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Warning

All installation works must be performed by a qualified installer and must comply with applicable laws and regulations.

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Hyundai Robot

Hi6-T230901CMEN6

Hi6-T Controller Maintenance Manual

- Hi6-T15

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Overview

The main purpose of this chapter is to describe the matters about the safety for the users of the industrial robot and for the workers who maintain and operate the robot.
Every worker who installs, replaces, adjusts, operate, preserves and maintains the robot system must carefully read and fully understand the operation manual and maintenance manual. Also, keep the manuals nearby so that you can view it whenever necessary.

Our company plans and implements the preservation, maintenance and operation trainings so the person using the robot should ensure that the workers working in the robot system should receive the relevant trainings. It must be ensured that only those who have completed this course can handle the robot.

The users of our industrial robots are responsible for surely understanding and complying with safety-related laws applicable in concerned countries and for properly designing, installing, and operating safety devices to protect workers working in robot systems.
The dangerous areas of the robot system, in other words, the areas where the robot, tools and peripheral devices are operating, should be equipped with safety devices according to ANSI / RIA R15.06-2012 to prevent an object, other than the workers and the workpiece, from entering the dangerous areas. The robot system should be configured in a way that it can be stopped immediately by an emergency stop device when a worker or object needs to enter the dangerous area in spite of possible danger. The workers are responsible for installing, checking and operating these safety devices.

This manual has been created based on standard specifications, so some contents may differ depending on the options and model of the product that you have purchased. In addition, the contents and specifications of this manual are subject to change without prior notice to improve the performance of the product, and Hyundai Robotics is not responsible for situations that could be caused by inaccuracies or typos in the manual. For detailed information on the revision of the manual, you need to visit our internet website (www.hyundai-robotics.com).

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Safety Cautions

Before using the product, you must fully understand the following safety cautions for proper use, user safety, and prevention of property damage

■ Danger

⚠ Danger	Imminent danger: Incompliance may cause the death of or serious injuries to the worker.

- Make sure that the safety circuit is never ignored, modified or altered in any way.
- Considering that additional problems may occur due to gravity or brake release, you must take a measure, before carrying out works, such as using a rope and crane that are to be used for transport of individual robots to prevent the brake from running down or additional accidents from taking place during the release of the brake.

■ Warning

⚠ Warning	Potential danger: Incompliance may cause injuries to the worker or damage to property, such as significant damage to the product.

- Any act of damaging the safety labels, such as relocating the name plates, warning markings, safety symbols, name markings and wire markings or painting over them or blocking them with a cover is prohibited.
- When the robot is operating, there is a risk of collision between the robot and the worker. Therefore, install a safety fence to prevent the worker from getting close to the robot.
- The robot should be installed and operated according to the guidelines of ISO 10218-2. In addition, it is required to comply with the relevant requirements of international standards and national laws. Our company (or the manufacturer) will not be responsible for any accidents that occur due to not complying with the relevant requirements of international standards and national laws or due to not reviewing the “risk assessment”.
- Must observe the safety work procedures to prevent safety accidents. Do not change or ignore safety devices or circuits under any circumstances, and pay attention to possible electric shock. In auto mode, all normal works should be performed outside the safety guard. Before carrying out works, make sure that there are no people in the operation area of the robot.
- Sufficiently check under your feet when teaching. In particular, you must perform the teaching work outside the safety guard when teaching at a high speed (250mm/s or above).
- When it comes to changing of components or addition of optional equipment (both hardware and software) to the robot both of which may affect safety-related functions, you must check whether the functions are in normal conditions, by paying attention to the items described in “1.11 Safety Works When Operating the Robot”.

- When installing and operating an end effector, you must perform application, maintenance and operation according to ISO/TR 20218-1:2018.
- When transporting the product by using lifting equipment, you should comply with the relevant national and local safety regulations and equipment usage guidelines. When moving the product using a crane, you must make sure that that no workers are under the product. Also, never work or walk under a crane or the product.
- If a general safety guard is to be installed and used, the robot should be operated after confirming that the emergency stop operates normally. Also, check if the emergency stop input is disabled. This is an essential measure that must be taken in advance for the safety of workers.
- If an automatic safety guard is to be installed and used, the robot should be operated after confirming that the emergency stop operates normally. Also, check if the emergency stop input is disabled. . This is an essential measure that must be taken in advance for the safety of workers.
- If a safety input is to be installed and used, the robot should be operated after confirming that the input function operates normally. This is an essential measure that must be taken in advance for the safety of workers.
- The robot should be installed and operated according to the guidelines of ISO 10218-2. In addition, it is required to comply with the relevant requirements of international standards and national laws.

  Our company (or the manufacturer) will not be responsible for any accidents that occur due to not complying with the relevant requirements of international standards and national laws or due to not following the above “caution”.
- If a safety-related input is installed and enabled, you must check whether the function operates normally by referring to “1.11 Safety Measures When Operating the Robot”.
- If an emergency stop output is to be installed and used, the robot should be operated after confirming that the emergency stop output operates normally. This is an essential measure that must be taken in advance for the safety of workers.

■ Caution

⚠ Caution	Low-level danger factor: Incompliance may result in minor injury to the worker or damage to property, such as damage to the product.

- Mark the installation and dangerous areas of the robot in a way that they can be clearly differentiated from other facilities and devices in terms of type, color and style.
- As the emergency stop function immediately cuts off the motor power, so reckless use of the function may result in accumulation of fatigue that affects the durability of the robot. The function must be used only in emergency situations.
- Our company is not responsible if the jogging operation does not work due to the failure of the hardware limit switch. You must check it periodically. For the measure to take in case of a failure, please refer to the troubleshooting manual.

- You should not be negligent in paying attention to sudden movements while entry is made possible. Under any circumstances, you must avoid approaching the robot without preparing for possible emergency situation.
- In the case of trial-operation, there may be a design error, teaching error, or defect in manufacturing with regard to the entire system including the teaching program, jigs, and sequencing. For this reason, you should work with elevated safety awareness in trial-operation. Multiple factors can contribute to safety accidents. Observe the following measures considering that safety is very important when trial-operating the robot.
- During maintenance and inspection of the manipulator, the robot arm may fall, or there could be a different type of danger. So, you must proceed with the work according to the instructed procedures
- When moving the axis of the robot that has no driving force applied, there is a risk of the axis dropping due to gravity and also an additional risk due to the release of the brake system. So, you must proceed with the work according to the instructed procedures.
- Before turning on the power, check that there is no worker inside the robot operation area and you are in a safe place.
- Before installing the product, you must perform a sufficient risk assessment and then set the safety functions based on the assessment results. For details on safety functions, refer to “1. Safety” section.
- When installing and repairing the product, contact the customer support team and ask an expert.
- Do not install and use the product in an area that has lots of dust or is dirty. Dust or foreign substances may cause product failure or performance problems.
- Mark the installation and dangerous areas of the robot in a way that they can be clearly differentiated from other facilities and devices in terms of type, color and style.
- If the product is not installed in the recommended locations, the performance and service life of the product may be reduced. Install and use the product according to the recommendations.
- 1. Before connecting the cables, turn “off” the controller's main power switch and then lock it by using a padlock.

  2. The controller has DC400V charged energy. Be careful. Wait at least 5 minutes after turning “off” the power switch, and then wait 5 minutes at least to discharge the charged energy.

  3. When handling the PCB, take precautions not to allow static electricity to damage it

  4. Wiring and connection of wires must be performed by qualified personnel.
- Since the contact part of the connector for each robot may be different from the figure above, you must read the relevant robot maintenance manual carefully before connecting the wire harness.

- 1. When performing the wiring work for the controller and manipulator, separate the signal line and the power line. In addition, use a separate duct for the high power line and the signal line respectively.

  2. Use a protective cover for the wiring, as a measure to prevent the wiring from getting damaged when people are passing nearby.

  3. Before supplying the primary power, you must check again the relationship with regard to connection, the power specification and power supply specification of the controller.
- The person in charge of maintenance should work after understanding the placement of various devices and parts and their functions inside the controller.
- The DIP switch is set to OFF mode when shipped from the factory, and the setting should not be changed arbitrarily by the user.
- The user cannot change the following items arbitrarily, and needs to refer to them only when required to reprogram through FPGA JTAG.
- The drive module differs depending on the type of the robot, so you must check the type when replacing it.
- 1. Do not release more than two axes at the same time.
- 2. Must keep a safe distance from the robot first before using the brake release unit.
- 3. Use the brake release unit after preparing for the dropping of the robot's axis by using equipment such as a crane.

  4. Check the safety matters while working in a group of at least 2 people.
- When using the brake release unit, follow the procedures below.

  1. Turn off the AC220V power switch and check that the DC24V power switch is turned off.

  2. Connect the AC power cable to the AC power connector.

  3. Turn on the AC220V power switch.

  4. Turn on the DC24V power switch.

  - When the use of the brake release unit is finished, follow the procedures below.

  1. Turn off the DC24V power switch.

  2. Turn off the AC220V power switch.

  3. Disconnect the AC power cable.

  - Do not use AC220V power and DC24V battery power at the same time.
- Fieldbus communication must be available to use commercial remote IO. Therefore, you should configure the PCI communication card together by referring to the Paragraph 5.1 mentioned above.

- The drive unit differs depending on the type of the robot, so you must check the type when replacing the drive unit.
- When transporting the product, you should maintain a proper posture and work in a group of at least two workers. Otherwise, injury to parts of the body such as the back, arms and legs may result.
- If you transport the product by using lifting equipment, you should comply with relevant national and local safety regulations and equipment usage guidelines.
- When transporting the product, you should fully understand the transport-related contents in the manual and follow the instructions. Our company will not be responsible for any damage to or breaking of the product due to the customer's transport of the product.
- These are important parts to be prepared for daily maintenance and inspection.
- These are maintenance parts to be prepared when multiple units are purchased.

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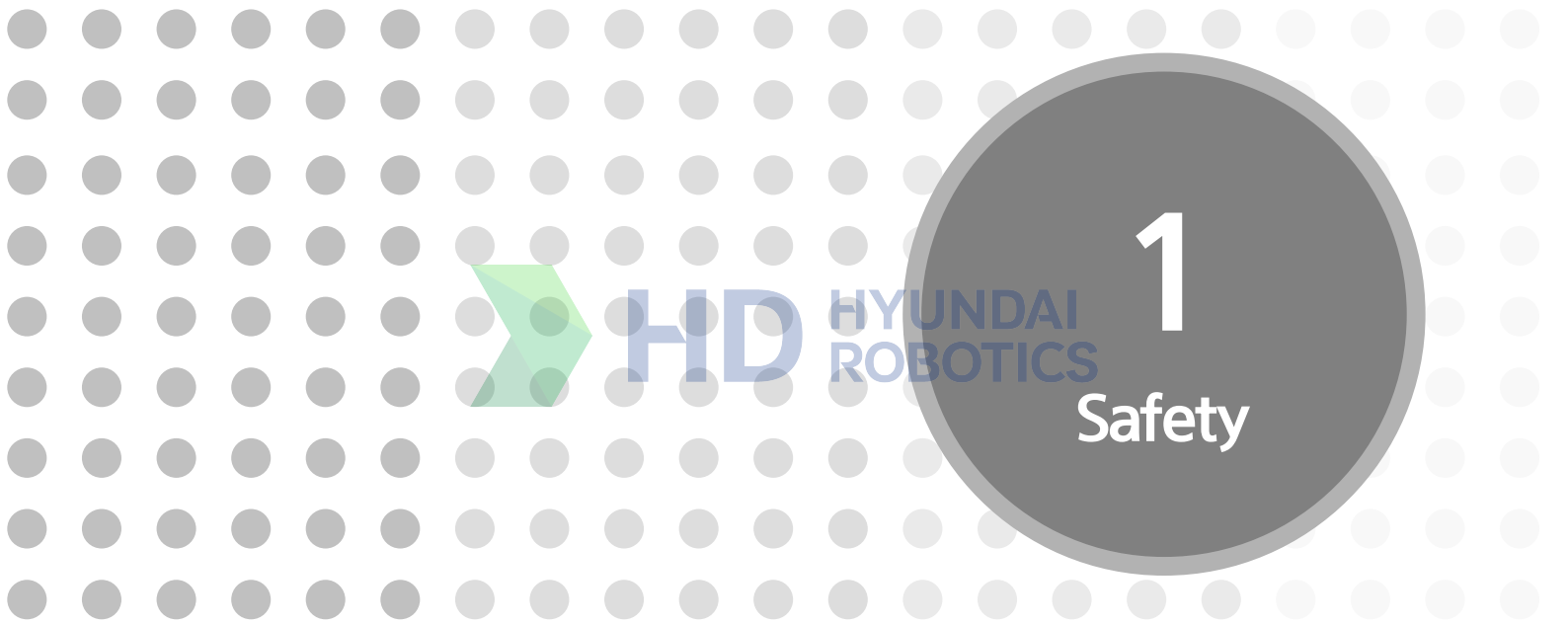


1 Safety

1.1. Applicable Standards

The safety standards applied to the product are as follows.

- ANSI/RIA/ISO 10218-1:2011 Robots and robotic devices - Safety requirements for industrial robots - Part 1: Robots
- ANSI/RIA R15.06-2012 - Industrial Robots and Robot Systems - Safety Requirements
- ISO 10218-2:2011 Robots and robotic devices - Safety requirements for industrial robots - Part 2: Robot systems and integration
- IEC 61508-1:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements
- IEC 61508-2:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
- IEC 61508-3:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 3: Software requirements
- IEC 61508-4:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 4: Definitions and abbreviations
- IEC 61508-5:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 5: Examples of methods for the determination of safety integrity levels
- IEC 61508-6:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3
- IEC 61508-7:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 7: Overview of techniques and measures
- IEC 61800-5-1:2007/A1:2017 Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy
- IEC 61800-5-2:2015 Adjustable speed electrical power drive systems - Part 2: General requirements - Rating specifications for low voltage adjustable speed a.c. power drive systems
- ISO 13849-1:2015 Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design
- ISO 13849-2:2012 Safety of machinery - Safety-related parts of control systems - Part 2: Validation
- IEC 62061:2005/A2:2015 Safety of machinery. Functional safety of safety-related electrical, electronic and programmable electronic control systems
- IEC 61800-3:2017 Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods

- IEC 61000-6-7:2014 Electromagnetic compatibility (EMC) - Part 6-7: Generic standards - Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations
- IEC 61326-3-1:2017 Electrical equipment for measurement, control and laboratory use. EMC requirements. Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - General industrial applications
- IEC 60204-1:2016 Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- ISO 11161:2007 Safety of machinery - Integrated manufacturing systems - Basic requirements

1.2. Safety Performance

The performance of the industrial robot's safety modules is as follows.

Table 1-1 Safety Performance of Safety Modules

Item	Safety performance	Applicable standards
HFT	1	IEC 61508/62061/61800-5-2
SIL (Safety Integrity Level)	2	
Category	3	ISO 13849-1
PL (Performance Level)	d	

1.3. Safety Trainings

In order to use the functions of the product effectively, you must fully understand the contents of the manual and then install, use and maintain the product properly. The users of the product are responsible for fully understanding and complying with robot-related safety laws in the area where the robot is installed and used, and also responsible for properly designing, installing, and operating safety devices to ensure the safety of users working in the robot system.

- All the workers who install, use, and maintain the robot system must read the manual carefully and understand the contents completely. In particular, they must fully understand the safety cautions.
- Our company plans and implements the trainings for the installation, use and maintenance of the product. So, the product users and the workers must complete relevant training courses before using the product.
- The workers responsible for teaching and inspecting the robot must complete the robot use and safety trainings before using the robot. The contents covered in the safety training courses include the following items.
    - The concept of safety. and the purpose and function of the safety devices
    - Procedures for safe handling of the robot
    - Performance and potential danger of the robot and robotic system
    - Items including the works related to specific applications of the robot

1.4. Risk Assessment

When it comes to configuring an integrated system including a robot, risk assessment is one of the most critical factors that are handled as legal requirements in most countries. A risk assessment of an integrated system cannot be performed only on a single robot because the safety assessment for the installation of the will differ depending on how the robot is integrated into the system.

The system administrator should configure and operate the system according to the guidelines of ISO 12100 and ISO 10218-2 to conduct a risk assessment.

You should conduct the risk assessment by taking into account the entire process of an integrated system including the robot. The main objectives of the risk assessment are as follows.

- Basic settings for the use of the robot, and teaching of the robot
- Trouble diagnosis, and maintenance
- Normal operation of the installed robot

After installing the robot and configuring the system, you must conduct a risk assessment. The risk assessment mainly determines the appropriateness of safety devices in the robot integrated system, as well as the necessity for additional emergency stop devices and other safety devices. It is very important to know the appropriate safety devices and properly configure the robot integrated system. You should configure the integrated system by referring to the relevant information in the manual. For details on configuring the safety functions, refer to “1.8. Safety Functions”. In addition, when installing the robot in a specific location or configuring safety-related functions by using the safety I/O, the important items in the risk assessment of an integrated robot system are as follows.

- Severity
- Frequency of exposure to risks
- Possible occurrence
- Possible avoidance

In the process of configuring an integrated system, if the safety-related functions of the robot do not sufficiently eliminate the risk factors, it is possible to check the necessity for additional protective devices during the risk assessment.

1.5. Potential Risks

If the results of the risk assessment of an integrated system linked to the robot reveal that the risk factors have not been sufficiently removed only with the safety-related functions of the robot, additional protective measures must be taken.

The items to take into consideration when establishing additional protective measures is as follows.

- During installation, fingers can be pinched (caught) between the robot base and the mounting table.
- Injuries (puncture wound, penetrating injury, etc.) from sharp edges or pointed parts of obstacles or tools in the operation area.
- Injuries (bruise, falling over, fracture, etc.) due to collision with the robot
- Injuries caused (puncture wound, penetrating injury, fracture, etc.) due to obstacles around the robot
- Injuries that may occur because the fastening part is not completely fixed
- Injuries (skin damage, shortness of breath, etc.) that may occur when working with toxic and hazardous substances
- Separation of a workpiece from the tool due to sudden power failure
- A mistake caused by confusing with the emergency stop switch of other equipment
- Errors due to arbitrary change of the setting of safety-related functions.

The type of risk that may occur depends on the system configuration, so you must conduct the risk assessment before using the integrated system.

1.6. Effectiveness and Responsibility

It is required to observe the safety requirements according to the safety regulations and laws of the countries and regions where the robot is installed and used. Suppliers and users of the robot integrated systems have a variety of responsibilities, including the following items.

- Risk assessment of the robot integrated system
- Addition and removal of safety devices according to the risk assessment results
- Check whether the integrated system is configured, installed and set up correctly.
- Establishment of the methods and guidelines to use the integrated system, and trainings for the users
- Management of safety devices (Prohibition of user's arbitrary change and manipulation of safety devices)

- Provision of important information, as well as contact information, related to the use and safety of the product
- Provision of all kinds of technical documents including manuals

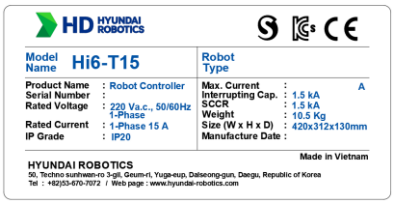
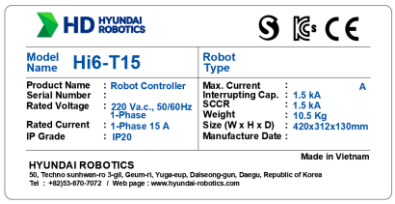
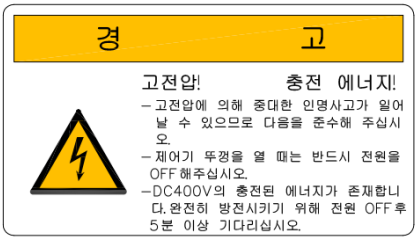
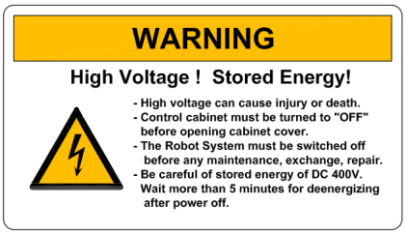
The safety information in this manual does not cover all risk factors and situations that may arise while using the product.

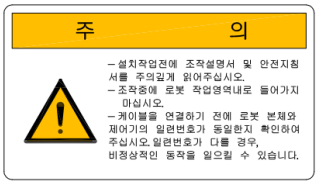
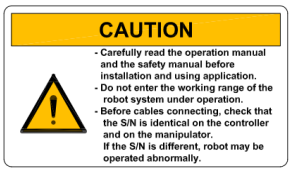
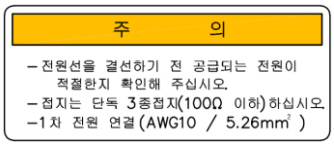
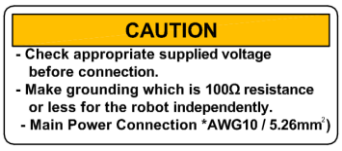
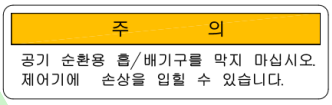
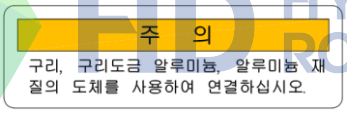
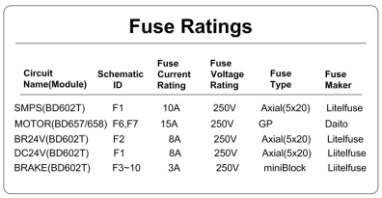
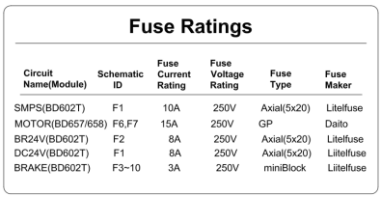
1.7. Safety Labels

Name plates, warning markings, safety symbols, etc. are attached on the inside and outside of the controller. Any act of damaging the safety labels, such as relocating the name plates, warning markings, safety symbols, name markings and wire markings or painting over them or blocking them with a cover is prohibited. Mark the installation and dangerous areas of the robot in a way that they can be differentiated from other facilities and devices in terms of type, color and style.

Figure 1.1 Safety Labels

Table 1-2 Safety Labels

No.	Item	Korean	English
1	Nameplate		
2	NRTL Certification mark		
3	High voltage Warning		
4	High voltage Indication		

No.	Item	Korean	English
5	Input power Indication	AC220 VOLTS	AC220 VOLTS
6	Installation precautions		
7	Caution for Power and Grounding		
8	Air circulation of ventiduct precautions		
9	Ground wire connection precautions		
10	Ground mark		
11	Fuse Specifications		

⚠ Warning	Any act of damaging the safety labels, such as relocating the name plates, warning markings, safety symbols, name markings and wire markings or painting over them or blocking them with a cover is prohibited.
⚠ Caution	Mark the installation and dangerous areas of the robot in a way that they can be differentiated from other facilities and devices in terms of type, color and style.

1.8. Safety Functions

The safety system of the robot is designed in dual configuration (HFT=1) to satisfy the safety performance (PL) = d Cat3 of [ISO13849-1:2015] and the safety integrity level (SIL) 2 of [IEC62061:2005], and continuously monitors the status of safety related devices. When an error is detected by self-diagnosis, or a safety related signal is inputted, the safety functions will stop the robot according to the classification of stop situations determined based on the risk assessment. Also, when any of the dual switches of the safety circuit is activated, the motor drive power and brake drive power will be cut off by the safety functions to secure a safe state. Information on the relevant status can be checked through the Teach pendant.

⚠ Danger	Make sure that the safety circuit is never ignored, modified or altered in any way.

The safety-related main functions of the robot are as follows.

1.8.1. Main Safety Functions

- Emergency stop (IEC 60204-1,10,7)

There is one emergency stop button on the controller and teach pendant respectively. It is possible to connect, if necessary, an additional emergency button to the safety chain circuit of the robot. The emergency stop function is to be applied with higher priority over all other control functions of the robot. The function will immediately cut off the power supply to the motors of individual axes of the robot, stopping the robot and making it impossible to use safety related functions controlled by the robot.

⚠ Caution	As the emergency stop function immediately cuts off the motor power, so reckless use of the function may result in accumulation of fatigue that affects the durability of the robot. The function must be used only in emergency situations.

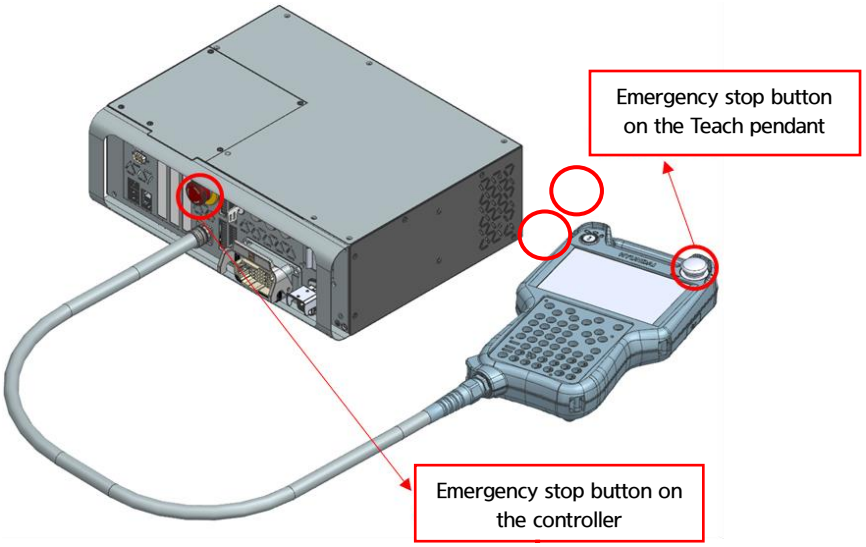


Figure 1.2 Emergency Stop Buttons on the Controller and Teach Pendant

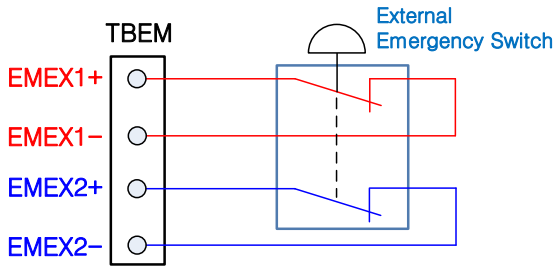


Figure 1.3 Connection of an Additional Emergency Stop Device

- Protective stop (ISO 10218-1:2011)

The robot should have multiple safety inputs so that it can be used in connection with external safety devices such as safety guards, safety pads, and safety lamps. These safety inputs will make the robot stop when there is an input from the robot itself and peripheral facilities, securing a safe state. For details on the connection to the safety inputs, refer to “4.3.2. Safety Module (BD630/BD631)”.

- Speed limit (EN ISO 10218-1:2011)

In manual operation mode, the speed of the robot is limited to a maximum of 250 mm / s. The speed limit applies not only to the TCP (Tool Center Point) but also to all other parts of the robot that are to be operated in manual mode. It should be also made possible to monitor the speed of the equipment mounted on the robot.

- Operation area limit (ANSI/RIA R15.06-2012)

When applying a robot, in order to secure a sufficient safety area, the operation range of the robot can be limited by using a hardware limit or a stopper. This function can minimize the damage if the robot collides with an external safety device such as a safety guard. Axis 1, 2, and 3 are mainly limited by a stopper or hardware limit. If the operation range is changed due to a mechanical stopper or hardware limit, the operation range limit parameter should be also changed in software as well. Please refer to the operation manual about the change. The operation area limit of each axis can be changed by the user, and at the time of shipment, it is set to the maximum operation range of the robot. The safety system of the Hi6 controller can support up to 4 hardware limit switches as an option. Refer to “4.3.2. Please refer to “Safety Module (BD630/BD631)” for the matters related to the connection.

- Operation mode selection (ANSI/RIA R15.06-2012)

You can operate the robot in manual, automatic or remote mode. The maximum speed in manual mode is limited to 250 mm/s, and you can perform operation only with the teach pendant. In addition, it is possible to mount a mode switch additionally on the control panel by configuring it as an option. For details on the operation, please refer to the operation manual.

1.8.2. Other Related Functions

Required to fully understand the following items and take actions if a person is pinched due to an accident caused by the arm of the robot.

