

Manual Version 1.7
Software Version 2.5.4

Doosan Robot

A0509 | A0509S | A0912 | A0912S

Installation Manual



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Preface

Thank you for choosing this Doosan Robotics product. Before installing the product, please read through this manual and follow the instructions for each installation process provided in this manual. The contents of this manual are current as of the date this manual was written, and product-related information may be modified without prior notification to the user.

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For details of updated manuals, refer to the robot LAB website (<https://robotlab.doosanrobotics.com/>).

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For related inquiries, contact the Marketing Department of Doosan Robotics (marketing.robotics@doosan.com).

1. Safety

This chapter provides safety information the user must be aware of before installing or operating the robot. All robot's have risks of high voltage, electricity and collision. Therefore, in order to minimize the risk of injuries and mechanical damage, one must observe the basic safety cautions while operating the robot and using related parts. To protect user safety and prevent property loss, make sure to read and follow the instructions carefully. The contents of the manual and specifications of the product may change for product and performance improvements.







1.1 Manual Indication Conventions

To communicate safety precautions related to the use of the product, the following symbols are indicated in this manual.

Symbol	Name	Description
	Danger	Failure to observe instructions with this symbol may result in serious accidents that could result in death or serious injury to the operator.
	Warning	Failure to observe instructions with this symbol may result in serious accidents that could result in death or serious injury to the operator.
	Caution	Failure to observe instructions with this symbol may result in product damage or cause injury to the operator.
	Note	This is additional information to help the user.

1.2 Safety Symbols

Among the symbols used in this manual, symbols related to user safety are as follows:

Symbol	Description
 Danger	This symbol means that immediate hazards can occur due to electrical conditions such as high voltage. Failure to observe instructions with this symbol may result in serious accidents that could result in death or serious injury to the operator.
 Danger	This symbol means that immediate hazards can occur. Failure to observe instructions with this symbol may result in serious accidents that could result in death or serious injury to the operator.
 Warning	This symbol means that potentially dangerous situations can occur due to electrical conditions such as high voltage. Failure to observe instructions with this symbol may result in serious accidents that could result in serious injury to the operator.
 Warning	This symbol means potentially dangerous situations can occur. Failure to observe instructions with this symbol may result in serious accidents that could result in serious injury to the operator.
 Caution	This symbol means dangerous situations can occur due to overheating. Failure to observe instructions with this symbol may result in serious accidents that could result in serious injury to the operator.
 Caution	The product may become damaged or the operator may be injured.

1.3 General Instructions

This chapter describes general danger and warning items related to operating the robot.



Warning

- If the robot is installed with electrical devices, install the robot referring to the Installation Manual.



Warning

- If the setting(Section **3.3.10 Emergency Stop Button Setting Switch**) of the emergency stop button setting switch(A-Series) is different from the actual configuration, the emergency stop button may fail and cause injury to the user in an emergency situation, so check the setting condition and operation of the emergency stop button.
- If a device is installed on the tool during robot installation, make sure to use appropriate bolts.
- Suitable safety measures, such as safety fences, must be implemented to protect the staff and robot during installation.
- Do not wear loose-fitting clothes or accessories when operating the robot. If one's hair is long, make sure to tie up the hair to prevent it from getting caught between robot joints.
- Never operate a damaged robot.
- Take caution of the robot's movement when using the teaching pendant and smart pendant (A-series).
- If the teaching pendant warns the user of a critical error, immediately engage the emergency stop switch, identify the cause of the error, resolve the error and then resume robot operation. If the critical error cannot be resolved, contact the sales agent or robot supplier.
- Make sure to connect safety protection equipment to a safety interface. If such equipment is connected to a general interface, the integrity of safety functions may not be guaranteed.
- Make sure to become completely familiar with the robot user manual prior to operating the robot.
- If the robot collides with an external object, a significant impact may be generated. The impact the robot receives is proportionate to the kinetic energy, so higher speeds and high payload can generate large impacts. Make sure to maintain a safe speed and payload during operation in collaborative spaces.
- Direct teaching must only be performed in safe environments. Do not operate the robot if there are sharp edges or jamming near the tool and its surroundings.
- Before performing direct teaching, make sure accurate inputs (tool length, weight, center of gravity) are made. If inputs are different from the tool specification, direct teaching error or malfunctioning can occur.
- To ensure user safety, joints may operate at a certain speed or higher, or the maximum speed of the TCP may be limited during direct teaching. If the limit is exceeded, the protective stop

function activates.

- Enable/disable the direct teaching function when the robot has completely stopped. If the direct teaching function is enabled/disabled during robot operation, malfunctions may occur.
- If the robot axis must be rotated when the robot is not operated, it can be rotated at a torque greater than 400 Nm.
- Modifying the robot without prior approval may cause critical breakdowns and accidents.



Caution

- Operating the robot and controller for an extended period of time generates heat. Do not touch the robot with bare hands after operating for an extended period of time. Before performing work that requires touching the robot, such as tool installation, leave the robot for more than 1 hour after turning off the power of the control unit to cool down the robot.



Caution

- Do not expose the robot to powerful magnetic fields. It may cause damage to the robot.
- Do not use the controller being laid. To avoid getting a hand caught in the door by accident, make sure to keep it upright while working with the door open.

1.4 Product Usage

This is an industrial product designed specifically for purposes of transferring and assembling objects by attaching components to products using tools, and it must be operated in the conditions specified in its specifications.

This product features special safety functions designed for the purpose of collaborating with human operators, and it operates with human operators without specific boundaries. Conduct work with the system only when all applications, including the tool, workpiece, boundary and other equipment, are confirmed to have no harm.

The following uses are considered inappropriate because they exceed the boundaries of the product's intended purpose. Doosan Robotics will not be held responsible for any damage and malfunctioning of the robot, property losses and injuries to users due to such inappropriate uses.

- Use in an environment with potential explosions
- Use in applications related to medicine and human lives
- Use in transporting humans and animals
- Use without risk assessment
- Use in locations where the performance and operation environment specifications are not met
- Use in environments with insufficient safety functions
- Use of the robot as a step to stand on
- Use in environments where electromagnetic waves are generated at levels greater than the IEC standard, such as welding

1.5 Risk Assessment

One of the most important aspects of a system integrator is risk assessment. Risk assessment is legally mandatory in most countries. In addition, safety assessment of robot installation changes according to the overall system integration method, so it is impossible to perform risk assessment solely with the robot.

In order to perform risk assessment, the administrator overseeing the overall system establishment must install and operate the robot according to ISO12100 and ISO10218-2. In addition, the administrator can refer to the technical specification, ISO/TS 15066.

Risk assessment must consider the overall work process in terms of the overall life cycle of the robot application. Key objectives of risk assessment are as follows:

- Robot setting and work teaching for robot operation
- Troubleshooting and maintenance
- Proper robot installation

Before supplying power to the robot arm, make sure to perform a risk assessment. Setting appropriate safety settings and identifying the need for additional emergency stop buttons and other protective measures are parts of risk assessment.

Identifying appropriate safety settings is a critical aspect of developing a collaborative robot application. For more information, refer to the corresponding chapter of the manual.

Some safety functions are designed specifically for collaborative robot applications. These functions can be set up through safety function settings, and they are optimized for responding to specific risks identified through the risk assessment performed by the integrator.

The safety functions of the collaborative robot can be set up in the safety setting menu, and they offer the following features:

- Force and power limitation: Limits the stopping force and pressure of the robot in case of collisions between the robot and a worker
- Momentum limitation: Limits the energy and impact load by reducing the speed of the robot when a collision between the robot and a worker occurs
- Joint position and TCP limitation: Limits robot movement to prevent moving towards specific body parts of users such as the neck or head
- TCP and tool pose limitation: Limits certain areas or characteristics of a tool and workpiece to minimize related risks (i.e., limits the movement of sharp edges of workpieces aimed at users)
- Speed limitation: Limits robot movement to stay at low speed in order to secure time for the user to avoid a collision before a collision between the robot and a worker occurs

Applying appropriate safety settings is considered to be the same as fixing the robot to a specific location and connecting it to a safety-related I/O. For example, setting password protection can prevent unauthorized safety setting changes by individuals not approved by the system integrator.

Key items to note when performing risk assessment of the collaborative robot application are as follows:

- Severity of individual potential collisions
- Probability of individual potential collision occurrence
- Probability of individual potential collision avoidance

If the robot is installed on a non-collaborative robot application that cannot sufficiently remove risks using its internal safety functions (e.g., use of dangerous tool), the system integrator must decide to install additional protection devices during risk assessment (e.g., use of protection devices capable of protecting the integrator during installation and programming).

1.6 Potential Risks

- Jamming fingers between the manipulator base and mount
- Jamming limbs between the Link 1 and Link 2 (between Joint 3 (J3) and Joint 4 (J4))
- Jamming limbs between Joint 1 and Joint 2 (J1 and J2) and Joint 5 and Joint 6 (J5 and J6)
- Penetration of skin by sharp edges or surfaces of the tool
- Penetration of skin by sharp edges or surfaces of objects in the operating space of the robot
- Contusion caused by robot movement
- Bone fracturing due to movement between heavy payload and hard surface
- Accidents that occur due to loosening of bolts securing the robot flange or tool
- Object falls from the tool due to inappropriate grip or sudden power shortage
- Accidents that occur due to mistaking an emergency stop button of different equipment
- Errors that occur due to unauthorized safety parameter modification

1.7 Validity and Responsibility

This manual does not provide information about the design, installation and operation methods of robot applications integrated with other systems. In addition, this manual does not provide information that may influence the safety of the integrated system.

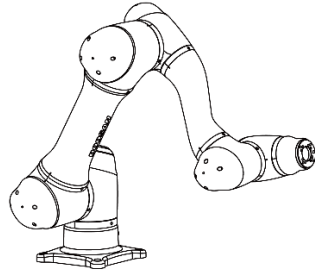
The system administrator must install the robot in a way that observes various safety requirements according to the related national standards and regulations. In addition, the staff in charge of integrating and managing the robot in a system must guarantee that all related national safety legislation and regulations are observed. The entity or user of the final system in which the robot is integrated has the following responsibilities, and such responsibilities are not limited to the items listed below.

- Risk assessment of the system with the robot integrated
- Installation and removal of safety devices according to the outcome of the risk assessment performed
- Confirmation of whether the system is properly designed, set up and installed
- Establishment of system operation and instructions
- Management of suitable safety settings in the software
- Prevention of users modifying safety devices
- Validity check of design and installation of integrated system
- Indication of contact information or important notifications related to use and safety
- Provision of technical documents including various manuals
- Provision of information on standards and legislation applied: <http://www.doosanrobotics.com/>

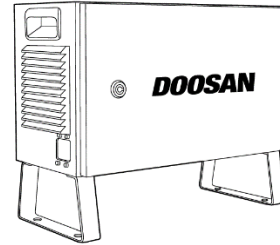
Compliance with the safety requirements in this manual does not mean all risks can be prevented.

2. Product Introduction

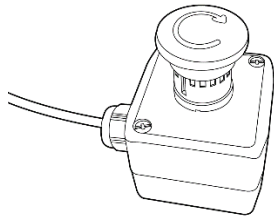
2.1 Component Check



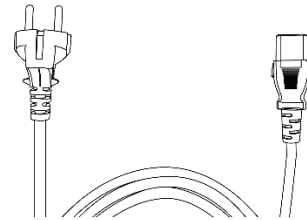
Manipulator (including connection cables)*



Controller*



Emergency Stop Button*



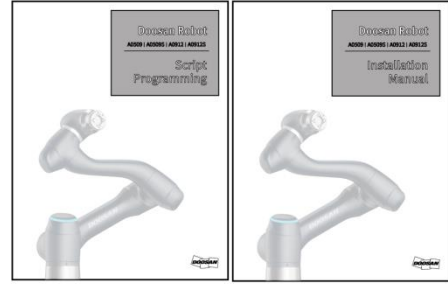
Controller Power Cable



Teach Pendant**



Smart Pendant**



Laptop (for DART Platform installation, not included)

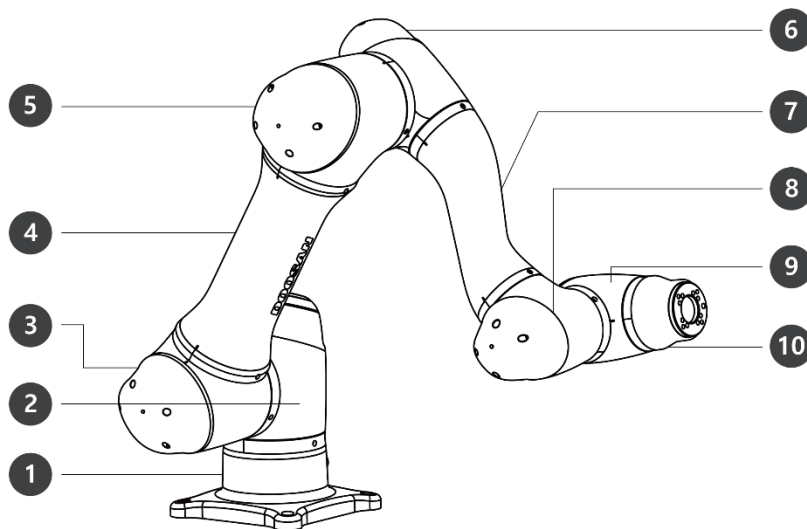
Manual*

 **Note**

- Components may vary depending on the robot model.
- Items are indicated as standard items (*) and optional items (**, sold separately)
- The laptop is not included in the package, and it is necessary when installing the DART Platform.

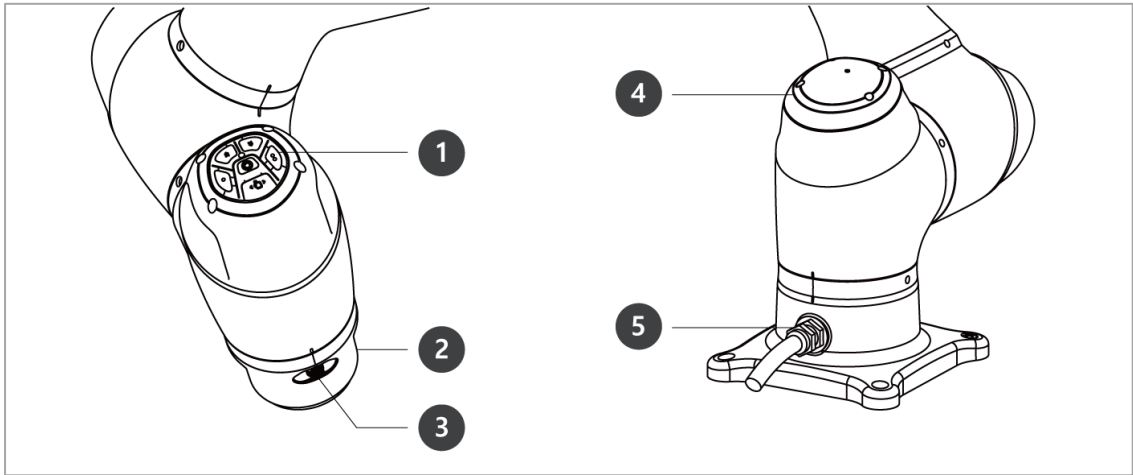
2.2 Names and Functions

2.2.1 Manipulator



• Names of Parts

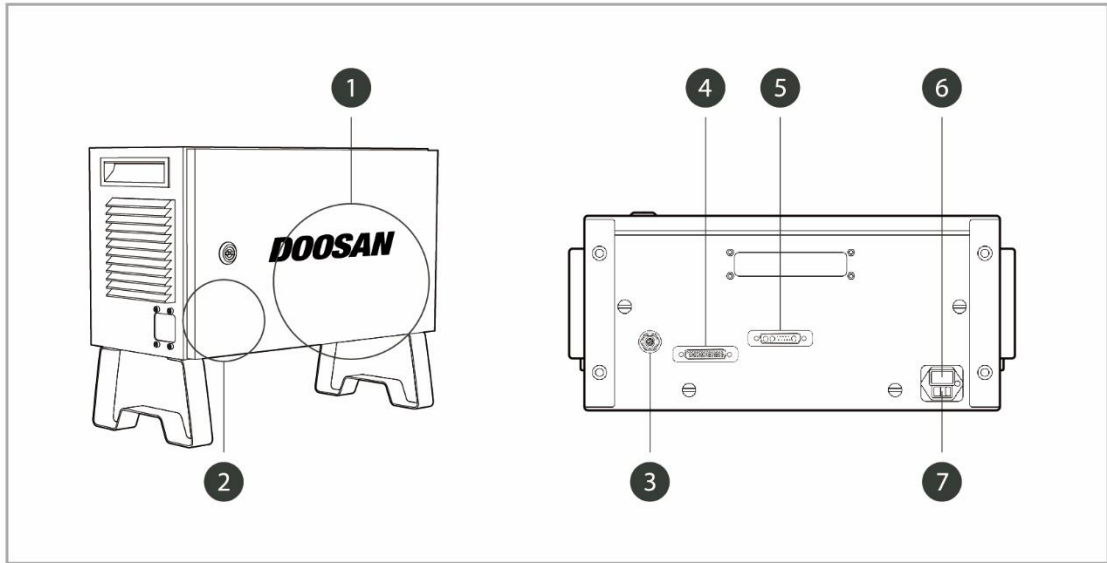
No.	Name	No.	Name
1	Base	6	J4
2	J1	7	Link2
3	J2	8	J5
4	Link1	9	J6
5	J3	10	Tool flange



• **Key Features**

No.	Item	Description
1	Cockpit	Controller used for direct teaching.
2	Tool flange	Area to install tools.
3	Flange I/O	I/O port for tool control. (Digital input 2ch, output 2ch)
4	LED (1-axis)	Displays the robot state with different colors. For more information about robot state, refer to the “5.4 State and Flange LED Color for Each Mode”
5	Connector	Used for supplying power to and communication of the robot.

