPN • SMT-IO06-48PN-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.	
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	

Input range	0 – 10 V	0 ~ 20 mA
AD/DA conversion data	0 – 1000	0 – 2000
Input impedance	1 MΩ	250 Ω
Precision	±1.0% FS (±100 mV)	±1.0% FS (±200 uA)
Ambient temperature	0 – 55℃	
Absolute maximum input	-0.5 – +26 V	-2.5 ~ +25 mA

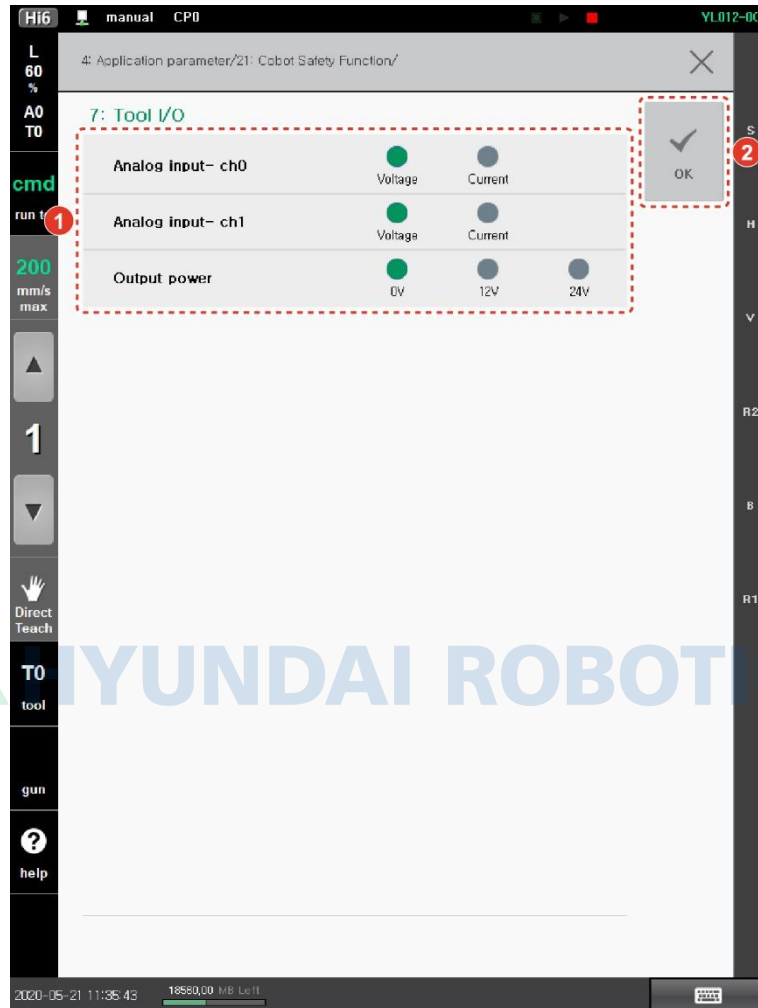### ■ I/O voltage

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

■ General specifications

Division		Description
Communication interface	Protocol	EtherCAT
	Connector	Hirose connector x 2 (EtherCAT input and output)
Product	Weight	30 g max.
	Diameter	70 Ø
Environment	Operating temperature	0 – 50℃
	Storage temperature/humidity	-20 – 60℃ / ≤90% RH (non-condensing)

3.1.2   Tool I/O setting

1. Click [Configure] button 〉[4: Application parameters 〉 21: Collaborative robot 〉 3: 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.

- • [Voltage output]: Select one from 0 V (off), 12 V, and 24 V. The set values will be retained after the power is turned off and on.

3.2　Analog I/O

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

3.2.1　Default specifications of the analog I/O

■　Analog input

Division	Voltage	Current
No. of channels	2	
Input range	Use-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 – 125 ℃	

■　Analog output

Division	Voltage	Current
No. of channels	2	
Input range	Use-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 – 125 ℃	

3.2.2   Analog I/O setting

1.   Click **[Configure]** button 〉**[4: Application parameters 〉 21: Collaborative robot 〉 3: Collaborative robot I/O setting 〉 2: Analog I/O]** menu.