- Release of the manual brake

⚠ Danger	Considering that additional problems may occur due to gravity or brake release, you must take a measure, before carrying out works, such as using a rope and crane that are to used for transportation of individual robots to prevent the brake from running down or additional accidents from taking place during the release of the brake.

- ■ After removing power from the controller, connect the brake release unit to the designated connector of the robot or the internal board connector of the controller and then release the manual brake for each axis as needed.
- ■ Refer to the maintenance manual of each robot for the information on individual axes of each robot, and for the designated transport equipment (ex: rope, crane) for each robot.

When the robot is stopped by the limit switch, it is possible to change the position by jogging the robot with the Teach pendant in the constant setting mode. After designating the soft limit according to the site situation, make sure that it is installed by a trained worker.

⚠ Caution	Our company is not responsible if the jogging operation does not work due to the failure of the hardware limit switch. You must check it periodically. For the measure to take in case of a failure, please refer to the troubleshooting manual.

1.9. Stop

The safety system of Hi6-T15 controller can handle the stop operation as shown below. Safety inputs can be classified as follows according to the stop classification criteria specified in IEC 60204-1.

- Stop classification Stopping (uncontrolled stopping) occurs as the power to the machine actuator is immediately removed.

  ➔ Emergency stop button

- Stop classification 1: Controlled stop in which the machine actuator still has a power that can be used to achieve the stopping. The power will be removed when the stopping is achieved.

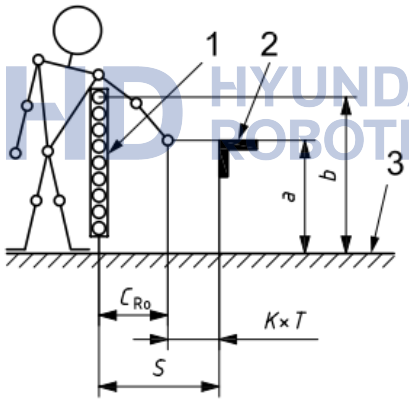
  ➔ Safety inputs except for the emergency stop button

1.10. Safety Measures When Installing

1.10.1. Installing the Safety Guard

⚠ Warning	**When the robot is operating, there is a risk of collision between the robot and the worker. Therefore, install a safety fence to prevent a worker from getting close to the robot.**

When the robot is operating, there is a risk of collision between the robot and the worker. Therefore, install a safety fence to prevent a worker from getting close to the robot according to ISO 13855:2010. Configure the system to ensure that the robot stops when a worker opens the door of the safety fence and approaches the facility, during the robot operation, for any reason, such as inspecting the robot or a welding fixture, performing tip dressing or tip changing, etc.



Key

1	electro-sensitive protective equipment
2	hazard zone
3	reference plane
a	height of the hazard zone
b	height of the upper edge of the detection zone of electro-sensitive protective equipment
C_{RO}	additional distance which a part of the body can be moving towards the hazard zone prior to the actuation of the safeguard (see values in Table 1)
S	minimum distance for reaching over

Figure 1.4 Connection of the Safety Fence

Source: ISO 13855:2010 Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body

Table 1-3 Installation Standards of the Safety Fence

Height of hazard zone *a*	Height of upper edge of the detection zone of the electro-sensitive protective equipment *b*											
	900	1 000	1 100	1 200	1 300	1 400	1 600	1 800	2 000	2 200	2 400	2 600
	Additional distance to hazard zone C_{RO}											
2 600[a]	0	0	0	0	0	0	0	0	0	0	0	0
2 500	400	400	350	300	300	300	300	300	250	150	100	0
2 400	550	550	550	500	450	450	400	400	300	250	100	0
2 200	800	750	750	700	650	650	600	550	400	250	0	0
2 000	950	950	850	850	800	750	700	550	400	0	0	0
1 800	1 100	1 100	950	950	850	800	750	550	0	0	0	0
1 600	1 150	1 150	1 100	1 000	900	850	750	450	0	0	0	0
1 400	1 200	1 200	1 100	1 000	900	850	650	0	0	0	0	0
1 200	1 200	1 200	1 100	1 000	850	800	0	0	0	0	0	0
1 000	1 200	1 150	1 050	950	750	700	0	0	0	0	0	0
800	1 150	1 050	950	800	500	450	0	0	0	0	0	0
600	1 050	950	750	550	0	0	0	0	0	0	0	0
400	900	700	0	0	0	0	0	0	0	0	0	0
200	600	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0

When a value of zero is given, the calculation of the minimum distance, S, should be made in accordance with 6.2 to 6.4.

NOTE 1 Electro-sensitive protective equipment with a height of the

— upper edge of the detection zone below 900 mm is not included since they do not offer sufficient protection against circumventing or stepping over

— lower edge of the detection zone above 300 mm in relation to the reference plane does not offer sufficient protection against crawling below.

NOTE 2 The data for this table were researched at a study of the German BG, see [22].

NOTE 3 Most values given in Table 1 are lower in relation to the values of ISO 13857:2008, Tables 1 and 2, since parts of the body cannot support themselves on safeguards in case of reaching over.

[a] Approach to the hazard zone by reaching over is impossible.

Source: ISO 13855:2010 Safety of machinery - Positioning of safeguards with respect to the approach speeds of parts of the human body

- The safety fence should cover the operation area of the robot, and should secure enough space so that there is no interference when the worker carries out works, such as teaching, maintenance, etc. The safety fence should be made solid to prevent it from being moved easily and should be structured in a way not to allow people to enter inside the fence by going over the safety fence.
- In principle, it is required to install and use a fixed type safety fence that does not have dangerous parts such as uneven or sharp parts.
- An entrance door should be installed to allow people to enter inside the safety fence, and a safety plug must be installed on the door in a way that the door should not open unless the plug is removed.

In addition, wiring should be configured in a way that allows the motor to be turned off and the brake to be in hold state when the safety plug is removed or the safety fence is opened.

- If you want to operate the robot even when the safety plug is removed, wiring should be configured in a way that allows the robot to play back at low speed.
- Install the emergency stop button of the robot at a location where the operator can quickly press it.
- If a safety fence is not to be installed, safety devices such as photoelectric switches and mat switches should be installed covering the entire area that falls within the specification of the safety guard range of the robot, as substitute devices for the safety fence, making it possible for the robot to stop automatically when a person enters inside the safety fence.
- Make sure that the robot's operation area (danger area) can be identified in some way, such as painting the floor.

1.10.2. Placement of the Robot and Peripheral Devices

⚠ Warning	The robot should be installed and operated according to the guidelines of ISO 10218-2. In addition, it is required to comply with the relevant requirements of international standards and national laws. Our company (or the manufacturer) will not be responsible for any accidents that occur due to not complying with the relevant requirements of international standards and national laws or due to not reviewing the "**risk assessment**".

Installation of the product should be performed by a qualified installer according to relevant national and local regulations and laws.

- When unpacking the product, check it for damage that may occur while transporting or unpack it.
- Before installing the product after unpacking it, you must check the safety regulations, instructions, information related to the product installation and use environments, and fully understand the installation methods.
- When connecting the primary power of the controller or peripheral device, perform the connection after checking first whether the supply side power is turned off. Since high voltage is used as the primary power source, there is a risk of electric shock.
- Put up a sign "No entry during operation" at the entrance of the safety fence, and inform the workers of the intents.
- Place the controller, interlock panels, and other control panels in a way that they can be operated from outside the safety fence.
- When installing the operation stand, attach an emergency stop button to it also. Wherever you operate the robot, you should be able to stop the robot in an emergency situation.

- Do not allow the wiring or piping of the manipulator, controller, interlock panel, timer, etc. to get caught on by the workers' feet or to get stepped on directly by the forklift. Otherwise, there is a risk of accidents of the worker getting electric shock or the wires getting disconnected.
- Place the controller, interlock panel, and operation stand at a place where the operation of the manipulator can be seen sufficiently. If the robot is operating abnormally in an area from which the robot operation cannot be seen, or the worker is working on something in the area, there is a risk of major accidents taking place during operation.
- If the required robot operation area is narrower than the allowable robot operation area, you should limit the robot operation area. It can be limited by soft limit, hardware limit, mechanical stopper, etc. Even when the robot operates off the normal operation area due to abnormal operation such as mistakes in the operation of the robot, the robot will be stopped in advance by the operation area limit function.
- During welding, spatter may fall on or fall near the worker and cause a burn or fire. Install a light shield plate, cover, etc. in the range where the movement of the manipulator can be seen sufficiently.
- When it comes to a device that shows the auto and manual operation modes of the robot, an easily visible device should be installed to ensure that the status can be recognized from a distance. In case of starting the operation in auto mode, a buzzer or an alarm will be useful.
- Make sure there is no protruding part on the peripheral devices of the robot. If necessary, place a cover on them. Otherwise, in general, an accident could occur when the worker comes into contact with a protruding part, and a major accident could occur when a worker surprised over a sudden movement of the robot could fall over.
- Do not design a system that requires the worker to put in hands inside the safety fence to carry in and carry out a workpiece.

Placement of the Peripheral Devices and Workers for the Industrial Robot

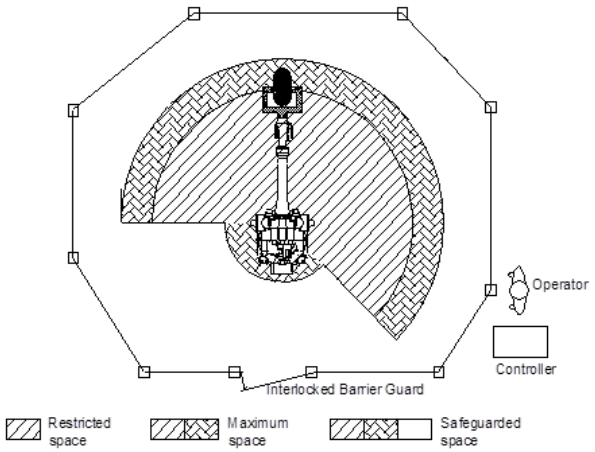


Figure 1.5 Cylinder Type Safety Fence for the Industrial Robot

1.10.3. Installation of the Robot

⚠ Warning	The robot should be installed and operated according to the guidelines of ISO 10218-2. In addition, it is required to comply with the relevant requirements of international standards and national laws. Our company (or the manufacturer) will not be responsible for any accidents that occur due to not complying with the relevant requirements of international standards and national laws or due to not reviewing the "**risk assessment**".

Installation of the product should be performed by a qualified installer according to relevant national and local regulations and laws.

- When unpacking the product, check it for damage that may occur while transporting or unpacking it.
- Before installing the product after unpacking it, you must check the safety regulations, instructions, information related to the product installation and use environments, and fully understand the installation methods.
- The worker who uses the robot should fully understand the contents described in the application and auxiliary manuals, and operate and handle the industrial robot skillfully.
- The worker who installs the robot should be able to apply the safety instructions during the installation if there is a problem.
- The system supplier should guarantee that all circuits used for safety functions perform their functions surely.
- The main power supply to the robot should be installed in a way that it can be cut off from outside the robot operation area.
- The system supplier should surely guarantee that all circuits used for safety functions perform their functions safely.
- The emergency stop button should be located at a place where the worker can easily approach it when required to stop the robot urgently.
- By taking into consideration the dimensions of the manipulator and the operation range, make sure that that there is no interference with peripheral devices.
- Avoid installing the robot in a place that is exposed to direct sunlight, has high level of humidity, has oil or chemicals around and has lots of metal powder or explosive gas in the air.
- Install the robot in an area where the ambient temperature is 0 - 45 ℃.
- Secure enough space for disassembling and inspecting the robot easily.
- Install a safety fence and prevent people from entering the robot operation range.
- Make sure there is no obstacle in the robot operation area.

- When installing the robot in an area exposed to direct sunlight or near a heating element, you should take measures in consideration of the thermodynamic state of the controller.
- Take additional measures when installing the robot in an area that has lots of dust such as metal powder in the air.
- Carry out installation in a way that welding current never flows to the robot. In other words, there should be insulation between the spot gun and the wrist of the robot.
- Since grounding is important for preventing a malfunction due to noise and an electric shock, you should install the robot as shown below.
    - Install the dedicated grounding terminal while setting it as Type 3 Grounding higher.
    - Connect the grounding wire to the grounding bus bar inside the control panel.
    - When the manipulator is installed, if it is directly grounded to the floor by an anchor, etc., the controller side and the manipulator side will make a two-point grounding, forming a closed circuit, which conversely may cause malfunctioning due to some reasons such as noise. In this case, connect the grounding wire to the base part of the manipulator, but not to the controller side. In addition, if there is shaking when the robot stops, there is a high possibility that the grounding is incomplete or there is a closed circuit. It is required to check the grounding again.
    - If you use a gun with an embedded transformer, there is a risk of dropping because the primary power cable is connected directly to the spot gun. In this case, in order to protect the control panel and prevent electric shock, connect the grounding wire directly to the base part of the manipulator and do not connect it to the controller.
- Carry out the installation by referring to the robot maintenance manual for each robot.
- After designating the soft limit suitable for the site situation, the positioning and adjustment of the hardware limit must be performed by a trained worker. After installation, you must check whether the functions are working well.

1.11. Safety Works When Operating the Robot

⚠Warning	Must observe safety work procedures to prevent safety accidents. Do not change or ignore safety devices or circuits under any circumstances, and pay attention to possible electric shock. In auto mode, all normal works should be performed outside the safety guard. Before carrying out works, you must make sure that there are no people in the operation area of the robot.

1.11.1. Safety Measures When Operating the Robot

Observe the following measures considering that safety is very important when operating the robot.

- The worker who operates or may operate the robot, and the supervisor should take certain trainings. Except for those who are recognized to be fully aware of the safety and functions of the robot and designated accordingly, any unqualified person should not operate the robot.
- Before operating the robot, you must check whether the product has been installed by a qualified installer in compliance with the relevant national and regional regulations and laws.
- Before operating the robot, check whether the safety functions are working normally.
- Must wear a safety helmet, protective glasses and safety shoes.
- Two people must work together. One person should be teaching and the other should be monitoring from the operation panel. One of the two should be ready to press the emergency stop switch at any time, and the other should perform the work quickly with sufficient care in the operation area. In addition, check the evacuation route before starting the work.
- Supply the power after confirming that there is no worker within the safety guard.
- Works such as teaching should be performed outside the robot safety guard in principle. However, when required to stop the system and work within the operation range, the worker should bring in the mode switch key (or a switch to change to the auto mode), or the safety plug when going inside. Such action is necessary to make sure that no other worker accidentally changes the robot to the auto operation mode. Also, pay special attention to the direction of the operation of the robot just in preparation for the robot malfunctioning or operating in wrong conditions.

  ※ The supervisor should observe the followings.

  - The supervisor should be positioned at a location where she or he can see the robot entirely and should be dedicated to the duties of supervision.
  - If there is any problem, press the emergency stop button immediately.
  - Other people except for the persons involved in the work should not be allowed to stay within the operation range.

- In manual operation mode, the speed should be limited to a maximum of 250 mm/sec. At this time, you should progress the work while being prepared, together with the worker outside the guard, to press the emergency stop switch at any time if a problem occurs.
- When operating the robot manually in high-speed mode, you should progress the operation from outside the safety guard.
- When performing a teaching work, you should put up a sign [Teaching in progress].
- When required to enter inside the safety guard, the worker should pull out the safety plug or an equivalent, and then bring it in when going inside.
- Do not use equipment that could be a source of noise near the teaching place or its surroundings.
- Do not operate the robot operation buttons on the teach pendant just by using the feeling at the hands while watching the teaching points. Instead, operate the buttons while checking with bare eyes.

⚠ Warning	Sufficiently check under your feet when teaching. In particular, you must perform the teaching work outside the safety guard when teaching at a high speed (250mm/s or above).

- Take the following measures when abnormality occurs.
  - If abnormal operation is found, immediately press the emergency stop button.
  - If abnormality is to be checked following an emergency stop, the stop status of the concerned facility must be checked.
  - If the robot stops automatically due to abnormality with the power. Check first that the robot is stopped completely, and then investigate the cause and take measures.
  - If the emergency stop device does not perform functions properly, immediately shut off the main power, and then investigate the cause and take measures.
  - The investigation of the cause of the abnormality should not be performed by any other than the designated person. After the emergency stop, you should restart the system after surely identifying the cause of the abnormality and taking measure accordingly.
- Prepare proper work regulations, considering the installation location and work details, with regard to the robot operation and manipulation methods, and actions to take when abnormality occurs. In addition, work should be carried out according to the work regulations.
- Precautions to take when the robot is stopped

■ Must avoid approaching the robot recklessly while thinking that the robot is stopped. When you approach the robot because you think it is stopped, the robot may suddenly move, causing an accident in many cases. The robot will be in the stopped state in the following cases.

Table 1-4 Status of the robot when it stop mode

No.	State of the robot	Source of driving	Entry
1	In temporary stop mode (Minor abnormality, temporary stop switch)	ON	X
2	In emergency stop mode (Major abnormality, emergency stop switch and safety door)	OFF	O
3	Waiting for input signal from peripheral devices (Start interlock)	ON	X
4	Playback being completed	ON	X
5	Waiting in progress	ON	X

⚠ Caution	You should not be negligent in paying attention to sudden movements even when entry is made possible. Must avoid approaching without preparing for possible emergency situation under any circumstances.

■ If the entrance door needs to be opened to take measures for minor abnormalities (such as nozzle contact, deposition detection and arc abnormality) during a temporary stop, the same measures as taken for opening the door for the teaching should be taken.

- After completing the robot operation, clean the inside of the safety fence to make sure that no tools, oil or foreign substances remain. If the operation area is stained with oil, or if tools are left in the operation area, it could cause an accident such as falling over. Make sure that arranging and organizing are performed always.

1.11.2. Safety Measures When Trial-Operating the Robot

⚠ Caution	In the case of trial-operation, there may be a design error, a teaching error, or a defect in manufacturing with regard to the entire system including the teaching program, jigs, and sequencing. For this reason, you should work with elevated safety awareness in trial-operation. Multiple factors can contribute to safety accidents. Observe the following measures considering that safety is very important when trial-operating the robot.

- Before operating the robot, check the functions of buttons such as the emergency stop button and the stop button as well as the functions of relevant signals. After that, check the operation related to detection of abnormality. First of all, it is important to check all the signals that stop the robot. When an accident is expected, the most important thing is to stop the robot.
- When performing trial operation of the robot, first set it to manual mode, input a job program with which you can test all axes, and then check the operation by repeating more than 1 cycle for each

step While the robot is moving, open the safety guard or remove the enabling switch (enabling switch on the Teach pendant) to see whether the robot stop. If a problem is found, press the emergency stop button to check whether the robot stops. If the emergency stop device does not perform its function well, immediately shut off the main power. After that, you should call the responsible aftersales person. If there is no problem, increase the speed in sequence (50% → 75% → 100%), and check the operation by repeating more than 1 cycle each. Operating at high speed from the beginning may lead to a major accident.

- It is not possible to predict what kind of problem will occur during trial-operation. Never enter inside the safety fence during trial-operation. As the reliability is low, it is very likely that unexpected accidents could occur

1.11.3. Safety Measures for Auto Operation

Observe the following measures considering that safety is very important when operating the robot in auto mode.

- Put up a sign [No entry during operation] on the safety fence entrance and ask the worker to refrain from entering during operation. If the robot is stopped, you may enter inside the safety fence after judging the situation.
- When starting the auto operation, you must check whether there is a worker inside the safety fence. If you work without checking whether there is a worker inside, it may cause an accident involving people.
- When starting the auto operation, check first that that the program number, step number, mode, start selection, etc. are in proper state for auto operation. If you start the robot while an irrelevant program or step is selected, the robot may behave unexpectedly causing an accident.
- When starting the auto operation, check in advance that the robot is in the position where the robot can start the auto operation. Check also whether the program number or step number matches with the robot position. Even when the program or step is correct, if the robot is in a different position, an accident may occur due to an operation different from a normal operation
- Be prepared to press the emergency stop button immediately at the start of auto operation. If an unexpected robot operation or unexpected situation occurs, immediately press the emergency stop button.
- Check the operation path, operation status, and operation sound, etc. of the robot to judge whether there is any abnormal state. The robot may suddenly cause an abnormality such as a failure, but it may give some symptoms before the failure occurs. In order to predict this in advance, it is required to well understand the normal operation status of the robot.
- If any abnormality is found, immediately make an emergency stop and take proper measure for it. Using the robot without proper measures could lead to a severe failure that may lead to production interruption and significant accidents involving people.

- While completing measures and checking the operation after an abnormality occurred, do not operate the robot while the worker is still inside the safety fence. Unexpected accidents such as other abnormalities may occur as the reliability is low.
- Before selecting the auto mode, if there is a safety device function that has been stopped, you should progress works after recovering the function back to completely normal state.

1.12. Safety Measures When Entering Inside the Safety Fence

When required to enter the safety door in the robot operation area, a worker and a super visor who have received certain trainings should perform works in a group of two. Also, they must wear a safety helmet, protective glasses and safety shoes. The supervisor should be prepared to press the emergency stop switch at any time, and the worker must bring in the teach pendant when going inside, making impossible for other people to operate the robot. Must put up a sign on the control panel to indicate that the robot is being operated.

When you enter the robot operation area, you must full understand the following items.

- No one except for the teaching person should enter the robot operation area.
- The operation setting mode of the controller should be manual mode on the control panel.
- Always wear certified work clothes.
- Do not wear gloves when operating the controller.
- Don't let underwear, shirt, tie etc. come out of the work clothes.
- Do not wear large jewelry such as earrings, rings or necklaces.
- Must wear safety shoes, safety helmet and protective glasses, and, when necessary, should wear safety gear such as safety gloves.
- Before operating the robot, check if the emergency stop circuit is functioning well to turn off the motor when the emergency stop button on the control panel or the teach pendant is pressed
- Work in a position facing the manipulator.
- Follow predetermined work procedures.
- Thinking that the robot may rush towards you unexpectedly, you should prepare a method or place for evacuation.

⚠ Caution	You should not be negligent in paying attention to sudden movements even when entry is made possible. Must avoid approaching without preparing for possible emergency situation under any circumstances.

1.13. Safety Measures When Maintaining and Inspecting

1.13.1. Safety Measures When Maintaining and Inspecting the Controller

Observe the following safety measures when maintaining and inspecting the robot controller.

- Maintenance and inspection works should be performed only by those who have received special maintenance trainings and fully understand the related contents.
- Progress the work according to the controller maintenance and inspection procedures.
- For the maintenance and inspection works, you must check the surroundings for safety and secure a passage or a place to avoid danger before progressing the work safely.
- Must turn off the power before performing daily inspection or maintenance of the robot or replacement of parts. In addition, in order to prevent other workers from inadvertently turning on the power, put a warning marking such as [Power-On Prohibited] on the primary power supply.
- Always use the designated replacement parts.
- When required to open the controller door, you must turn off the power first and then wait for about 3 minutes before starting the work.
- Use external lighting when sufficient illumination is not secured when performing maintenance and inspection works inside the controller.
- Do not touch the heat sink and regenerative resistor of the servo amplifier because they generate excessive heat. After maintenance, check whether tools, foreign substances, etc. are left behind inside the controller, and then close the door securely.

1.13.2. Safety Measures When Maintaining and Inspecting the Robot System and Manipulator

Observe the following safety measures when maintaining and inspecting the robot system and manipulator.

- Refer to safety measures for the maintenance and inspection of the controller.
- When maintaining and inspecting the robot system and manipulator, proceed with the work according to the instructed procedures.
- Must cut off the main power of the controller. In order to prevent other workers from powering it up again, put a warning marking such as [Power-On Prohibited] on the primary power supply.

⚠ Caution	During maintenance and inspection of the manipulator, the robot arm may fall, or there could be a different type of danger. So, you must proceed with the work according to the instructed procedures.

⚠ Caution	When moving the axis of the robot without driving force applied, there is a risk of the axis dropping due to gravity and also an additional risk due to the release of the brake system. So, you must proceed with the work according to the instructed procedures.

1.13.3. Actions to Take after Maintenance and Inspection

Observe the following actions after maintenance and inspection.

- Check if the wires or parts inside the controller are connected normally.
- After maintenance, check whether any tool is left behind inside and around the controller, manipulator or the robot system, and keep them surely arranged and organized. Must close every door.
- If any problem or fatal defect is found, do not turn on the power of the robot.
- Turn on the main breaker in the control panel.
- Check the current position and status of the robot.
- Operate the robot at a low speed.

⚠ Caution	Before turning on the power, check that there is no worker inside the robot operation area and you are in a safe place

⚠ Warning	When it comes to the change of components or addition of optional equipment (both hardware and software) to the robot both of which may affect safety-related functions, you must check whether the functions are in normal conditions, by paying attention to the items described in “1.11 Safety Works When Operating the Robot”.

1.14. Safety Related to End Effectors

⚠ Warning	When installing and operating end effectors, you must comply with ISO 10218-1:2018 in applying, maintaining and operating them.

Refer to the maintenance manual of each robot for detailed specifications regarding the installation of end effectors.

1.14.1. Gripper

- When a gripper is used to hold a workpiece, there should be a measure to take against abrupt dropping of the workpiece.
- When installing the device onto an end effector or arm, you should use the bolts of specified sizes and the specified number of bolts, and tighten them completely according to regulated torques by using torque wrenches. You should use bolts that are not rusted or stained.
- When manufacturing an end effector, you should take into account that it can be used within the allowable load value of the wrist of the robot. An end effector should have a structure that will not allow a gripped material to be released or dropped even when the power supply or air supply is interrupted, and the corners and protrusions should be surely treated in order to prevent people or objects from suffering any damage.

1.14.2. Tools/Workpieces

- It should be possible to safely change tools such as a milling cutter. Until the cutter stops rotating, the safety devices should surely perform proper functions.
- The tool should be designed in a way that the workpiece will not have any abnormality even when a sudden power failure or control failure occurs. In manual operation, it should be possible to separate the workpiece.

1.14.3. Pneumatic / Hydraulic Systems

- Special safety laws will be applied to the pneumatic and hydraulic systems.
- In this type of systems, as residual energy may remain even after the system is shut down, you should pay attention in particular. Before repairing the pneumatic or hydraulic systems, you must remove the pressure inside the devices.