2.2.2 Controller



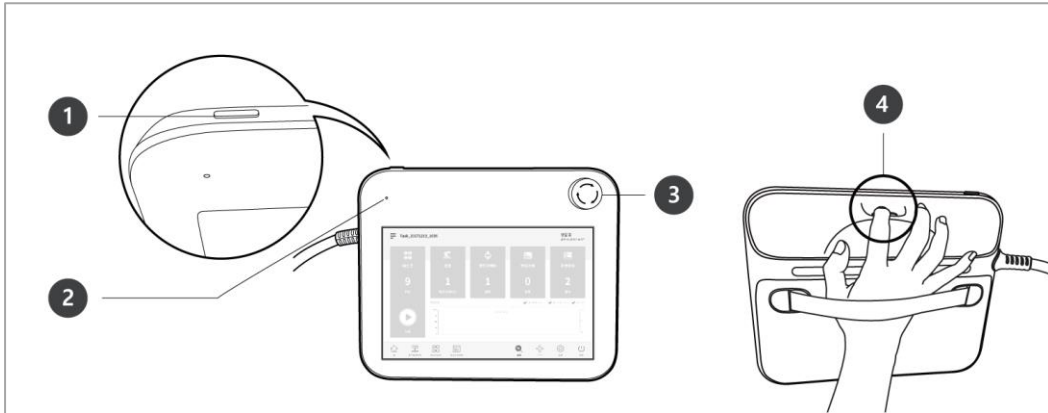
No.	Item	Description
1	I/O connection terminal (internal)	Used to connect the controller or peripherals.
2	Emergency stop button setting switch	To use the Teach Pendant, Smart Pendant, or Emergency Stop buttons, the switch must be set to match the actual configuration.
3	Emergency stop button and smart pendant connection terminal	Connects the emergency stop button or smart pendant cable to the controller.
4	Teach pendant cable connection terminal	Used to connect the teach pendant cable to the control box.
5	Manipulator cable connection terminal	Used to connect the manipulator cable to the controller.
6	Power connection terminal	Used to connect the controller power supply.
7	Power switch	Used to turn ON/OFF the main power of the controller.



Warning

- If the setting (Section 3.3.10 **Emergency Stop Button Setting Switch**) of the emergency stop button setting switch is different from the actual configuration, the emergency stop button may fail and cause injury to the user in an emergency situation, so check the setting condition and operation of the emergency stop button.

2.2.3 Teach pendant



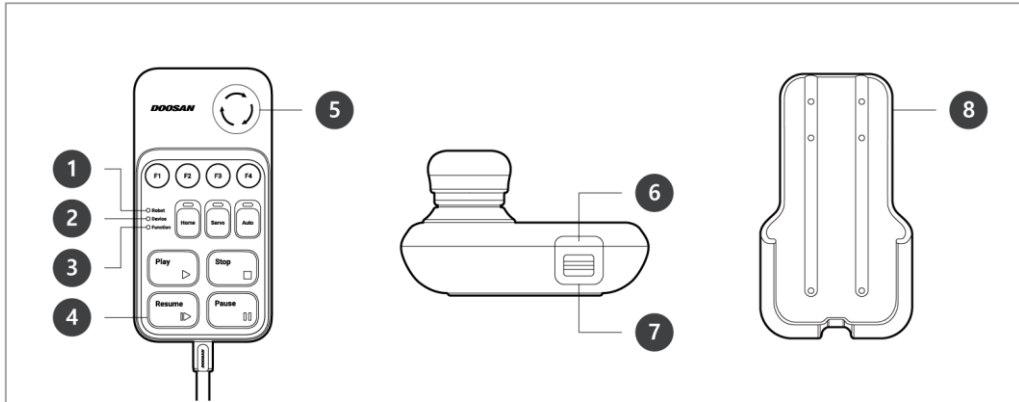
No.	Item	Description
1	Power button	Used to turn ON/OFF the main power of the teach pendant.
2	Power LED	Turns ON when power is supplied.
3	Emergency Stop Button	In case of an emergency, press the button to stop robot operation.
4	Hand guiding button	Press and hold the button to move the robot freely into a desired pose.

※ The teach pendant is not a standard item but an optional item, so it must be purchased separately

Note

- If you need to protect and hold the Teach Pendant during work, you can use it more safely and easily with a soft cover supplied by Doosan Robotics.

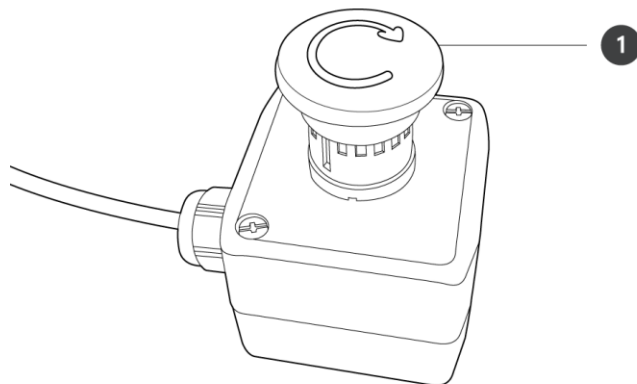
2.2.4 Smart Pendant



No.	Item	Description
1	Robot LED	Used to indicate the robot's state by displaying the same color as the robot status LED to the user.
2	Device LED	Used to indicate whether the system entered smart pendant mode.
3	Function LED	Pressing four input signal buttons (F1-F4) lights the LED, indicating the press status.
4	Buttons	There are a total of 11 buttons including four input signal buttons (F1-F4) for each function, home, servo, auto, play, stop, resume and pause.
5	Emergency Stop Button	In case of an emergency, press the button to stop robot operation.
6	Power Button	Used to turn ON/OFF the main power of the smart pendant.
7	Strap Anchor	Used to add a strap to the device.
8	Holder bracket	Install the holder bracket on a wall to store the smart pendant.

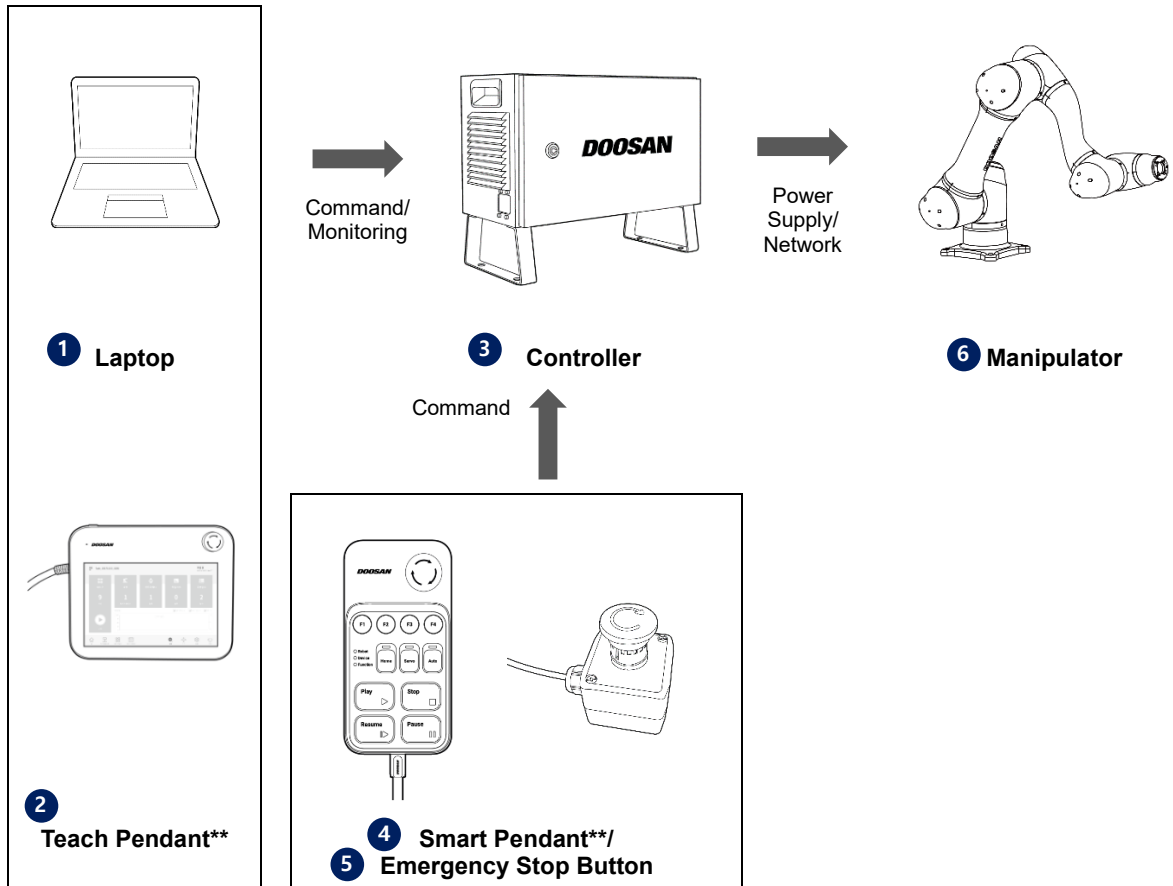
※ The smart pendant is not a standard item but an optional item, so it must be purchased separately

2.2.5 Emergency Stop Button



No.	Item	Description
1	Emergency stop button	In case of an emergency, press the button to stop robot operation.

2.3 System Configuration



- **1 Laptop**: After installing the DART Platform, a work environment identical to the teach pendant can be set up.
- **2 Teach Pendant****: It is a device that manages the overall system, and it is capable of teaching the robot specific poses and setting the manipulator and items related to the installation of the controller and manipulator. (purchased separately as an option)
- **3 Controller**: It controls the robot movement according to the pose or movement set by the teach pendant. It features various I/O ports that allow the connection and use of various equipment and devices.
- **4 Smart Pendant****: The robot can be easily controlled using a pendant capable of performing simple functions such as turning on the servo ON/OFF or executing/closing preset programs. (purchased separately as an option)
- **5 Emergency Stop Button**: If a laptop is used as part of the system, it acts as the emergency stop button of the teach pendant.
- **6 Manipulator**: It is an industrial collaborative robot that can perform transport or assembly tasks with various tools.

2.4 Product Specifications, General

M-Series	Technical Data
A0509(S)	refer to A.1.1 A0509(S)
A0912(S)	refer to A.1.2 A0912(S)

2.5 Robot Specifications

2.5.1 Basic Specifications

Model Name	A0509	A0509s ¹⁾	A0912	A0912s ¹⁾
Weight	21 kg		31 kg	
Payload within Work Radius	5 kg		9 kg	
Max. Work Radius	900 mm		1200 mm	
Number of Axes	6			
Max. TCP Speed	Over 1 m/s			
Position Repeatability (ISO 9283)	±0.03 mm		±0.05 mm	
Protection Rating	IP 54			
Noise	< 65 dB			
Installation Direction	Floor / Wall / Ceiling / Any			
Controller and Teaching Pendant	Doosan Controller, DART Platform & Teach Pendant (Option)			
Vibration and Acceleration	10≤f< 57Hz - 0.075 mm amplitude 57≤f≤150Hz - 1G			
Impact	Max Amplitude : 50m/s ² (5G) * Time: 30 ms, Pulse: 3 of 3 (X,Y,Z)			
Operating Temperature	-5 - 45°C (268K-318K)			
Storage Temperature	-5 - 50°C (268K-323K)			
Humidity	90% RH (non-condensing)			

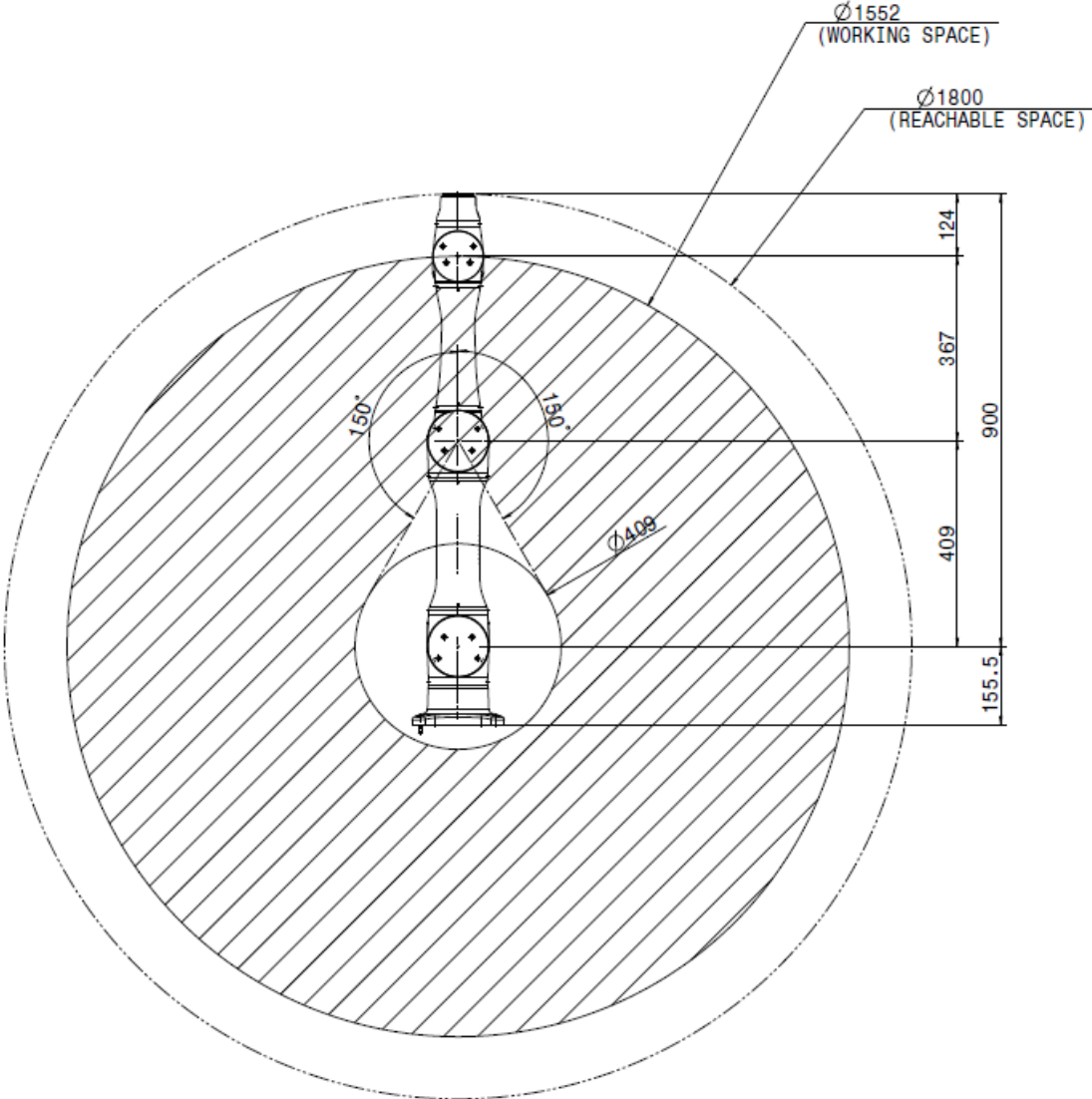
- 1) This is the model with an integrated Force Torque Sensor, so make sure to check the **FTS Specification**.