2.   Set I/O voltage, current, gain, and offset, and click the **[OK]** button.
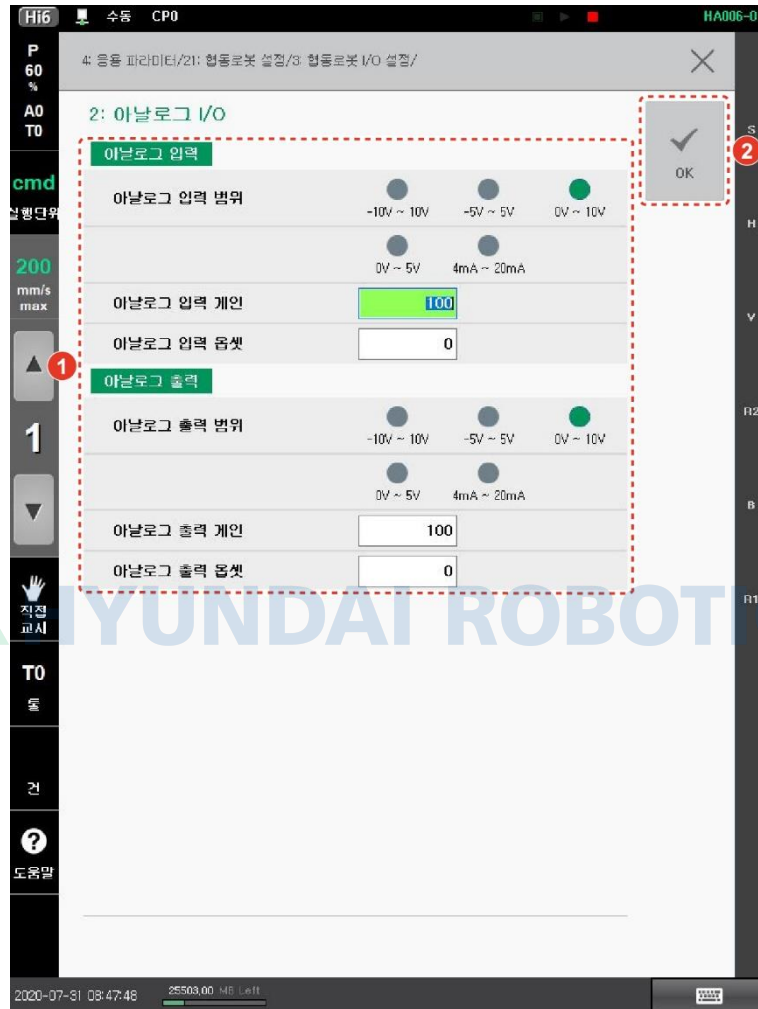
*   **[Analog I/O range]**: Select the voltage or current range of the analog I/O channel.

*   **[Analog I/O gain]**: Set analog I/O gain. (Unit: %)

*   **[Analog I/O offset]**: Set analog I/O offset. (Unit: mV or uA)

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

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 due to a failure in the 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 due to a failure in the 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 due to a failure in the 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 CPU diagnosis	Error in the CPU EFUSE	• Reboot the controller.

Code	Message	Cause	Solutions
	at the safety controller		• If the error persists, replace the safety controller board.
E7011	Error in the CPU diagnosis at 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 at the safety controller	Error in the CPU POSCON diagnosis	• Reboot the controller. • If the error persists, replace the safety controller board.
E7013	Error in the CPU diagnosis at 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 at 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 at 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 at 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 at 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	Error of invalid memory access	• Reboot the controller.

Code	Message	Cause	Solutions
	at the safety controller	by the CPU	• If the error persists, replace the safety controller board.
E7019	Error in the CPU diagnosis at 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 at 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 at 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 at 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 at the safety controller	Error of invalid peripheral access by the CPU	• Reboot the controller. • If the error persists, replace the safety controller board.
E7023	Error in the CPU diagnosis at 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 at 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	Error of invalid peripheral	• Reboot the controller.

Code	Message	Cause	Solutions
	at the safety controller	access by the CPU	• If the error persists, replace the safety controller board.
E7026	Error in the CPU diagnosis at 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 at 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 at 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 at 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 at 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 at 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 at 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	ERR_VIM_SOFTWARE_TEST	• Reboot the controller.

Code	Message	Cause	Solutions
	at the safety controller		• If the error persists, replace the safety controller board.
E7034	Error in the CPU diagnosis at 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 at 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 at 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 at 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 at 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 at 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 at 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	ERR_DCAN2_ECC_TEST_MODE	• Reboot the controller.