HYUNDAI ROBOTICS

2

Details of Specifications

2.1. Details of Specifications of Each Controller Model

Table 2-1 Details of Specification of Each Controller Model

Model		Hi6-T15
CPU		2.7GHz Dual core
Program execution method		Teaching and playback
Operation method		Menu-based
Interpolation type		PTP, linear and circular
Memory backup method		Batter backup IC memory
Encoder type		Absolute encoder
Servo drive unit		6 axes integrated, digital servo
Maximum number of units		Maximum 32 axes simultaneously
Step		10,000,000 steps
Program selection		255 (binary)/8 (discret)
Display on the teach pendant		7” colorful TFT-LCD(800x480)
Fieldbus interface (optional)		DeviceNet, ProfiNET, Modbus TCP/UDP, EtherCAT
Digital I/O (optional)		Input: 48 points (maximum 496 points) / Output: 80 points (maximum 496 points)
Analogue I/O (optional)		Input: 4 points / Output: 4 points
Conveyor pulse counter (optional)		Line driver / Open collector
Communication interface		3 Ethernet port/ 2 USB 2.0 ports/ 2 RS232 ports
Circuit board	Main module	H6COM-T

Model		Hi6-T15
	Servo control board	BD641T
	Safety IO board	BD632T
	Power supply board	BD667T
	Backplane Board	BD602T
	Amp board	BD657T:15A 3-axis Amp BD658T: 35A 3-axis Amp BD657TA: 15A 4-axis Amp BD658TA: 35A 4-axis Amp
Wire harness		CEC1
Teach pendant		TP630
Rated supply voltage		single-phase 220V(50/60 Hz)±10%
Maximum power consumption		1.5KVA
Operation temperature		0 ~ 45 ℃
Operation humidity		75 %
Protection grade		IP20
Noise level		Maximum 68 dB
Exterior dimension*1 (WxHxD)		400 x 130 x 285 mm
Weight		10.5kg

Table 2-2 Power Requirements

Controller type	Capacity *1) [KVA]	Input voltage *2) [V]	Frequency [Hz]	Peak current [A]
Hi6-T15	Max. 1.5 KVA	220 V	50/60	15A

Note 1) Power capacity: Refers to the power supply capacity of the controller. For the power capacity of each robot, refer to the manipulatory maintenance manual.
Note 2) Voltage range: ±10% (at the power terminal of the controller)

2.2. Exterior of the Controller

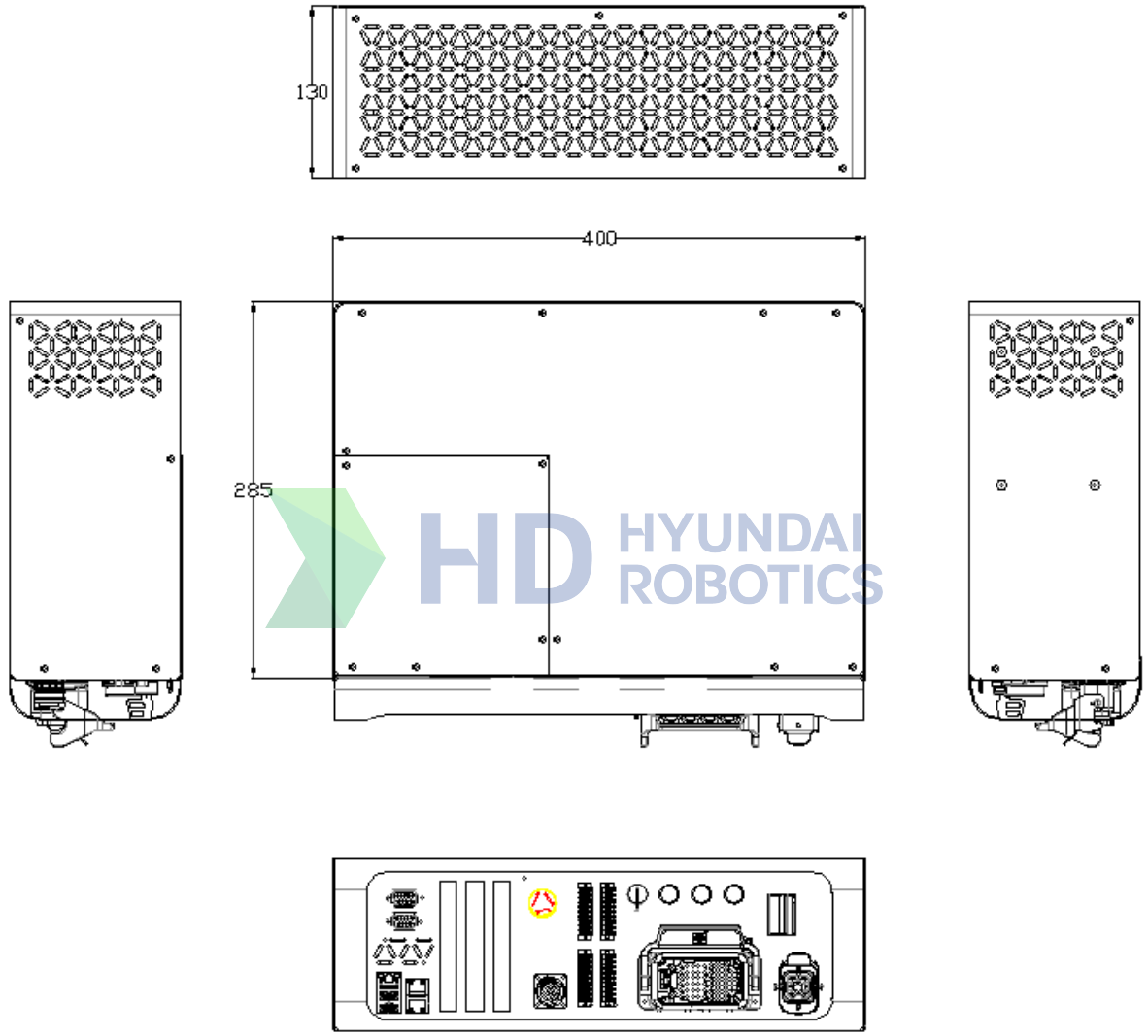


Figure 2.1 Exterior of Hi6-T15 Controller (Unit: mm)

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3

Installation of the Controller

If you properly install, transport, and store the product in consideration of the position and direction of the installation and the size of the surrounding space, you can secure the service life of the product and prevent the degradation of its performance.

- Configuration
- Checking of the installation and use environments
- Transport of the controller
- Storage of the controller
- Discarding of the controller

⚠ Caution	Before installing the product, you must perform a risk assessment sufficiently and then set the safety function based on the assessment results. For details on safety functions, refer to “1. Safety”.

3.1. Configuration

3.1.1. Basic Configuration

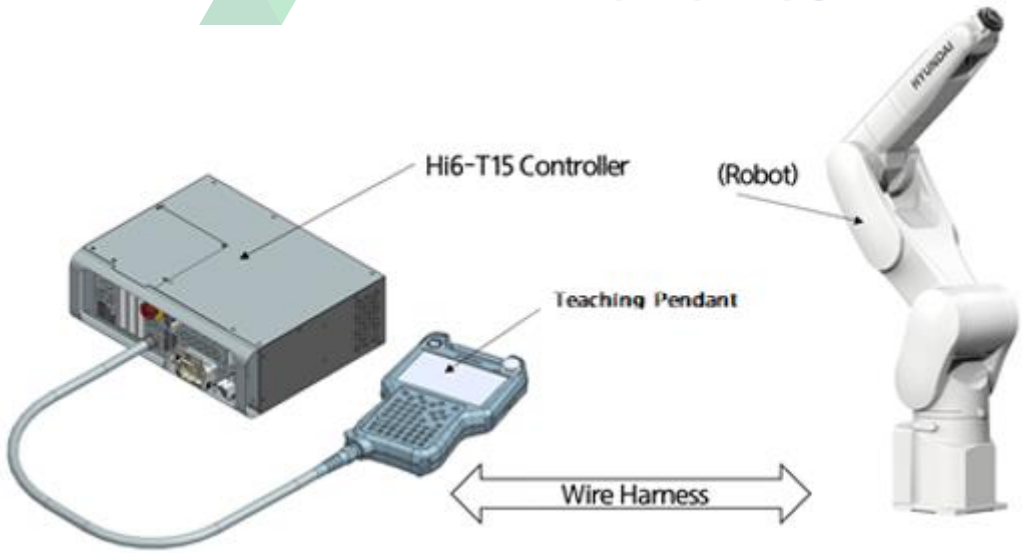


Figure 3.1 Basic Installation Configuration of the Industrial Robot

- Hi6-T15 controller
- Teach pendant
- Wire harness (Hi6 controller ↔ robot)
- Robot

3.1.2. Checking of Various Name Plates

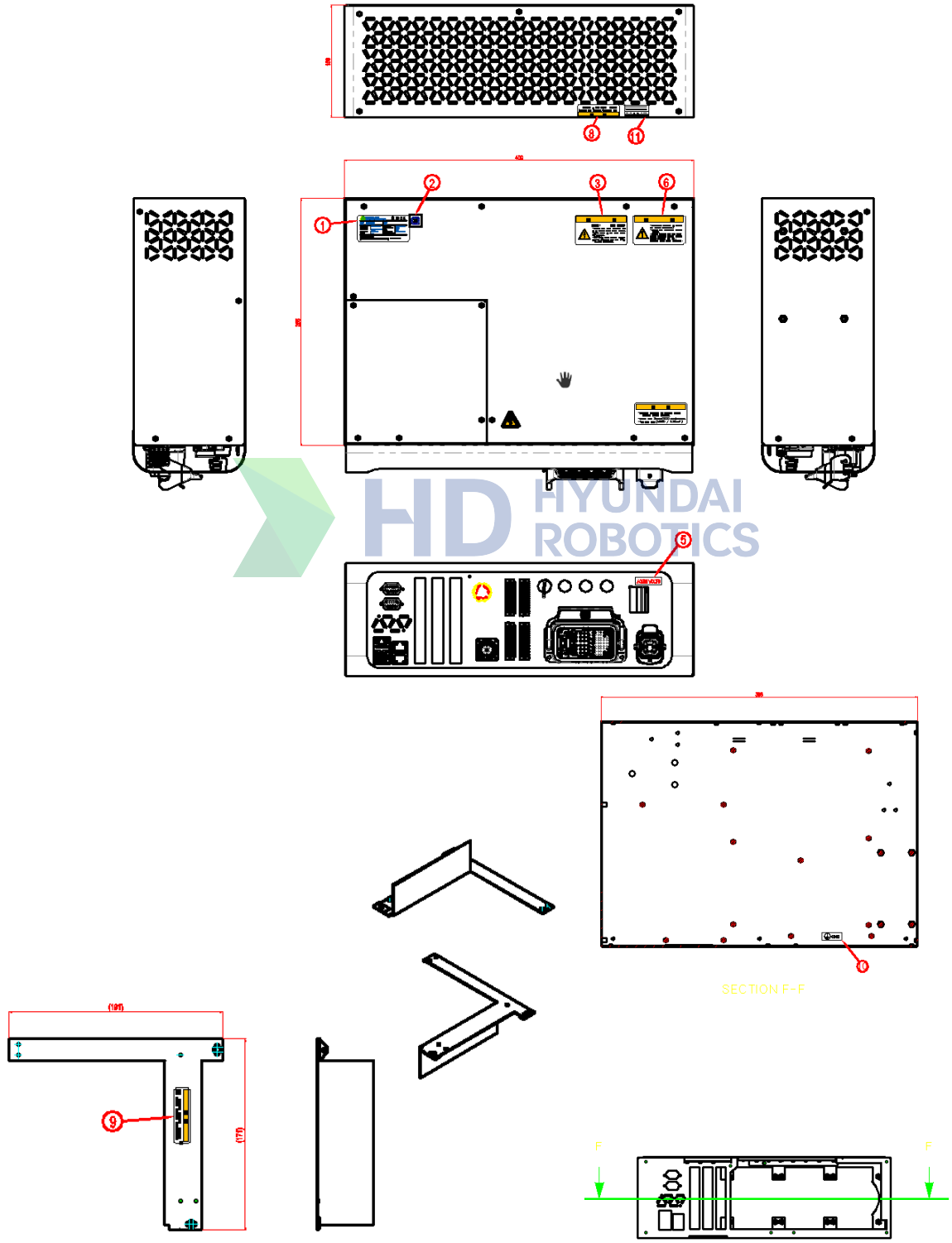
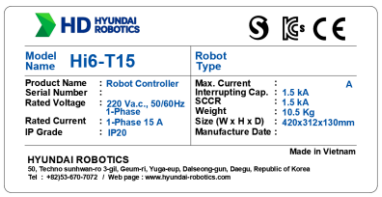
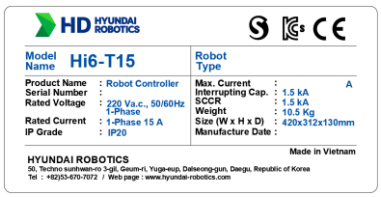
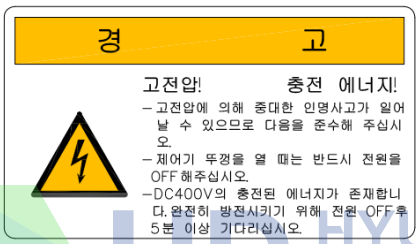
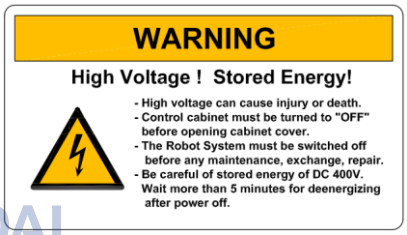
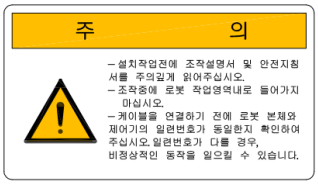
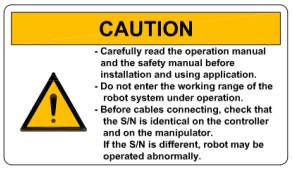
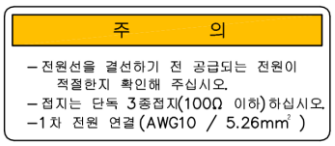
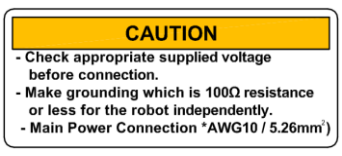
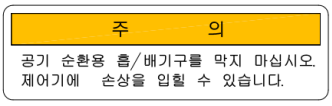
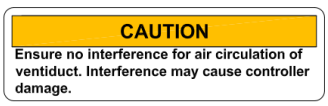
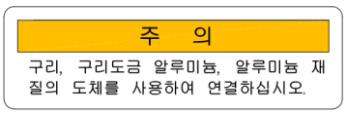
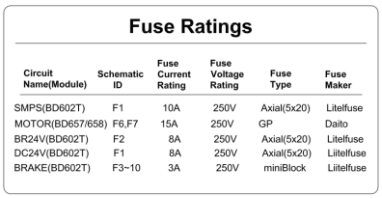
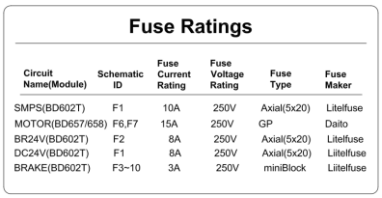


Figure 3.2 Controller's Labels

Table 3-1 Label Type

No.	Item	Korean	English
1	Nameplate		
2	NRTL Certification mark		
3	High voltage Warning		
4	High voltage Indication		
5	Input power Indication		
6	Installation precautions		
7	Caution for Power and Grounding		
8	Air circulation of ventiduct precautions		
9	Ground wire connection precautions		

No.	Item	Korean	English
10	Ground mark		
11	Fuse Specifications		

Fuse Ratings

Circuit Name(Module)	Schematic ID	Fuse Current Rating	Fuse Voltage Rating	Fuse Type	Fuse Maker
SMPS(BD602T)	F1	10A	250V	Axial(5x20)	Litelfuse
MOTOR(BD657/658)	F6,F7	15A	250V	GP	Daito
BR24V(BD602T)	F2	8A	250V	Axial(5x20)	Litelfuse
DC24V(BD602T)	F1	8A	250V	Axial(5x20)	Liitelfuse
BRAKE(BD602T)	F3~10	3A	250V	miniBlock	Liitelfuse

Fuse Ratings

Circuit Name(Module)	Schematic ID	Fuse Current Rating	Fuse Voltage Rating	Fuse Type	Fuse Maker
SMPS(BD602T)	F1	10A	250V	Axial(5x20)	Litelfuse
MOTOR(BD657/658)	F6,F7	15A	250V	GP	Daito
BR24V(BD602T)	F2	8A	250V	Axial(5x20)	Litelfuse
DC24V(BD602T)	F1	8A	250V	Axial(5x20)	Liitelfuse
BRAKE(BD602T)	F3~10	3A	250V	miniBlock	Liitelfuse

⚠ **Warning**	Any act of damaging the safety labels, such as relocating the name plates, warning markings, safety symbols, name markings and wire markings or painting over them or blocking them with a cover is prohibited.
⚠ **Caution**	Mark the installation and dangerous areas of the robot in a way that they can be differentiated from other facilities and devices in terms of type, color and style.

3.2. Installation and Use Environments

Install the product in an appropriate place in consideration of the installation and use environments and conditions.

- The proper use temperature of the product is 0℃ - 45℃, and the proper storage humidity is 20 to 85%RH.
- Do not drop the product or apply a strong impact to it while moving or using it.
- Transport and install the product in a correct way based on the weight of the product while paying attention to the safety.
- Install and use the product in a solid, flat and vibration-free area where the product will not turn over easily.
- Do not install and use the product in an area with a lot of foreign substances such as water, moisture, gas, dust, or in a dirty place.
- Do not install or use the product in an area with flammable and corrosive substances or gases, or in an area where heat is generated, or near heat of fire.
- Do not install or use the product in an area that has a source of strong electrical noise or is affected by it.
- Install the controller in a safe area by referring to “1.10 Safety Measures When Installing”.
- Carry out the controller maintenance work by referring to “1.13. Safety Measures When Maintaining and Inspecting”.
- When installing the product in an area where welding work is performed, install the product in a location where there will be no effect from welding spatter and cooling water.
- When installing the controller, keep a distance of at least 500mm if there is a wall or obstacle nearby.
- For the matters related to the installation of the robot, refer to each robot maintenance manual.

⚠ **Caution**	If the product is not installed in the recommended locations, the performance and service life of the product may be reduced. Install and use the product according to the recommendations.

⚠ **Warning**	The robot should be installed and operated according to the guidelines of ISO 10218-2. In addition, it is required to comply with the relevant requirements of international standards and national laws. Our company (or the manufacturer) will not be responsible for any accidents that occur due to not complying with the relevant requirements of international standards and national laws or due to not reviewing the “**risk assessment**”.

3.3. Transport of the Controller

The following items describe the precautions to take in packing, transporting, and unpacking the Hi6-T15 controller. Refer to the robot maintenance manual for the matters related to the packing and transport of the robot.

3.3.1. Packing

- Attach the model's name plate to the box.
- Protect all exposed connectors with a dust cap or polyvinyl.
- When the teach pendant is packaged in a box, use an air-filled cushioning to prevent the LCD from getting damaged due to external impact.
- Attach the waterproofed packing list to the outside of the box.

3.3.2. Transport

- Remove anything that is not fixed onto the controller.
- As the controller is a precision device, pay attention to the transport of it to prevent any strong impact from being applied to it.
- When using a forklift, fix the controller in a way to prevent the controller from shaking.
- When transporting the product, fully understand the contents related to the packing and transport, and follow the instructions. Our company will not be responsible for any damage to or breaking of the product due to customer's carelessness, inexperience in operation, or negligence.

⚠ Warning	If you transport the product by using lifting equipment, you should comply with the relevant national and local safety regulations and equipment usage guidelines. When moving the product by using a crane, you must make sure that that no workers are under the product. Also, never work or walk under the crane or the product.

3.3.3. Unpacking

- Fully understand the safety regulations and other guidelines carefully before unpacking and installing the robot.
- Unpack the product according to the unpacking instructions.

- Check whether the location is an area where the robot and controller can be safely installed.
- Check if a path that allows the robot and controller to move safely is secured.
- Transport of the robot should be performed by a qualified person.
- When unpacking the product, check that whether there is any damage that might have occurred during transport or unpacking.

3.4. Storage of the Controller

When storing the controller, instead of installing it, refer to the following items.

- Store the controller while keeping it in the packaged state and seal the power and communication connection parts tightly.
- When storing the controller for a long time, you must take safety measures against the risk of it falling over.
- When storing the controller wrapped in packing material, pack it with a desiccant or store it in a dry place. If it is stored in a highly humid place, moisture may form inside the packing material, damaging the product.
- Avoid places where temperature and humidity may change easily (where condensation occurs) and store the controller in a cool, dry place where the ambient temperature ranges from -15 ℃ to 40 ℃.
- Do not store the controller in locations where there are chemical products, acid and alkali products, batteries, circuit breakers, etc.

3.5. Discarding of the Controller

In order to ensure user safety and protect the environment, certain parts should be managed and discarded according to specified methods, and if they contain industrial waste materials, they must never be discarded together with general industrial or household waste. When discarding all or part of the robot system, you must comply with the relevant national or local regulations and laws. For details on the discarding and disposal of the product, please contact our customer support team.

3.6. Connection

⚠ Caution	1. Before connecting the cables, turn “off” the controller's main power switch and lock it by using use a padlock. 2. The controller has DC220V charged energy. Be careful. Turn “off” the power switch and then wait 5 minutes at least to discharge the charged energy. 3. When handling the PCB, take precautions not to allow static electricity to damage it. 4. Wiring and connection of wires must be performed by qualified personnel.

3.6.1. Connection of the Teach Pendant

Connect the cable connector of the teach pendant to the CNRTP receptacle of the controller.

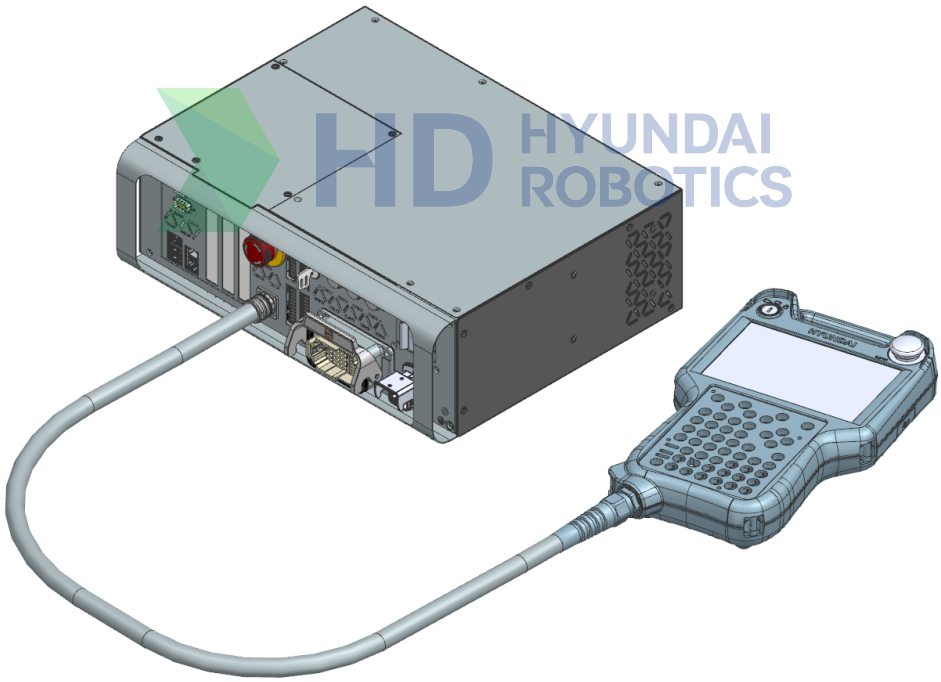
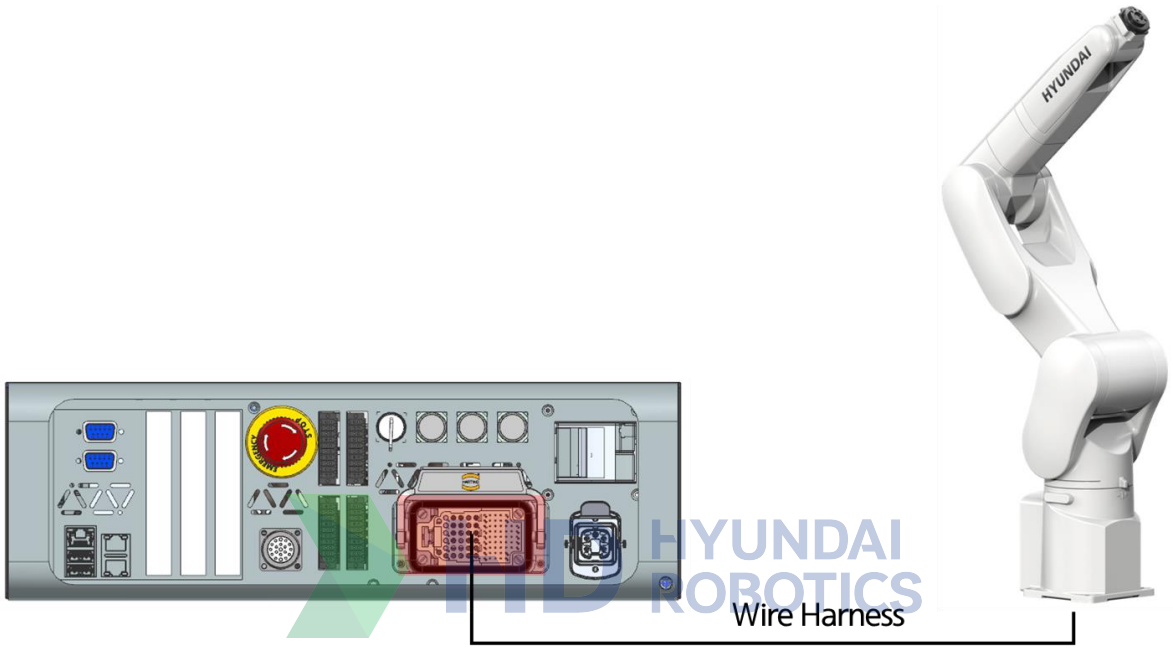


Figure 3.3 Connection of Hi6-T15 Teach Pendant (TP630)

3.6.2. Connection of the Manipulator and Controller

Connect between the manipulator and controller by using a wire harness. Check the names of individual receptacles while connecting them.



⚠ Caution	Since the contact part of the connector for each robot may be different from the figure above, you must read the relevant robot maintenance manual carefully before connecting the wire harness.

Figure 3.4 Connection of the Manipulator and Controller (Hi6-T15)

3.6.3. Connection of the Controller and Primary Power

In the case of a Hi6-T15 controller, Connect the power cable through the power inlet.
At this time, use a terminal receptable of an appropriate size for the end side of the primary power supply cable.

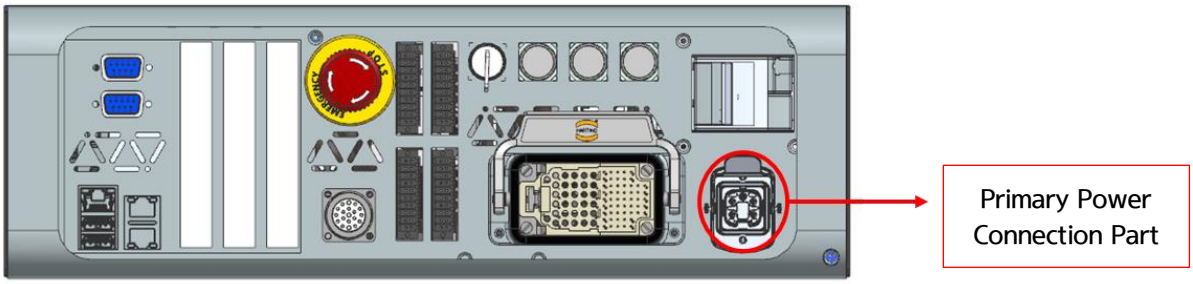


Figure 3.5 Primary Power Connection Part of Hi6-T15 Controller

3.6.3.1. Power Requirements

Table 3-2 Power Requirements

No.	Controller type	Capacity*1) [KVA]	Input voltage *2) [V]	Frequency [Hz]	Peak current [A]
1	Hi6-T15	Max. 1.5KVA	220V	50/60	15A

Note 1) Power capacity
Refers to the power supply capacity of the controller. For the power capacity of each robot, refer to the “Manipulator Maintenance Manual”.
Note 2) Voltage range: ±10% (at the power terminal of the controller)

3.6.3.2. Power Cable Thickness

Table 3-3 Recommended Minimum Cable Thickness

No.	Cable length m(feet)	Cable thickness (Hi6-T15)	
		mm^2	AWG
1	0 - 50(0 - 160)	1.5	16
2	50 - 100(160 - 320)	2.5	14
3	100 - 180(320 - 590)	2.5	14
4	180 - 300(520 - 980)	2.5	14

3.6.4. The Controller and Grounding

For using the controller safely, connect the grounding wire to the controller. Use a grounding wire of 5.5 ㎟ or more. (Grounding of Category 3).

3.6.5. Other Cautions

⚠ Caution	1. When wiring the controller and manipulator, separate the signal line and the power line In addition, use separate ducts respectively for high power lines and signal lines. 2. Use a protective cover for the wires, as a measure to prevent the wires from getting damaged when people are passing. 3. Before supplying the primary power, you must check again the relationship in terms of connection, the power specification and the power supply specification of the controller.

3.6.6. Connection of the Ethernet Port for the User (Option)

The Ethernet port for the user is located on the front door of the controller. The pin description and connection with a Pc are as follows.

Table 3-4 Pin Description (RJ45 Connector Specification; RJ 45P Shield)

RJ45 Pin No.	Name	Abbreviation	Direction
1	Transmit Data +	TX +	Out
2	Transmit Data -	TX -	Out
3	Receive Data +	RX +	In
6	Receive Data -	RX -	In

HD
HYUNDAI
ROBOTICS

4

Basic Configuration of the Controller

⚠ Caution	The person in charge of maintenance should work after understanding the placement of various devices and parts and their functions inside the controller.