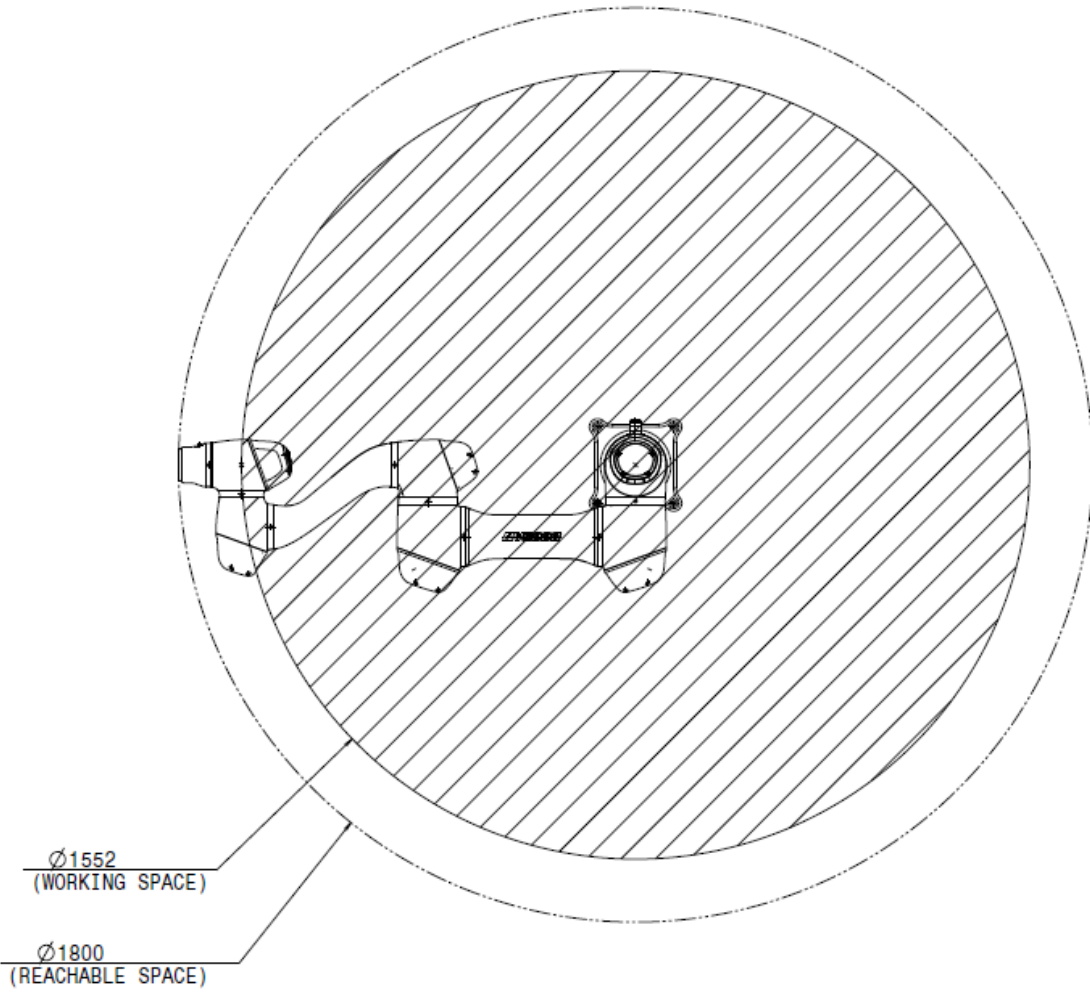
2.5.2 Axis Specifications

Model Name	A0509	A0509s	A0912	A0912s
Operating Angle				
J1	±360°		±360°	
J2	±360°		±360°	
J3	±160°		±160°	
J4	±360°		±360°	
J5	±360°		±360°	
J6	±360°		±360°	
Max. Speed per Axis (rated payload operation)				
J1	180 °/s		180 °/s	
J2	180 °/s		180 °/s	
J3	180 °/s		180 °/s	
J4	360 °/s		360 °/s	
J5	360 °/s		360 °/s	
J6	360 °/s		360 °/s	