Code	Message	Cause	Solutions
	at the safety controller	_2BIT_FAULT_INJECT	• If the error persists, replace the safety controller board.
E7042	Error in the CPU diagnosis at 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 at 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 at the safety controller	ERR_SRAM_ECC_ERROR_FORCING_1BIT	• Reboot the controller. • If the error persists, replace the safety controller board.
E7045	Error in the CPU diagnosis at the safety controller	ERR_SRAM_ECC_ERROR_FORCING_2BIT	• Reboot the controller. • If the error persists, replace the safety controller board.
E7046	Error in the CPU diagnosis at the safety controller	ERR_ALL1PORTMEM_PBIST_EXECUTE	• Reboot the controller. • If the error persists, replace the safety controller board.
E7047	Error in the CPU diagnosis at the safety controller	ERR_ALL2PORTMEM_PBIST_EXECUTE	• Reboot the controller. • If the error persists, replace the safety controller board.
E7048	Error in the CPU diagnosis at the safety controller	ERR_ALLROMMEM_PBIST_EXECUTE	• Reboot the controller. • If the error persists, replace the safety controller board.
E7049	Error in the CPU diagnosis	ERR_CCMR5F_CPUCOMP_SELF_	• Reboot the controller.

Code	Message	Cause	Solutions
	at the safety controller	TEST	• If the error persists, replace the safety controller board.
E7050	Error in the CPU diagnosis at 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 at 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 at 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 at 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 at 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 at the safety controller	ERR_CCMR5F_PDCOMP_SELF_T EST	• Reboot the controller. • If the error persists, replace the safety controller board.
E7056	Error in the CPU diagnosis at 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	ERR_CCMR5F_PDCOMP	• Reboot the controller.

Code	Message	Cause	Solutions
	at the safety controller	_ERROR_FORCING_TEST	• If the error persists, replace the safety controller board.
E7058	Error in the CPU diagnosis at 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 at 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 at 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 at the safety controller	ERR_CCMR5F_CPUCOMP_ERROR_FORCING_TEST_FAULT_INJECT	• Reboot the controller. • If the error persists, replace the safety controller board.
E7062	Error in the CPU diagnosis at the safety controller	ERR_CCMR5F_VIMCOMP_ERROR_FORCING_TEST_FAULT_INJECT	• Reboot the controller. • If the error persists, replace the safety controller board.
E7063	Error in the CPU diagnosis at the safety controller	ERR_CCMR5F_PDCOMP_ERROR_FORCING_TEST_FAULT_INJECT	• Reboot the controller. • If the error persists, replace the safety controller board.
E7064	Error in the CPU diagnosis at the safety controller	ERR_CCMR5F_INMCOMP_ERROR_FORCING_TEST_FAULT_INJEC	• Reboot the controller. • If the error persists, replace the safety controller board.

Code	Message	Cause	Solutions
		T	
E7065	Error in the CPU diagnosis at the safety controller	Error in RAM diagnosis (ERR_RAM_MARCH_TEST)	• Reboot the controller. • If the error persists, replace the safety controller board.
E7066	Error in the CPU diagnosis at 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 safety controller board.
E7101	Error in the safety CPU (CH0) watchdog at 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 at 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.

Code	Message	Cause	Solutions
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. • 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.

Code	Message	Cause	Solutions
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 the safety controller	An error occurred during the axis 1 torque sensor diagnosis.	• Check that 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.
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 that the tool data match the actual tool. • Check the CAN communication cable between the safety controller

Code	Message	Cause	Solutions
			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 that 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 that 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 that 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.
E7120	Error (2) in the axis 6 torque sensor diagnosis by	An error occurred during the axis 6 torque sensor diagnosis.	• Check that 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.
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 at 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 3.3V power at 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

Code	Message	Cause	Solutions
			safety controller board.
E7178	Error in the 3.3V power at 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 5V power at 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 24V power at 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 48V power at the safety controller	The 48 V power of Channel 0 is below the specified value.	• Reboot the controller. • Check the 48V power of the controller.
E7182	Error in the 1.2 V power at 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 3.3V power at 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 3.3V power at 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 5V power at 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 24V power at 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

Code	Message	Cause	Solutions
			controller.
E7187	Error in the 48V power at the safety controller	The 48 V power of Channel 1 is below the specified value.	• Reboot the controller. • Check the 48V power of the controller.
E7188	Error in the 1.2 V power at 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.
E7189	Error in the 3.3V power at 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 3.3V power at 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 5V power at 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 24V power at 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 48V power at the safety controller	The 48 V power of Channel 0 is above the specified value.	• Reboot the controller. • Check the 48V power of the controller.
E7194	Error in the 1.2 V power at 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.
E7195	Error in the 3.3V power at	The 3.3 V power of Channel 1	• Reboot the controller.