4.1. Configuration

The controller consists of the main body and teach pendant.

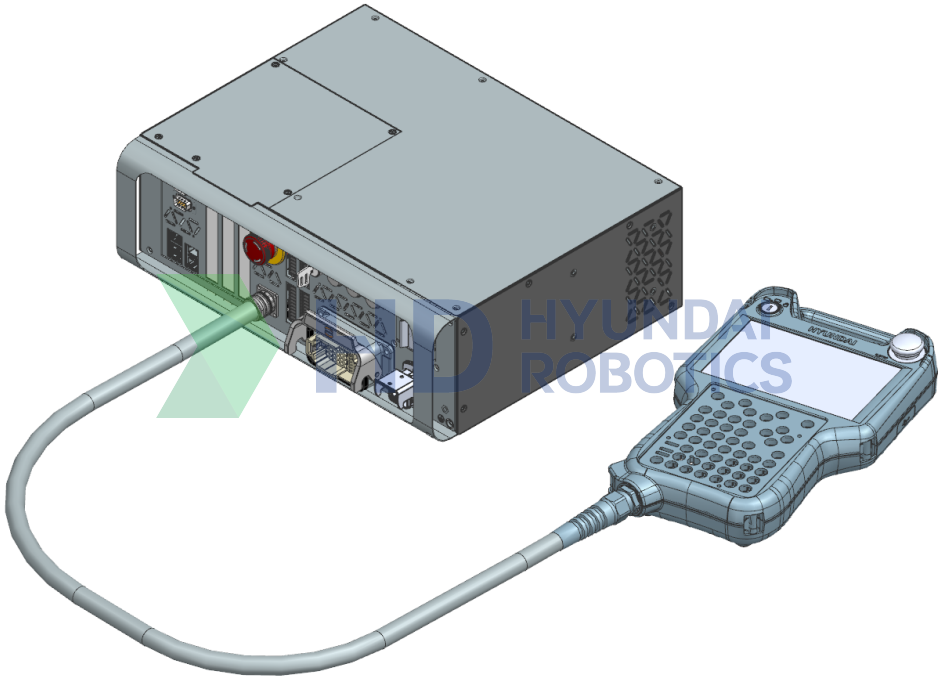


Figure 4.1 Hi6-T15 Controller & Teach Pendant (TP630)

4.2. Placement of Parts

The main components of the Hi6-T15 controller and their individual names are arranged as shown in below.

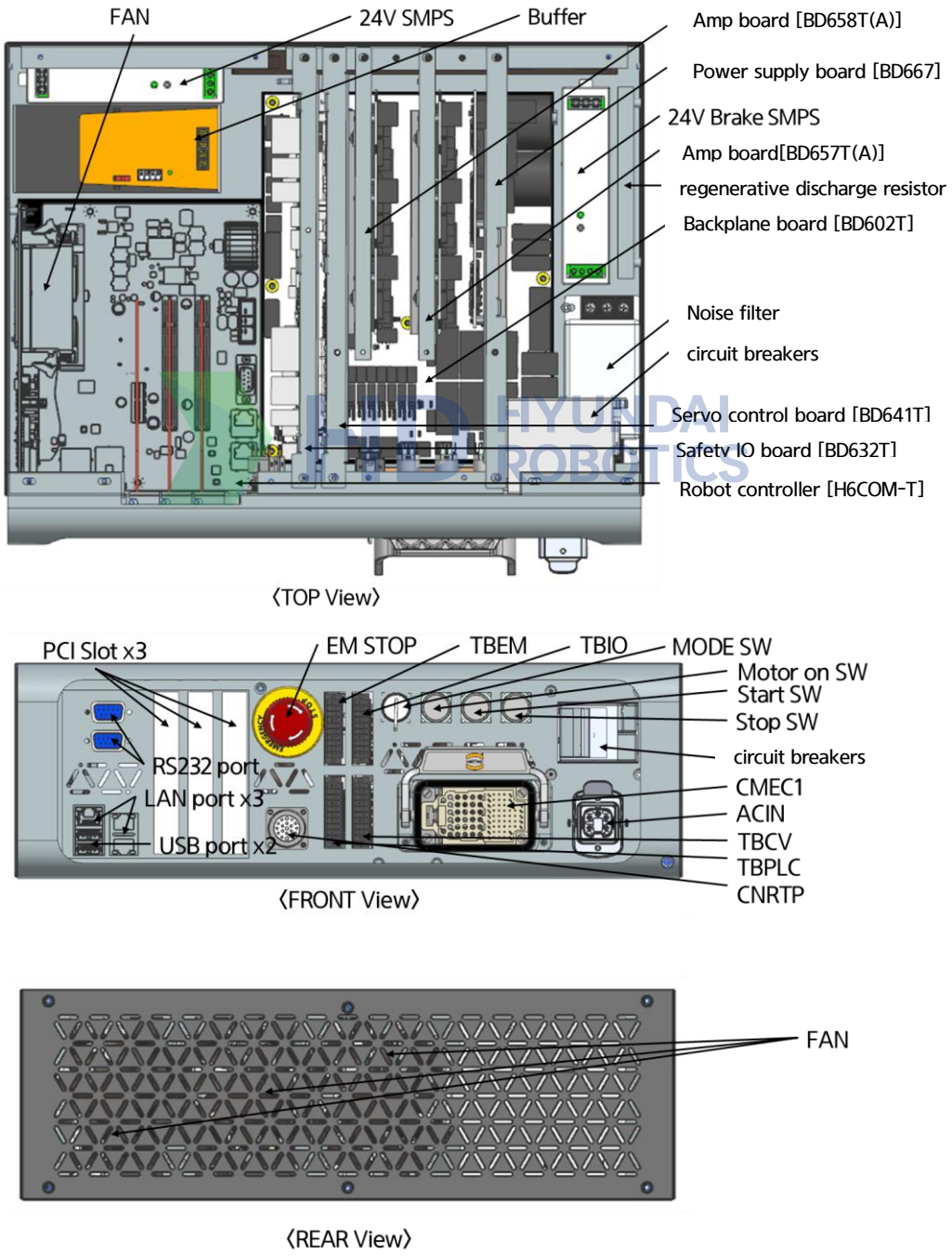


Figure 4.2 Placement of Parts of the Hi6-T15 Controller

4.3. Functions of the Individual Components

Table 4-1 Summary of Functions of the Individual Components

Components		Functions
Control module	Robot controller [H6COM-T]	● Recording the record points and calculating the operation paths ● Preservation of the programs and robot integers ● Teach pendant (T/P) communication ● LAN, USB, serial communication (RS232) connection
	Safety IO board [BD632T]	● I/O in the controller (I/O for the system) ● Control of the sequence inside the panel ● Processing of various input signals from the manipulator ● Open/close outputs for the servo motor ● Safety chain circuit
	Servo control board [BD641T]	● DSP for servo control ● Encoder connection (Serial I/F) ● Sequence control
	Amp board [BD657/BD658]	● Motor drive circuit
	Backplane board [BD602T]	● Motor power on/off relay, and a brake power on/off relay ● Brake drive circuit ● EtherCAT IF ● Power failure detection drive unit circuit
	Power supply board [BD667]	● Motor drive power generation ● Regenerative discharge
T/P (Teach Pendant)	TP630	● Display of various information (LCD) ● Button inputs and switch inputs (function/jog, etc.) ● Emergency stop, enable, and T/P On/Off inputs
Cooling device	Fan	● Air circulation inside the panel ● Cooling of the drive module

4.3.1. Robot Controller (H6COM-T)

4.3.1.1. Overview

H6COM-T is structured as shown in Figure 4.3, combining the main CPU board and the carrier board. The main CPU board consists of a SSD slot, a CPU slot, a memory card slot, a DP port, a COM port, and a bus connector connecting the carrier board. The carrier board includes three external LAN ports, two LAN ports for internal system, two USB ports, one GPIO port, two PCI connectors, one PCI-e connector, and one DC 24V power connector. The LAN ports for internal systems are used for the EtherCAT communication and for the interface with the teach pendant, and the GPIO port is used for the detection of the power failure signal from the power system. The DP port and USB ports are used for debugging. To support other general-purpose bus interfaces, a PCI expansion slot and three additional external LAN ports are provided, and, through relevant slots, connection to other communication interfaces, other than the EtherCAT, can be made.

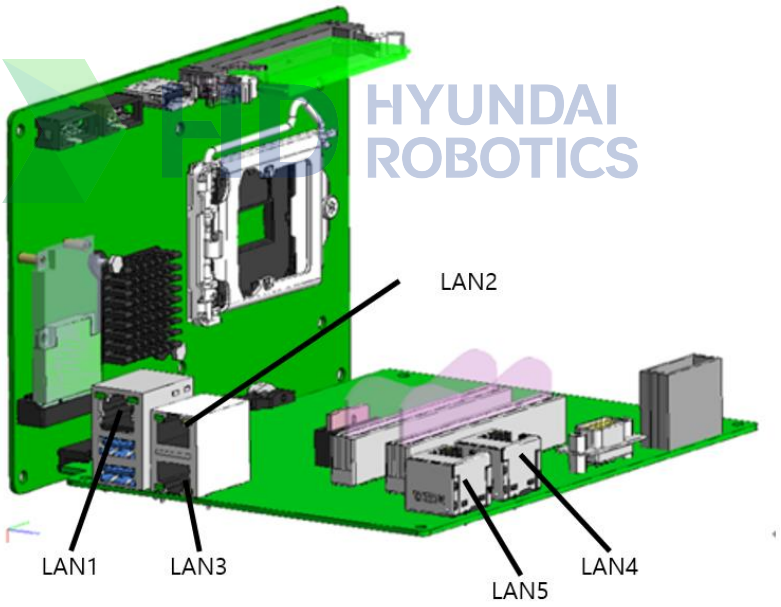


Figure 4.3 3D Modeling of H6COM

4.3.1.2. Connectors

Table 4-2 describes the usage of the connector and the connection of external devices.

Table 4-2 Types and Usage of the Connectors of Hi6COM

Name	Usage	Connection of external devices
DC IN 12-24V	DC24V main power supply	-
COM 1,2	Serial port (RS232/RS422/RS485)	-
GIO	Application of the power failure of the power unit	-
LAN 4	EtherCAT master connector port	EtherCAT connector
LAN 5	Ethernet port: For communication between teach pendants	TP connector
LAN 1	Ethernet port: For the user (PC I/F)	EtherCAT connector (For option)
LAN 2	Ethernet port: For the user (PC I/F)	-
LAN 3	Ethernet port: For the user (PC I/F)	-
PCI, PCIe	Optional expansion board slot	-
DP	For CMOS set up	-
USB	USB port: For the user (PC I/F)	-

4.3.2. Safety Module (BD632T)

4.3.2.1. Overview

To meet the requirement of PLr=d cat3 (SIL2) in compliance with ISO 13849-1, the safety module (BD632T) is designed in a dualized safety electric circuit and continuously monitors the status of safety-related inputs. If a system error or safety-related input is detected, this safety module renders the robot into a safe state by cutting off the motor power and brake power according to the classification of the types of the stops determined through risk assessment.

4.3.2.2. Connectors

The following figure shows the locations and usage of various connectors installed on BD632T (Safety IO Module).

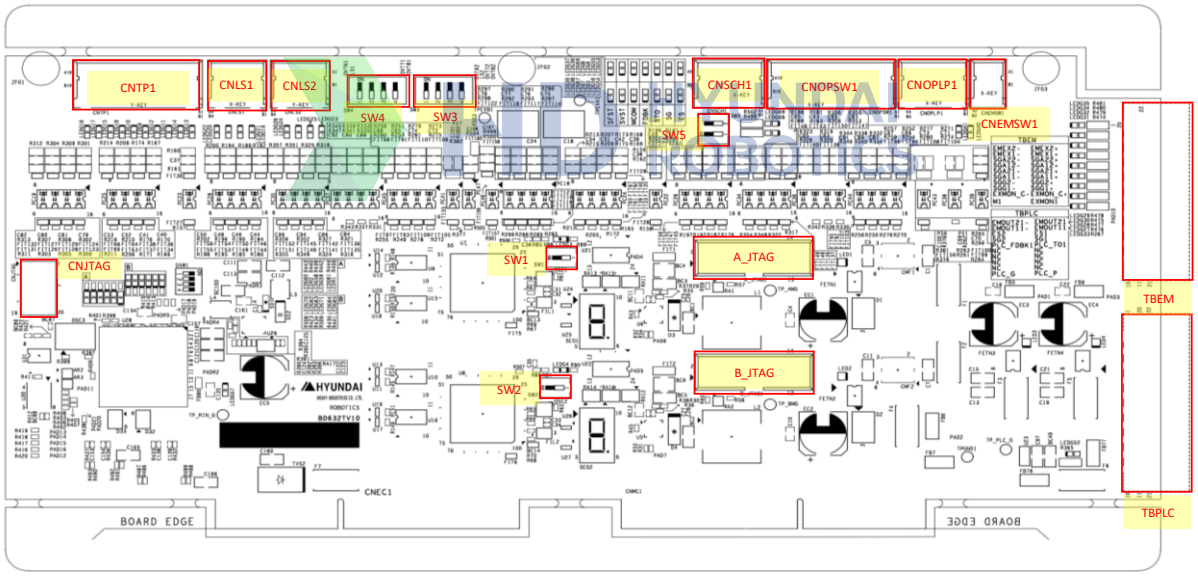


Figure 4.4 Placement of the Connectors and Switches of the BD632T (Safety IO Board)

Table 4-3 Types and Usage of the Connectors of the BD632T (Safety IO Board)

Name	Usage	Connection of external devices
CNTP1	Inputs of the emergency stop switch, mode switch, and enable switch of the teach pendant	Teach Pendant
CNLS1	Limit switch input for the detection of arm interference and over-travel	
CNLS2	Additional axis, extended axis, limit switch input for the detection of over-travel	
CNSCH1	Multi-robot safety chain input and output	External controller
CNOPSW	Inputs of the mode switch and keys of the Operational Panel (OP)	Operational Panel (OP)
CNOPLP1	Lamp output of the Operational Panel (OP)	Operational Panel (OP)
CNEMSW1	Emergency stop input of the Operational Panel (OP)	Operational Panel (OP)
TBEM	External safety inputs (Emergency stop, auto mode safety guard 1, auto mode safety guard 2, and general safety guard input)	User IO
TBPLC	Connection of the safety PLC safety signals	Safety PLC
A_JATG	JTAG connector	-
B_JATG	JTAG connector	-
CNJTAG	JTAG connector	-
SW1	OP(Operational Panel) setup switch	-
SW2	OP(Operational Panel) setup switch	-
SW3	Setup switch for arm interference and overtravel	-
SW4	Setup switch for arm interference and overtravel	-
SW9	Multi-robot setup switch	-

(1) External Safety Signal Terminal Block of the BD632T: TBEM

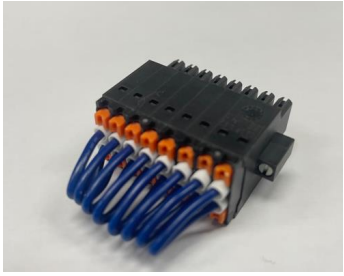


Figure 4.5 BD632T(Safety IO Board) TBEM

⚠ Caution	When a safety-related input is connected and activated, you must check whether the function is operating normally by referring to “1.11 Safety Works When Operating the Robot.”

Table 4-4 Description of TBEM of the BD632T (Safety IO Board)

Terminal no.	Terminal name	Usage	Others
11	EMEX2+	External emergency stop chain 2 input	If the external emergency stop chain 2 is not to be used, it should be short-circuited.
1	EMEX2-		
12	EMEX1+	External emergency stop chain 1 input	If the external emergency stop chain 1 is not to be used, it should be short-circuited.
2	EMEX1-		
13	SGA22+	Automatic safety guard 2 chain 2 input	If the automatic safety guard 2 chain 2 input is not to be used, it should be short-circuited.
3	SGA22-		
14	SGA12+	Automatic safety guard 2 chain 1 input	If the automatic safety guard 2 chain 1 input is not to be used, it should be short-circuited.
4	SGA12-		
15	SGA21+	Automatic safety guard 1 chain 2 input	If the automatic safety guard 1 chain 2 input is not to be used, it should be short-circuited.
5	SGA21-		
16	SGA11+	Automatic safety guard 1 chain 1 input	If the automatic safety guard 1 chain 1 input is not to be used, it should be short-circuited.
6	SGA11-		
17	SGG2+	General safety guard chain 2 input	If the general safety guard chain 2 input is not to be used, it should be short-circuited.

7	SGG2-		
18	SGG1+	General safety guard chain 1 input	If the general safety guard chain 1 input is not to be used, it should be short-circuited.
8	SGG1-		
19	EXMON_C+	Contact type external motor on	If the contact type external motor on is not to be used, it should be open-up.
9	EXMON_C-		
20	EXMON1	PNP type external motor on	If the PNP type external motor on is not to be used, it should be open-up.
10	M1		

(2) Safety PLC Connection Terminal Block of the BD632T: TBPLC

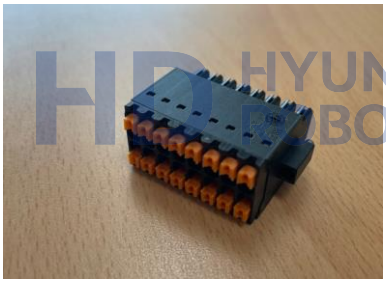


Figure 4.6 TBPLC of the BD632T (Safety IO Board)

⚠ Warning	When a safety-related input is connected and activated, you must check whether the function is operating normally by referring to “1.11 Safety Works When Operating the Robot.”

Table 4-5 Description of TBPLC of BD632T (Safety IO Board)

Terminal no.	Terminal name	Usage	Others
11	PLC_P	Safety PLC 24V	
10	PLC_G	Safety PLC GND	To function as Common for the SG/ES signal
12	N.C	-	-
9	N.C	-	-
13	N.C	-	-

8	N.C	-	-
14	SYS_T10	Relay state monitoring terminal Safety chain 1	Open when not used
7	FDBK10		
15	SYS_T20	Relay state monitoring terminal Safety chain 2	Open when not used
6	FDBK20		
16	PLC_TO1	Input terminal for the monitoring output of the safety IO	PNP output type applicable only
5	PLC_FDBK1	Feedback signal output for T0 of the safety IO	
17	SG1	Chain 1 for the safety guard input from the safety PLC	PNP output type applicable only
4	SG2	Chain 2 for the safety guard input from the safety PLC	
18	ES1	Chain 1 for the emergency stop input from the safety PLC	PNP output type applicable only
3	ES2	Chain 2 for the emergency stop input from the safety PLC	
19	EMOUT11+	Internal emergency stop output chain 1	PNP output type applicable only
2	EMOUT11-		
20	EMOUT21+	Internal emergency stop output chain 2	PNP output type applicable only
1	EMOUT21-		

4.3.2.3. Display Devices

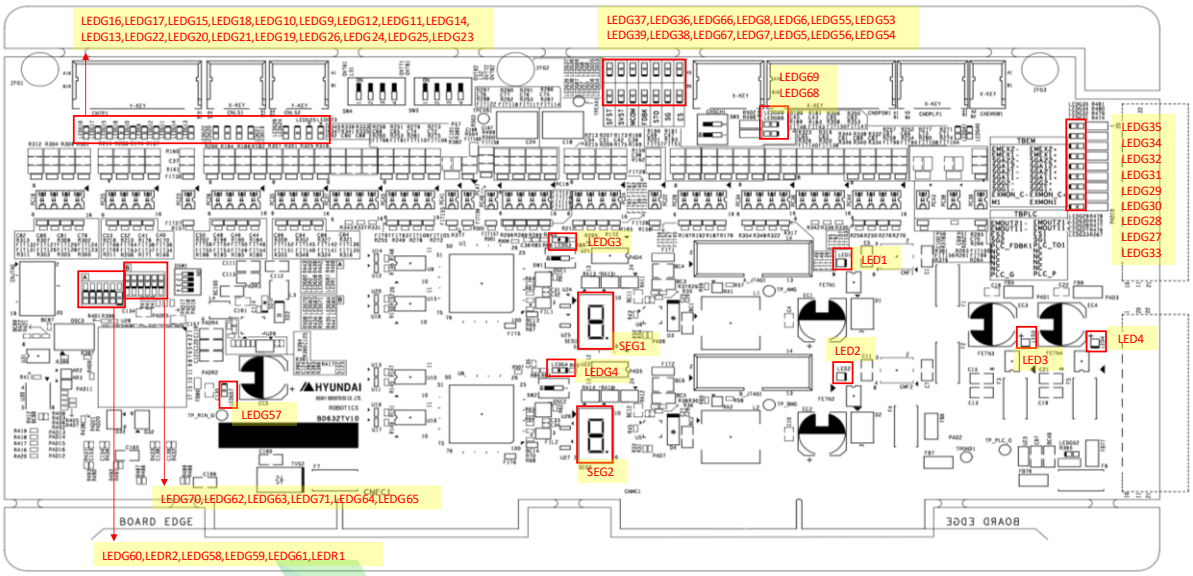


Figure 4.7 Display Devices of BD632T (Safety IO Board)

Table 4-6 Description of the Display Devices of the BD632T (Safety IO Module)

Name	Contents of display	Color	When normal	Actions to take when an abnormality occurs
LED1	24V power (Chain1)	Green Red	Green LED turned on	Phenomenon: Red LED turned on or off Action 1: Check the input voltage (24V). Action 2: If the LED is turned off, check the fuse (F1). Action 3: Replace the BD632T board.
LED2	24V power (Chain 2)	Green Red	Green LED turned on	Phenomenon: Red LED turned on or off Action 1: Check the input voltage (24V). Action 2: If the LED is turned off, check the fuse (F2). Action 3: Replace the BD632T board.
LED3	24V power (Chain1)	Green Red	Green LED turned on	Phenomenon: Red LED turned on or off Action 1: Check the input voltage (24V). Action 2: If the LED is turned off, check the fuse (F3). Action 3: Replace the BD632T board.
LED4	24V power (Chain 2)	Green Red	Green LED turned on	Phenomenon: Red LED turned on or off Action 1: Check the input voltage (24V). Action 2: If the LED is turned off, check the fuse (F5). Action 3: Replace the BD632T board.
LEDR1	Reset	Red	Turned off	Phenomenon: Red LED turned on Action 1: Replace the BD632T board.
LEDR2	EtherCAT communication error LED	Red	Turned off	Phenomenon: Red LED turned on Action 1: Check the EtherCAT cable connection state. Action 2: Replace the BD632T board. Action 3: Inspect H6COM or BD641T.
LEDG3	OP installation LED (Chain 1)	Green	Switch on (if the OP is installed) Green LED turned on	Phenomenon: States other than normal state Action 1: Replace the BD632T board. Action 2: Inspect the cable.
LEDG4	OP installation LED (Chain 2)	Green	Switch On (if the OP is installed) Green LED turned on	Phenomenon: States other than normal state Action 1: Replace the BD632T board. Action 2: Inspect the cable.
LEDG5	STO output LED (Chain 2)	Green	STO On: Turned on STO Off: Turned off	Phenomenon: States other than normal state Action 1: Replace the BD632T board. Action 2: Replace the BD602T board.
LEDG6	STO output LED (Chain 1)	Green	STO On: Turned on STO Off: Turned off	Phenomenon: States other than normal state Action 1: Replace the BD632T board. Action 2: Replace the BD602T board.
LEDG7	MC state check LED (Chain 2)	Green	MC Close: Turned on MC Open: Turned off	Phenomenon: States other than normal state Action 1: Replace the BD632T board. Action 2: Replace the BD602T board.

LEDG8	MC state check LED (Chain 1)	Green	MC Close: Turned on MC Open: Turned off	Phenomenon: States other than normal state Action 1: Replace the BD632T board. Action 2: Replace the BD602T board.
LEDG9	Teach pendant manual mode input (Chain 1)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Replace the teach pendant. Action 2: Replace the BD632T board.
LEDG10	Teach pendant manual mode input (Chain 2)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Replace the teach pendant. Action 2: Replace BD632T.
LEDG11	Teach pendant auto mode input (Chain 1)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Replace the teach pendant. Action 2: Replace BD632T.
LEDG12	Teach pendant auto mode input (Chain 2)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Replace the teach pendant. Action 2: Replace BD632T.
LEDG13	Teach pendant remote mode input (Chain 1)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Replace the teach pendant. Action 2: Replace BD632T.
LEDG14	Teach pendant remote mode input (Chain 2)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Replace the teach pendant. Action 2: Replace BD632T.
LEDG15	Teach pendant enable input (Chain 1)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Replace the teach pendant. Action 2: Replace BD632T.
LEDG16	Teach pendant enable input (Chain 2)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Replace the teach pendant. Action 2: Replace BD632T.
LEDG17	Teach pendant emergency stop input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Replace the teach pendant. Action 2: Replace BD632T.
LEDG18	Teach pendant emergency stop input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Replace the teach pendant. Action 2: Replace BD632T.
LEDG19	OVT input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the OVT switch.

LEDG20	OVT input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the OVT switch.
LEDG21	Hard limit input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the hard limit switch.
LEDG22	Hard limit input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T Action 3: Replace the hard limit switch.
LEDG23	Additional axis OVT input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the additional axis OVT switch.
LEDG24	Additional axis OVT input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the additional axis OVT switch.
LEDG25	Expansion axis OVT input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the extended axis OVT switch.
LEDG26	Expansion axis OVT input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the extended axis OVT switch.
LEDG27	Safety guard input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the safety guard.
LEDG28	Safety guard input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the safety guard.

LEDG29	Auto mode safety guard 1 input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the auto mode 1 safety guard.
LEDG30	Auto mode safety guard 1 input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the auto mode 1 safety guard.
LEDG31	Auto mode safety guard 2 input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the auto mode 2 safety guard.
LEDG32	Auto mode safety guard 2 input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the auto mode 2 safety guard.
LEDG33	External motor on input (Contact type)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the external motor on contact switch.
LEDG34	External emergency stop input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the external emergency stop switch.
LEDG35	External emergency stop input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the external emergency stop switch.
LEDG36	Servo state input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace BD641T.
LEDG37	Safety module state output (Chain 1)	Green	When outputted: Turned off When not outputted: Turned on	Phenomenon: States other than normal state Action 1: Replace BD632T.

LEDG38	Servo state input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace BD641T.
LEDG39	Safety module state output (Chain 2)	Green	When outputted: Turned off When not outputted Turned on	Phenomenon: States other than normal state Action 1: Replace BD632T.
LEDG40	OP emergency stop input (Chain 1)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the OP emergency stop switch.
LEDG41	OP emergency stop input (Chain 2)	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace the OP emergency stop switch.
LEDG52	PLC power	Green	When connected: Turned on When not connected: Turned off	Phenomenon: States other than normal state Action 1: Inspect the fuse (F6). Action 2: Inspect the cable. Action 3: Replace BD632T. Action 4: Replace the connected board.
LEDG53	Emergency stop (npn type) input (Chain 1)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Inspect LEDG52 (When abnormal, take an action for LEDG52). Action 2: Inspect the cable. Action 3: Replace BD632T. Action 4: Replace the connected board.
LEDG54	Emergency stop (npn type) input (Chain 2)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Inspect LEDG52 (When abnormal, take an action for LEDG52). Action 2: Inspect the cable. Action 3: Replace BD632T. Action 4: Replace the connected board.
LEDG55	Safety guard (npn type) input (Chain 1)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Inspect LEDG52 (When abnormal, take an action for LEDG52). Action 2: Inspect the cable. Action 3: Replace BD632T. Action 4: Replace the connected board.
LEDG56	Safety guard (npn type) input (Chain 2)	Green	When inputted: Turned on When not inputted: Turned off	Phenomenon: States other than normal state Action 1: Inspect LEDG52 (When abnormal, take an action for LEDG52).