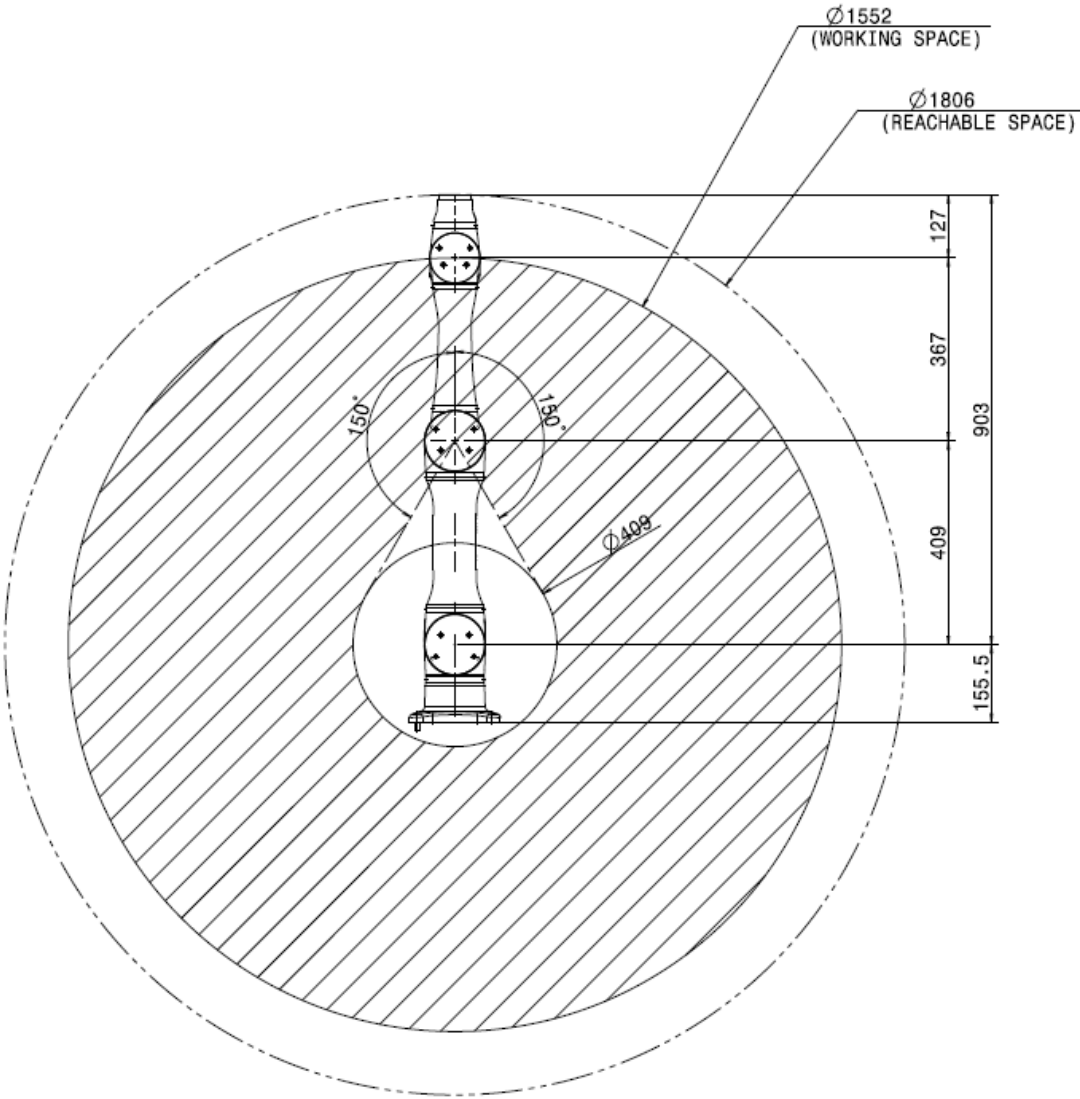
2.5.3 Robot operating space

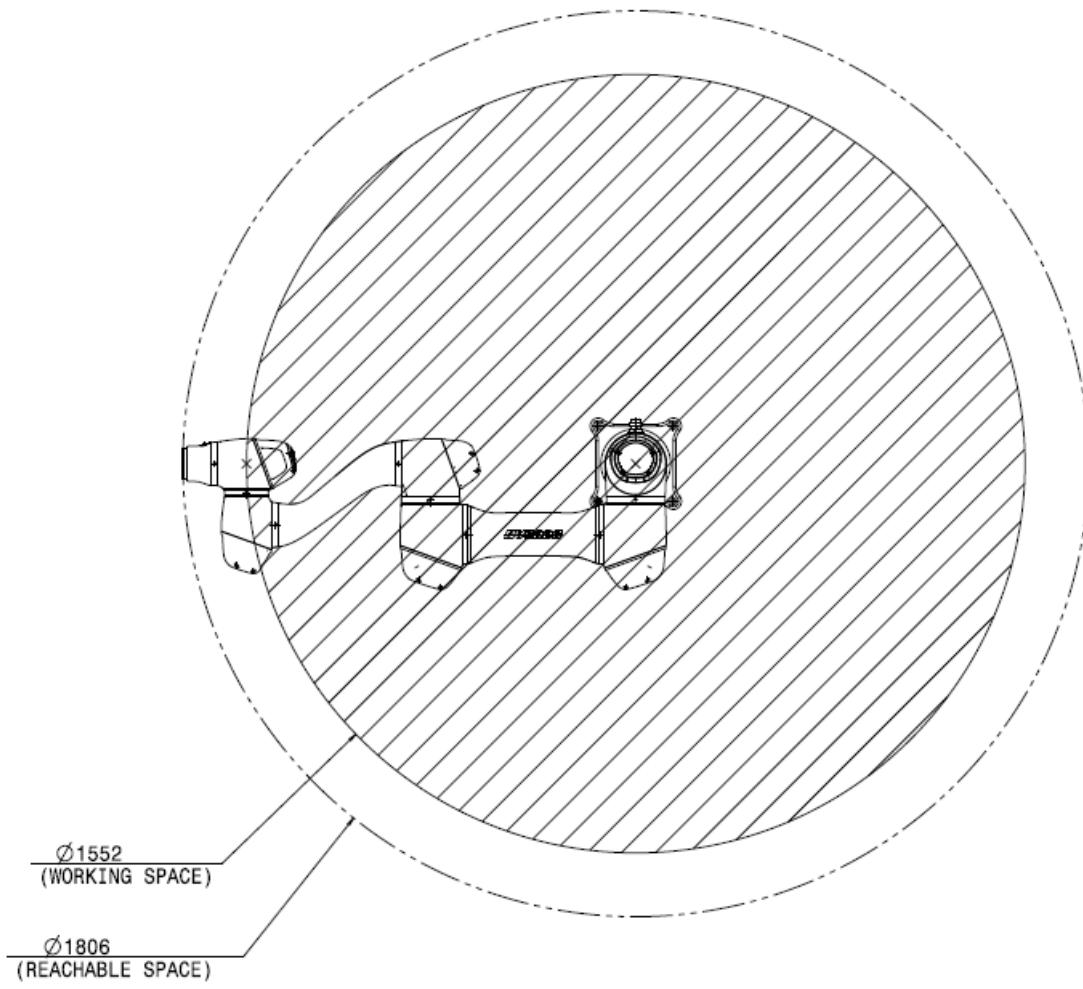
- A0509



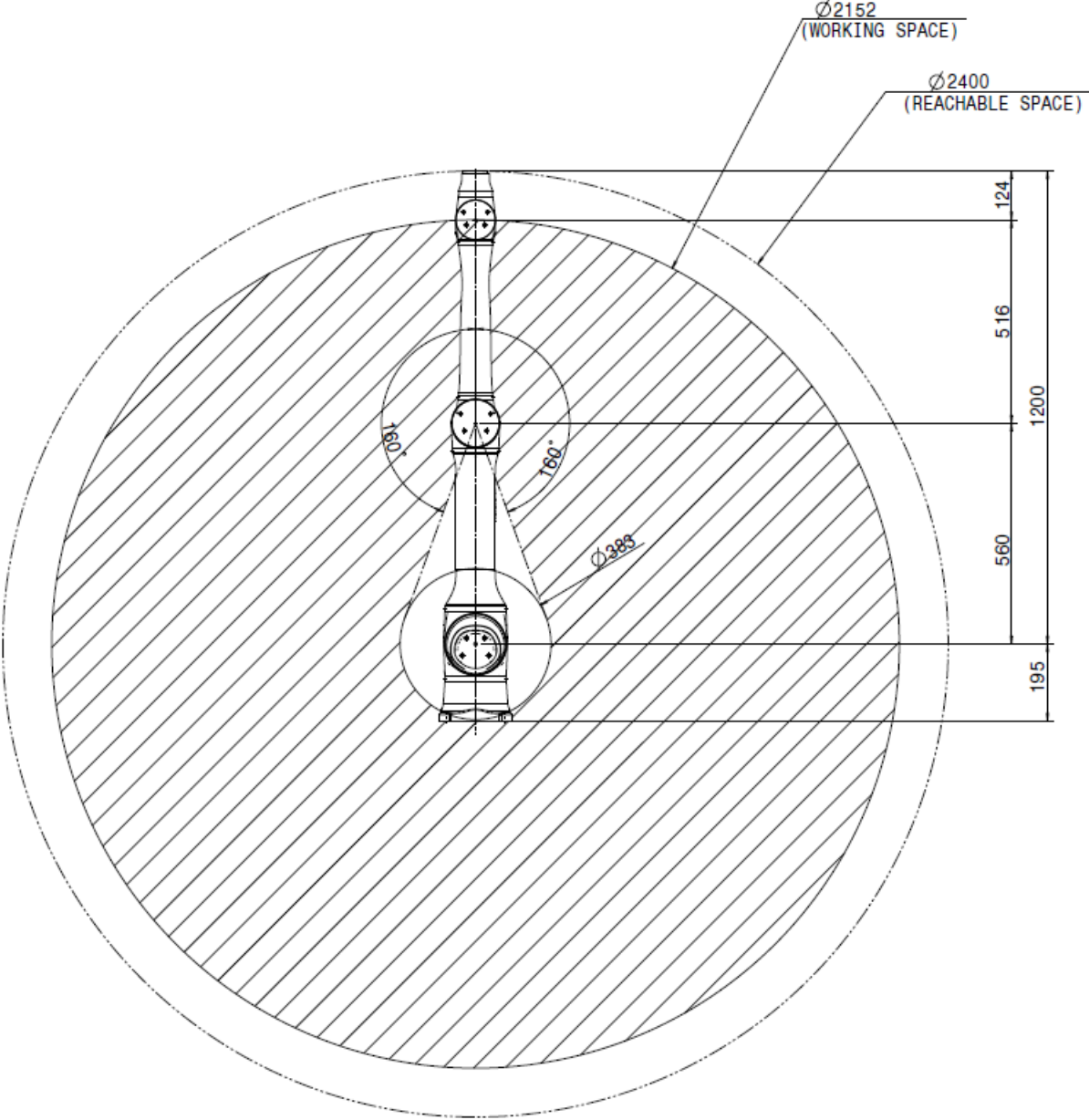


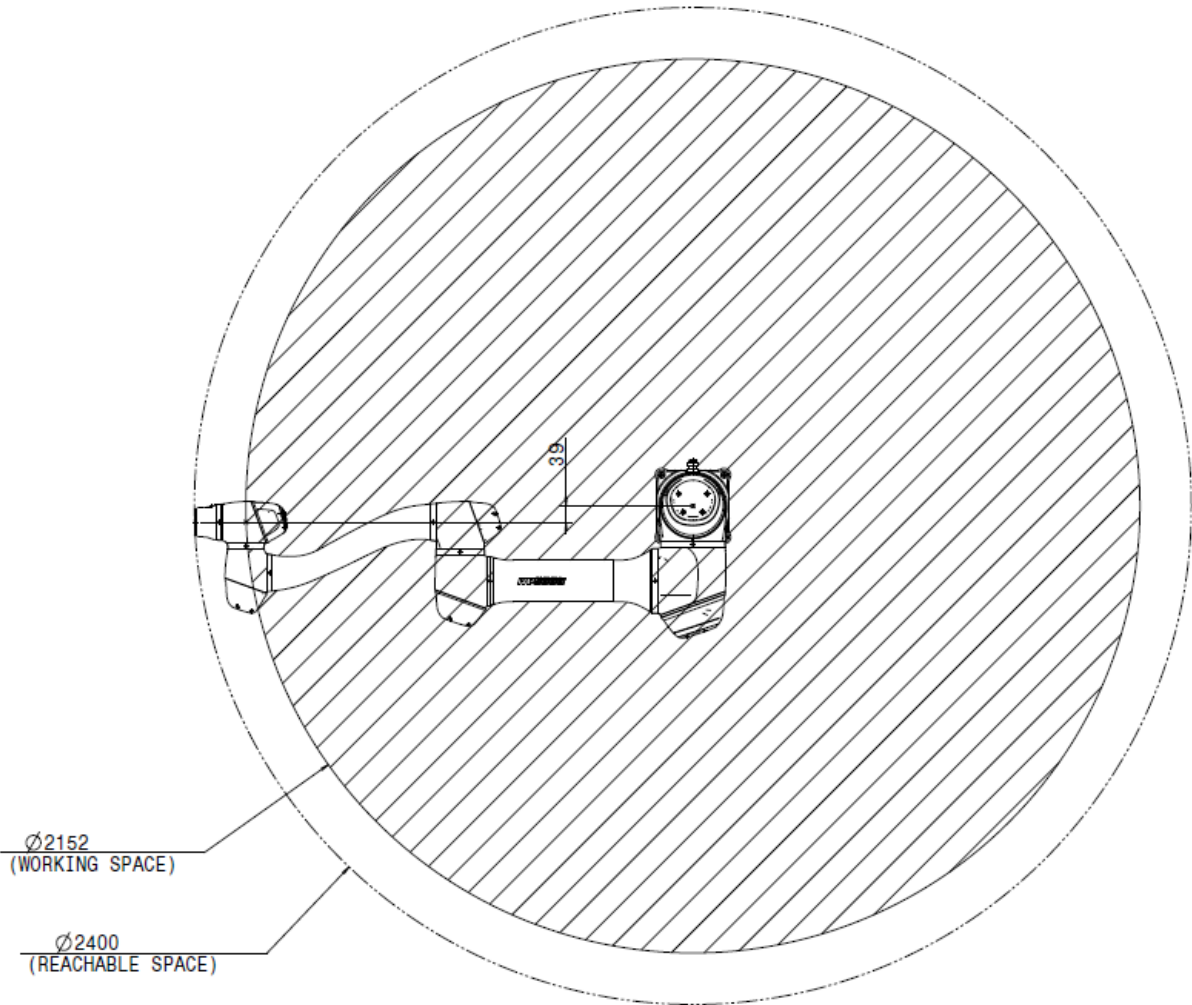
• A0509S



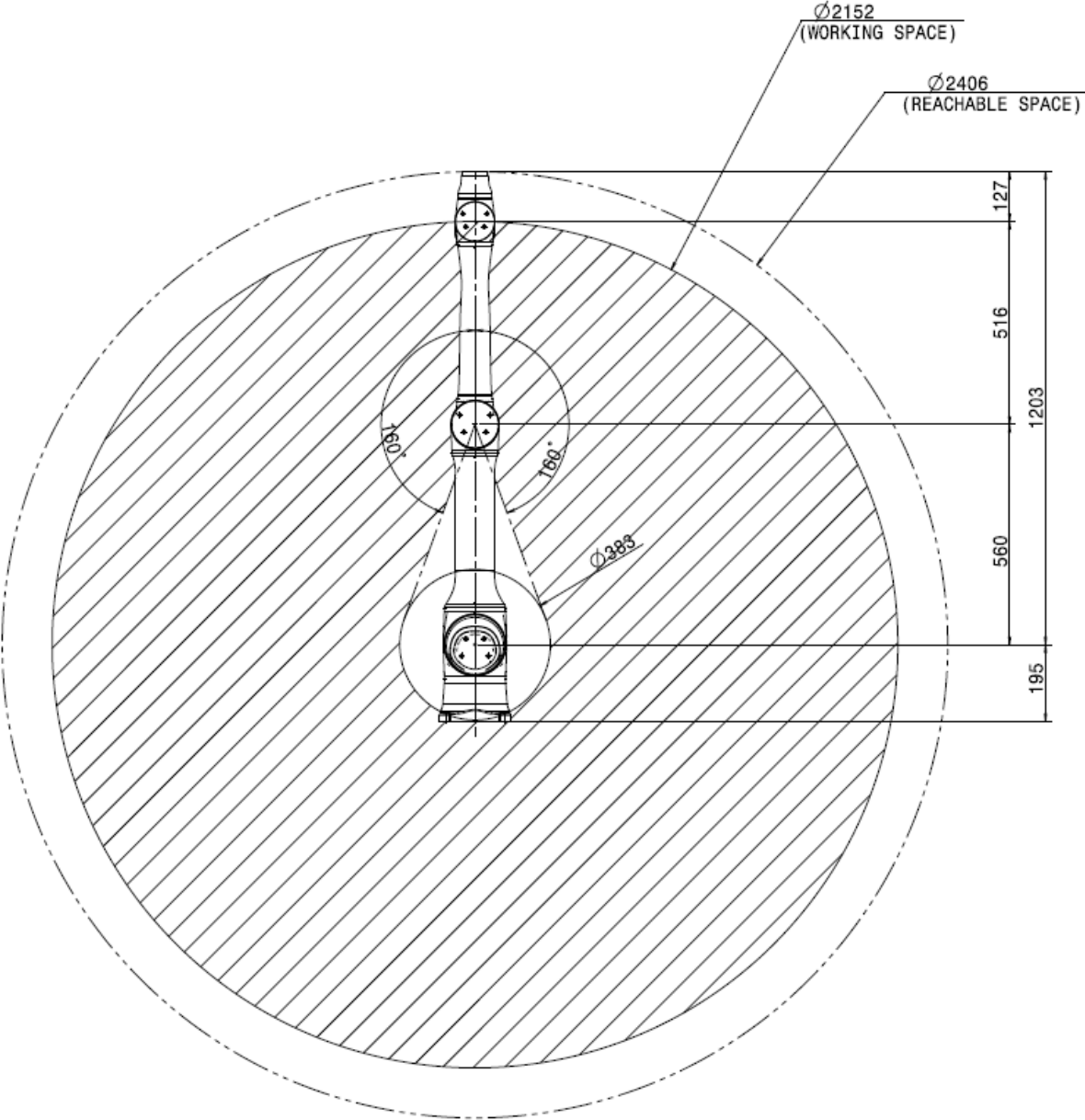


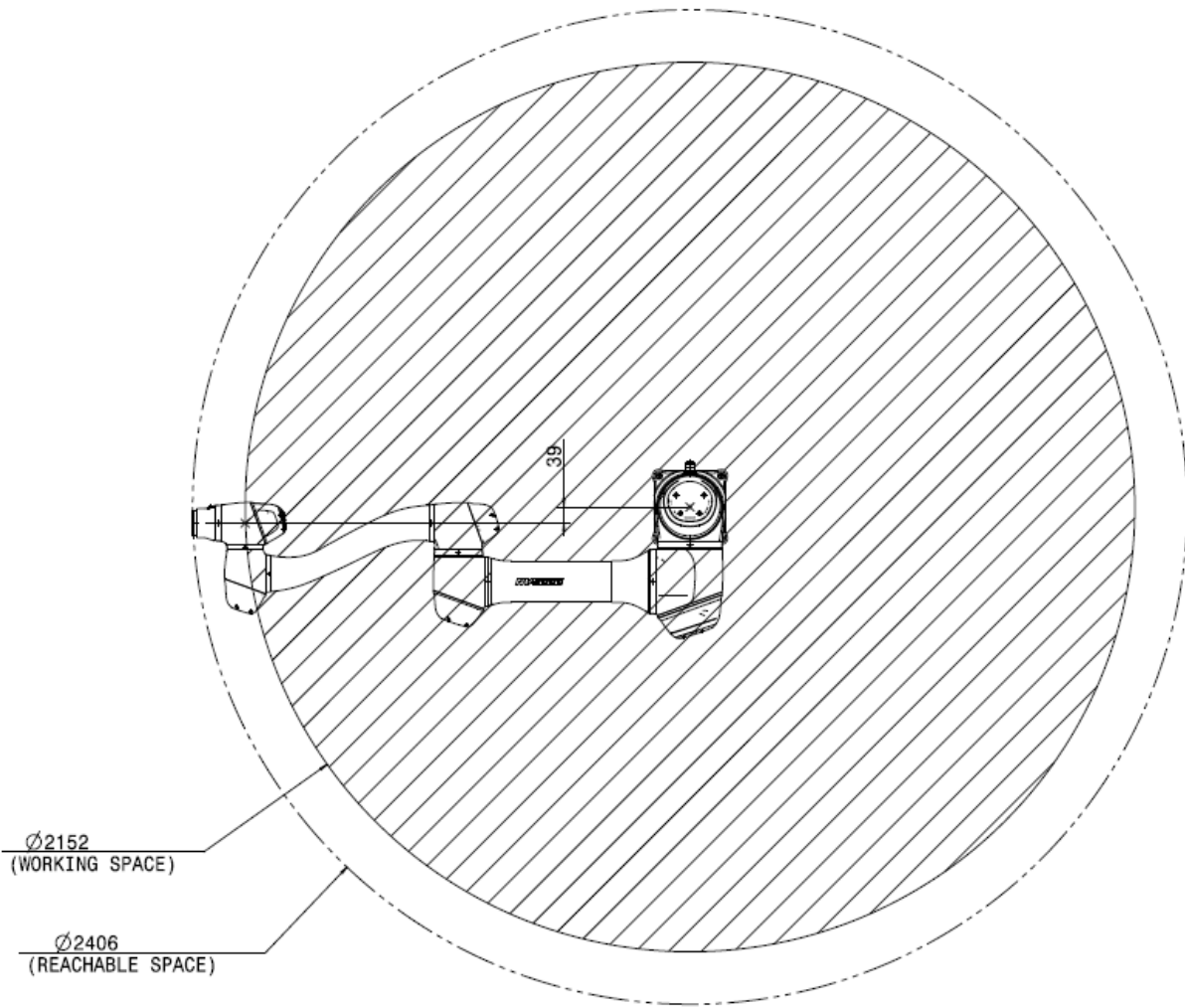
• A0912





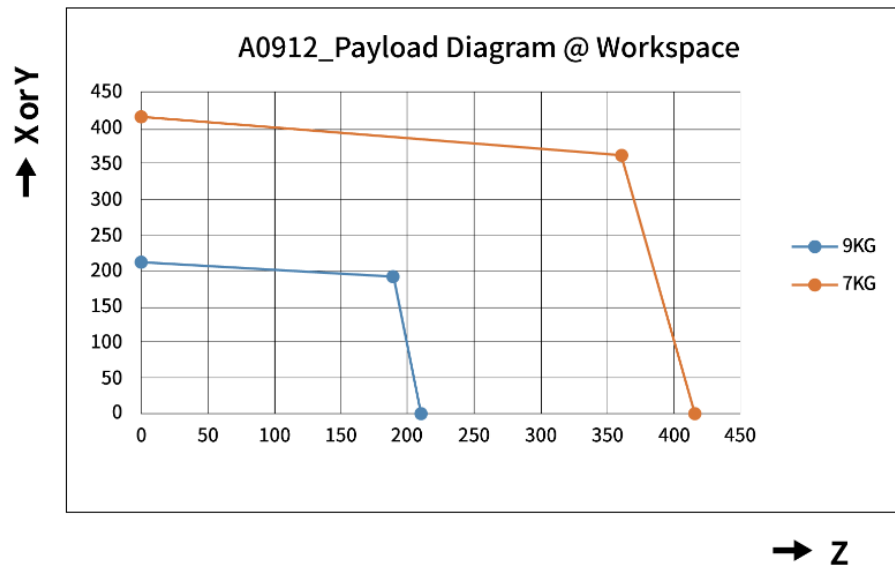
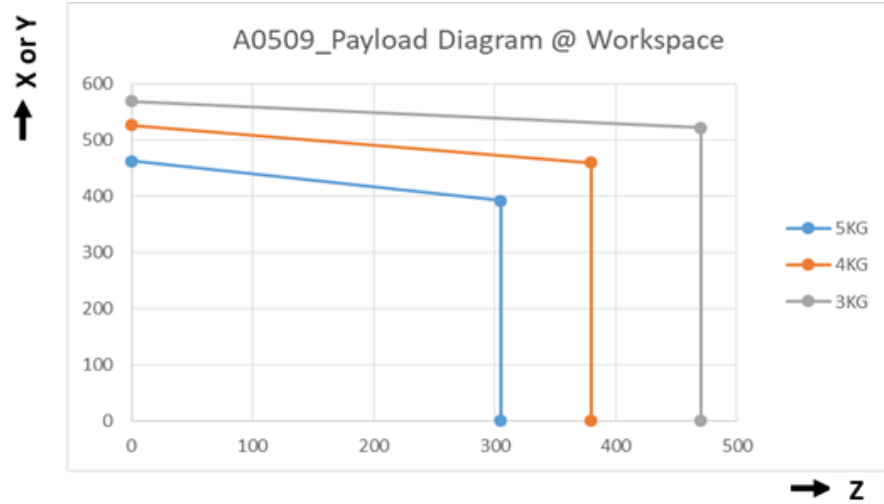
• A0912S





2.5.4 Max. Payload within operating space

The maximum payload of the robot within its operating space changes according to the distance from the center of gravity. Payload per distance is as follows:

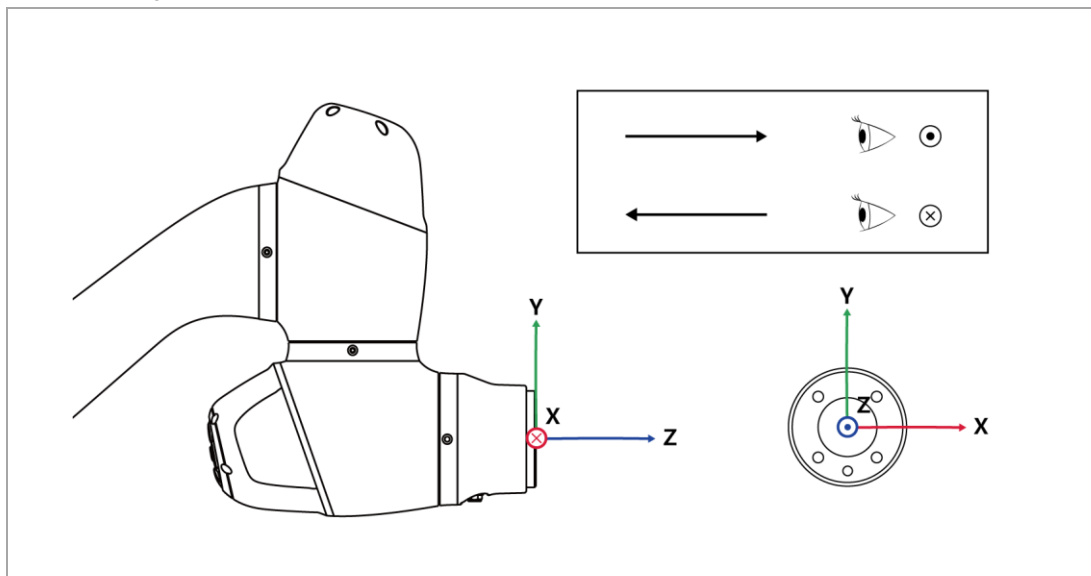


Note

- This load diagram assumes a small tool load volume. Tools with a larger volume will have greater limitations in payloads above the tool's center of gravity compared to a tool with equal weight but smaller volume, and in such cases, vibration may occur.

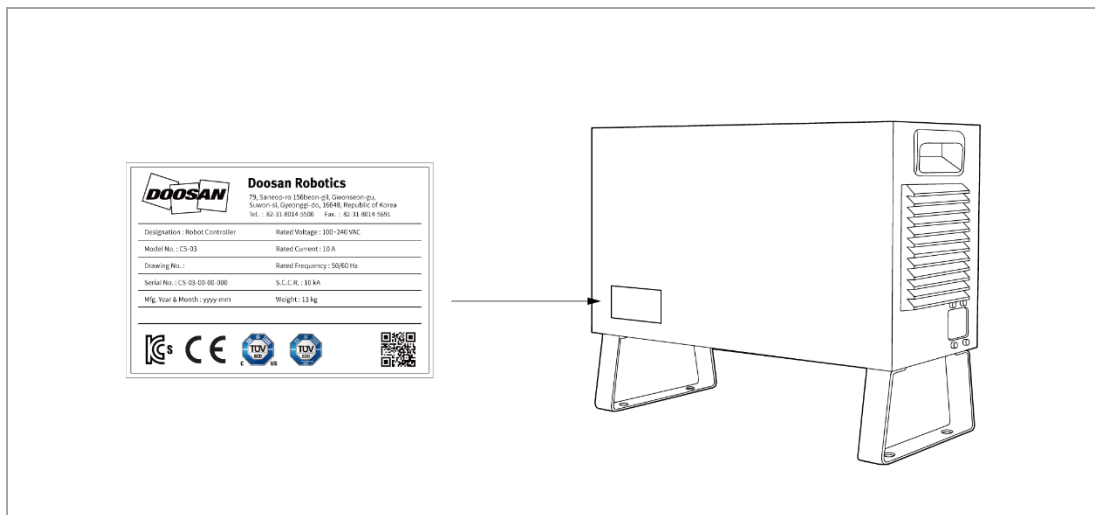
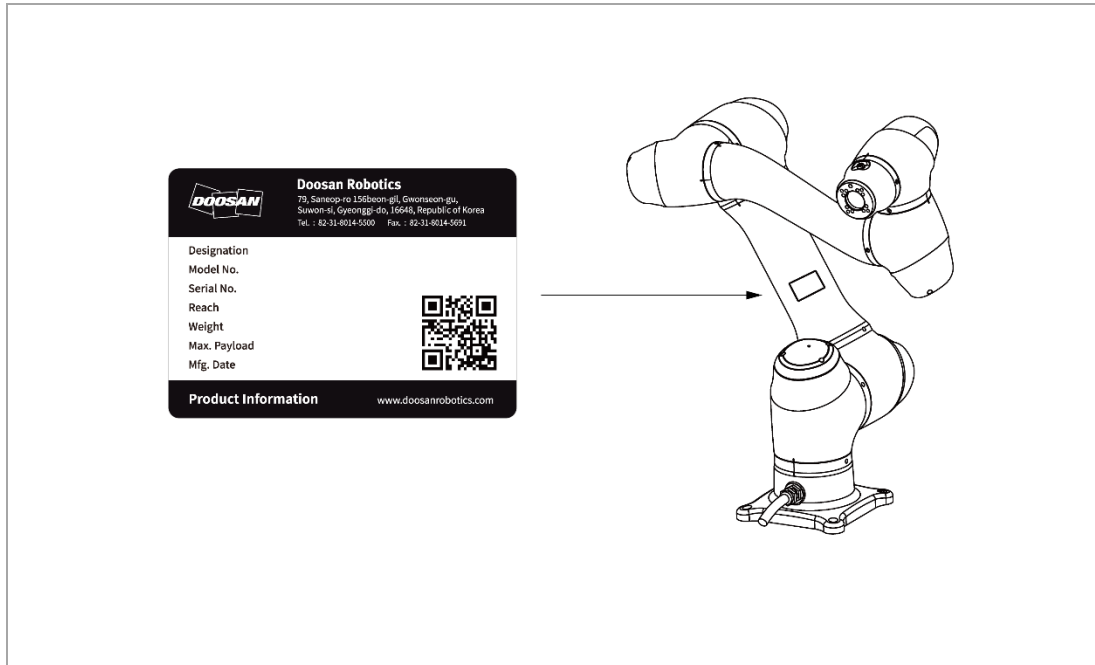
2.5.5 Tool Center Point (TCP)

Refer to the figure below for TCP.



2.6 Nameplates and Labels

Be careful not to remove or damage labels attached to the robot and controller.



3. Installation

3.1 Cautions during Installation

Warning

- Secure sufficient space for installation before installing the robot. If not enough space is secured, the robot may be damaged or the user may be injured.
- Safety devices to be connected to the controller must be connected to a safety contact input terminal or a configurable digital I/O set as Safety I/O using dual signals. If safety devices are connected to a regular I/O or connected using single signals, the devices cannot satisfy the required safety level.
- When connecting the power plug and power cable to a power source, do not touch them with wet hands. This can cause electrocution or injury. The maximum payload of the robot within its operating space changes according to the distance from the center of gravity.
- To use the Teach Pendant, Smart Pendant, or Emergency Stop buttons, the switch must be set to match the actual configuration.
- If the setting (Section **3.3.10 Emergency Stop Button Setting Switch**) of the emergency stop button setting switch is different from the actual configuration, the emergency stop button may fail and cause injury to the user in an emergency situation, so check the setting condition and operation of the emergency stop button.

Caution

- Ensure that the mounting bolts are completely tightened during installation. If the mounting bolts become loose, the base and robot may separate during operation, resulting in breakdowns.
- Make sure that safety measurements and robot safety setting parameters are correctly defined according to the risk assessment. If these are not established, the robot may be damaged or the user may be injured.
- Correctly set robot installation-related settings such as robot mounting angle, TCP weight, TCP offset and safety settings. If these are not established, the robot may be damaged or the user may be injured.

3.2 Installation Environment

Secure sufficient space to allow the robot to move freely. Check the operating space of the robot to ensure that the robot does not collide with external elements.