Code	Message	Cause	Solutions
	the safety controller	is above the specified value.	• If the error persists, replace the safety controller board.
E7196	Error in the 3.3V power at 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 5V power at 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 24V power at 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.
E7199	Error in the 48V power at the safety controller	The 48 V power of Channel 1 is above the specified value.	• Reboot the controller. • Check the 48V power of the controller.
E7200	Safety controller failure 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 failure 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 at the safety controller	The operating sequence of the safety program at the safety controller is abnormal.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7203	Error in the program sequence diagnosis at the	The operating sequence of the safety program at the safety	• Reboot the controller.

HYUNDAI ROBOTICS

Code	Message	Cause	Solutions
	safety controller	controller is abnormal.	• If the error persists, replace the safety controller board.
E7204	Error in the program sequence diagnosis at the safety controller	The operating sequence of the safety program at the safety controller is abnormal.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7205	Error in the program sequence diagnosis at the safety controller	The operating sequence of the safety program at the safety controller is abnormal.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7206	Error in the program sequence diagnosis at the safety controller	The operating sequence of the safety program at the safety controller is abnormal.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7207	Error in the program sequence diagnosis at the safety controller	The operating sequence of the safety program at the safety controller is abnormal.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7210	Error in the inter-channel status synchronization at 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 is in a non-defined status.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7212	Error in the channels at the safety controller	The IDs of the two channels are incorrect.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7213	Inter-channel synchronization timeout at	Two channels cannot be synchronized to each other.	• Reboot the controller. • If the error persists, replace the

Code	Message	Cause	Solutions
	the safety controller		safety controller board.
E7250	Error in the inter-channel status synchronization at 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 is in a non-defined status.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7252	Error in the channels at the safety controller	The IDs of the two channels are incorrect.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7253	Inter-channel synchronization timeout at the safety controller	Two channels cannot be synchronized to each other.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7761	Error in the tool number at 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 at 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 sub-index at the safety controller	Abnormal sub-index during the initialization data extraction	• Reboot the controller. • If the error persists, replace the safety controller board.
E7303	Safety communication timeout at the safety controller	Error in the communication with the EtherCAT slave	• Reboot the controller. • Check the EtherCAT communication cable between the main computer

Code	Message	Cause	Solutions
			and the safety controller.
E7304	Error in the safety communication at the safety controller	Abnormal header information on the communication frame	• Reboot the controller. • If the error persists, replace the safety controller board.
E7305	Safety communication CRC error at the safety controller	CRC error of the communication frame	• Reboot the controller. • If the error persists, replace the safety controller board.
E7306	Safety communication sub-index error at the safety controller	The sub-index 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 at 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 at the safety controller	A wrong factor was transmitted during communication with the EtherCAT slave.	• Reboot the controller. • If the error persists, replace the safety controller board.
E7309	Error in the safety communication at 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 at 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 at 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 set safety parameter is in the specified range.

Code	Message	Cause	Solutions
E7326	Parameter range exceeded in the safety controller	The Cartesian space 1 parameter exceeded the specified range.	Check whether the set safety parameter 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 set safety parameter 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 set safety parameter is in the specified range.
E7329	Parameter range exceeded in the safety controller	The Cartesian space 4 parameter exceeded the specified range.	Check whether the set safety parameter is in the specified range.
E7330	Parameter range exceeded in the safety controller	The Cartesian space 5 parameter exceeded the specified range.	Check whether the set safety parameter 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 set safety parameter 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 set safety parameter 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 set safety parameter 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 set safety parameter is in the specified range.
E7335	Parameter range exceeded in the safety controller	The Cartesian space 10 parameter exceeded the	Check whether the set safety parameter is in the specified range.