				Action 2: Inspect the cable. Action 3: Replace BD632T. Action 4: Replace the connected board.
LEDG57	24V power input	Green	Green LED turned on	Phenomenon: Turned off Action 1: Inspect the 24V power cable and voltage (Power for connecting CNSMS1 connector). Action 2: Inspect the fuse (F1). Action 3: Replace BD632T.
LEDG58	EtherCAT input act LED	Green	When EtherCAT cable connected: Turned on When EtherCAT cable not connected: Turned off During EtherCAT communication: Blinking	Phenomenon: States other than normal state Action 1: Inspect the EtherCAT cable. Action 2: Check the firmware. Action 3: Re[ace BD632T. Action 4: Replace BD641T or H6COM-T.
LEDG59	EtherCAT output act LED	Green	When EtherCAT cable connected: Turned on When EtherCAT cable not connected: Turned off During EtherCAT communication: Blinking	Phenomenon: States other than normal state Action 1: Inspect the EtherCAT cable. Action 2: Replace BD632T. Action 3: Replace BD641T or H6COM-T.
LEDG60	EtherCAT state LED	Green	When communication connected: Blinking When communication not connected: Turned off.	Phenomenon: States other than normal state Action 1: Inspect the EtherCAT cable. Action 2: Replace BD632T. Action 3: Replace BD641T or H6COM-T.
LEDG61	EtherCAT run LED	Green	When communication connected: Blinking When communication not connected: Turned off	Phenomenon: States other than normal state Action 1: Inspect the EtherCAT cable. Action 2: Replace BD632T. Action 3: Replace BD641T or H6COM-T.
LEDG62	EtherCAT input speed LED	Green	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the EtherCAT cable. Action 2: Replace BD632T. Action 3: Replace BD641T or H6COM-T.
LEDG63	EtherCAT input act LED	Yellow	When inputted: Turned off When not inputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the EtherCAT cable. Action 2: Replace BD632T. Action 3: Replace BD641T or H6COM-T.
LEDG64	EtherCAT output speed LED	Green	When connected: Turned on When not connected: Turned off	Phenomenon: States other than normal state Action 1: Inspect the EtherCAT cable. Action 2: Replace BD632T. Action 3: Replace BD641T or H6COM-T
LEDG65	EtherCAT output act LED	Yellow	When connected: Turned on When not connected: Turned off	Phenomenon: States other than normal state Action 1: Inspect the EtherCAT cable. Action 2: Replace BD632T. Action 3: Replace BD641T or H6COM-T.

LEDG66	Motor on signal LED (Chain 1)	Green	When the motor is turned off: Turned on When the motor is turned on: Turned off	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace BD641T.
LEDG67	Motor on signal LED (Chain 2)	Green	When the motor is turned off: Turned on When the motor is turned on: Turned off	Phenomenon: States other than normal state Action 1: Inspect the cable. Action 2: Replace BD632T. Action 3: Replace BD641T.
LEDG68	Safety chain input (Chain 1)	Green	When outputted: Turned off When not outputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the connected cable. Action 2: Replace BD632T. Action 3: Replace the connected board.
LEDG69	Safety chain input (Chain 2)	Green	When outputted: Turned off When not outputted: Turned on	Phenomenon: States other than normal state Action 1: Inspect the connected cable. Action 2: Replace BD632T. Action 3: Replace the connected board.
LEDG70	EtherCAT input link LED	Green	When connected: Blinking When not connected: Turned off	Phenomenon: States other than normal state Action 1: Inspect the EtherCAT cable. Action 2: Check the firmware. Action 3: Replace BD632T. Action 4: Replace BD641T.
LEDG71	EtherCAT output link LED	Yellow	When connected: Turned on When not connected: Turned off	Phenomenon: States other than normal state Action 1: Inspect the EtherCAT cable. Action 2: Check the firmware. Action 3: Replace BD632T. Action 4: Replace BD641T.
SEG1*	Safety module state LED (Chain 1)	7-seg	When normal: A number will be displayed and the dot will blink.	Phenomenon: Turned off, or the dot stops blinking. Action 1: Replace BD632T.
SEG2*	Safety module state LED (Chain 2)	7-seg	When normal: A number will be displayed and the dot will blink.	Phenomenon: Turned off, or the dot stops blinking. Action 1: Replace BD632T.

SEG*: For the meaning of the display of the 7-SEG, refer to the troubleshooting manual.

4.3.2.4. Setting Devices

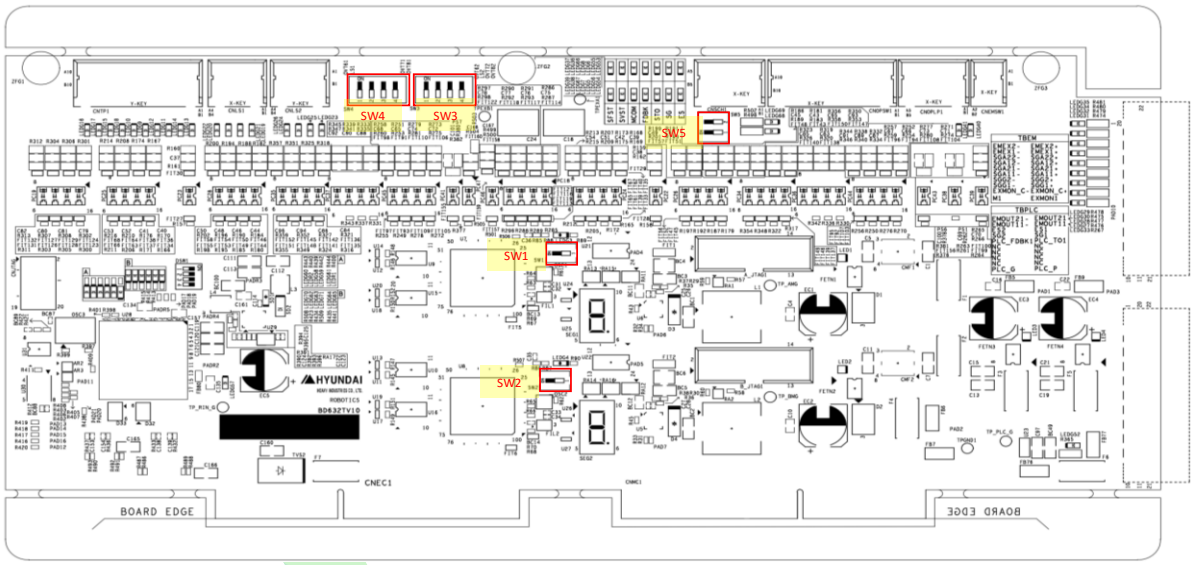


Figure 4.8 Description of the Setting Devices of the BD632T (Safety IO Board)

⚠ Warning	When a safety-related input is connected and activated, you must check whether the function is operating normally by referring to "1.11 Safety Works When Operating the Robot."

Table 4-7 Description of the SW1, SW2, SW3, SW4, SW7 and SW9 Setting Devices of BD632T (Safety IO Module)

Switch number		SW1	SW2	SW3	SW4	SW7	SW9
Usage		Sets whether to install the Operation Panel (OP) (Chain 1)	Sets whether to install the Operation Panel (OP) (Chain 2)	Sets whether to install OVT6, LS, OVT7 (additional axis), and OVT8 (extended axis) (Chain 1)	Sets whether to install OVT6, LS, OVT7 (additional axis), and OVT8 (extended axis) (Chain 2)	1: ES1 2: ES2 3: SG1 4: SG2	1: safety chain1 2: safety chain2 3: N.C 4: ACFLT
Contents of setting	Off	Non-installation	Non-installation	1: Installation of OVT6 2: Installation of LS 3: Installation of OVT7 4: Installation of OVT8	1: Installation of OVT6 2: Installation of LS 3: Installation of OVT7 4: Installation of OVT8	1: Installation (Chain 1) 2: Installation (Chain 2)	1: Installation 2: Installation 3: Installation 4: Installation

	On	Installation	Installation	1: No installation of OVT6 2: No installation of LS 3: No installation of OVT7 4: No installation of OVT8	1: No installation of OVT6 2: No installation of LS 3: No installation of OVT7 4:No installation of OVT8	1: No installation (Chain 1) 2: No installation (Chain 2)	1: No installation 2: No installation 3: No installation 4: No installation
Setting when shipped from the factory		OFF	OFF	1: OFF 2, 3, 4: ON	1: OFF 2, 3, 4: ON	1, 2, 3, 4: ON	1, 2, 3, 4: ON

4.3.2.5. Connections of the Emergency Stop

(1) External Emergency Stop of Contact Input Type

The external emergency stop (EMEX) is designed in a way that it can be operated regardless of the controller mode (automatic or manual) and is continuously monitored by the BD632T (Safety IO Board). When a safety input is coming in, the motor power will be shut off to put the robot in a safe state. The external emergency stop switch should be connected and used in the form of contact output, as shown in the figure below.

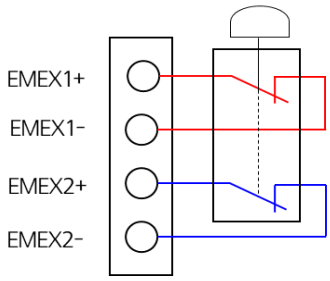


Figure 4.9 Method to Connect the External Emergency Stop Switch to the Terminal Block TBEM

If the external emergency stop is not to be used, connect the terminals of the terminal block TBEM (connect the pins 9-1 and 10-2 of the TBEM connector), as shown below, to disable the input.

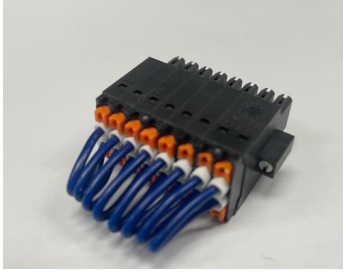


Figure 4.10 Method to Perform When Not Using the External Emergency Stop of Contact Input Type

⚠ Warning	If an external emergency stop is to be installed and used, the robot should be operated after confirming that the emergency stop operates normally. In addition, check if the emergency stop input is disabled. This is an essential measure that must be taken in advance for the safety of workers.

4.3.2.6. Connection of the Safety Guard

(1) General Safety Guard

The general safety guard operates regardless of the controller's mode (automatic or manual). In other words, when a person enters inside the installed safety guard or when the guard is broken, the controller will immediately shut off the motor power. The safety guard that can be used should be in the form of contact output. In the terminal block TBEM, terminals are configured in a way that they connect the contact outputs of the safety guard to the dual safety chain, as shown in the figure below.

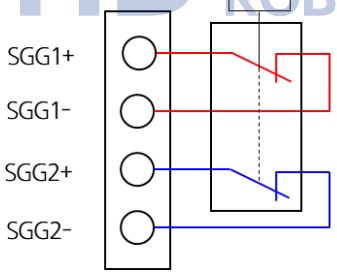


Figure 4.11 Method to Connect a General Safety Guard to the Terminal Block TBRMT

If the general safety guard is not to be used, connect the terminals (pins 15-7 and 16-8) of the terminal block TBEM, as shown below, to disable the input.

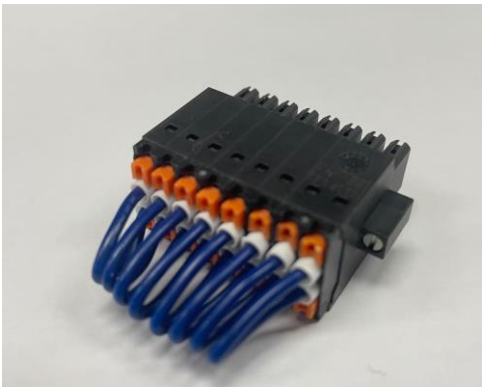


Figure 4.12 Method to Perform When Not Using a General Safety Guard

⚠ Warning	If a general safety guard is to be installed and used, the robot should be operated after confirming that the emergency stop operates normally. In addition, check if the emergency stop input is disabled. This is an essential measure that must be taken in advance for the safety of workers.

(2) Automatic Safety Guard of Contact Input Type

The automatic safety guard operates only when the controller is in the automatic mode and provides two inputs, as shown below. Like a general safety guard, the automatic safety guard should be in the form of contact output. In the terminal block TBEM, terminals are configured in a way that they connect the contact outputs of the safety guard to the dual safety chain, as shown in the figure below.

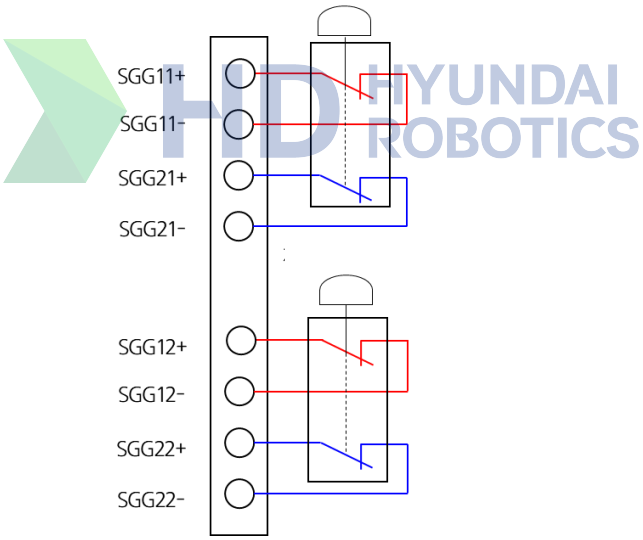


Figure 4.13 Method to Connect an Automatic Safety Guard of Contact Input Type to the Terminal Block TBEM

If the automatic safety guard is not to be used, connect the terminals of the terminal block TBEM((pins 11-3, 12-4, 13-5 and 14-6), as shown below, to disable the input.

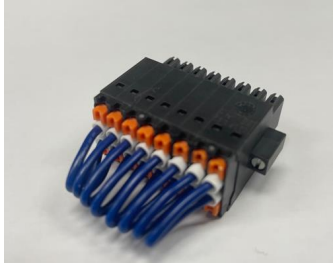


Figure 4.14 Method to Perform When Not Using an Automatic Safety Guard of Contact Input Type

⚠ Warning	If an automatic safety guard is to be installed and used, the robot should be operated after confirming that the emergency stop works normally. In addition, check if the emergency stop input is disabled. This is an essential measure that must be taken in advance for the safety of workers.

4.3.2.7. Connection of the Safety PLC/IO

The emergency input signal and monitoring output signal between the safety PLC or IO, and the robot controller should be connected in the following way.

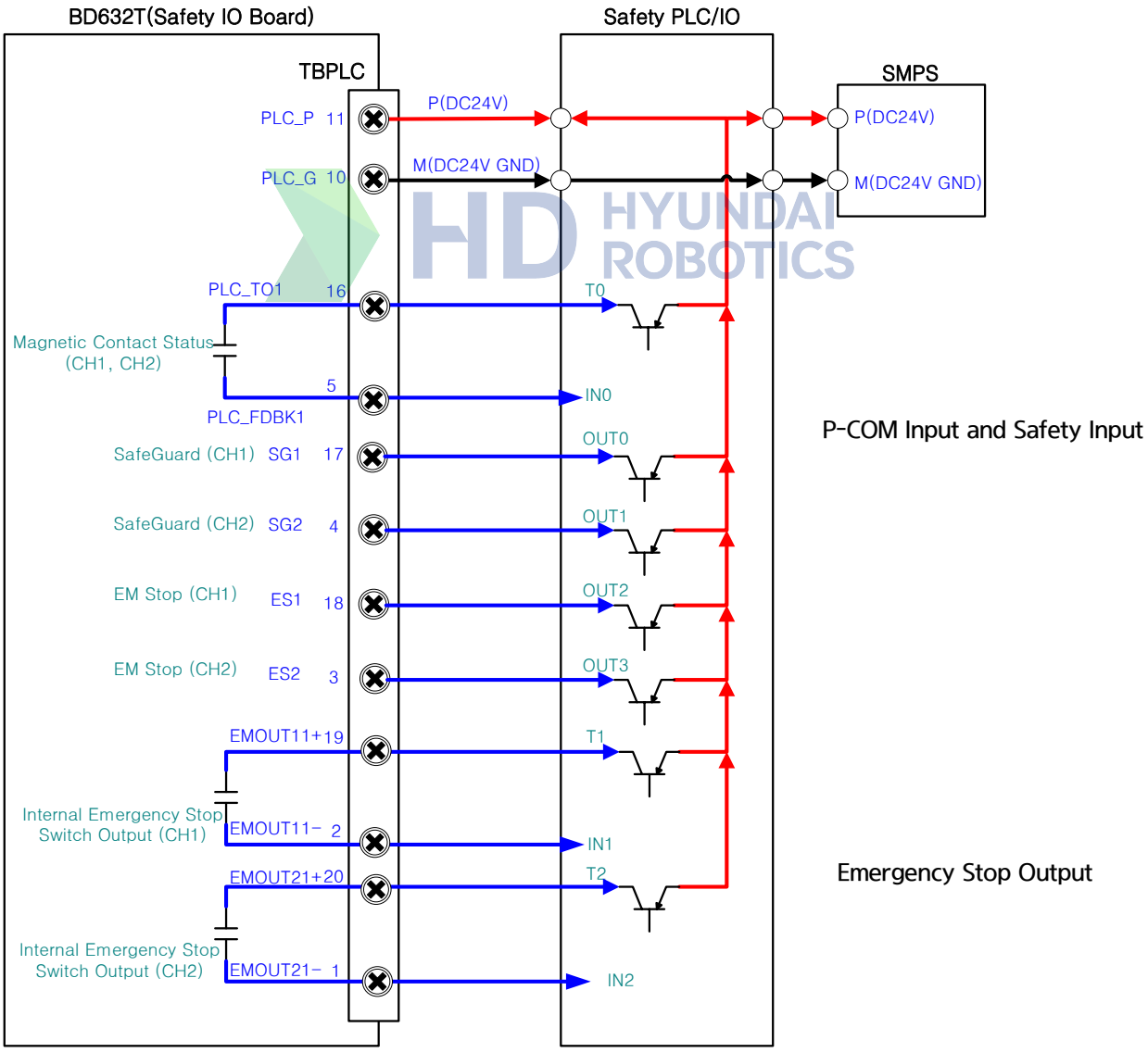


Figure 4.15 Method to Connect the Safety PLC/IO

(1) P-COM Input and Safety Input

The safety inputs (ES, SG) of the safety PLC are designed in a way that the controller can receive the PNP output, as an input, from the terminal block TBEM. Considering this, you must connect the power (DC24V) of the PLC before using the safety inputs.

⚠ Warning	If a safety input is to be installed and used, the robot should be operated after confirming that the function works normally. This is an essential measure that must be taken in advance for the safety of workers.

(2) Emergency Stop Output

Emergency stop output is designed in a way that allows the controller to use the PNP output by turning it on or off when it is necessary for an external device to use the status of the emergency stop switch (on the operation panel, teach pendant, etc.) installed inside the controller.

⚠ Warning	If an emergency stop output is to be installed and used, the robot should be operated after confirming that the emergency stop output operates normally. This is an essential measure that must be taken in advance for the safety of workers.

4.3.2.8. Connection of the External Motor On Signal

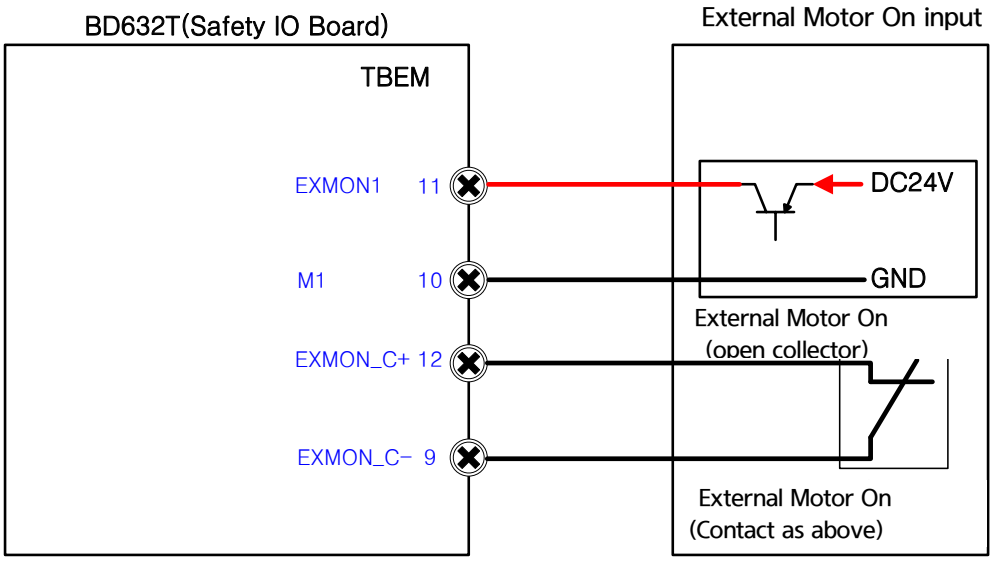


Figure 4.16 Method to Connect the External Motor On Signal

(1) External Motor On Signal

When using a motor on signal input from the outside of the controller, the relevant connection should be configured in the form of an open collector or contact as above.

4.3.3. Servo Control Board (BD641T)

4.3.3.1. Overview

The servo board controls the operation of six axes (maximum eight axes) according to the position command received from the main board through EtherCAT communication, and processes the encoder signal, checks the error status, and creates the PWM signal of the drive unit.

4.3.3.2. Connectors

The placement of the connectors of the servo control board (BD641T) is as shown in the following figure, and the usage and connection device for each connector are as shown in Table 4-8.

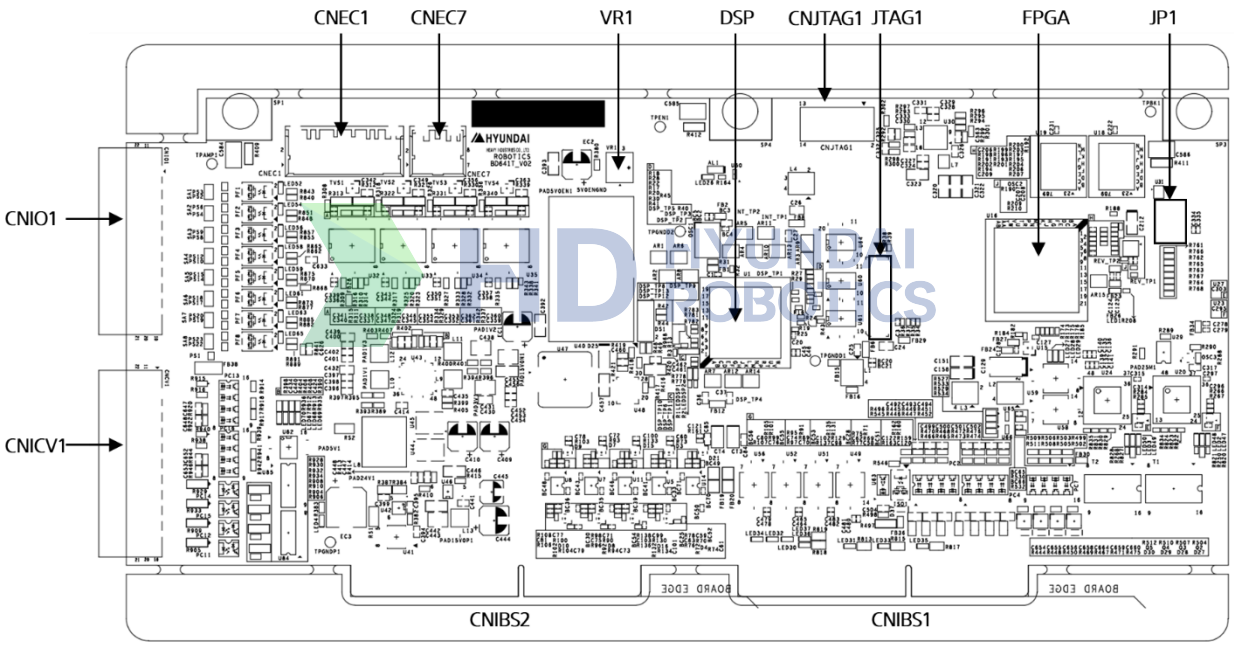


Table 4-8 Types and Usage of the Connectors of the Servo Control Board (BD641T)

Name	Usage	Connection of external devices
CNEC1	Connection of the encoder signal	CMEC1
CNEC7	Connection of encoder signal of the additional axis	CNR7 and CNR8
CNBS1,2	Connection of the drive unit signal	BD602T Card Edge Connector
CNJTAG1	FPGA JTAG emulator port	JTAG emulator
JP1	FPGA boot mode	FPGA flash and JTAG boot mode

VR1	Encoder input power regulator	-
CNIO1	Universal digital input and output accesses	-
CNCV1	Conveyor interface connection	-

4.3.3.3. Display Devices

The placement of the display devices of the servo control board (BD641T) is as shown in the following figure, and each use is shown in Table 4-9.

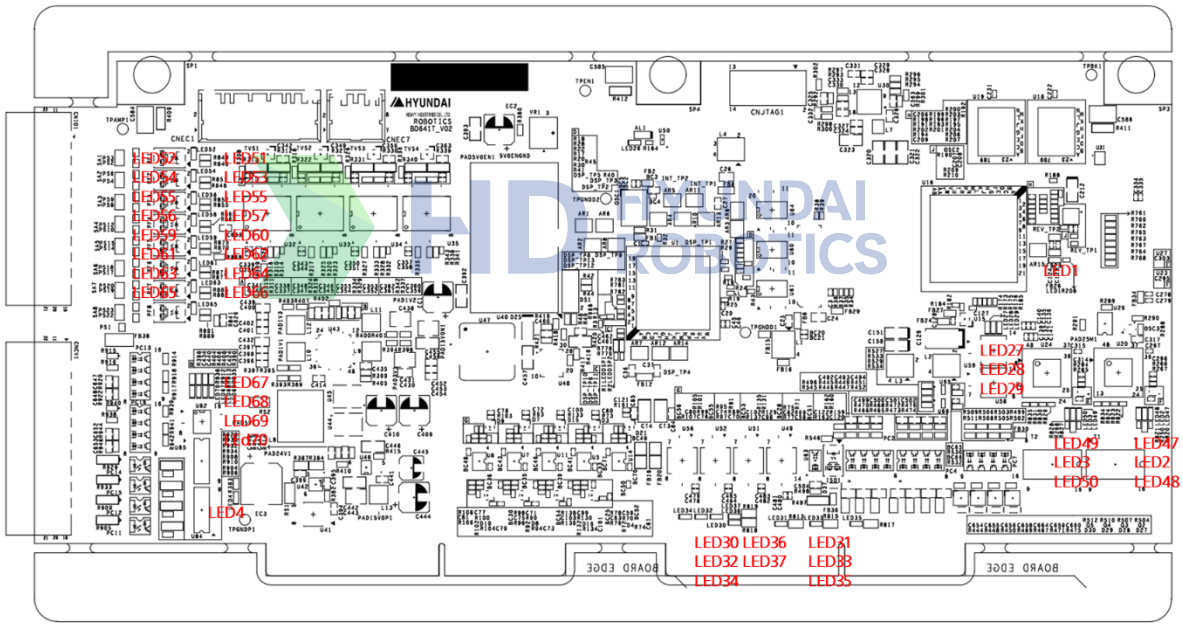


Table 4-9 LEDs of the Servo Board (BD641T)

State / Name	Contents of display	Color	When normal	Actions to take when an abnormality occurs
LED1	FPGA operation state	**Green**	Blinking	Phenomenon: Turned off Action 1: Check the input voltage (24V). Action 2: When turned off, check the fuse. Action 3: Replace BD641T.
LED2	EtherCAT In Speed	**Green**	Blinking	Phenomenon: Turned off Action 1: Check the input voltage (24V). Action 2: Inspect the EtherCAT communication line. Action 3: Replace BD641T.