3.2.1 Installation Location Check

Before installing the robot, secure sufficient space and consider the following:

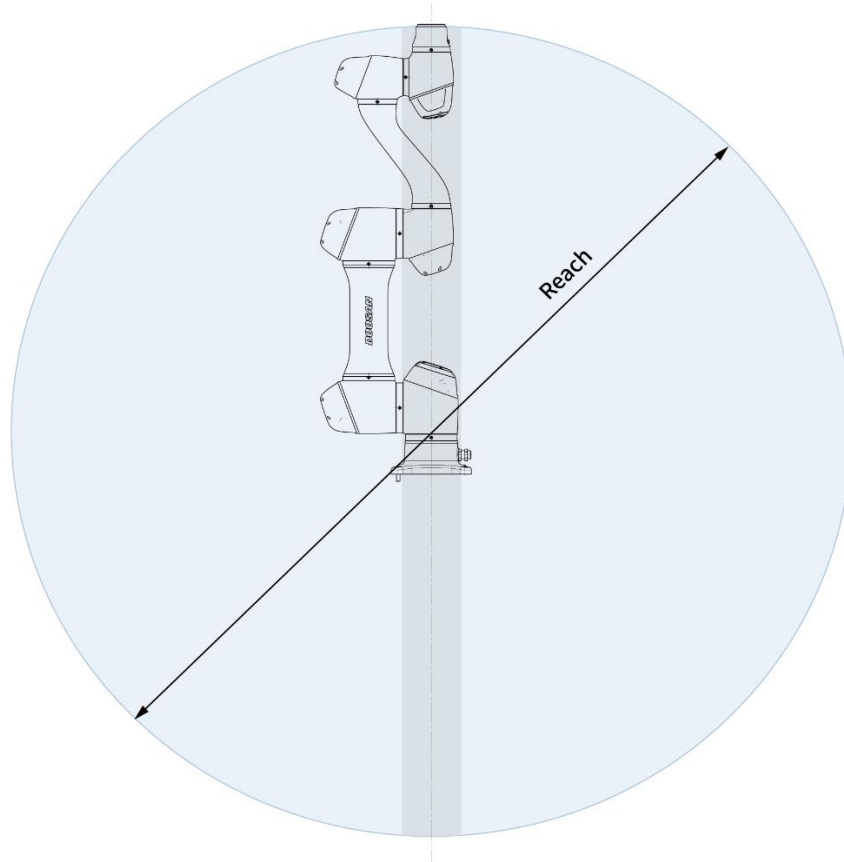
- Install the robot on a firm, even surface.
- Install the robot in a location with no water leakage and with constant temperature and humidity.
- Check whether flammable and explosive materials are near the installation location.



- Installing the robot in locations other than the recommended locations may result in reduced robot performance and product life.

3.2.2 Robot Work Area Check

Secure installation space considering the operating space of the robot. The operating space varies according to the robot model.



 **Note**

- The gray areas in the figure are areas where the robot has difficulty performing work. Within this area, the speed of tools is low but the speed of joints is high, making it difficult to conduct a risk assessment because the robot can operate inefficiently. Therefore, it is not recommended to operate the tool passing through the cylindrical section on the top and bottom of the base.

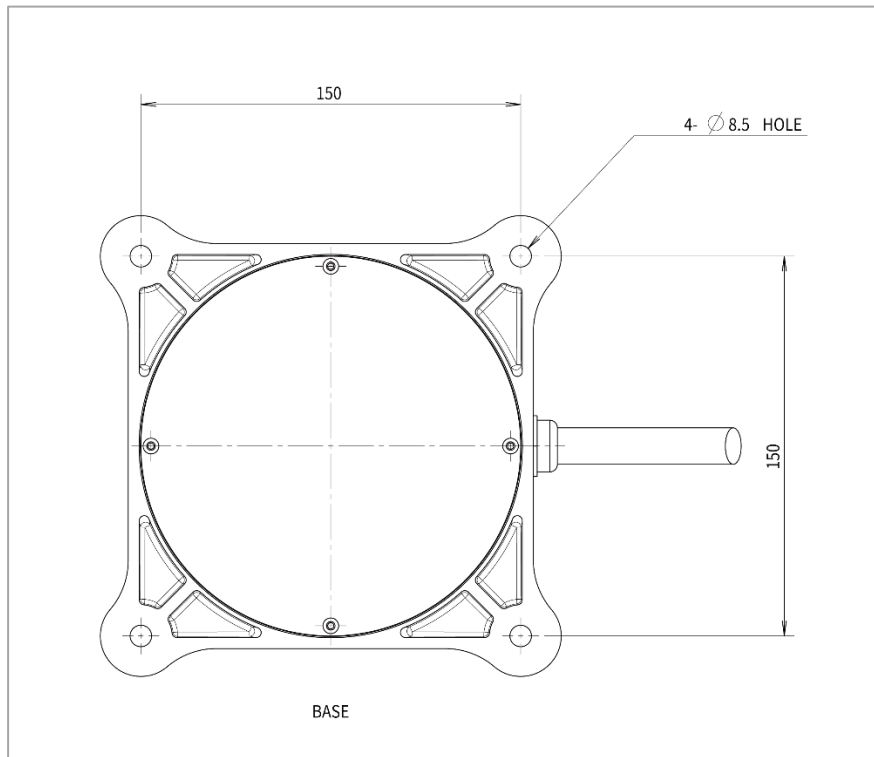
3.3 Hardware Installation

Install the robot, controller and teach pendant, the key components of the system in the work area, and supply power to them before operating the robot. The installation of each component is as follows:

3.3.1 Securing the Robot

Use M8 bolts in the four 9.5 mm holes in the manipulator base to secure the robot.

- It is recommended to use a tightening torque of 20 Nm to tighten the bolts.
And use a washer(plain or spring) to prevent loosening of the tension caused by vibration.
- Use a $\Phi 5$ place marker pin to accurately install the manipulator in a fixed location.



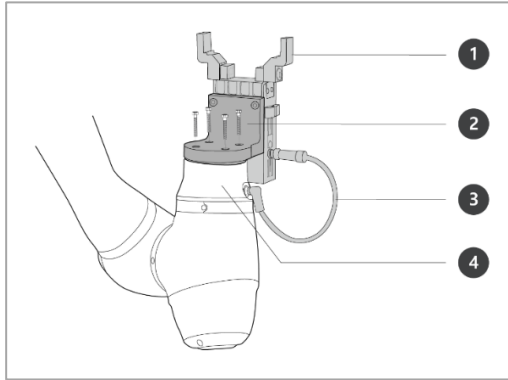
manipulator base drawing, use four M8 bolts. Unit [mm]



Warning

- Tighten the bolts all the way to prevent loosening during manipulator operation.
- Install the manipulator base on a solid surface that can withstand the load generated during operation (10 times the maximum torque and five times the weight of the robot).
- The manipulator will interpret robot base vibration as a collision and engage the emergency stop. Therefore, in the case of installation locations that automatically shift position, do not install the robot base in a location with high movement acceleration.
- Mount the manipulator arm in a specific location using appropriate methods. The mounting surface must be solid.
- The manipulator will be damaged if it comes in contact with water for an extended period of time. Do not operate the robot in conditions where it can get wet or under water.

3.3.2 Connecting the Robot and Tool

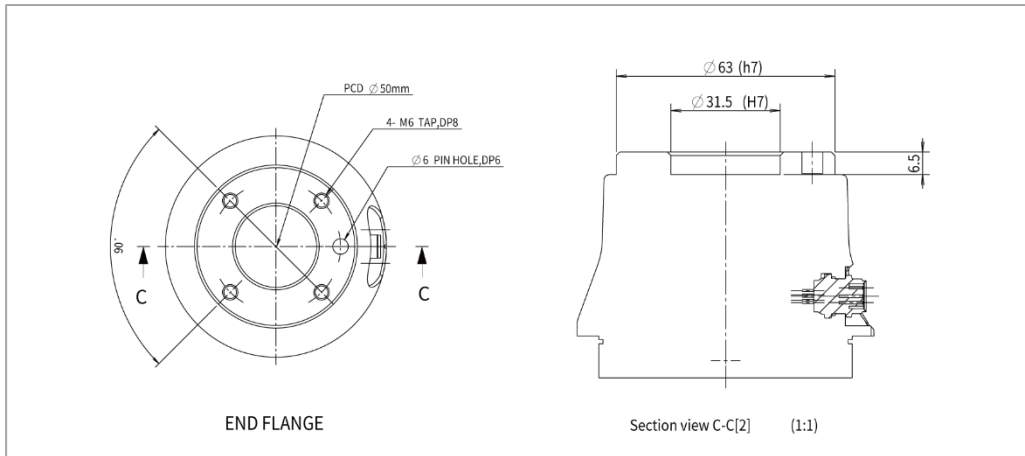


No.	Item
1	Tool
2	Bracket
3	Cable
4	Tool flange

- 1 Use four M6 bolts to secure the tool on the tool flange.
 - It is recommended to use tightening torque of 9 Nm to tighten the bolts.
 - Use a $\Phi 6$ place marker pin to accurately install the robot in a fixed location.
- 2 Connect the necessary cables to the tool I/O after the tool is secured.

 **Note**

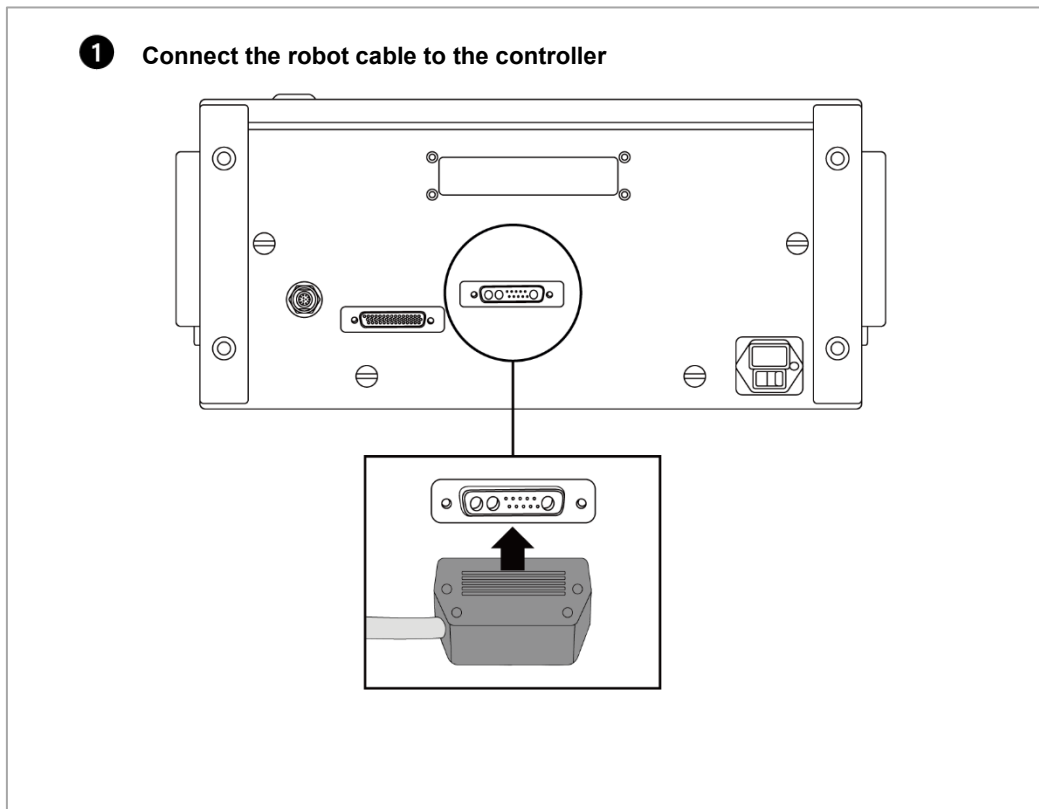
Methods of securing the tool may vary according to the tool. For more information about tool installation, refer to the manual provided by the tool manufacturer.



Tool output flange, ISO 9409-1-50-4-M6

3.3.3 Connecting the Manipulator and Controller

Push the manipulator cable connected to the robot into the corresponding controller connector until a click is heard to prevent the cable from becoming loose.

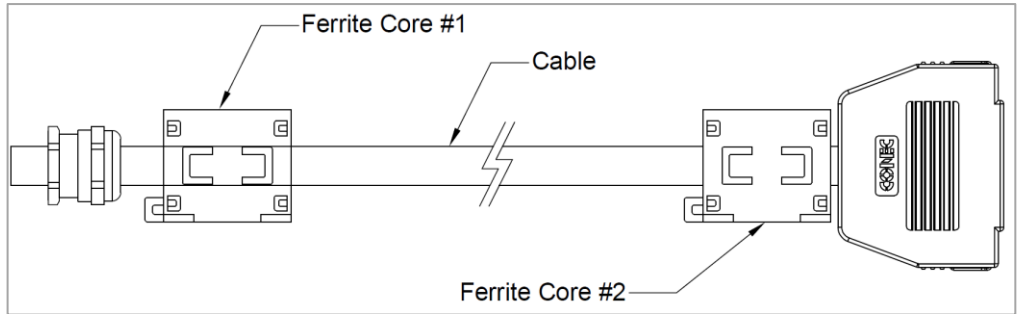


⚠ Caution

- Do not disconnect the manipulator cable when the robot is turned on. This can cause damage to the robot.
- Do not modify or extend the manipulator cable.
- When installing the controller on the floor, secure at least 50 mm of space on each side of the controller to enable ventilation.
- Make sure that connectors are properly connected before turning on the controller.

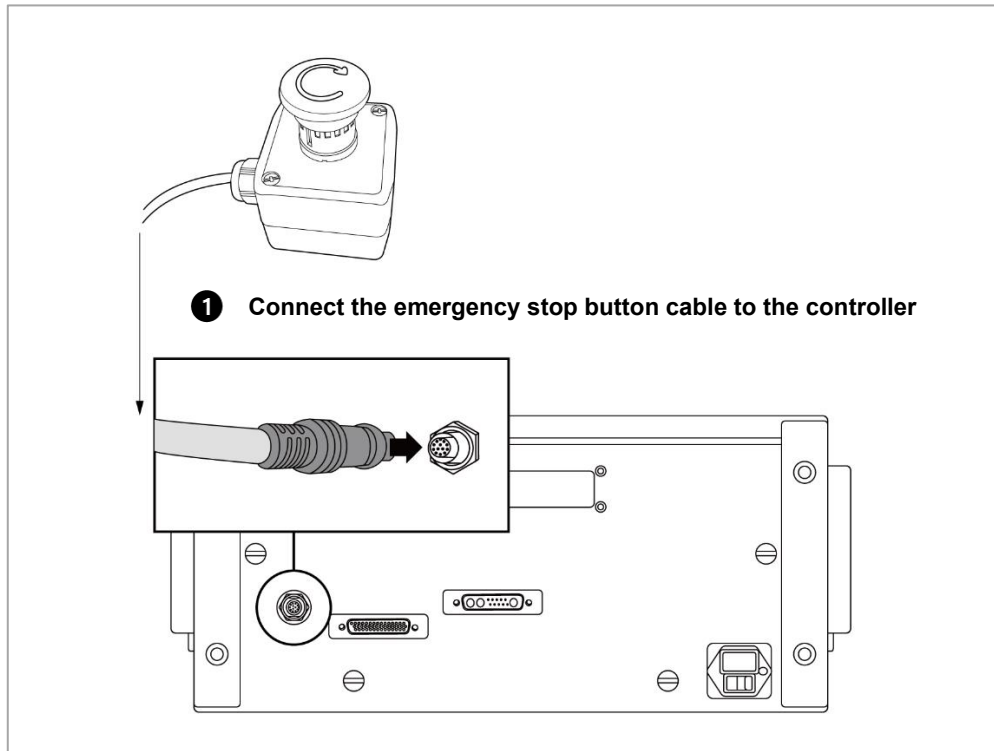
 **Note**

- When configuring the system, it is recommended to install a noise reducer to prevent noise influence among devices and system malfunctioning.
- If the controller is affected by the noise generated by electromagnetic waves, it is necessary to install a ferrite core to ensure normal operation. The installation location is as follows:



3.3.4 Connecting the Controller and Emergency Stop Button

Connect the emergency stop button cable to the corresponding controller connector and install a screw lock by turning it clockwise to prevent the cable from becoming loose.



Warning

- If the setting(Section **3.3.10 Emergency Stop Button Setting Switch**) of the emergency stop button setting switch is different from the actual configuration, the emergency stop button may fail and cause injury to the user in an emergency situation, so check the setting condition and operation of the emergency stop button.