Code	Message	Cause	Solutions
		specified range.	
E7336	Parameter range exceeded in the safety controller	The Cartesian space 11 parameter exceeded the specified range.	Check whether the set safety parameter 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 set safety parameter is in the specified range.
E7338	Failure in the parameter initialization at the safety controller	An overlapping safety parameter was received.	Reboot the controller.
E7339	Failure in the apparatus information initialization at the safety controller	An overlapping apparatus information was received from the main computer.	Reboot the controller.
E7340	Failure in the dynamic information initialization at the safety controller	An overlapping dynamic information was received from the main computer.	Reboot the controller.
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 for 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 might 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 might have been modified arbitrarily.	Set all the configurations of the collaborative robot again.
E7501	Error in the communication	Communication with the safety	Reboot the controller.

Code	Message	Cause	Solutions
	with the safety board of the collaborative robot	board of the collaborative robot is not established.	
E7601	Failure in the reading of version information on the axis 1 torque sensor at the safety controller	Failure in the reading of version information on the axis 1 torque sensor at 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 at the safety controller	Failure in the reading of version information on the axis 2 torque sensor at 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 at the safety controller	Failure in the reading of version information on the axis 3 torque sensor at 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.
E7604	Failure in the reading of version information on the axis 4 torque sensor at the safety controller	Failure in the reading of version information on the axis 4 torque sensor at 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 at the safety controller	Failure in the reading of version information on the axis 5 torque sensor at 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 at the safety controller	Failure in the reading of version information on the axis 6 torque sensor at 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 torque sensors of axes 1 through 6.
E7607	Failure in the reading of the version information on the axis 1 encoder at the safety controller	Failure in the reading of the version information on the axis 1 encoder at 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 at the safety controller	Failure in the reading of the version information on the axis 2 encoder at 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 at the safety controller	Failure in the reading of the version information on the axis 3 encoder at 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 at the safety controller	Failure in the reading of the version information on the axis 4 encoder at 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.
E7611	Failure in the reading of the version information on the axis 5 encoder at the safety controller	Failure in the reading of the version information on the axis 5 encoder at 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 at the safety	Failure in the reading of the version information on the axis 6 encoder at the safety	• Reboot the controller. • Check the CAN communication

Code	Message	Cause	Solutions
	controller	controller	• 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 at the safety controller	CAN communication timeout of the axis 1 torque sensor at the safety controller	• Reboot the controller. • Check the CAN communication cable of the robot manipulator.
E7614	Communication timeout of the axis 2 torque sensor at the safety controller	CAN communication timeout of the axis 2 torque sensor at the safety controller	• Reboot the controller. • Check the CAN communication cable of the robot manipulator.
E7615	Communication timeout of the axis 3 torque sensor at the safety controller	CAN communication timeout of the axis 3 torque sensor at the safety controller	• Reboot the controller. • Check the CAN communication cable of the robot manipulator.
E7616	Communication timeout of the axis 4 torque sensor at the safety controller	CAN communication timeout of the axis 4 torque sensor at the safety controller	• Reboot the controller. • Check the CAN communication cable of the robot manipulator.
E7617	Communication timeout of the axis 5 torque sensor at the safety controller	CAN communication timeout of the axis 5 torque sensor at the safety controller	• Reboot the controller. • Check the CAN communication cable of the robot manipulator.
E7618	Communication timeout of the axis 6 torque sensor at the safety controller	CAN communication timeout of the axis 6 torque sensor at the safety controller	• Reboot the controller. • Check the CAN communication cable of the robot manipulator.
E7619	Communication timeout of the axis 1 encoder at the safety controller	CAN communication timeout of the axis 1 encoder at the safety controller	• Reboot the controller. • Check the CAN communication cable of the robot manipulator.
E7620	Communication timeout of the axis 2 encoder at the safety controller	CAN communication timeout of the axis 2 encoder at the safety controller	• Reboot the controller. • Check the CAN communication cable of the robot manipulator.
E7621	Communication timeout of the axis 3 encoder at the	CAN communication timeout of the axis 3 encoder at the safety	• Reboot the controller.