LED3	EtherCAT Out Speed	Green	Blinking	Phenomenon: Turned off Action 1: Check the input voltage (24V). Action 2: Inspect the EtherCAT communication line. Action 3: Replace BD641T.
LED4	24V power input	Green	Turned on	Phenomenon: Turned off Action 1: Check the input voltage (24V). Action 2: When turned off, check the fuse. Action 3: Replace BD641T.
LED30	Display of Axis 3 motor on	Green	Turned on	
LED31	Display of Axis 6 motor on	Green	Turned on	
LED32	Display of Axis 2 motor on	Green	Turned on	
LED33	Display of Axis 5 motor on	Green	Turned on	
LED34	Display of Axis 5 motor on	Green	Turned on	
LED35	Display of Axis 4 motor on	Green	Turned on	
LED36	Display of Axis 8 motor on	Green	Turned on	
LED37	Display of Axis 7 motor on	Green	Turned on	
LED47	EtherCAT In LINK	Green	Blink	Phenomenon: Turned off Action 1: Check the input voltage (24V). Action 2: Inspect the EtherCAT communication line. Action 3: Replace BD641T.
LED48	EtherCAT In ACT	Green	Blink	Phenomenon: Turned off Action 1: Check the input voltage (24V). Action 2: Inspect the EtherCAT communication line. Action 3: Replace BD641T.
LED49	EtherCAT Out LINK	Green	Blink	Phenomenon: Turned off Action 1: Check the input voltage (24V). Action 2: Inspect the EtherCAT communication line. Action 3: Replace BD641T.
LED50	EtherCAT Out ACT	Green	Blink	Phenomenon: Turned off Action 1: Check the input voltage (24V). Action 2: Inspect the EtherCAT communication line.

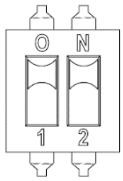
				Action 3: Replace BD641T.
LED51	Digital input channel 1	Green	Turned on	
LED52	Digital output channel 1	Green	Turned on	
LED53	Digital input channel 2	Green	Turned on	
LED54	Digital output channel 2	Green	Turned on	
LED55	Digital input channel 3	Green	Turned on	
LED56	Digital output channel 3	Green	Turned on	
LED57	Digital input channel 4	Green	Turned on	
LED58	Digital output channel 4	Green	Turned on	
LED59	Digital output channel 5	Green	Turned on	
LED60	Digital input channel 5	Green	Turned on	
LED61	Digital output channel 6	Green	Turned on	
LED62	Digital input channel 6	Green	Turned on	
LED63	Digital output channel 7	Green	Turned on	
LED64	Digital input channel 7	Green	Turned on	
LED65	Digital output channel 8	Green	Turned on	
LED66	Digital input channel 8	Green	Turned on	
LED67/LED68	Conveyor IF channel 1	Green		
LED69/LED70	Conveyor IF channel 2	Green		

Input Type	Differential input		Open collector		LED
Counting Mode	UP	UP/DN	UP	UP/DN	
Conveyor IF CH1	ON	ON	OFF	OFF	LED68
	ON	OFF	ON	OFF	LDE67
Conveyor IF CH2	ON	ON	OFF	OFF	LED70
	ON	OFF	ON	OFF	LED69

4.3.3.4. Setting Devices

⚠ Caution	The DIP switch is set to OFF mode when shipped from the factory, and the setting should not be changed arbitrarily by the user.

Table 4-10 Method to Set the DIP Switch (DS1) of the Servo Board (BD641T)

Switch number	1	2	Mode
Setting when shipped from the factory	OFF	OFF	GET MODE
When testing	ON	OFF	WAIT MODE
Switch exterior			

⚠ Caution	The user cannot change the following items arbitrarily and needs to refer to them only when required to reprogram through FPGA JTAG.

Table 4-11 Description of the Jumper (JP1) of the Servo Board (BD641T)

Name / Contents of the setting		JP1			
		1	2	3	
Setting of the jumper	QSPI (flash) boot mode	⦿	⦿		
	JTAG programming mode		⦿	⦿	
Setting when shipped from the factory	Jumper 1–2, or no connection				

(1) BD641T Conveyer Interface : TBCV

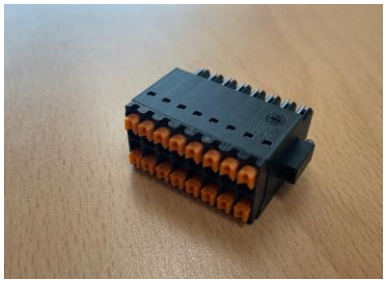


Figure 4.17 BD641T(Servo Control Board) TBCV

⚠ Warning	When performing activation by connecting a conveyor-related input, check whether the function works normally by referring to “1.11 Safety Measures When Operating the Robot.”

Table 4-12 Description of the BD641T(Servo Control Board) TBCV

Terminal no	Terminal name	Use	Input specification
11	PA1+	Channel 1 Line driver method Conveyor phase A pulse input	0–5 V, 100 kHz or less
12	PA1-		
13	PB1+	Channel 1 Line driver method Conveyor phase B pulse input	0 ~ 5V, 100kHz or less
14	PB1-		
15	LD_LS1	Channel 1 Line driver method Limit switch input for detecting a workpiece	0 ~ -30V
16	GND_LS1	Channel 1 Line driver method Power GND input	0V
17	P1+	Channel 1 Open-collector method Power input	20 ~ 30V
18	A1	Channel 1 Open-collector method Conveyor phase A pulse input	0 ~ -30V, 100kHz or less
19	B1	Channel 1 Open-collector method Conveyor phase B pulse input	0 ~ -30V, 100kHz or less
1	PA2+	Channel 2 Open-collector method	0 ~ -30V

		Limit switch input for detecting a workpiece	
2	PA2-	Channel 2 Line driver method Conveyor phase A pulse input	0 ~ 5V, 100kHz or less
3	PB2+		
4	PB2-	Channel 2 Line driver method Conveyor phase B pulse input	0 ~ 5V, 100kHz or less
5	LD_LS2		
6	GND_LS2	Channel 2 Line driver method Limit switch input for detecting a workpiece	0 ~ -30V
7	P2+	Channel 2 Line driver method Power GND input	0V
8	A2	Channel 2 Open-collector method Power input	20 ~ 30V
9	B2	Channel 2 Open-collector method Conveyor phase A pulse input	0 ~ -30V, 100kHz or less
10	OC_LS2	Channel 2 Open-collector method Conveyor phase B pulse input	0 ~ -30V, 100kHz or less
1	PA2+	Channel 2 Open-collector method Limit switch input for detecting a workpiece	0 ~ -30V

(2) Terminal block for connecting BD641T I/O

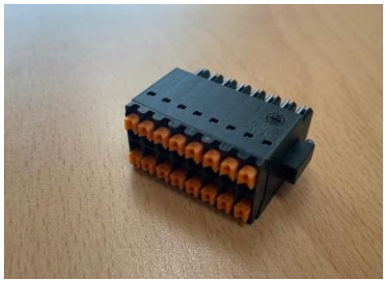


Figure 4.18 BD641T(Servo Control Board) TBIO

⚠ Warning	When performing activation by connecting an I/O-related input or output, check whether the function works normally by referring to “1.11 Safety Measures When Operating the Robot.”

Table 4-13 Description of the BD641T(Servo Control Board) TBIO

Terminal no	Terminal name	Use	I/O specification
11	DIN1	Digital Input - 1	0 ~ 24V
12	DIN2	Digital Input - 2	0 ~ 24V
13	DIN3	Digital Input - 3	0 ~ 24V
14	DIN4	Digital Input - 4	0 ~ 24V
15	DIN5	Digital Input - 5	0 ~ 24V
16	DIN6	Digital Input - 6	0 ~ 24V
17	DIN7	Digital Input - 7	0 ~ 24V
18	DIN8	Digital Input - 8	0 ~ 24V
19	DICOM1	Digital Input Power COM	0 ~ 24V
20	DICOM1		
1	DOUT1	Digital Output - 1	0 ~ 24V
2	DOUT2	Digital Output - 2	0 ~ 24V

3	DOUT3	Digital Output - 3	0 ~ 24V
4	DOUT4	Digital Output - 4	0 ~ 24V
5	DOUT5	Digital Output - 5	0 ~ 24V
6	DOUT6	Digital Output - 6	0 ~ 24V
7	DOUT7	Digital Output - 7	0 ~ 24V
8	DOUT8	Digital Output - 8	0 ~ 24V
9	DOCOM1	Digital Output Power COM	0 ~ 24V
10	DOCOM1		

4.3.4. Amp Board (BD657T/BD658T)

4.3.4.1. BD658T/BD657T (Amp Board)

The Amp Board performs a power amplification function that allows the current to flow to the individual phases of the motor according to the current command from the servo board. BD658T and BD657T enable simultaneous driving of 6 motors and are configured as follows.

The single-phase current supplied from the power supply module is rectified through a diode module and then converted into direct current and stored in a smoothing capacitor.

Table 4-14 Configuration of BD658T / BD657T (Amp Board)

Components		Functions
BD658T/657T (AMP Board)	Gate drive circuit	Generates the IPM gate signal
	Gate power module	Generates the gate power
	Current detection part	Detects the current that flows through the motor
Other parts	Heat sink	Releases the heat generated from power elements to the outside
	IPM	A switching device

■ Configuration of the Type Number of AMP Board

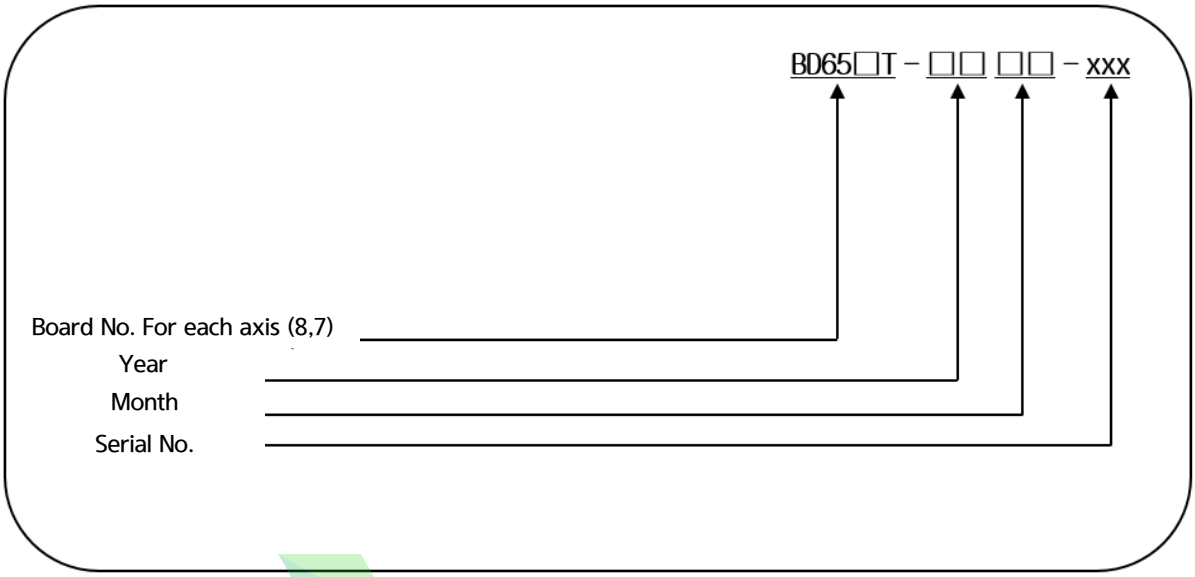


Table 4-15 Specification of Amp Board

Configuration	Classification		Application	
Board No. For each axis	8	BD658T	1~3 axes	6 axis use
	7	BD657T	4~6 axes	
Year	00 ~ 99		Production year: 2000~2099	
Month	01 ~ 12		Production month: January~December	
Serial No.	0001 ~ 999		Number of units produced monthly: 1~999	

⚠ Caution	The location where the amp board is fastened on the backplane board may be different, so you must check the type when replacing it.

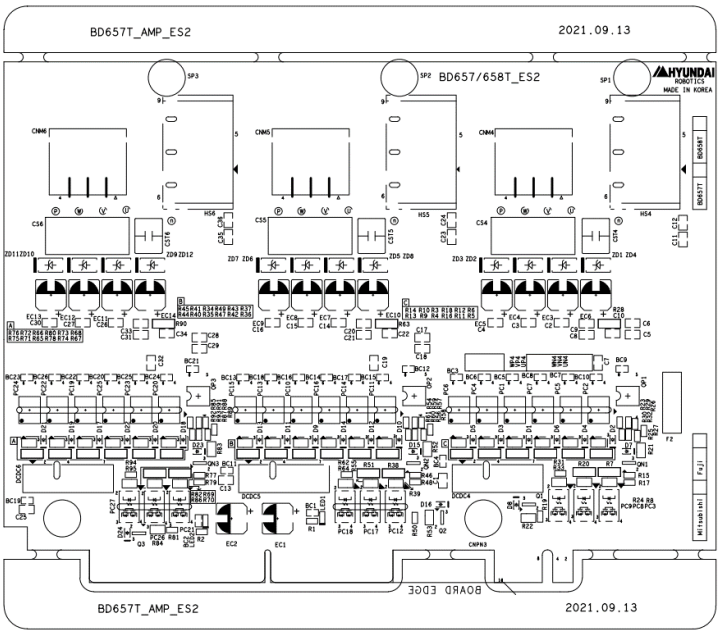


Figure 4.19 BD658T/657T part layout

Table 4-16 BD658T/657T connector description

Name	Usage	Connection of external devices
CNM4~6	BD658T: Motor drive output for Axis 1 to Axis 3, BD657T: Motor drive output for Axis 4 to Axis 6	CMEC1

4.3.4.2. BD658TA/BD657TA (AMP Board, additional axis included)

The AMP Board performs a power amplification function that allows the current to flow to individual phases of the motor according to the current command from the servo board. BD658TA and BD657TA enable simultaneous driving of 8 motors and are configured as follows.

Table 4-17 Configuration of BD658TA / BD657TA (AMP Board)

Components		Functions
BD658TA/657TA (AMP Board)	Gate drive circuit	Generates the IPM gate signal
	Gate power module	Generates the gate power
	Current detection part	Detects the current that flows through the motor
Other Parts	Heat sink	Releases the heat generated from power elements to the outside
	IPM	A switching device

■ Configuration of the Type Number of AMP Board

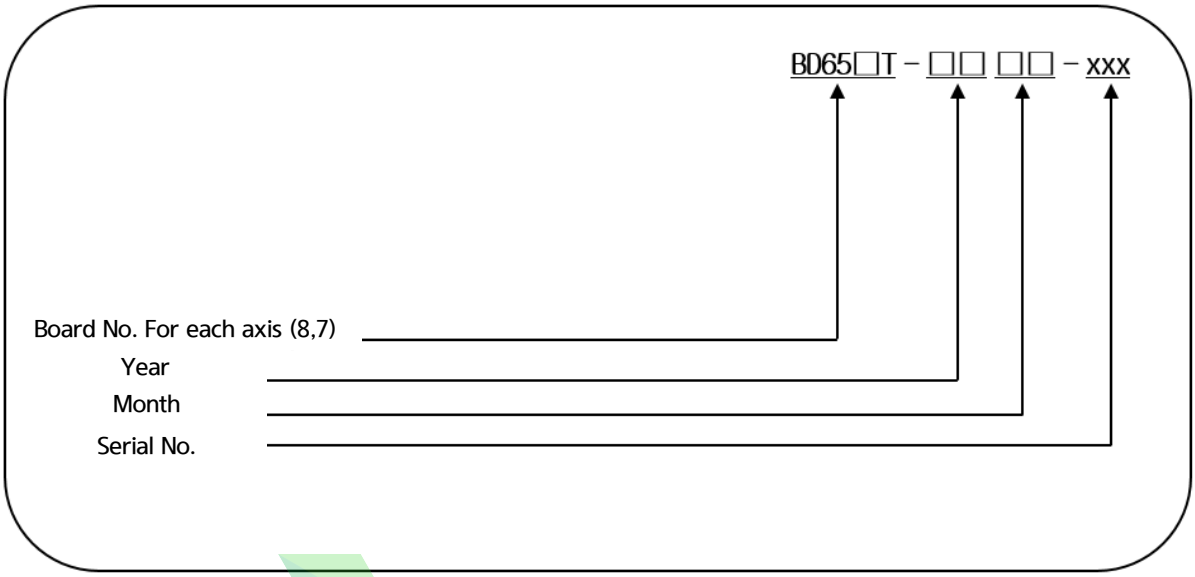


Table 4-18 Specification of the AMP Board

Configuration	Classification		Application	
Board No. For each axis	8	BD658TA	1~3 and 7 axes	8 axis use
	7	BD657TA	4~6 and 8 axes	
Year	00~99		Production year: 2000-2099	
Month	01~12		Production month: January-December	
Serial No.	0001~9999		Number of units produced monthly: 1~9999	

⚠ Caution	The location where the amp board is fastened on the backplane board may be different, so you must check the type when replacing it.

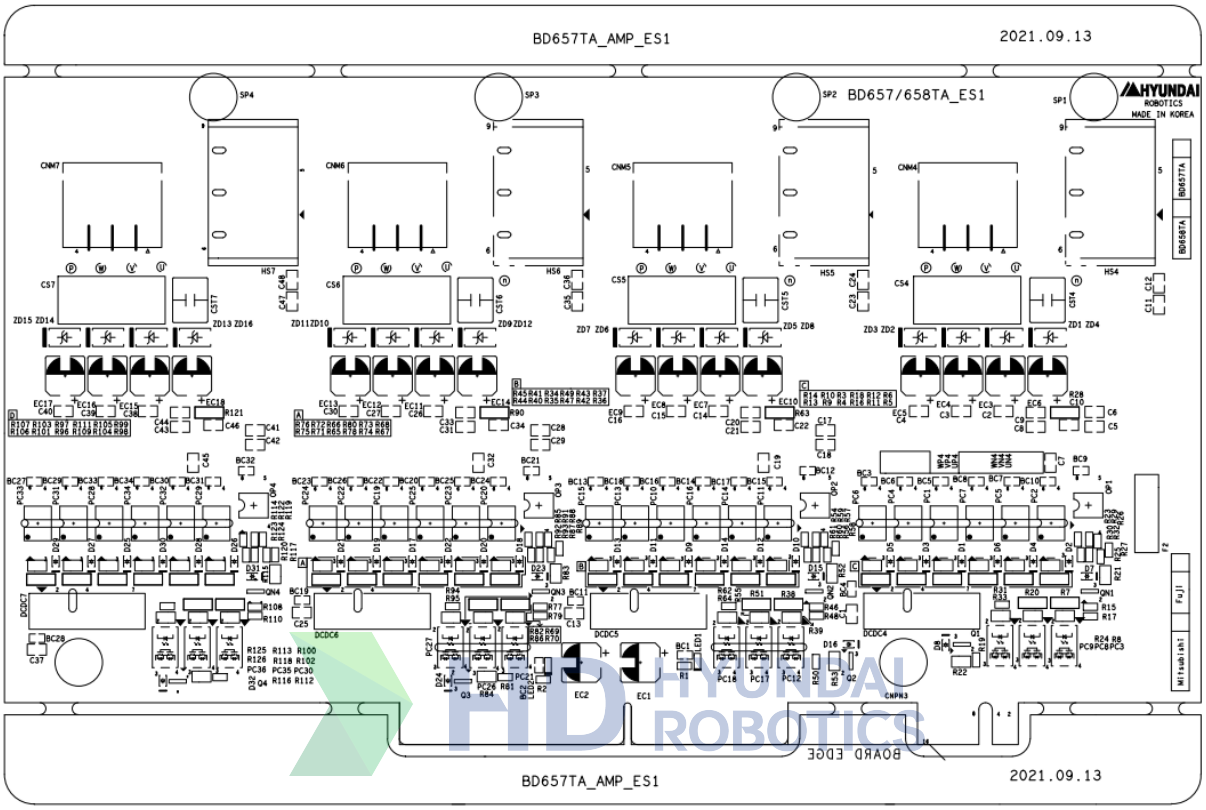


Figure 4.20 BD658TA/657TA part layout

Table 4-19 BD658TA/657TA connector description

Name	Usage	Connection of external devices
CNM4~7	BD658TA: Motor drive output for Axis 1 to Axis 4, and Axis 7 BD657TA : Motor drive output for Axis 4 to Axis 6, and Axis 8	CMEC1

4.3.4.3. BD658T-S (AMP Board, Major axis amp for HH4E)

The AMP Board performs a power amplification function that allows the current to flow to individual phases of the motor according to the current command from the servo board. BD658TA and BD657TA enable simultaneous driving of 6 motors and are configured as follows.

Table 4-20 Configuration of BD658T-S (AMP Board)

Components		Functions
BD658T-S	Gate drive circuit	Generates the IPM gate signal
	Gate power module	Generates the gate power
	Current detection part	Detects the current that flows through the motor
Other Parts	Heat sink	Releases the heat generated from power elements to the outside
	IPM	A switching device

■ Configuration of the Type Number of AMP Board

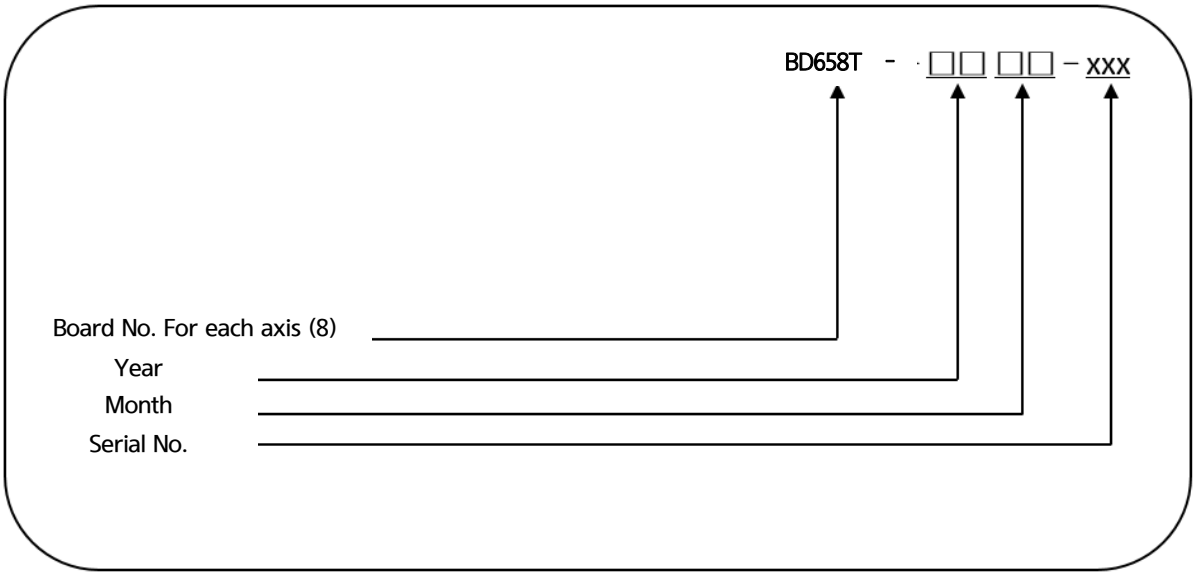


Table 4-21 Specification of the AMP Board

Configuration	Classification		Application	
Board No. For each axis	8	BD658T-S	1~3 axes	Major axis use for HH4
Year	00 ~ 99		Production year: 2000-2099	
Month	01 ~ 12		Production month: January-December	
Serial No.	0001 ~ 999		Number of units produced monthly: 1~9999	

⚠ Caution	The location where the amp board is fastened on the backplane board may be different, so you must check the type when replacing it.

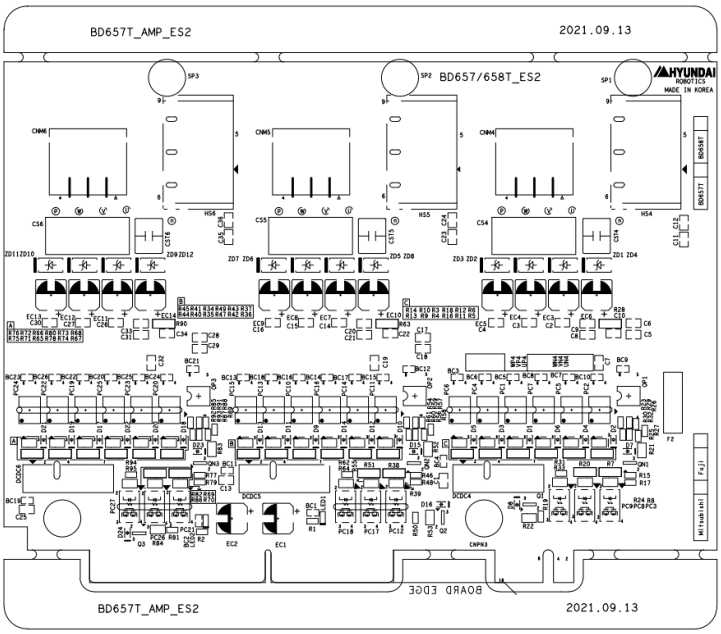


Figure 4.21 BD658T-S part layout

Table 4-22 BD658T-S connector description

Name	Usage	Connection of external devices
CNM4~6	BD658T : Motor drive output for Axis 1 to Axis 3	CMEC1

4.3.5. Backplane Board (BD602T)

4.3.5.1. Overview

The backplane board (BD602T) transfers signals between boards, operates the main relay to supply AC power, detects power failure signals, and drives the motor brake.

4.3.5.2. Connector

The placement of connectors on the backplane board (BD602T) is as shown in the following figure and the usage and access device for each is shown in Table 4-23.

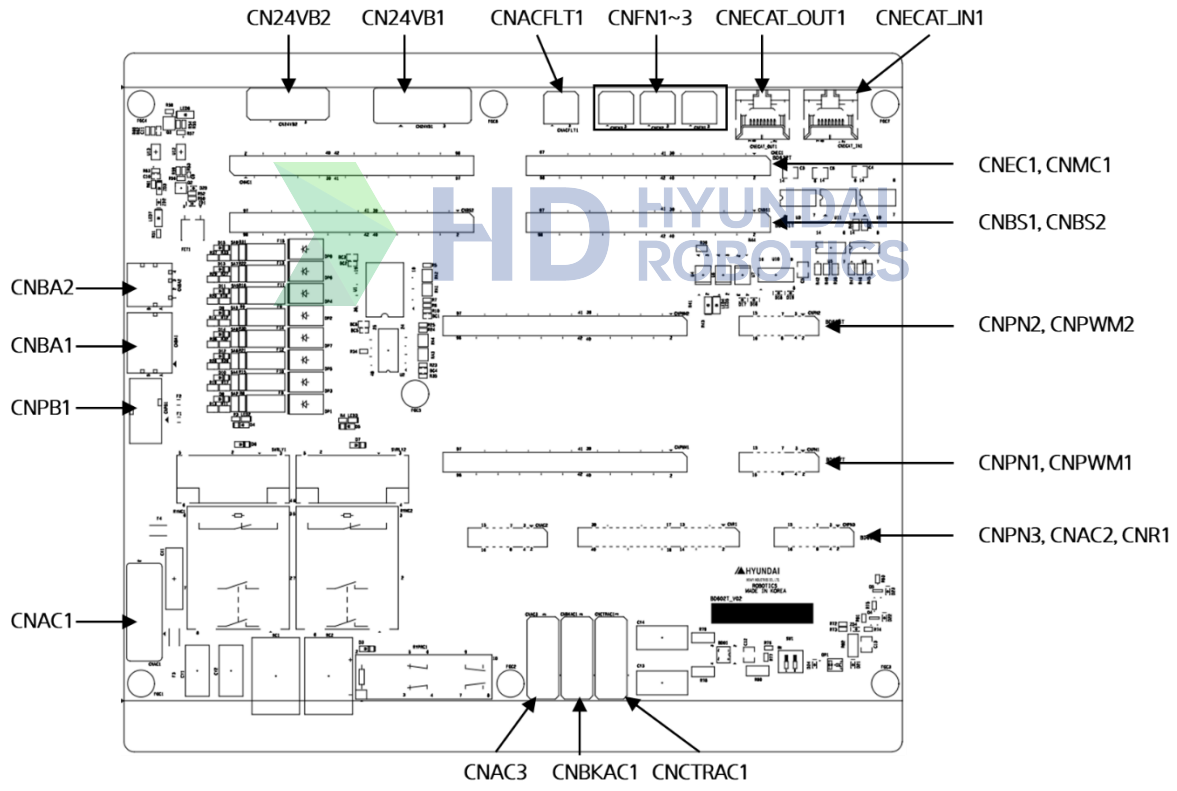


Figure 4.22 Connector of Backplane Board (BD602T)

Table 4-23 Types and Usage of BD602T connectors

Name	Usage	Specification
CN24VB1	Control power input	24VDC
CNAC1	Main power input	Single-phase 220V
CNPB1	Brake power input	24VDC
CNPA1	1~6 axes brake signal output	24VDC
CNPA2	7, 8 axes brake signal output	3-phase 220V, MC2 output side
CNAC3	SMPS power input	Single-phase 220V
CNBKAC1	SMPS power output for brake	Single-phase 220V
CNCTRAC1	SMPS power output for control power	Single-phase 220V
CN24VB2	H6ComT power input	24VDC,
CNECAT_IN1	EtherCAT communication input	-
CNECAT_OUT1	EtherCAT communication output	-
CNFN1~3	FAN power output	24VDC
CNACFLT1	Power failure detection signal output	H6COM DIO
CNEC1, CNMC1	BD632T connection connector	-
CNBS1, CNBS2	BD641T connection connector	-
CNPN2, CNPWM2	BD658T connection connector	-
CNPN1, CNPWM1	BD657T connection connector	-
CNPN3, CNAC2, CNR1	BD667T connection connector	-

4.3.5.3. Display Devices

The placement of display devices of the backplane board (BD602T) is as shown in the following figure, and each use is shown in Table 4-24.