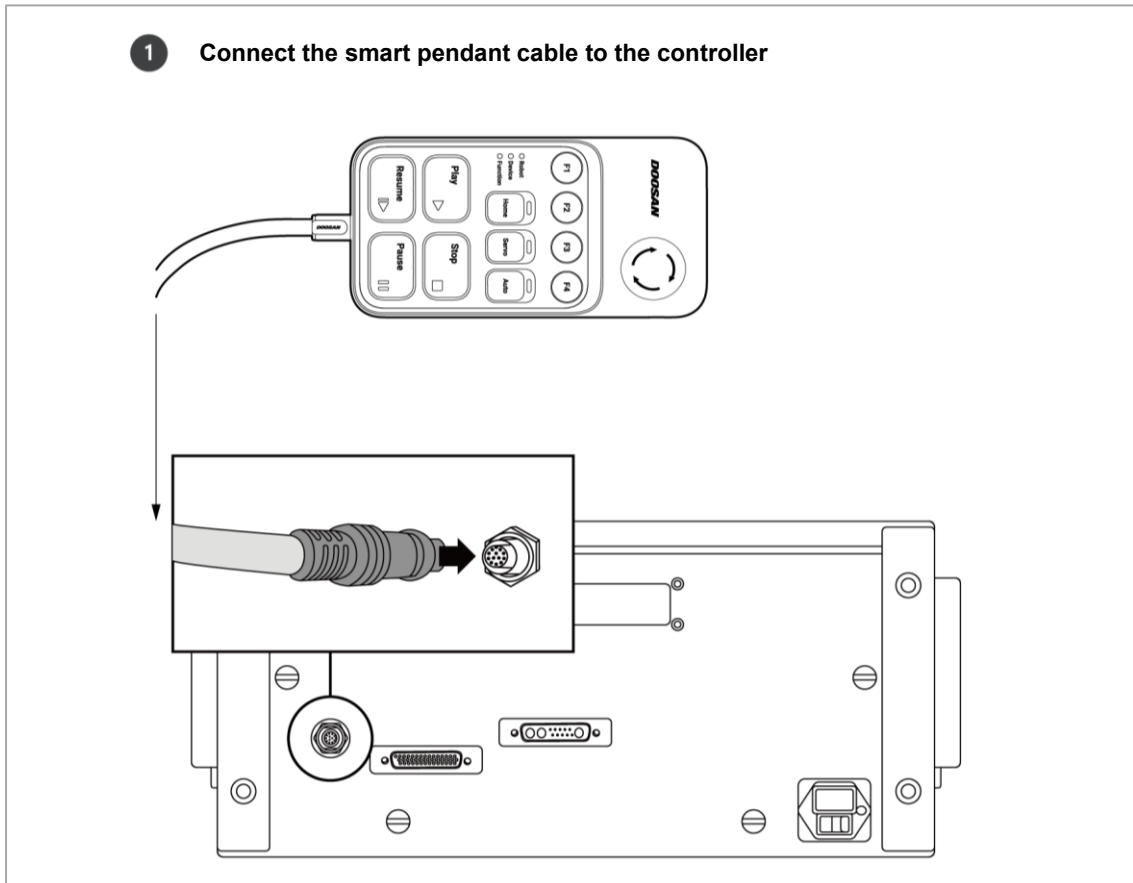


Caution

- Make sure to check the connector shape before connecting the cable.
- If the emergency stop button is used, be careful not to trip on the connecting cables.
- Be careful not to allow the controller, emergency stop button and cable to come in contact with water.
- Do not install the controller, and emergency stop button in a dusty or wet environment.
- The controller, and emergency stop button must not be exposed to dust conditions exceeding IP40 ratings. Be especially careful in environments that have conductive dust.
- Do not disconnect the emergency stop button cable during robot operation.

3.3.5 Connecting the Controller, and Smart Pendant

Connect the smart pendant cable to the corresponding controller, connector and install a screw lock by turning it clockwise to prevent the cable from becoming loose.



Warning

- If the setting (Section **3.3.10 Emergency Stop Button Setting Switch**) of the emergency stop button setting switch is different from the actual configuration, the emergency stop button may fail and cause injury to the user in an emergency situation, so check the setting condition and operation of the emergency stop button.



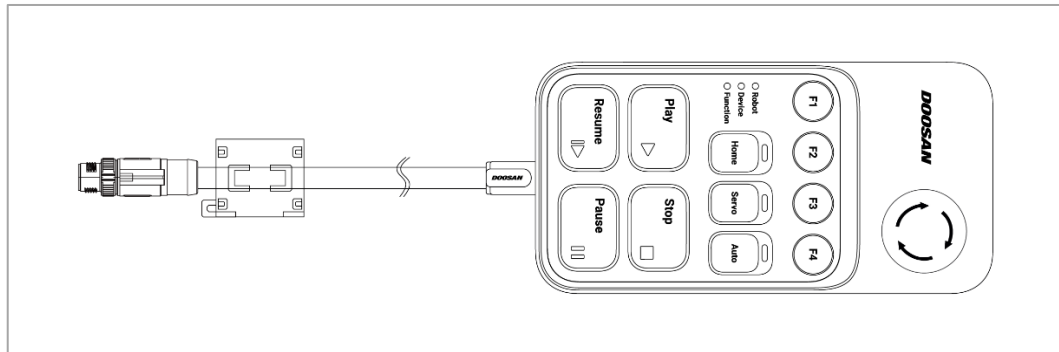
Caution

- Make sure to check that the pins of the cable end are not damaged or bent before connecting the cable.
- If the smart pendant is used by hanging it on the wall or on the controller, be careful not to trip on the connecting cables.
- Be careful not to allow the controller, smart pendant and cable to come in contact with water.
- Do not install the controller and smart pendant in a dusty or wet environment.
- The controller and smart pendant must not be exposed to dust conditions exceeding IP20 ratings. Be especially careful in environments that have conductive dust.
- Ensure that the smart pendant cable curvature is greater than the minimum curvature radius (120 mm).



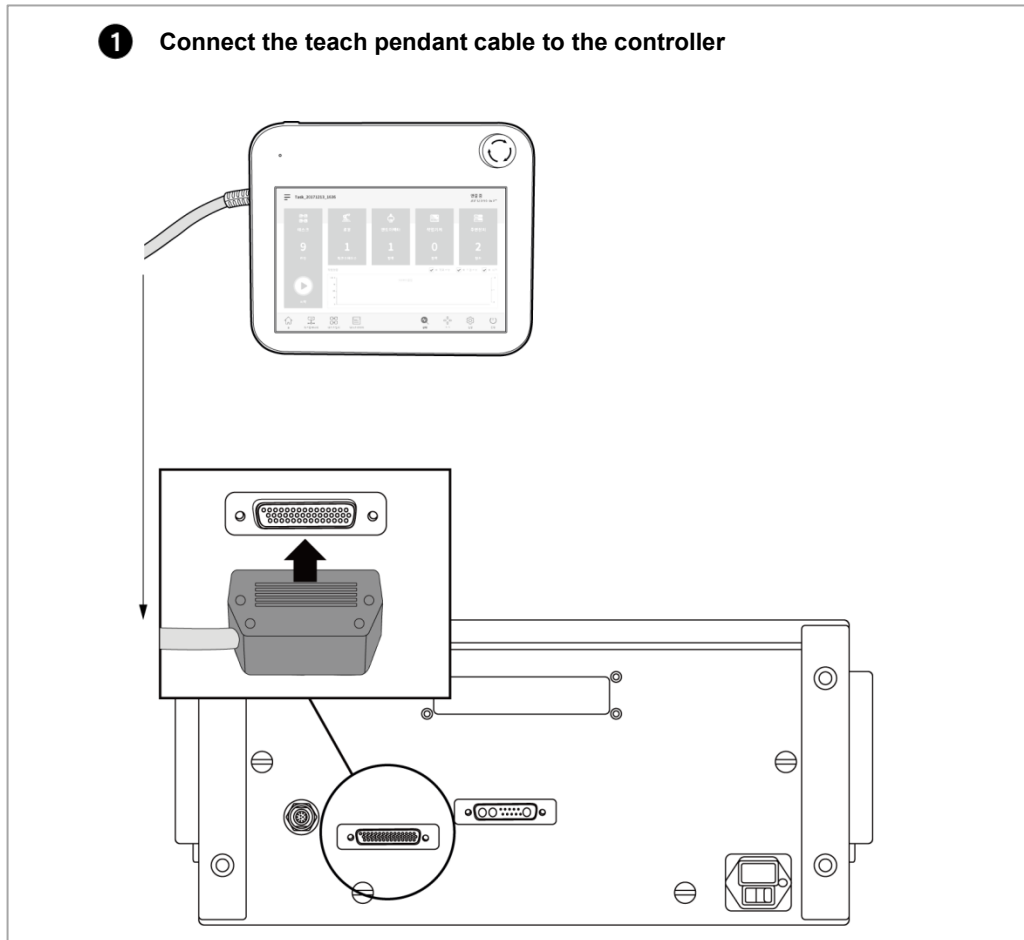
Note

- When configuring the system, it is recommended to install a noise reducer to prevent noise influence among devices and system malfunctioning.
- If the smart pendant is affected by the noise generated by electromagnetic waves, it is necessary to install a ferrite core to ensure normal operation. The installation location is as follows:



3.3.6 Connecting the Controller and Teach Pendant

Push the teach pendant cable into the corresponding controller connector until a click is heard to prevent the cable from becoming loose.



Warning

- If the setting(Section **3.3.10 Emergency Stop Button Setting Switch**) of the emergency stop button setting switch is different from the actual configuration, the emergency stop button may fail and cause injury to the user in an emergency situation, so check the setting condition and operation of the emergency stop button.



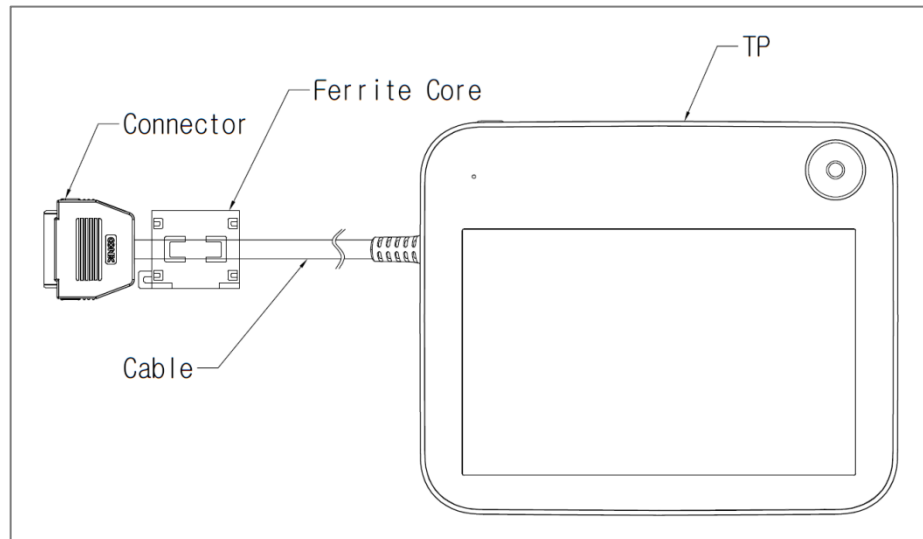
Caution

- Make sure to check that the pins of the cable end are not damaged or bent before connecting the cable.
- If the teach pendant is used by hanging it on the wall or on the controller, be careful not to trip on the connecting cables.
- Be careful not to allow the controller, teach pendant and cable to come in contact with water.
- Do not install the controller and teach pendant in a dusty or wet environment.
- The controller and teach pendant must not be exposed to dust conditions exceeding IP30 ratings. Be especially careful in environments that have conductive dust.



Note

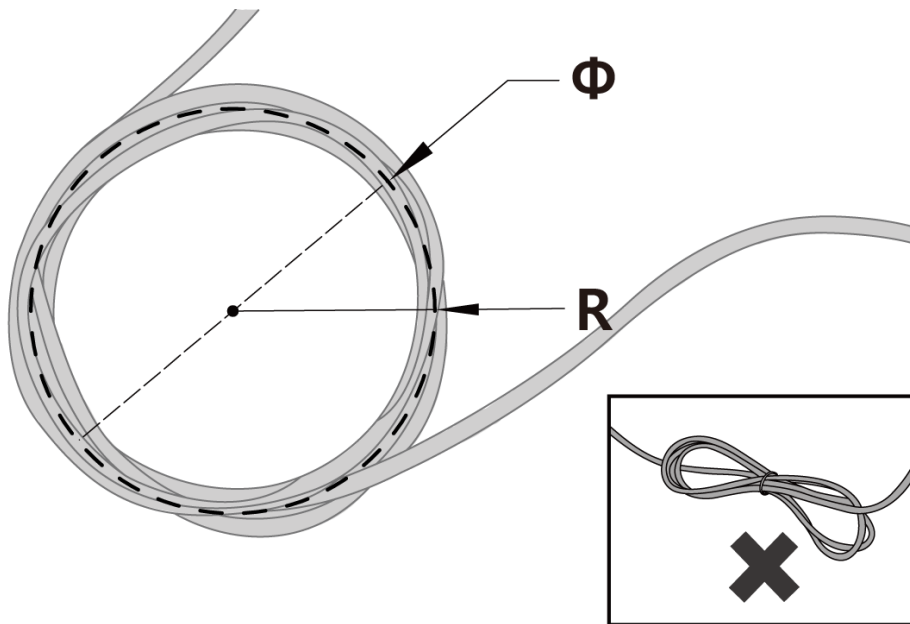
- When configuring the system, it is recommended to install a noise reducer to prevent noise influence among devices and system malfunctioning.
- If the teach pendant is affected by the noise generated by electromagnetic waves, it is necessary to install a ferrite core to ensure normal operation. The installation location is as follows:



3.3.7 Routing of Cables

Ensure that the cable curvatures are greater than the minimum curvature radius. The minimum curvature radius of each cable is as follows:

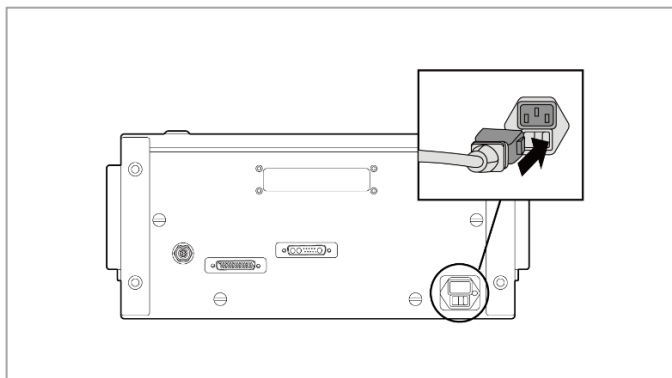
Cable	Minimum Curvature Radius (R)
Teach pendant cable	120 mm
Robot cable	120 mm
Smart pendant cable	100 mm
Emergency stop button cable	100 mm



3.3.8 Supplying Power to the Controller

To supply power to the controller, connect the power cable of the controller to a standard IEC power outlet.

- Use a cable with a standard power plug that matches the outlet of country of use.
- Push the plug completely into the corresponding controller connector to prevent the cable from becoming loose. Connect a standard IEC C14 plug and corresponding IEC C13 cord (refer to below) to the controller.



Warning

- After connecting the power cable, make sure that the robot is properly grounded (electronic ground connection). Establish a common ground for all equipment in the system with an unused bolt related to the ground symbol inside the controller. The ground conductor must satisfy the maximum current rating of the system.
- Protect the input power of the controller using a circuit breaker.
- Do not modify or extend the robot cable. It can cause a fire or controller breakdown.
- Make sure that all cables are properly connected before supplying power to the controller. Always use the original cable included in the product package.



Note

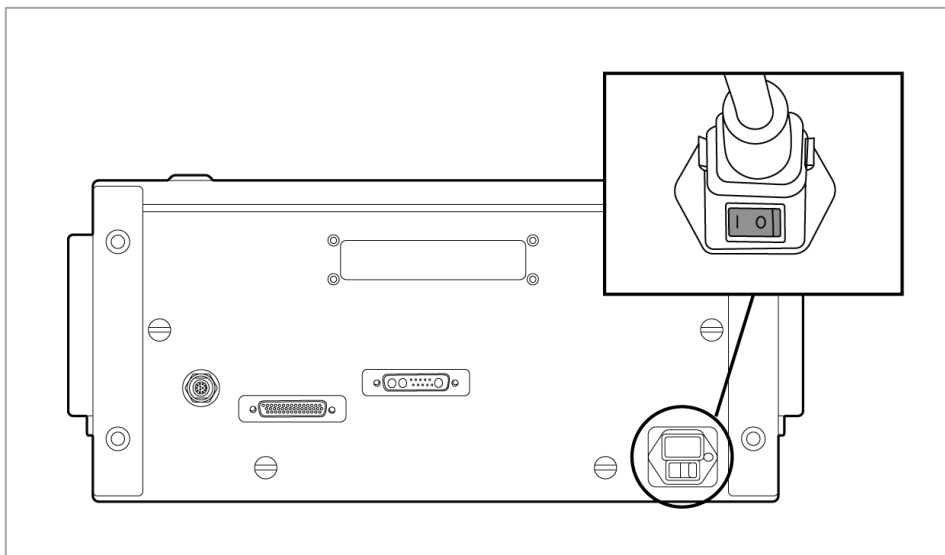
- When configuring the system, it is recommended to install a power switch that can turn off power to all devices in the system at once.
- The power supply must satisfy minimum requirements such as ground and circuit breakers. The electrical specifications are as follows:
- If the input voltage is less than 180V, the robot's movement may be limited according to the load and motion.

Parameter	Specifications
Input Voltage	100 – 240 VAC
Input Power Fuse (@100-240V)	15 A
Input Frequency	47 – 63 Hz

3.3.9 System Power-Up

Press the power button located on the bottom of the controller.