Code	Message	Cause	Solutions
	safety controller	controller	• Check the CAN communication cable of the robot manipulator.
E7622	Communication timeout of the axis 4 encoder at the safety controller	CAN communication timeout of the axis 4 encoder at the safety controller	• Reboot the controller. • Check the CAN communication cable of the robot manipulator.
E7623	Communication timeout of the axis 5 encoder at the safety controller	CAN communication timeout of the axis 5 encoder at the safety controller	• Reboot the controller. • Check the CAN communication cable of the robot manipulator.
E7624	Communication timeout of the axis 6 encoder at the safety controller	CAN communication timeout of the axis 6 encoder at 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 criteria.	• Check the values set 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 criteria.	• Check the values set 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 criteria.	• Check the values set in the menu for setting the conditions of the safety functions. • Check the tools direction in the edited program.
E7704	Robot's power factor violation (%s [N])	The robot's power factor violated the safety criteria.	• Check the values set 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 criteria.	• Check the values set 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 safe stop violation	The robot's motion was detected in the stop mode.	Check that the brakes of the axes function normally.
E7707	A collision was detected. – SCM (%s axis)	A collision was detected at the robot.	• Identify the collision, and remove its causes. • Adjust the collision detection level.
E7708	A collision was detected at the collaborative robot. – main	A collision occurred due to an external factor.	• Identify the collision, and remove its causes. • Adjust the collision detection level.
E7711	TCP position violation of safety area (Cartesian space %s)	The TCP position exceeded a safety area.	• Move to the safety area status monitoring window. • Click the recovery mode button for changing the mode. • Move the robot to a safe space.
E7731	Axis 1 violation of safety area (%s [deg])	The position of axis 1 exceeded a set safety area.	• Move to the safety area status monitoring window. • Click the recovery mode button for changing the mode. • Move the robot to a safe space.
E7732	Axis 2 violation of safety area (%s [deg])	The position of axis 2 exceeded a set safety area.	• Move to the safety area status monitoring window. • Click the recovery mode button for changing the mode. • Move the robot to a safe space.
E7733	Axis 3 violation of safety	The position of axis 3	• Move to the safety area status

Code	Message	Cause	Solutions
	area (%s [deg])	exceeded a set safety area.	monitoring window. • Click the recovery mode button for changing the mode. • Move the robot to a safe space.
E7734	Axis 4 violation of safety area (%s [deg])	The position of axis 4 exceeded a set safety area.	• Move to the safety area status monitoring window. • Click the recovery mode button for changing the mode. • Move the robot to a safe space.
E7735	Axis 5 violation of safety area (%s [deg])	The position of axis 5 exceeded a set safety area.	• Move to the safety area status monitoring window. • Click the recovery mode button for changing the mode. • Move the robot to a safe space.
E7736	Axis 6 violation of safety area (%s [deg])	The position of axis 6 exceeded a set safety area.	• Move to the safety area status monitoring window. • Click the recovery mode button for changing the mode. • Move the robot to a safe space.
E7741	Axis 1 violation of safe speed (%s [deg/s])	The speed of axis 1 exceeded the set safety criteria.	• In the menu for setting the conditions of the safety functions, check the speeds of the axes. • Check the speeds in the edited program.
E7742	Axis 2 violation of safe speed (%s [deg/s])	The speed of axis 2 exceeded the set safety criteria.	• In the menu for setting the conditions of the safety functions, check the speeds of the axes. • Check the speeds in the edited program.
E7743	Axis 3 violation of safe	The speed of axis 3 exceeded	• In the menu for setting the

Code	Message	Cause	Solutions
	speed (%s [deg/s])	the set safety criteria.	conditions of the safety functions, check the speeds of the axes. • Check the speeds in the edited program.
E7744	Axis 4 violation of safe speed (%s [deg/s])	The speed of axis 4 exceeded the set safety criteria.	• In the menu for setting the conditions of the safety functions, check the speeds of the axes. • Check the speeds in the edited program.
E7745	Axis 5 violation of safe speed (%s [deg/s])	The speed of axis 5 exceeded the set safety criteria.	• In the menu for setting the 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 set safety criteria.	• 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 set safety criteria.	• 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 set safety criteria.	• 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.

Code	Message	Cause	Solutions
E7753	Axis 3 violation of torque (%s [Nm])	The torque of axis 3 exceeded the set safety criteria.	• 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 set safety criteria.	• 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 set safety criteria.	• 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.
E7756	Axis 6 violation of torque (%s [Nm])	The torque of axis 6 exceeded the set safety criteria.	• 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 at the safety controller	Abnormal mode switch signal input	Check the TP cable.
E7804	Error in the inter-channel communication at 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	Error in the feedback of the STO signal for servo power	• Reboot the controller.