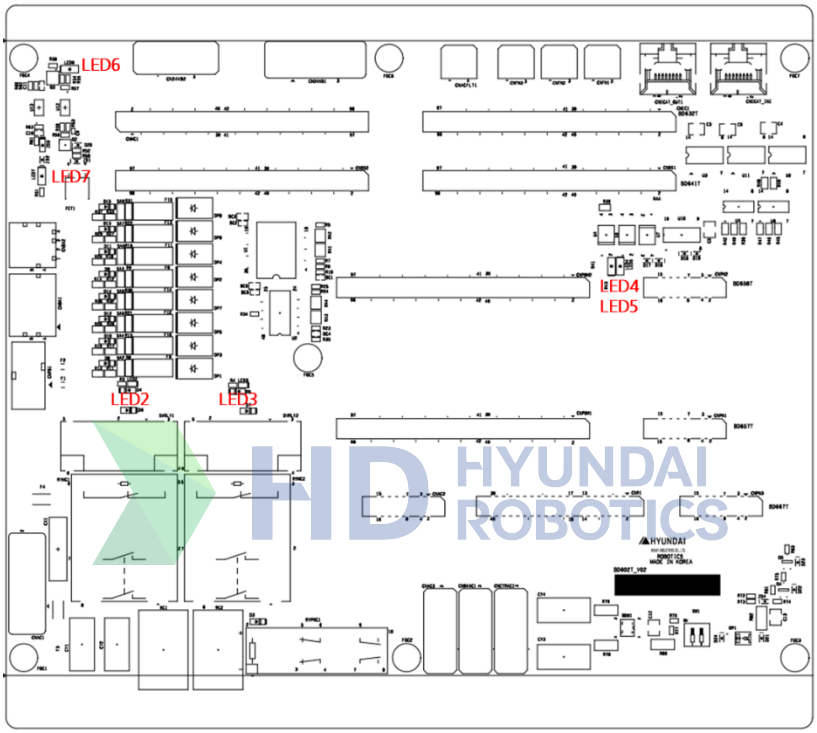


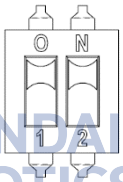
Table 4-24 LEDs of the Backplane Board (BD602T)

State / Name	Contents of display	Color	When normal	Actions to take when an abnormality occurs
LED2	RYMC1 contact state	Green	Turned on	
LED3	RYMC2 contact state	Green	Turned on	
LED4	Motor on state	Green	Turned on	
LED5	PWM output state	Green	Turned on	
LED6	Brake on signal	Green	Turned on	
LED7	Brake power	Green	Turned on	Phenomenon: Turned off Action 1: Check the input voltage (24V). Action 2: If turned off, check the fuse. Action 3: Replace BD602T.

4.3.5.4. Setting Devices

⚠ Caution	The DIP switch is set to OFF mode when shipped from the factory, and the setting should not be changed arbitrarily by the user.

Table 4-25 Method to Set the DIP Switch (DS1) of the Backplane Board (BD602T)

Switch number	1	2	Mode
Setting when shipped from the factory	OFF (45%)	OFF (3 cycles)	Long MODE
When testing	ON (70%)	ON (1.5 cycle)	Short MODE
Switch exterior			

4.3.6. Power Rectifier Board (BD667T)

4.3.6.1. Overview

The PN power and regenerative discharge module (BD667T) is designed as a module that supplies the motor control power to the controller and performs regenerative discharge of the back electromotive force generated from the motor.

4.3.6.2. Connector

The following figure shows the locations and usage of various connectors on BD667T (PN regenerative discharge module).

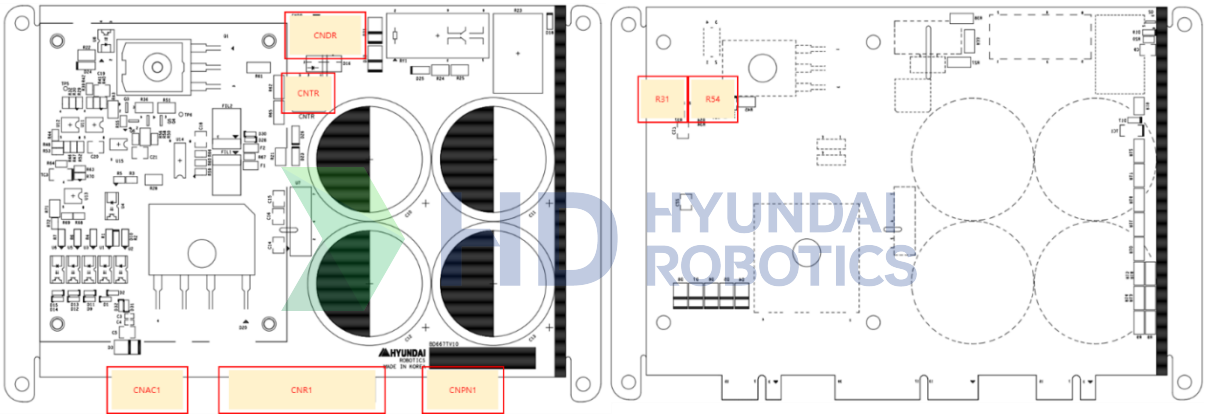


Figure 4.23 Placement of Connectors of BD667T (PN Regenerative Discharge Module)

Table 4-26 Types and Usage of BD667T connectors (PN regenerative discharge module)

Name	Usage	Connection of external devices
CNDR	Discharge of regenerative discharge power	Regenerative discharge resistor
CNTR	Regenerative discharge resistor temperature measuring	Regenerative discharge resistor temperature sensor
CNAC1	Connection for 15V power supply to digital devices, and connection for state signals	BD602
CNR1	220VAC power supply, and the motor drive power GND output.	BD602 -〉 AMP
CNPN1	Motor drive power VDC output	BD602 -〉 AMP
R31	Overvoltage detection level setting (Default 5.7V)	

Name	Usage	Connection of external devices
R54	Regenerative discharge operation detection level setting (Default 5.45V)	

4.3.6.3. Display Devices

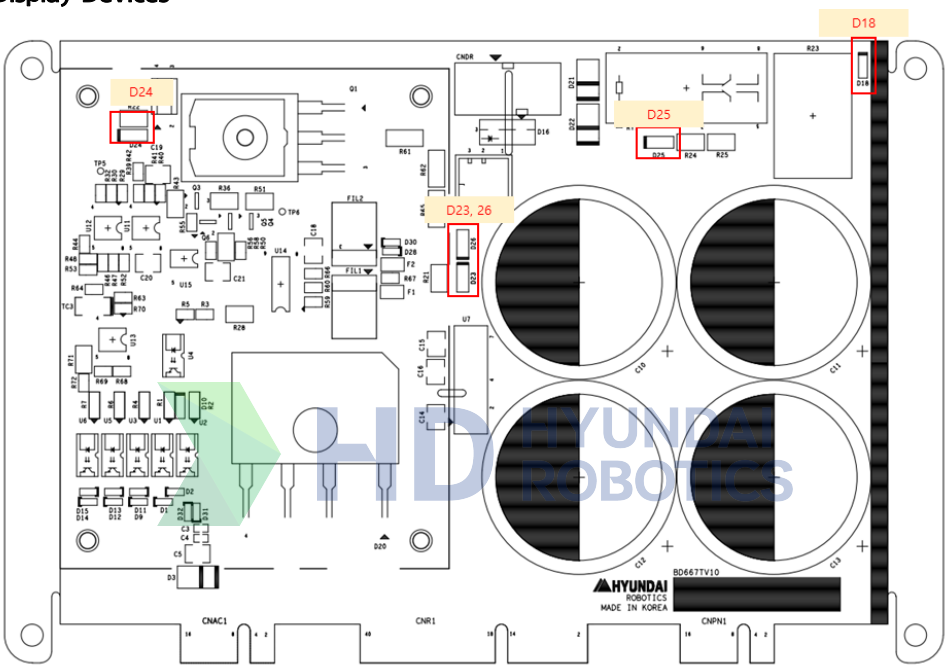


Figure 4.24 Display Devices of BD667T (PN Regenerative Discharge Module)

Table 4-27 Description of the Display Devices of BD667T (PN Regenerative Discharge Module)

State / Name	Contents of display	Color	When normal	Actions to take when an abnormality occurs
D24	Control signal for the discharge signal	Yellow	Turned off Will be turned on when discharge occurs. (Motor off)	Phenomenon: Turned off when the motor is turned off Action 1: Check the input voltage (15V). Action 2: Visually check the element for any damage. Action 3: Replace the BD667T board.
D23	15V power	Yellow	Yellow LED turned on	Phenomenon: Turned off Action 1: Check the input voltage (15V) Action 2: Check the 4-pin output voltage of U7. Action 3: Replace the BD667T.
D26	Regenerative discharge operation	Yellow	Turned off Will be blinking during the regenerative. discharge operation	Phenomenon: Yellow LED turned on, or blinking occurs without the robot being operated. Action 1: Check the R54 voltage setting.

				Action 2: Check the 5.45V regenerative discharge voltage setting. Action 3: Replace the BD667T board.
D25	Discharge resistor relay drive state	Yellow	Will be turned on right after the power is turned on. Will be then turned off after a while. Will be turned on when the motor is turned off.	Continues to be turned on, or will be turned off when the motor is turned off. Action 1: Check the input voltage (15V) Action 2: Check the safety relay (RY 1) NC state. Action 3: Replace the BD667T board.
D18	PN power state	Green	Green LED turned on	Phenomenon: Turned off Action 1: Check the 220VAC power supply of the BD602T board. Action 2: Replace the BD667T.

4.3.6.4. Setting Devices

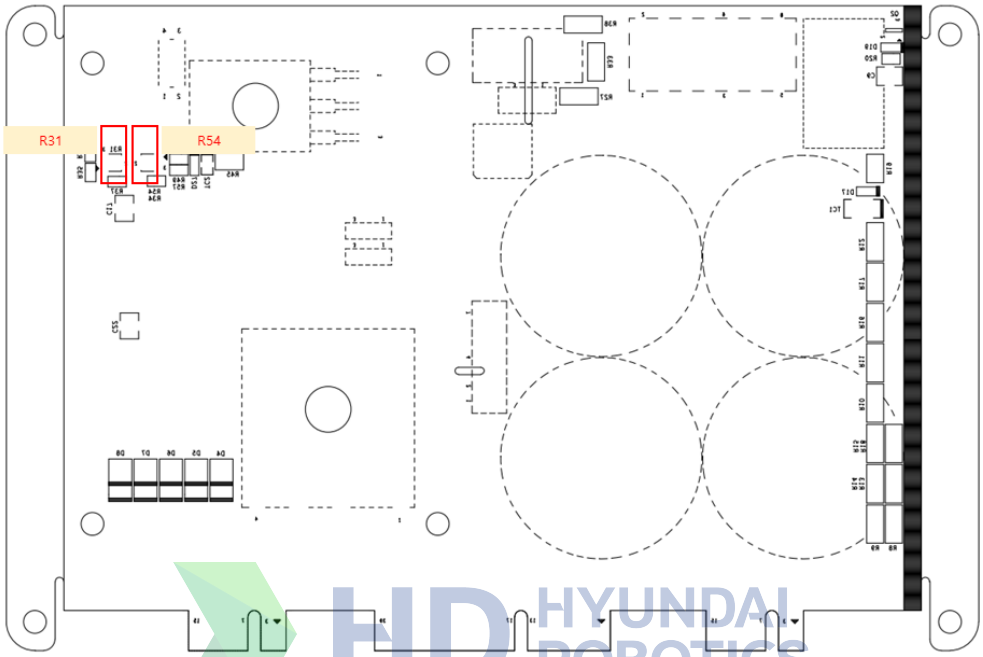


Figure 4.25 Description of the Setting Devices of BD667T (PN Regenerative Discharge Module)

Name	Contents of setting	Setting value	Setting method
R31	Setting of the voltage value for overvoltage monitoring	5.7V(392V)	Set the voltage between Pin 2 of the resistor and the GND to be 5.7V by turning the variable resistor R31, while keeping a multimeter attached.
R54	Setting of the regenerative discharge operation voltage	5.45V(375V)	Set the voltage between Pin 2 of the resistor and the GND to be 5.45V by turning the variable resistor R31, while keeping a multimeter attached.

4.3.7. Teach Pendant (TP630)

4.3.7.1. Overview

The teach pendant (TP630) communicates with the main module (H6COM) of the controller through Ethernet and allows the user to directly operate the following functions.

- Monitoring : Job program / Data of each axis / Input and output signals / Status of the robot, etc.
- Log management : System version, operation time, error log, stop log, etc.
- File management : Version and teach program up/down
- Setting of various variables : User environment / control / robot / application / automatic integer, etc.
- Robot teaching : Jog and teach program registration
- Robot operation : Motor on / start / stop / mode settings

The teach pendant is also equipped with a three-stage enable switch and emergency stop switch to ensure user safety.
In addition, a USB A type connector is mounted under the rubber cover at the bottom of the teach pendant, allowing the user to upload/download necessary files, such as data and teaching programs, as well as versions of diverse types of boards using a USB memory stick.

Figure 4.26 Exterior of the Teach Pendant TP630

Sign	Name	Specification
A	Mode switch	3-Position rotary switch
B	Emergency stop button guard	Option
C	Emergency stop button	Push lock type
D	USB port	1 channel (2.0)
E	Touch screen	7inch
F	Dead man's switch	3Dot type switch
G	Keypad	-
H	Connector	-

4.3.7.2. USB Cover

There is a USB A type connector mounted under the rubber cover at the bottom of the teach pendant, allowing the user to upload/download necessary files, such as versions of diverse types of boards, as well as data and teaching programs, using a USB memory stick.

Figure 4.27 USB Cover of the Teach Pendant TP630

⚠ Caution	Keep the rubber cover of the USB port closed when not using the port.

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5

Optional Components of the Controller

5.1. PCI Communication Card

5.1.1. Overview

To use industrial communication in the Hi6-T15 controller, you can use a PCI communication card. Descriptions below are provided based on a PCI communication card for Ethernet, which is a general model. For details, please refer to the contents for the PC Cards CIFX 50 model in the document "PC Cards CIFX 50 50E 70E 100EH UM 51 EN."

Table 5-1 Part Names of PCI Communication Cards

No.	Model Name	Communication type	Interface Connector
1	CIFX 50-RE/ML-HRC	HRC Real-Time Ethernet Master PCI	RJ45
2	CIFX 50-RE-HRC	HRC Real-Time Ethernet Slave PCI	RJ45
3	CIFX 50E-RE/ML-HRC	HRC Real-Time Ethernet Master PCIe	RJ45
4	CIFX 50E-RE-HRC	HRC Real-Time Ethernet Slave PCIe	RJ45
5	CIFX 50-CC-HRC	CC-Link Slave PCI	CombiCon Male, 5 pin
6	CIFX 50E-CC-HRC	CC-Link Slave PCIe	CombiCon Male, 5 pin
7	CIFX 50-DN/ML-HRC	DeviceNet Maser PCI	CombiCon Male, 5 pin
8	CIFX 50-DN-HRC	DeviceNet Slave PCI	CombiCon Male, 5 pin
9	CIFX 50E-DN/ML-HRC	DeviceNet Maser PCIe	CombiCon Male, 5 pin
10	CIFX 50E-DN-HRC	DeviceNet Slave PCIe	CombiCon Male, 5 pin
11	CIFX 50-DP/ML-HRC	PROFIBUS Master PCI	Dsub Female, 9 pin
12	CIFX 50-DP-HRC	PROFIBUS Slave PCI	Dsub Female, 9 pin
13	CIFX 50E-DP/ML-HRC	PROFIBUS Master PCIe	Dsub Female, 9 pin
14	CIFX 50E-DP-HRC	PROFIBUS Slave PCIe	Dsub Female, 9 pin
15	CIFX 50E-CCIES-HRC	CC-Link IE Fileld PCIe	RJ45

5.1.2. Configuration of the PCI Communication Card

A PCI communication card is basically configured, as shown below (when Ethernet-based communication is used), and varies in the number of connectors and LEDs depending on the type of industrial communication.

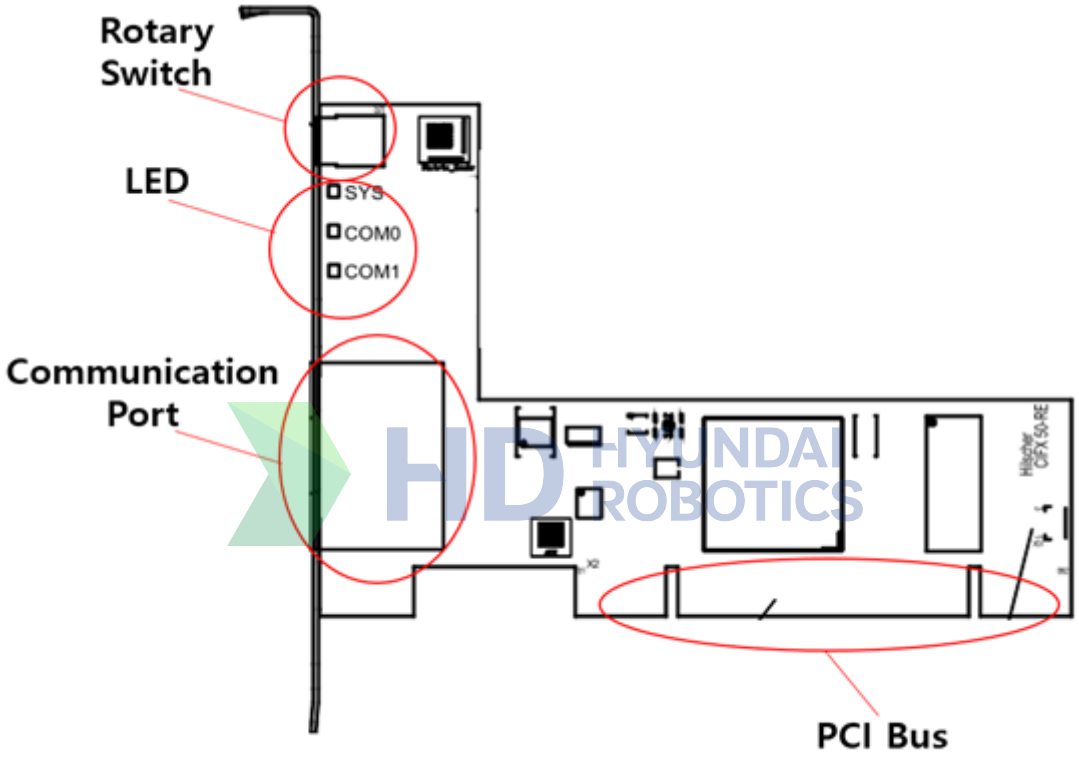

Figure 5.1 Exterior of the PCI Communication Card

Table 5-2 Description of the Exterior of the PCI Communication Card

Name	Usage
Rotary switch	Sets the communication according to the slot ID
LED	Displays the system and communication status
Communication port	Communication connection port
PCI bus	PC connection bus

5.1.3. Front Part of the PCI Communication Card

You can check the communication setting, communication cable connection, and communication status through the front part of the PCI communication card. Basically, you can use the card by setting the rotary switch to 1-4 in order according to the location of the H6COM PCI slot.

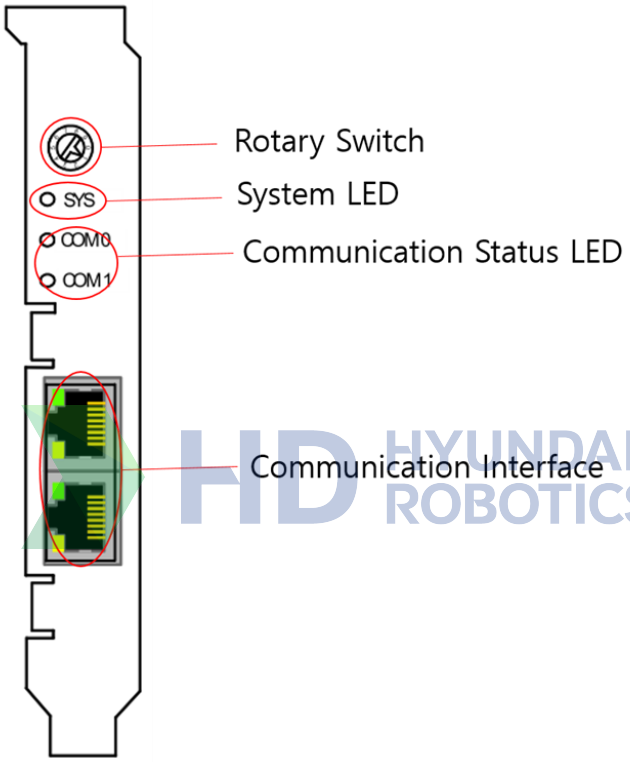

Figure 5.2 Front Part of the PCI Communication Card

Table 5-3 Configuration of the Front Part of the PCI Communication Card, and the Description of the Functions

Name	Usage	Description of Functions
Rotary switch	Sets the communication for each slot number	H6COM PCI slots are fixed as #1~#4 sequentially starting from the one at the top (Communication to be set from TP).
System LED	System status checking LED	Green: System in operation Yellow: Boot loader waiting
Communication status LED	Communication status checking LED	Green: Communication in operation Red: Communication error
Communication Interface	Communication cable connection port	Use of connectors suitable for communication

5.2. Brake Release Unit

5.2.1. Overview

The brake release unit can be used when it is necessary to release the motor brake for each axis of the robot. It can help to set the robot posture mainly during the initial installation of the robot. When releasing the brake, you must fully understand the safety information of “Release of the manual brake” in “1.8.2 Other Related Functions” before using the robot.

⚠ Caution	1. Do not release more than two axes at the same time. 2. Keep a safe distance from the robot first before using the brake release unit. 3. Use the brake release unit after preparing for the dropping of the robot’s axis using equipment such as a crane. 4. Check the safety matters while working in a group of at least two people.

⚠ Warning	The robot should be installed and operated according to the guidelines of ISO 10218-2. In addition, it is required to comply with the relevant requirements of international standards and national laws. Our company (or the manufacturer) will not be responsible for any accidents that occur because of not complying with the relevant requirements of international standards and national laws or not following the above “caution.”

5.2.2. Brake Release Switch

The placement of the switches of the brake release unit is as shown in Figure 5.3, and their individual usage and operation are described in Table 5-4. To release the brake of the targeted axis, first press the Enable button, and then, while pressing the Enable button, press one of the buttons B1~B8 at the same time. Then, the relevant axis will be released.

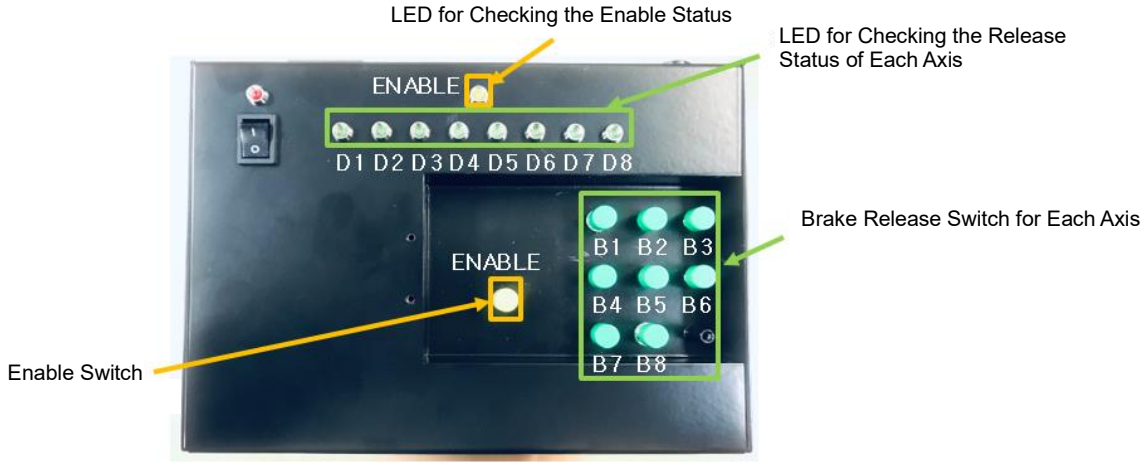

Figure 5.3 Switches and Status Checking LEDs of the Brake Release Unit

Table 5-4 Usage of the Switches of the Brake Release Unit

Name	Usage	During operation
E	Brake Release Enable	Yellow Enable LED ON
B1	Axis 1 Brake Release	Green D1 LED ON
B2	Axis 2 Brake Release	Green D2 LED ON
B3	Axis 3 Brake Release	Green D3 LED ON
B4	Axis 4 Brake Release	Green D4 LED ON
B5	Axis 5 Brake Release	Green D5 LED ON
B6	Axis 6 Brake Release	Green D6 LED ON
B7	Axis 7 Brake Release	Green D7 LED ON
B8	Axis 8 Brake Release	Green D8 LED ON

5.2.3. Power and Connectors

The placement of the power and connectors of the brake release unit is as shown in Figure 5.4 below, and their individual usage and connection devices are as shown in Table 5-5 below.

⚠ Caution	- When using the brake release unit, follow the procedures below. 1. Turn off the AC220V power switch and check that the DC24V power switch is turned off. 2. Connect the AC power cable to the AC power connector. 3. Turn on the AC220V power switch. 4. Turn on the DC24V power switch. - When the use of the brake release unit is finished, follow the procedures below. 1. Turn off the DC24V power switch. 2. Turn off the AC220V power switch. 4. Disconnect the AC power cable. - Do not use AC220V power and DC24V battery power at the same time.
⚠ Warning	Our company (or the manufacturer) will not be responsible for any accidents that occur because of not complying with the above “caution.”

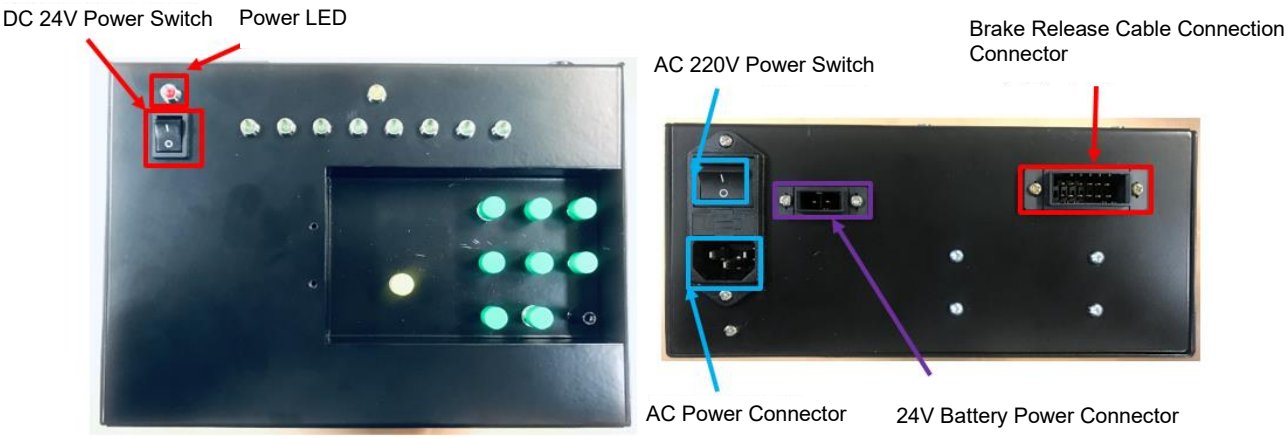

Figure 5.4 Switches and Connectors of the Brake Release Unit

Table 5-5 Types and Usage of the Connectors of the Brake Release Unit

Name	Usage	Connection of external devices
AC 220V power connector and switch	Application of the AC power	100V AC~240V AC Single phase

Name	Usage	Connection of external devices
Brake release cable connection connector	Connection of the brake release unit and controller	CNBA1, and CNBA2 of BD602T
DC24V battery power connector	Connection of the power of a portable 24V battery	Portable 24V battery
DC24V power switch	Brake release unit drive on/off	None

5.2.4. Brake Release Unit Status Display LEDs

The LEDs for displaying the status of the brake release unit are as shown in Figure 5.3, and their individual usage and operation status are as shown in Table 5-6 below.