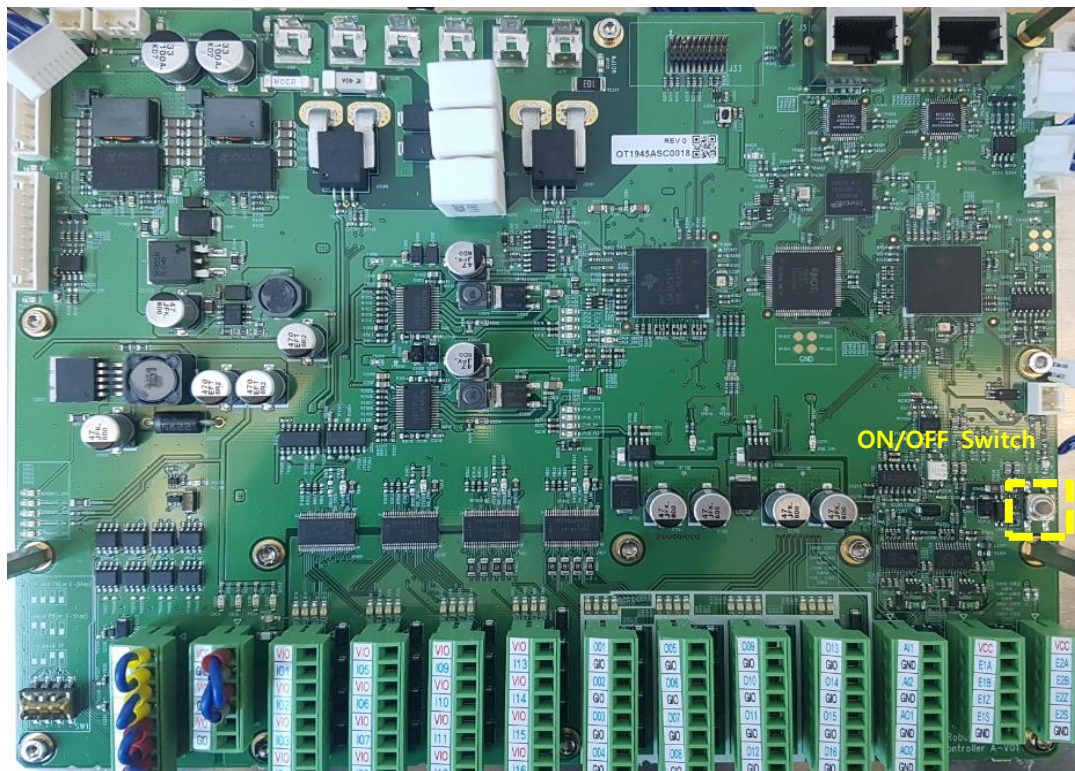
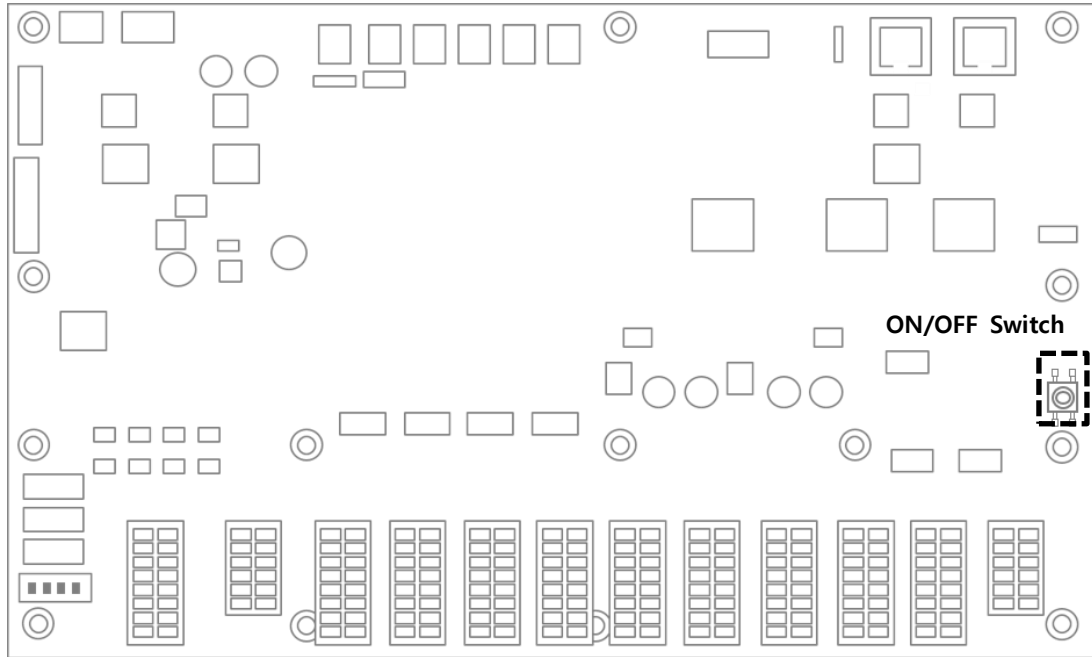
- Power is supplied to systems including the robot, controller, teach pendant and smart pendant.



[PC Power ON/OFF when only E-STOP Box is available - Standard Item]

Open the controller door, and press and hold the power button located below the bottom right of the Safety board.

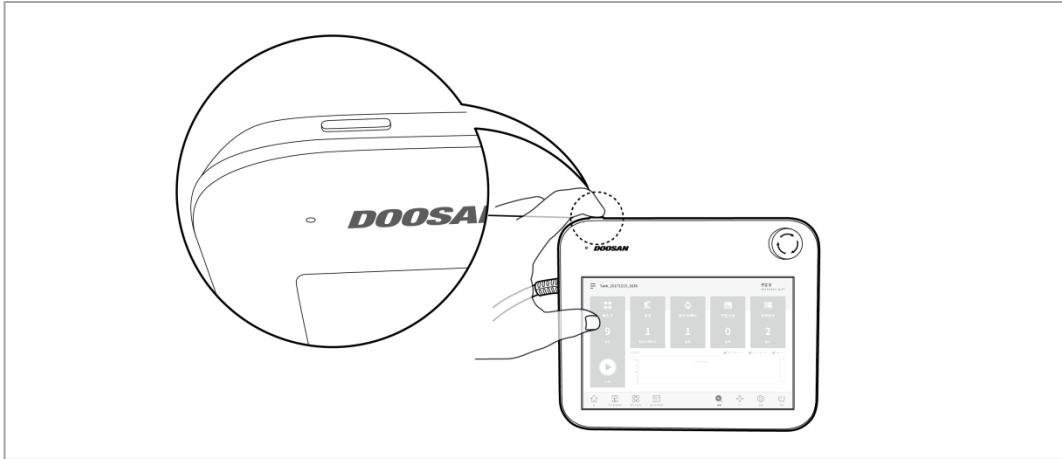
- To turn off the power, press and hold the button.



[PC Power ON/OFF when Teach Pendant is used - Optional Item]

Press and hold the power button located on the top left of the teach pendant.

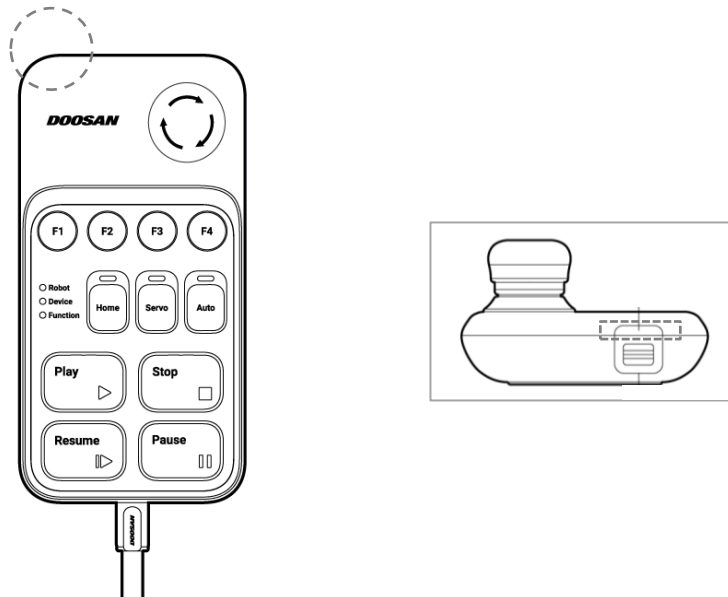
- To turn off the power, press and hold the button.



[PC Power ON/OFF when Smart Pendant is used - Optional Item]

Press and hold the power button located on the top left of the smart pendant.

- To turn off the power, press and hold the button.



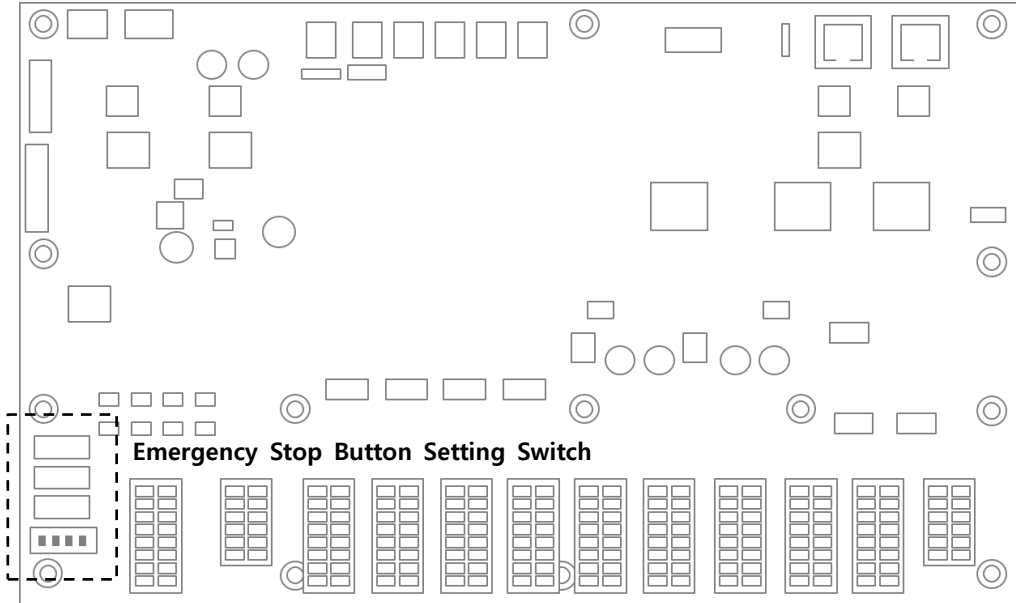
 **Note**

- If a system does not power up, check the power switch located on the bottom of the controller.

3.3.10 Emergency Stop Button Setting Switch

Configure the emergency stop button setting switch on the Case according to components and additional components before connecting and starting up the product. If the setting is not configured according to the guide, the robot will not operate properly.

The emergency stop button setting switch is located on the bottom left of the board inside the controller door (refer to below).



Configure the setting according to the components as follows. Upon first receiving, the setting is configured as Case 1.

Case 1	1. Teach Pendant(O), Smart Pendant(O)	On	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	2. Teach Pendant(O), Emergency Stop Button(O) 3. All use	Off	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Case 2	1. Smart Pendant(O), Teach Pendant(X)	On	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	2. Emergency Stop Button(O), Teach Pendant(X)	Off	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Case 3	1. Teach Pendant(O), Smart Pendant(X)	On	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	2. Emergency Stop Button(X)	Off	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



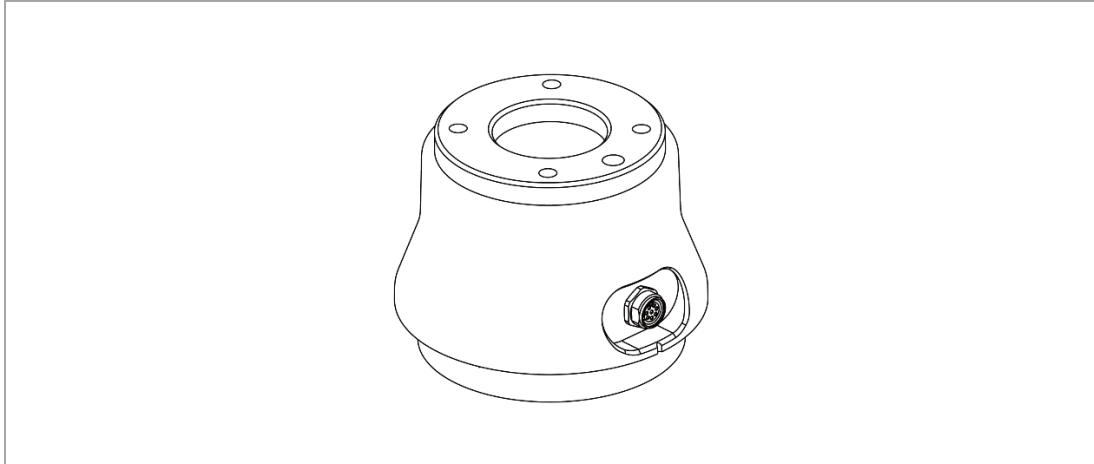
Warning

- If the setting of the emergency stop button setting switch is different from the actual configuration, the emergency stop button may fail and cause injury to the user in an emergency situation, so check the setting condition and operation of the emergency stop button.

4. Interface

4.1 Flange I/O

The end flange cover of the robot has one M8 spec 8-pin connector, and refer to the figure below for the location and shape.

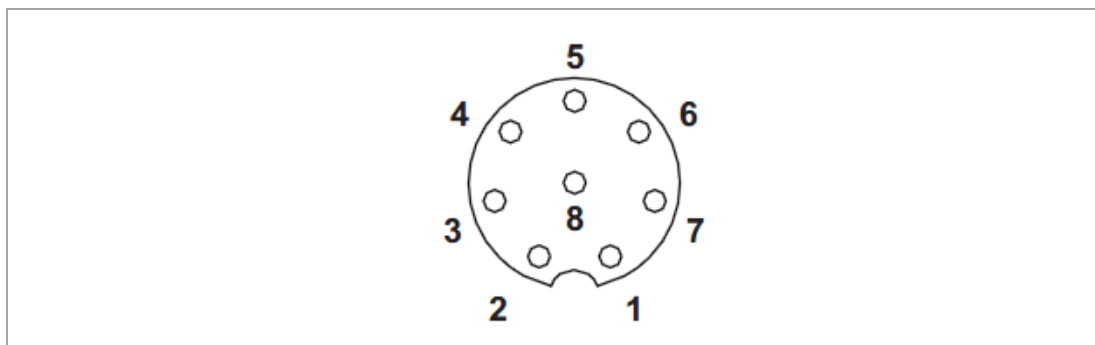


The connector supplies power and control signals necessary to operate the gripper or sensors embedded within specific robot tools. The following are sample industrial cables (equivalent cables can be used):

- Phoenix contact 1404178 (Straight)
- Phoenix contact 1404182 (Right Angle)

The pin map of each connector is as follows:

• Schematic Diagram



The I/O functions provided through X1 connector are different from each other, and refer to the table below for detailed I/O settings.

- X1 Setting (Digital I/O, RS 485)

No	Signal	Note
1	RS485 A	Mfg date 2020.07.06 ~ 2021.01.21
2	RS485 B	
3	Digital Output 1	
4	Digital Output 2	
5	+24V	
6	Digital Input 2	
7	Digital Input 1	
8	GND	

- X1 Setting (Digital I/O, RS 485)
- The setting has been changed as follows since January 21, 2021

No	Signal	Note
1	Digital Input 1	Mfg date Before July 6, 2020
2	Digital Output 1	
3	Digital Output 2	Mfg date After January 21, 2021
4	RS485 A	
5	+24V	Other serial numbers applied VMA6F5-A0509S WAA6H7-A0912 WAA6H8-A0912
6	RS485 B	
7	Digital Input 2	
8	GND	



Caution

- Configure tools and grippers after checking I/O configuration based on production date (robot label mfg date).
- You can find it on Doosan Robotlab.(<https://robotlab.doosanrobotics.com>)
- If you run robot tools ignoring I/O configuration, the product can be damaged permanently.

Internal power of the flange I/O is set to 24V, and refer to the table below for detailed power specifications during I/O connection.

Parameter	Min	Typ	Max	Unit
Supply voltage	-	24	-	V
Supply current	-	2	3	A
Digital output	-	2	-	EA
Digital input	-	2	-	EA



Warning

- Set up the tool and gripper so that they do not cause any hazards when power is cut off.
(E.g., workpiece falling from the tool)
- The No. 5 terminal of each connector outputs 24V at all times while power is supplied to the robot, so make sure to cut the power supply to the robot when setting up the tool and gripper.

4.1.1 Flange Digital Output Specifications

Flange digital output is a PNP specification, and photo coupler output is set up in the output.

The corresponding output channel becomes +24V when digital output is activated. The corresponding output channel is open (floating) when digital output is deactivated.

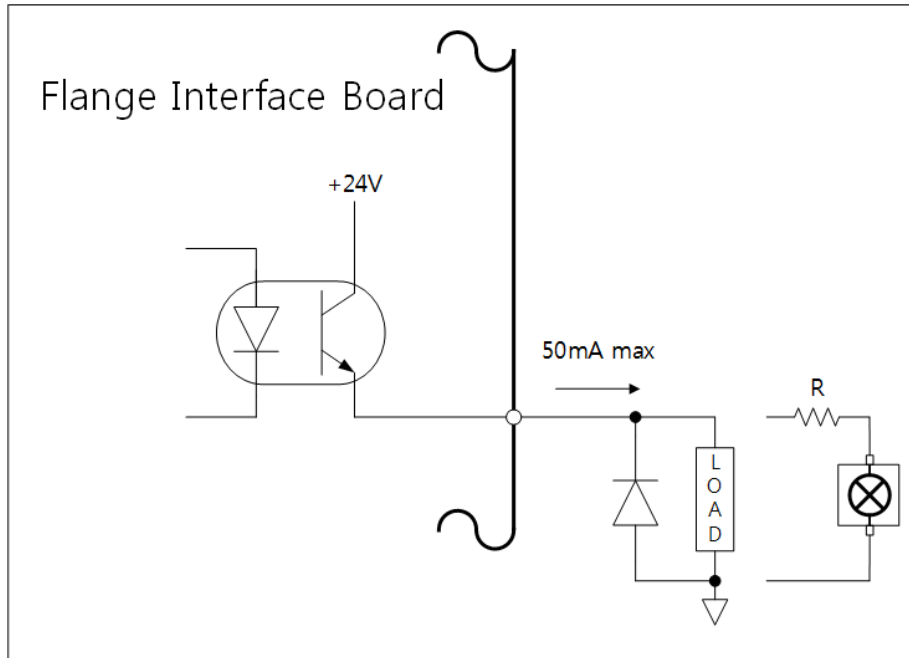
The electrical specifications of the digital output are as follows:

Parameter	Min	Typ	Max	Unit
Voltage when driving 10mA	23	-	-	V
Voltage when driving 50mA	22.8	-	23.7	V
Current when driving	0	-	50	mA



Caution

- Digital output is not subject to current limitation. Ignoring the specifications above during operation may cause permanent damage to the product.
- The figure below is an example of a digital output setup, so refer to it while connecting the tool and gripper. Make sure to disconnect the power from the robot when setting up the circuit.



4.1.2 Flange Digital Input Specifications

Flange digital input features a photo coupler input.