Code	Message	Cause	Solutions
	control by the safety controller	control	• If the error persists, replace the safety controller.
E7806	Error in the TP emergency stop signal at the safety controller	Error in the emergency stop signal of the TP	Check the TP cable.
E7807	Error in the TP enabling switch signal at the safety controller	Error in the enabling switch signal of the TP	Check the TP cable.
E7808	Error in the external safeguarding signal at the safety controller	Error in the external safeguarding signal	Check the external safeguarding signal cable.
E7809	Error in the external emergency stop signal at 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 at 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 at 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 at 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 at the safety controller	Mismatch between the external safeguarding dual-channel signals	Check the external safeguarding cable.
E7815	Mismatch of the TP emergency stop signals at the safety controller	Mismatch between the TP emergency stop dual-channel signals	Check the TP cable.
E7816	Mismatch of the safety	Mismatch between the safety	Check the input signal cable.

Code	Message	Cause	Solutions
	input signals (#0) at the safety controller	input #0 dual-channel signals	
E7817	Mismatch of the safety input signals (#1) at the safety controller	Mismatch between the safety input #1 dual-channel signals	Check the input signal cable.
E7818	Mismatch of the safety input signals (#2) at the safety controller	Mismatch between the safety input #2 dual-channel signals	Check the input signal cable.
E7819	Mismatch of the safety input signals (#3) at the safety controller	Mismatch between the safety input #3 dual-channel signals	Check the input signal cable.
E7821	Error in the safety output signal setting at 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 at 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 at the safety controller	Mismatch of the usage setting of dual safety output signals	Check the output signal assignments of the safety parameters.
E7825	Error in the TP enabling signal diagnosis at 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 at 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 at 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	Failure in the high voltage	Check the TP cable.

Code	Message	Cause	Solutions
	stop signal diagnosis at the safety controller	diagnosis during the TP emergency stop signal diagnosis	
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. • If the error persists, replace the safety controller.
E7901	Error in the communication between the safety CPUs at 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 at 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 at the safety controller	Communication timeout between the safety CPUs at the safety controller	• Reboot the controller. • If the error persists, replace the safety controller.
E7904	Error in the communication between the safety CPUs at the safety controller	Error in the communication TX between the safety CPUs at the safety controller	• Reboot the controller. • If the error persists, replace the safety controller.
E7905	Error in the communication between the safety CPUs at the safety controller	Error in the communication TX between the safety CPUs at the safety controller	• Reboot the controller. • If the error persists, replace the safety controller.

Warranty

Hyundai Robotics (hereinafter, "We"), provides warranty for raw materials defects and manufacturing defects of this product according to the details specified in the Warranty Statement for protecting benefits of the customers who purchase robot systems manufactured by us and sold by us or 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 materials and manufacturing defects.

The only responsibilities of ours and the only remedial measures relating to any of our products will be limited to 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 loss of income, loss of use, loss of production, or damages of other products or equipment due to defects of our products.

■ Warranty period

We provide one-year warranty for product quality beginning on the date on which our product is delivered to a site after the customer purchase 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) does not match each other, the delivery date will be the beginning date of 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 warranty valid, the customer should comply with the maintenance procedure specified by us, and keep the relevant records. When we decide as follows because the customer does not comply with the maintenance procedure, the warranty will be void.

- Product faults and damages due to customer's carelessness, unskillful operation, erroneous or arbitrary modification, disassembly, and repairing

- Product faults and damages due to the installation and use of parts, consumables, software, etc. that are not authorized by us

- Product faults and damages due to non-compliance with the instructions and precautions specified in the product manual

- Product faults and damages due to its use for purposes other than its intended purposes

- Product faults and damages due to use of the product at inadequate environments, or dropping or giving impact to the product.

- Product faults and damages due to arbitrary installation, repair, or maintenance carried out by persons (customers, unauthorized persons, or non-licensed maintenance workers, etc.) 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 due to 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 responsibilities for any defects of products, functionality, and performance that are beyond the scope specified in the warranty statement.

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 queries about products or services, please contact our Customer Support Team

HYUNDAI ROBOTICS