Table 5-6 Usage and Operation of the LEDs for the Status of the Brake Release Unit

Name	Usage	LED On operation
Enable	Checking by pressing the Enable switch	When the Enable switch is pressed, the yellow Enable LED will be turned on.
D1	Checking by pressing the switch for axis 1	When the switch for axis 1 is pressed, the green D1 LED will be turned on.
D2	Checking by pressing the switch for axis 2	When the switch for axis 2 is pressed, the green D2 LED will be turned on.
D3	Checking by pressing the switch for axis 3	When the switch for axis 3 is pressed, the green D3 LED will be turned on.
D4	Checking by pressing the switch for axis 4	When the switch for axis 4 is pressed, the green D4 LED will be turned on.
D5	Checking by pressing the switch for axis 5	When the switch for axis 5 is pressed, the green D5 LED will be turned on.
D6	Checking by pressing the switch for axis 6	When the switch for axis 6 is pressed, the green D6 LED will be turned on.
D7	Checking by pressing the switch for axis 7	When the switch for axis 7 is pressed, the green D7 LED will be turned on.
D8	Checking by pressing the switch for axis 8	When the switch for axis 8 is pressed, the green D8 LED will be turned on.

5.3. Remote IO

5.3.1. Overview

To use general IO signals in the Hi6-T15 controller, you need the commercial remote IO. Basically, the commercial remote IO can be used by connecting an “IO module” (selected by the user) to one “communication module.” The module introduced below is a commercial remote IO module of Crevis, and you may purchase and use a commercial remote of other companies. For details on how to use each module, you are required to ask the company about the IO module you purchased.

⚠ Caution	Fieldbus communication must be available to use the commercial remote IO. Therefore, you should configure the PCI communication card together by referring to “5.1 PCI Communication Card” mentioned above.

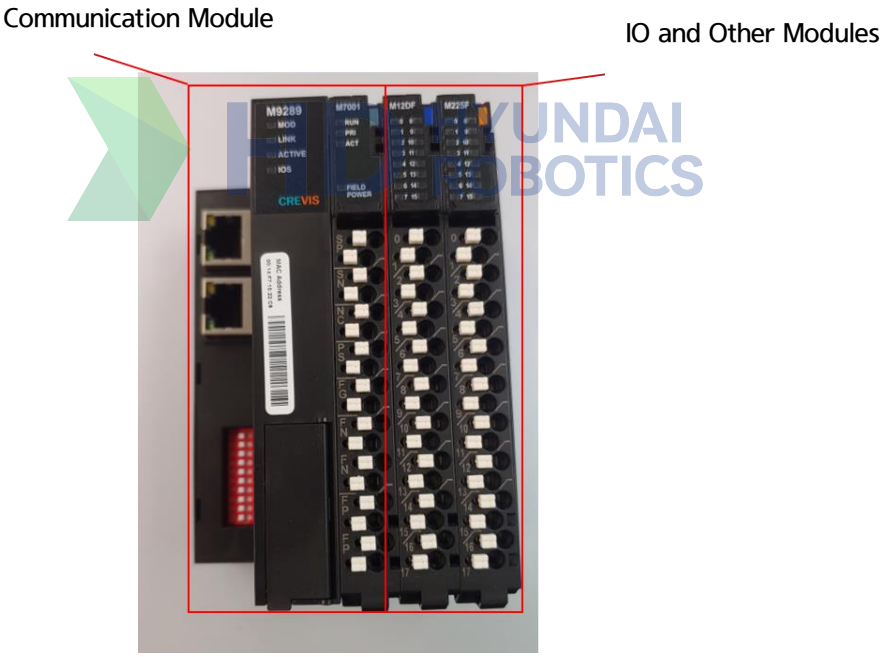

Figure 5.5 Example of Configuration of Commercial Remote IO

5.3.2. Communication Module (of Crevis)

The types of communication modules are as shown below and can be used according to the desired communication.

Table 5-7 Communication Module (of Crevis)

No.	Model name	Specification
1	M9212	DeviceNet Network Adapter
2	M9287	ProfiNet Network Adapter
3	M9289	Modbus TCP/UDP, EthernetIP Network Adapter
4	M9386	EtherCAT ID Network Adapter, 1452 bytes

5.3.3. IO and Other Modules (of Crevis)

The types of IO and other modules are as shown below and can be configured and used according to the desired operation.

Table 5-8 IO Module (of Crevis)

No.	Model name	Specification
1	M12DF	Digital Input 16 Points, Universal (Sink or Source), 24VDC, 18RTB
2	M12FA	Digital Input 32 Points, Universal (Sink or Source), 24VDC, Hirose 40P
3	M225F	Digital Output 16 Points, Sink, 24VDC/0.3A, 18RTB
4	M226F	Digital Output 16 Points, Source, 24VDC/0.3A, 18RTB
5	M22BA	Digital Output 32 Points, Sink, 24VDC/0.3A, Hirose 40P
6	M2618	Digital Output 8 Points, Sink, 24VDC/1A, Max 8A, 18RTB
7	M2628	Digital Output 8 Points, Source, 24VDC/1A, Max 8A, 18RTB

Table 5-9 Relay Module (of Crevis)

No.	Model Name	Specification
1	M2788	MOS Relay, 8 Points, 110VDC/AC, 1A, 18RTB

Table 5-10 Analogue IO Module (of Crevis)

No.	Model Name	Specification
1	M3534	Analog Input 4ch Voltage, -10 to 10VDC, 14 bits
2	M4534	Analog Output 4ch Voltage, -10 to 10VDC, 14 bits

Table 5-11 Pulse Measuring Module (of Crevis)

No.	Model Name	Specification
1	M5112	High-speed counter, 2 Channels, 24VDC, 18RTB (Open Collector)
2	M5102	High-speed counter, 2 Channels, 5VDC, 18RTB (RS422 Differential)

Table 5-12 Serial Communication Module (of Crevis)

No.	Model Name	Specification
1	M5212	RS232 Serial Interface, 2 Channels Full Duplex
2	M5232	RS485 Serial Interface, 2 Channels Full Duplex

HYUNDAI ROBOTICS

6 Periodic Inspections

The periodic inspection of the controller is designed to minimize the occurrence of failures and to maintain the performance continuously. This section describes the cautions and contents of works during the periodic inspection.

6.1. Inspection Schedule

Inspections should be carried out according to the schedule shown in the figure below. Periodic inspections are designed to prevent failures in advance and to secure safety and maintain accuracy even when the controller and manipulator are used for a long time. Periodic inspections are absolutely necessary and must be conducted even during normal operation.

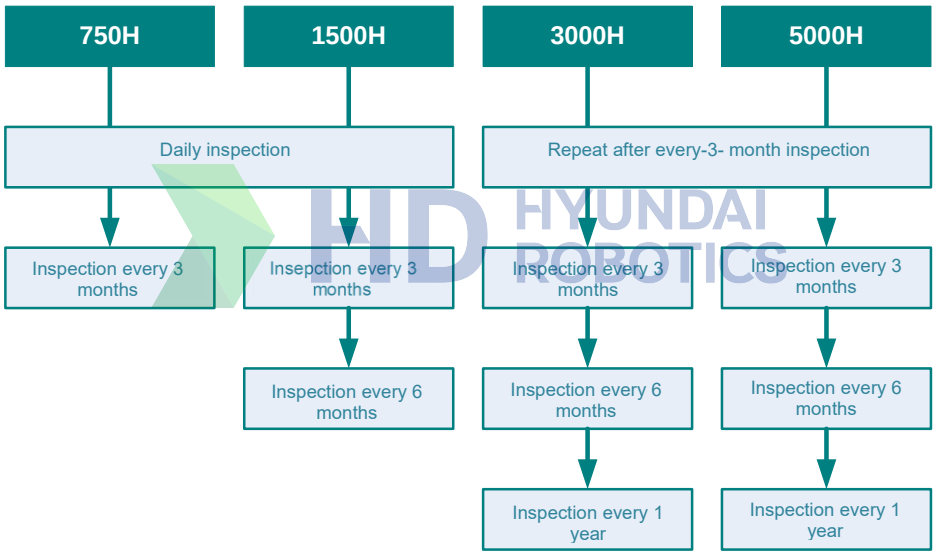

Figure 6.1 Inspection Schedule

6.2. General Cautions for Periodic Inspections

- The inspection work should be conducted by a person who has completed the courses implemented at the robot training center by our company.
- Before carrying out inspection works, check the parts, tools, drawings, etc. necessary for the work.
- Use the specialized replacement parts designated by our company.
- Turn off the power when inspecting the manipulator.
- When conducting works while keeping the door open, turn off the primary power and take precautions to prohibit dust, etc. to fly into the surrounding area.
- When required to touch the parts of the controller, you should take special care not to allow the IC to be destroyed by static electricity (Be careful also when contacting the connector).
- When performing periodic inspections while operating the manipulator, take precautions to prohibit anyone from entering inside the operation range.
- You should measure the voltage at a designated place and take precautions for electric shock and short-circuiting.
- Do not inspect the robot and the controller at the same time.
- After inspection, you must perform a trial-operation to check the operation of the robot before performing the normal operation.

6.3. General Inspections

Table 6-1 Daily Inspection

No.	Elements to inspect	Items to inspect	Remarks
1	Controller	Are the display lamps normal?	Check with your own eyes.
		Is the door closed properly?	Check with your own eyes.
		Is there any problem with the screen of the teach pendant?	Check with your own eyes.
2	Manipulator	Is there any noise during the operation?	Listen with your own ears.
		Is there any loosening of the screw at the front-end connection part?	Fasten.
		Is there any scratch, contamination, or damage to the wiring and wire harness of the manipulator?	Check with your own eyes.
		Is there any dirt or obstacle that causes damage to the manipulator?	Check with your own eyes, then clean.
3	Others	Is there any interference with the surrounding area of the controller and manipulator?	Check with your own eyes.

6.4. First Inspection (Inspection When Reaching 750 Hours)

Table 6-2 First Inspection

No.	Elements to Inspect	Items to Inspect	Remarks
1	External and main screws	Loosening of screws	Fasten.
2	Electric wiring connectors and wire harnesses of the manipulator	Loosening of connectors	Fasten.
3	Screws for fastening the dogs and limit switches	Loosening of screws	Fasten.

6.5. Cyclic Inspections

Table 6-3 Cyclic Inspections

No.	Cycle (Months)			Elements to Inspect	Items to Inspect	Remarks
	3	6	12			
1		◎	◎	Packing of the door	·Checking for deformation and detachment	
2	◎	◎	◎	Back	·Checking dust on and rotation of the cooling fan blade part	
					·Checking the regenerative discharge resistor for damage and dust	
					·Checking the transformer room for any heat using the sense of touch, and then cleaning the room	
					·Checking the transformer terminal block for any loosening and damage	
3	◎	◎	◎	Wire harness	·Checking the connectors for any loosening and damage	
4		◎	◎	Motor drive	·Checking the connectors and terminals for any loosening and damage	
5		◎	◎	Connectors of each board	·Checking for any loosening using the sense of touch	
6	◎	◎	◎	Operation panel	· Checking the status of buttons and switches	
7		◎	◎	The whole controller	·Cleaning dust	
8	◎	◎	◎	Nameplate	·Inspecting various nameplates	
9		◎	◎	Voltage measurement	·Voltage of the primary power	
					·CNFN1 B2-C2	
					·CNPB1 PB-MB	
					·CN24VB1 P24B-24GND	
10		◎	◎	Grounding	·Checking the terminals for any loosening and detachment	
11		◎	◎	Battery	·Checking the voltage and replacing the battery Periodically	Main board LEDs
12	◎	◎	◎	Teach pendant	·Inspecting the exterior and checking the connector connection part	
					·LCD Display Checking the status of the LCD display	
					·Checking the display of LEDs	
					·Checking the status of the buttons,	

					switches, and LEDs	
13	◎	◎	◎	Safety-related parts	·Checking the emergency stop switch (on the controller and teach pendant)	
	◎	◎	◎		·Checking the main power circuit breaker switch (NFB1)	
	◎	◎	◎		·Checking the Enable device of the teach pendant	
	◎	◎	◎		·Checking the circuit protector (CP1)	
	◎	◎	◎		·Checking the magnetic contacts (MC1, MC2)	
14	◎	◎	◎	Safety-related board	·Checking the BD632T (Connectors, LEDs)	

6.6. Inspection When Going on a Long Vacation

When going on a long vacation, you should check the following items first before turning off the controller of the robot.

(1) Check whether the yellow LED (BATLOW) for battery discharge detection on the main board is turned on. The yellow LED will be turned on if there is a problem with the battery. In this case, replace the battery with a battery of rated capacity. If the controller input power is turned off while there is a problem with the battery, various programs and integer data in the board will be removed after about seven days. Therefore, you must back them up using HRView or a USB memory.

(2) Check if the door of the controller is secured.

6.7. Maintenance Parts

The characteristics of individual parts are described below.

Maintenance Parts of the Category A

⚠ Caution	These are the important parts to be prepared for daily maintenance and inspection.

To maintain normal operation, the parts of the category A-2 and parts of the category A-3 are the minimum necessary parts, and at least one set of each group should be prepared.

Table 6-4 Inspection of Maintenance Parts of the Category A

Type	Contents	Remarks (Reference)
Maintenance parts of the category A-1	Spare parts for standard parts	
Maintenance parts of the category A-2	Important backup parts	
Maintenance parts of the category A-3	Periodic replacement parts	

Table 6-5 Maintenance Parts of the Category A-1 (Spare Parts for Standard Parts)

No.	Part name	Type	Maker	Quantity (EA)	Remarks
1	Fuse (F1, F2)	GP75 (250V, 7.5A)	Daito	2	BD6C2
2	Fuse (F3, F4)	GP75 (250V, 7.5A)	Daito	2	BD6C2
3	Fuse (F5, F6)	GP75 (250V, 7.5A)	Daito	2	BD6C2

Table 6-6 Maintenance Parts of the Category A-2 (Important Backup Parts)

No.	Part name	Type	Maker	Quantity (EA)	Remarks
1	Robot Controller	H6COM-T	Hyundai Robotics	1	
2	Safety IO Board	BD632T	Hyundai Robotics	1	
3	Servo Control Board	BD641T	Hyundai Robotics	1	
4	AMP Board	BD657T /BD658T	Hyundai Robotics	1	
5	Backplane Board	BD602T	Hyundai Robotics	1	
6	Power Rectifier Board	BD667T	Hyundai Robotics	1	
7	Teach pendant	TP630	Hyundai Robotics	1	

Table 6-7 Maintenance Parts of the Category A-3 (Periodic Replacement Parts)

No.	Part name	Type	Maker	Quantity (EA)	Remarks
1	Battery (3.6V AA size)	ER6V-T1	TOSHIBA (JAPAN)	1	Replace it every two years

Maintenance Parts of the Category B

⚠ Caution	These are the maintenance parts to be prepared when multiple units are purchased.

Table 6-8 Maintenance Parts of the Category B

Type	Contents	Remarks (Reference)
Maintenance parts of the category B-1	Parts that should be purchased from Hyundai Robotics	
Maintenance parts of the category B-2	Parts that can be purchased directly from the parts maker	

Table 6-9 Maintenance Parts of the Category B-1 (Parts that should be purchased from Hyundai Robotics)

No.	Part Name	Type	Maker	Quantity (EA)	Remarks
1	Wire harness	CMEC1	Hyundai Robotics	1	

Table 6-10 Maintenance Parts of the Category B-2 (Parts that can be purchased directly from the parts maker)

No.	Part Name	Type	Maker	Quantity (EA)	Remarks
1	No fuse breaker (NFB)	-	-	1	
2	Magnetic contact (MC1, MC2)	-	-	2	
3	Circuit protector (CP1)	-	-	1	

⚠ Caution	Considering that the boards are equipped with high-performance parts, take precautions about the following items for carrying out maintenance.

Preservation temperature 0° C-40° C

For long-term preservation and maintaining high reliability, you should keep the temperature at 25±10° C and avoid rapid temperature variation (±10° C/hour).

Preservation humidity 20%-80%

For long-term preservation and maintaining high reliability, you should keep the humidity at 45%-65% and take special care not to allow condensation to take place.

Prevention of static electricity

If the tip of the electrode is preserved in a dry state, static electricity will be easily charged, and when the charged static electricity is discharged, the semiconductor will be easily destroyed. Therefore, when storing the substrate separately, please use antistatic wrapping paper.

Others

It is required to store the boards in a place where there is no toxic gas, no dust, or in a place where no load will be applied.

Appendices

Rules on Occupational Safety and Health Standards, and Notice for Safety Inspection

The industrial robot should be installed in consideration of the inspection standards, both of the Rules on Occupational Safety and Health Standards and of the Notice for Safety Inspection (if subject to inspection).

■ Rules on Occupational Safety and Health Standards

Article 222 (Teaching, etc.): When it is required to perform works such as teaching (this refers to setting or changing the operation sequence, position and speed of the manipulator, or checking the result, and will be the same in the following) on the robot within the operation range of an industrial robot (hereinafter "robot"), the business owner is required to take the measures described under the following items to prevent the danger that could be caused by the unexpected operation of or mistakes in the operation of the robot. However, if the works are performed with the robot's driving source cut off, measures 1–2 below may not be taken 〈Revised on April 7, 2016〉.

1. Establish guidelines for the following items and make sure that works are performed according to the guidelines.

   A. Robot operation method and sequence

   B. Manipulator speed during a work

   C. Signaling method when having two or more workers to carry out works

   D. Measures to take when finding an abnormality

   E. Measures to take when finding an abnormality and stopping the operation of the robot and restarting the operation

   F. Other measures necessary to prevent the danger that could be caused by the unexpected operation of or mistakes in the operation of the robot

2. Workers engaged in the works or those who monitor the workers should take measures to stop the operation of the robot immediately if an abnormality is found.

3. In the process of performing works, it is required to take measures such as putting up a marking on the start switch, for example, to indicate that works are underway, to prevent workers other than the ones currently engaged in the works from manipulating the start switch.

Article 223 (Prevention of Dangers During Operation): The business owner is required to install a fence of 1.8 m or more in height (when considering the operation range of the robot, the height can be adjusted lower if there is no danger that could occur because of the height) to prevent the risk of injuries that may occur because of the operation of the robot (excluding the operation of the robot for the teaching according to Article 222 and also the operation of the robot in compliance with conditions of Article 224). In some sections where a fence cannot be installed because of the installation of a conveyor system, etc.,

a responsive, protective device such as a safety mat or optoelectronic protective device should be installed. However, if the Minister of Employment and Labor acknowledges that the safety standard for the robot meets the safety standards set by Korean industrial standards under Article 12 of the Industrial Standardization Act or internationally accepted safety standards, it is possible to forego measures according to the text of this document.

Article 224 (Including the measures to take when performing works such as repairing): When the work such as repairing, inspecting, adjusting (excluding teaching), cleaning, refueling the robot, or confirming relevant results within the operation range of the robot is underway, the business owner should take necessary measures to ensure that the robot can be stopped. These measures include locking up the start switch of the robot using a key and managing the key separately, or putting up a signboard on the start switch, indicating that work is underway. These measures should also be taken to ensure that anyone other than the workers engaged in the work will be prevented from manipulating the start switch. However, this is not the case if work must be performed even during the operation of the robot, and, in such a situation, measures of the individual items under Article 222 are taken to prevent the danger that could be caused by an unexpected operation or mistakes in operation

【Appendix 14】 Inspection Standards for Industrial Robots (Related to Article 30)

Automatic operation mode	A. In the automatic operation mode, safety devices such as fences should maintain the normal function, and if a person enters the protected area, the protective stop function should be activated. B. Protective stop or emergency stop should not be reset or disabled when the automatic operation mode is selected. C. Automatic operation mode should be deactivated when a stop signal is given. D. When the automatic mode is selected, the starting of the automatic mode should be possible only by a separate start operation outside the protected area. E. Changing from automatic operation mode to other operation modes should be possible only when driving is stopped.
Control of the pendant	If the pendant has a string, its length should be sufficient for the teaching operator to perform the work safely.
Electric connection devices	Electric connection devices such as electric outlets that are to be connected to the robot should not be separated arbitrarily.
Control of the pendant Electric connection devices Robot system layout design	The layout of the robotic system for the operation area, access, and free space should be appropriate in compliance with the following items. A. The maximum area of the robot should be checked first. Then, the restricted area and operation area should be set, and there should be a free space between the robot and obstacles such as pillars of the building. B. A passage such as a pedestrian passage should be secured for safe movement. C. Access to and from the path to the control system should be safe.

【Appendix 14】 Inspection Standards for Industrial Robots (Related to Article 30)

	D A safety passage for approaching for inspection, cleaning, repair, maintenance, etc. should be secured. E. There should be no risk of slipping, tripping, or falling over because of wiring or other dangerous sources. F. There should be no danger caused by the cable tray, etc. G. Operation controllers and auxiliary equipment (welding controllers, pneumatic valves, etc.) that workers need to access during automatic operation should be located outside the protected area.
Robot system stop function	All robot systems should have a protective stop function and also a separate emergency stop function. A. Emergency stop function 1) The robot system should have a single emergency stop function that operates for all relevant parts of the system. 2) In the case of multi-robots or multi-cells, the control range can be divided, and the control range should be clearly indicated using characters or symbols near the emergency stop device. 3) When there are more than two control positions, the emergency stop device installed in each control position should always maintain its function. 4) This function should take priority over all other robot controls and, in case of an emergency stop, should remove the driving power from the robot drive unit and maintain the stop state until initialization. 5) Initialization should be performed manually only, and restarting should not be performed immediately after initialization but should be carried out through a separate starting operation. 6) The performance of the emergency stop circuit should satisfy the safety-related control system performance requirements of item no. 4. B. Protective stop function 1) The robot system should be equipped with one or more protection stop circuits for connection with external protection devices. 2) When activated, the protective stop circuit should be capable of stopping the robot operation, removing the actuator power, and controlling all dangerous sources controlled by the robot. 3) Protective stop should be started manually or by the control logic. 4) At least one protection stop function should utilize the 0-stop method or 1-stop method. Note 1) 0-stop method: Stopping will be performed through immediate cut-off of the actuator power. Note 2) 1-stop method: The power will be cut off after the machine stops while the actuator power is supplied.

【Appendix 14】 Inspection Standards for Industrial Robots (Related to Article 30)

	5) The performance of the protective stop circuit should satisfy the safety-related control system performance requirements of item no. 4.
Manual resetting, starting, and restarting	The robot system should be in compliance with the following items to prevent unexpected starting. A. Starting and restarting should be possible only when all safety functions and protective measures are operating normally. B. If the power supply is interrupted and then resumed, a starting interlocking device should be installed to prevent the automatic starting of dangerous operations and should be reset only by manual operation. C. Start and restart control should be manually operated outside the protected area and should be impossible to activate within the protected area. D. The start and restart control unit should be located where the protected area can be visibly seen. However, if it is difficult to secure a view of the protected area, it is required to comply with one of the following items. 1) Installation of a detection device that can detect the presence of workers in the protected area 2) Installation of means to keep the door open 3) Installation of an additional device for time limit reset inside the protected area 4) Generation of audible and visual warning signals that can be sufficiently recognized inside the protected area, and provision of sufficient evacuation time E. When it comes to complying with item no. 4 of D above, it is required to install a sufficient number of emergency stop devices in the protected area at a location that the operator can access easily.
Protected area, fence, etc.	Protected areas and fences should be in compliance with the following items. However, in the case of cooperative robots, some applications may be excluded, depending on the operation method. A. The restricted area should be located within the protected area. B. The protected area should be established using a fence. However, when it comes to an opening for taking in and out materials or parts, the protected area should be established by a responsive, protective device, etc. C. The fence for the robot cell should be appropriate in compliance with the following items. 1) The fence should be firmly installed not to be easily damaged by external force and should be of a structure that can be removed only with tools. 2) If the fence has an opening for taking in and out materials or parts, it is required to physically prevent workers from accessing dangerous points under, next to, or through the opening, and if such measures are not possible, it is required to take additional measures such as using responsive, protective devices.

【Appendix 14】 Inspection Standards for Industrial Robots (Related to Article 30)

	3) The height of the fence should be over 1,800 mm. However, if there is no danger that could occur because of the height, in consideration of both the operation range of the robot and the safety distance according to KS B ISO 13857, the height of the fence may be above 1,400 mm. 4) The movable fence (entry door) should be opened to the side or in the direction of moving away from a source of danger and should be structured in a way that it does not open toward the protected area. 5) An interlocking device should be installed to the movable fence (entry door), and it should be able to turn the source of danger into a safe state before the workers approach it. However, if there is a possibility of accessing the dangerous area before the source of danger is removed, there should be a locking device for the entry door, in addition to the interlocking device. 6) The movable fence (entry door) locking device should allow the start of the robot only when the movable fence (entry door) is closed and locked.

Quality Assurance

To protect the interests of customers who have purchased products manufactured by Hyundai Robotics (hereinafter the “Company”) and sold by the Company or authorized distributors, the Company provides quality assurance against defects in the raw materials and in the manufacturing of products in accordance with the contents stipulated in the quality assurance. This quality assurance is provided only to the end users (hereinafter the “Customers”) of the products.

■ Coverage of Quality Assurance

Robots and relevant parts are covered by the Company’s quality assurance against defects in materials and manufacturing.

The Company’s sole responsibility and the sole remedy for the Customer with respect to all our products are limited to the repair or replacement of our products that are directly defective at our discretion. The Company will not compensate for any indirect or incidental, special, or consequential damages, such as loss of income, loss of use, loss of production, or damage to other products or equipment resulting from defects in the product.

■ Period of Quality Assurance

The Company guarantees the quality of the product for one year from the date that the Customer purchased the product and received it on-site, or the Customer issued the acceptance certificate after completing the trial-operation. However, if the contract date is different from the delivery date (installation and trial-operation completion date), the period of quality assurance will be based on the delivery date, and when the product is replaced with a new finished product, the period of assurance will be calculated from the date of replacement.

■ Limitation of and Exception for Assurance

To maintain quality assurance, you must follow the maintenance procedures and keep records as specified by the Company. When we decide that the Customer does not comply with the terms and conditions as follows, the quality assurance will be made invalid.

- Damage to or breakdown of the product because of the Customer’s carelessness, inexperience in operation, negligence, arbitrary modification, disassembly, or repair
- Failure of or damage to the product because of the use and installation of parts, consumables, software, etc. that are not certified by the company
- Failure of or damage to the product because of incompliance with the instructions and precautions in the manual
- Failure of or damage to the product because of the use for purposes other than the original purpose
- Failure of or damage to the product caused by using it in inappropriate environments, dropping the product, or applying a strong impact on the product

- Failure of or damage to the product because of the installation, repair, and maintenance by a person (customer, uncertified or unauthorized mechanic, etc.) other than an installation expert
- When the service life of a consumable part is due
- If a service request for a defect is received after the warranty period has expired

We do not provide quality assurance against damage to the product caused by external circumstances beyond our reasonable control, such as theft, willful destruction, fire, natural disasters, wars, or acts of terror. Moreover, we are not responsible for the defects in the product, operation, and performance not pertaining to the range specified in the warranty.

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제품이나 서비스에 대한 자세한 문의는 당사의 고객지원팀으로 연락하시기 바랍니다.

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