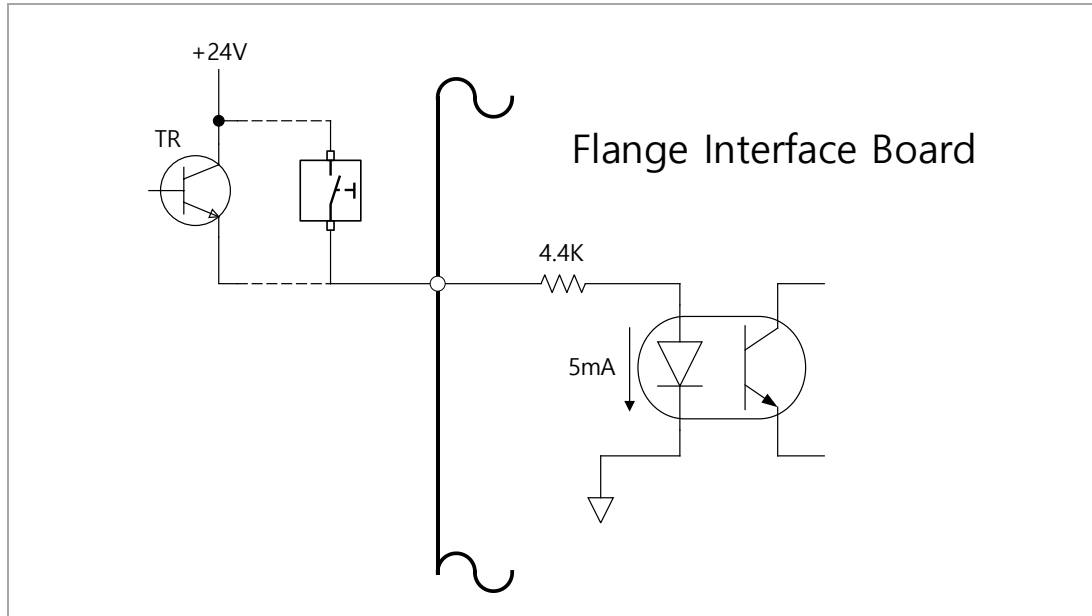
The current based on 24V input is limited to 5mA by internal resistance.

The electrical specifications of the digital input are as follows:

Parameter	Min	Typ	Max	Unit
Input voltage	0	-	26	V
Logical high	4.4	-	-	V
Logical low	0	-	0.7	V
Input resistance	-	4.4k	-	Ω

The figure below is an example of a digital input setup, so refer to it while connecting an input device.

Make sure to disconnect the power from the robot when setting up the circuit.

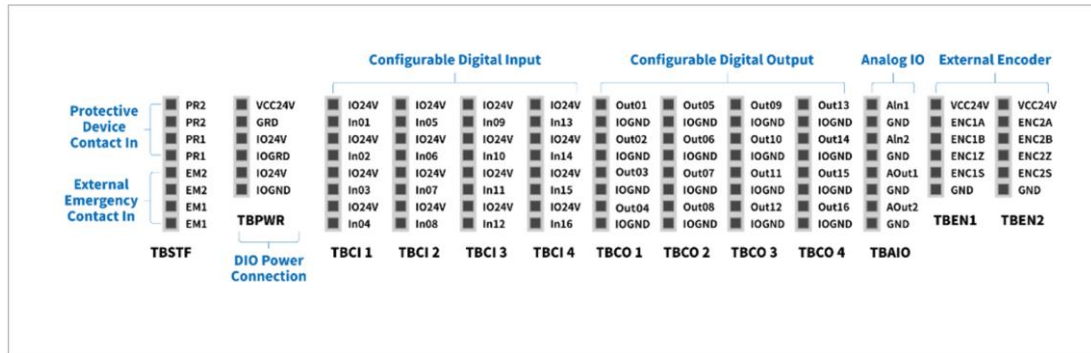


4.2 Controller I/O Connection

In addition to the manipulator and teach pendant, various external equipment can be connected to the controller through the controller I/O terminal. Various peripherals such as safety devices, including emergency stop switch, light curtain and safety mats, and devices required during robot work cell setup including pneumatic solenoid valves, relays, PLCs and conveyor belt encoders can be connected. The controller I/O consists of the following six units:

- Terminal Block for Safety Contact Input (TBSFT): Used to connect devices required for emergency stopping and protective stopping
- Terminal Block for Digital I/O Power (TBPWR):
- Configurable Digital IO Block (TBCI1- 4, TBCO1– 4): Used to connect peripherals required for robot operation
- Terminal Block for Analog I/O (TBAIO):
- Terminal Block for Encoder Input (TBEN1, TBEN2)

The figure below depicts the electric interface layout of the controller interior.



Caution

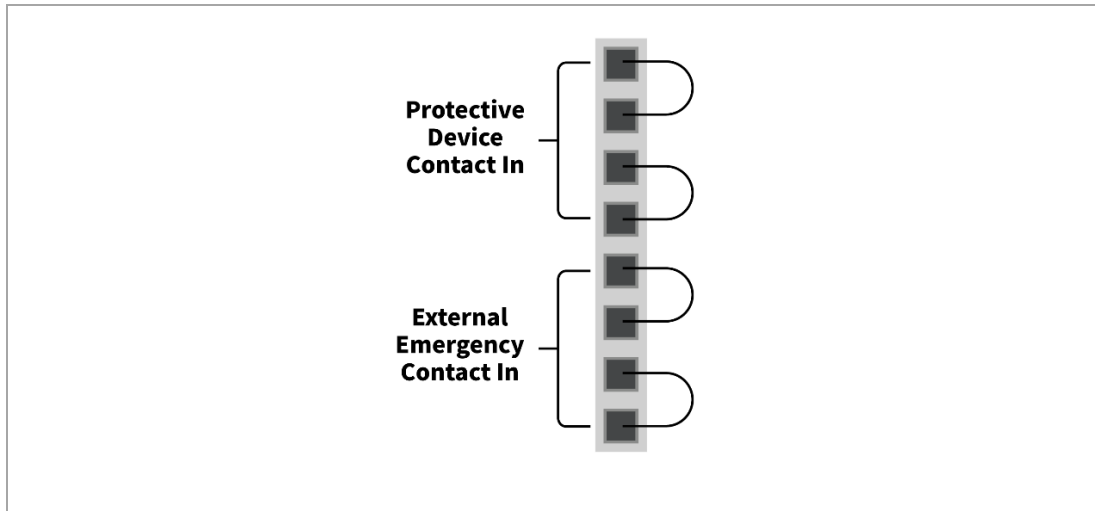
- Turn off the power when connecting terminals to the controller I/O to prevent product damage and breakdown.
- Doosan Robotics will not compensate any product damage caused by inappropriate terminal connection or user negligence.
- Make sure to turn off the external power source when turning off the controller power.

4.2.1 Setting the Terminal Block for Contact Input (TBSFT)

The safety I/O of the controller consists of dual contact input terminals for connecting safety devices. These terminals are categorized into two groups depending on their use.

- Two pairs of external emergency contact in on the bottom: Used to connect devices required for emergency stopping such as external emergency switch.
- Two pairs of protective device contact in on the top: Used to connect devices for protective stopping such as light curtain and safety mat.

If no external safety device is connected, connect each contact input as follows:



The external safety device signal recognized by the safety controller depending on the normally closed contact status, where all four contact inputs are normally closed, is as follows:

Contact Status	EM1 contact	EM2 contact	PR1 contact	PR2 contact
Close	Normal	Normal	Normal	Normal
Open	Emergency Stop	Emergency Stop	Protective Stop	Protective Stop



Warning

- Do not connect the safety signal to regular PLCs that are not safety PLCs. Failure to do this will result in inappropriate operation of the safety stop function, which can cause severe injury or death to the user.
- If any of the contacts are open, the robot will stop operation according to the safety stop mode setting, and the LED on the right side of the TBSFT lights up. EMGA (Red), EMGB (Red), PRDA (Yellow), PRDB (Yellow)

 **Note**

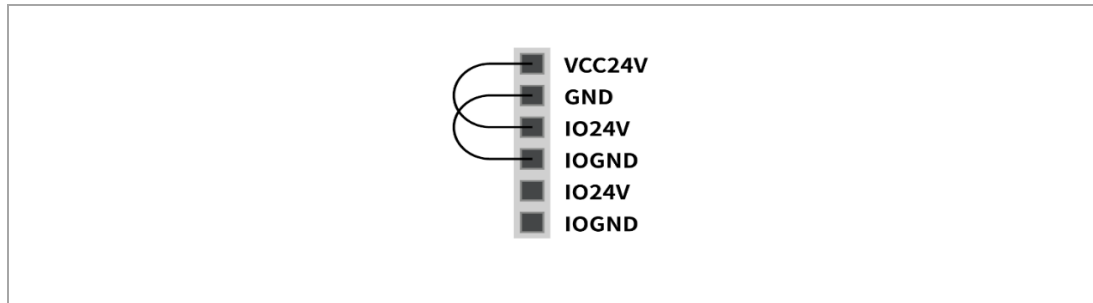
- EMGA : Emergency Stop channel A(EM1) LED
- EMGB : Emergency Stop channel B(EM2) LED
- PRDA : Protective Stop channel A(PR1) LED
- PRDB : Protective Stop channel B(PR2) LED

 **Caution**

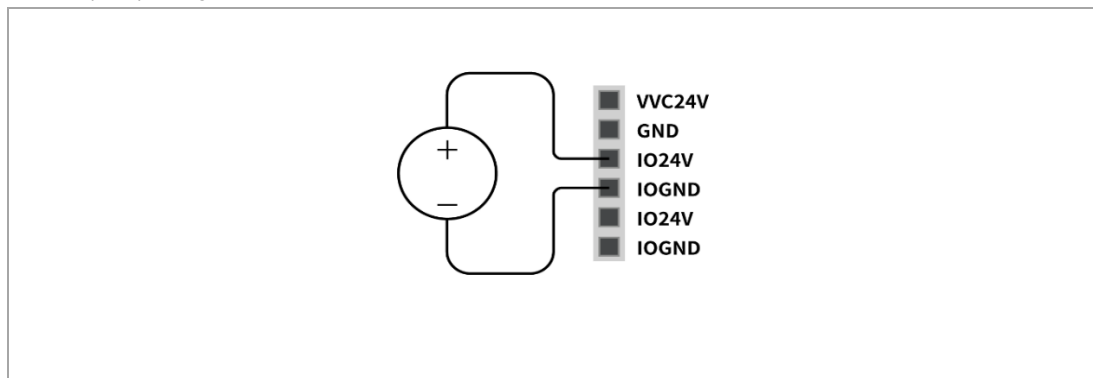
- To check for connection losses and connection shortages, this terminal must be connected to devices that output a safety signal as contacts. To connect peripherals that output safety signals as voltages to the safety controller, refer to the description for the Configurable Digital I/O Terminal Block.

4.2.2 Setting the Digital I/O Power Terminal (TBPWR)

VIO and GIO are power terminals used for the safety controller digital I/O located in the front of the controller and are separated from the VCC24V and GND that supply SMPS inside the controller. If the user uses a current of 2A or less for the configurable digital I/O, and if there is no insulation for the connected I/O device and controller, the internal power supply of the controller can be used as the I/O power supply, as shown in the figure below. (factory default setting)



If a current greater than 2 A is required, it will be necessary to connect a separate external power source (24V) using VIO and GIO terminals.



When VIO power is supplied, the IOPW (green) LED on top of the TBPWR lights up.



Caution

- Make sure to turn off the external power source (SMPS) when turning off the power for the controller.

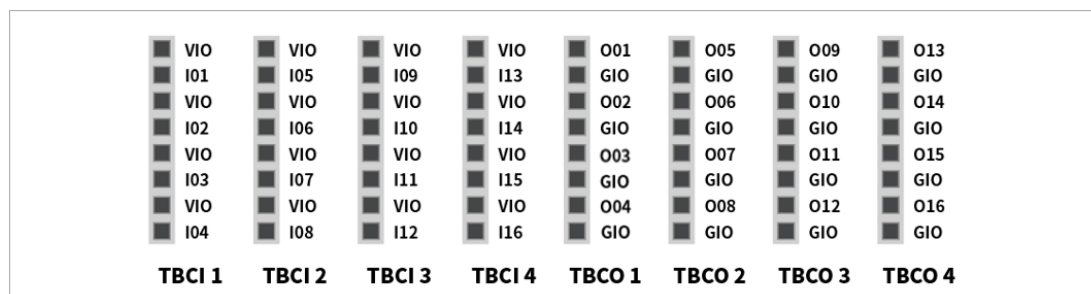


Note

- If a current greater than 2A is connected to the VCC and GND of TBPWR, the fuse in front of the terminal power output shorts to ensure the safety of the controller internal system connected to the same SMPS.
- If a current greater than 2A is required for the configurable digital I/O, make sure to connect an external power source (24V) to VIO and GIO.

4.2.3 Setting the Configurable Digital I/O (TBCI1 - 4, TBCO1 - 4)

The digital I/O of the controller consists of 16 inputs and 16 outputs. They are used to connect peripherals required for robot control or are set as a dual safety I/O to be used as safety signal I/O purposes.



The electrical specifications of the configurable digital I/O are as follows:

Terminal	Parameter	Specifications	
Digital Output	[Oxx]	Voltage	0 - 24 V
	[Oxx]	Current	0 - 1 A
	[Oxx]	Voltage Drop	0 - 1 V
	[Oxx]	Leakage Current	0 - 0.1 mA
Digital Input	[lxx]	Voltage	0 - 30 V
	[lxx]	OFF Range	0 - 5 V
	[lxx]	ON Range	11 - 30 V
	[lxx]	Current	2 - 15 mA



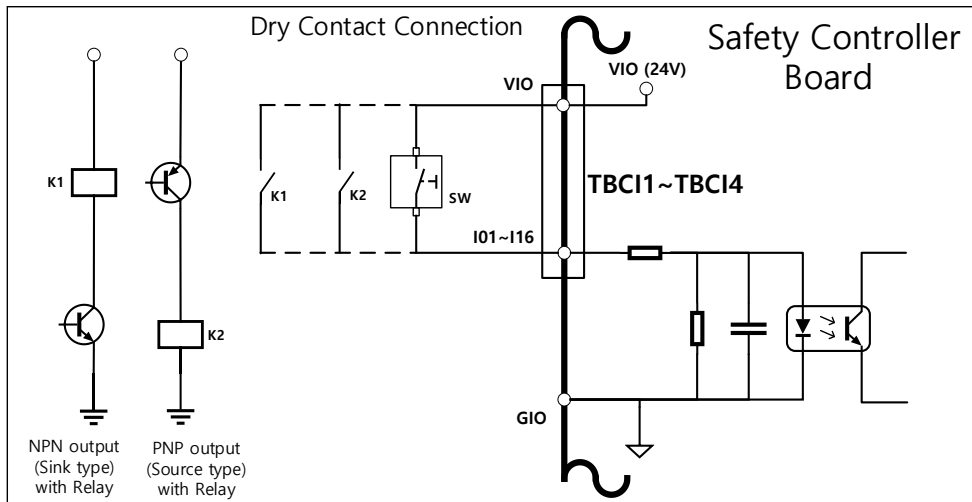
Caution

- The VIO (IO 24 V) and GIO (IO GND) terminals, which can be used as power supplies for digital I/O, are separated from the external power supply terminal VCC (24 V) and the GND on the safety I/O circuit. Use caution, as the diagnostic functions of the robot will detect errors if the internal power supply is connected as a digital I/O power supply through the terminal block for digital I/O power (TBPWR) and if the 24 V power is not supplied to the VIO and GIO terminals through an external power supply, the configurable digital I/O will not work and operating power to the robot will be shut off.

If the configurable digital I/O is used as a general digital I/O, various low current operations such as solenoid valves for voltage and signal exchanges with PLC systems or peripherals can be performed. The following is how to use the configurable digital I/O:

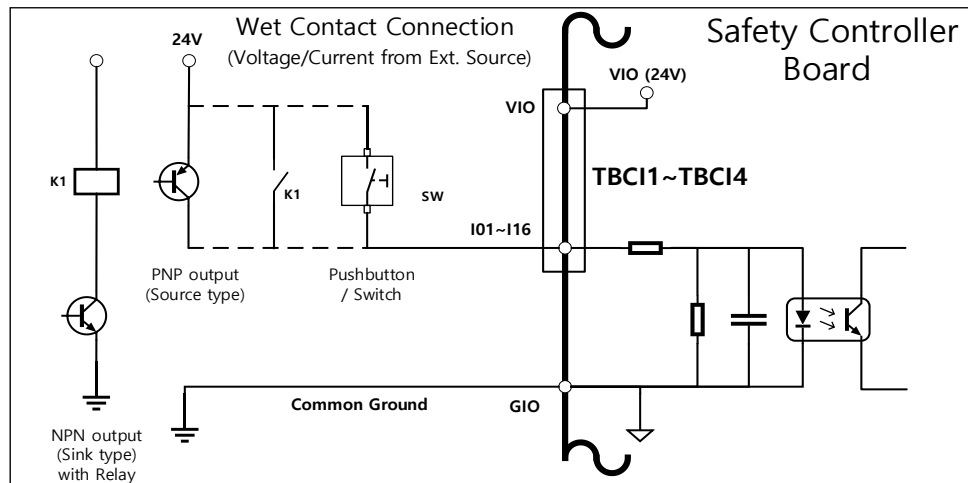
- If dry contact input is received

This is a method of connecting a switch or contact between the VIO terminal of terminal blocks TBC11-TBC14 and Ixx terminals. The output of the external device only acts on the open/close of the contact through the relay, so it is electrically insulated from external devices.



- If wet contact input is received

It receives voltage type signals from external devices. If the output of the target device is source type, it receives a voltage of 24V/0V as input. If the output of the target device is sink type, a relay can be added to receive voltage of 24V/0V as input. Because voltage input requires a reference, the external devices and the external power supply must be connected to a common ground.

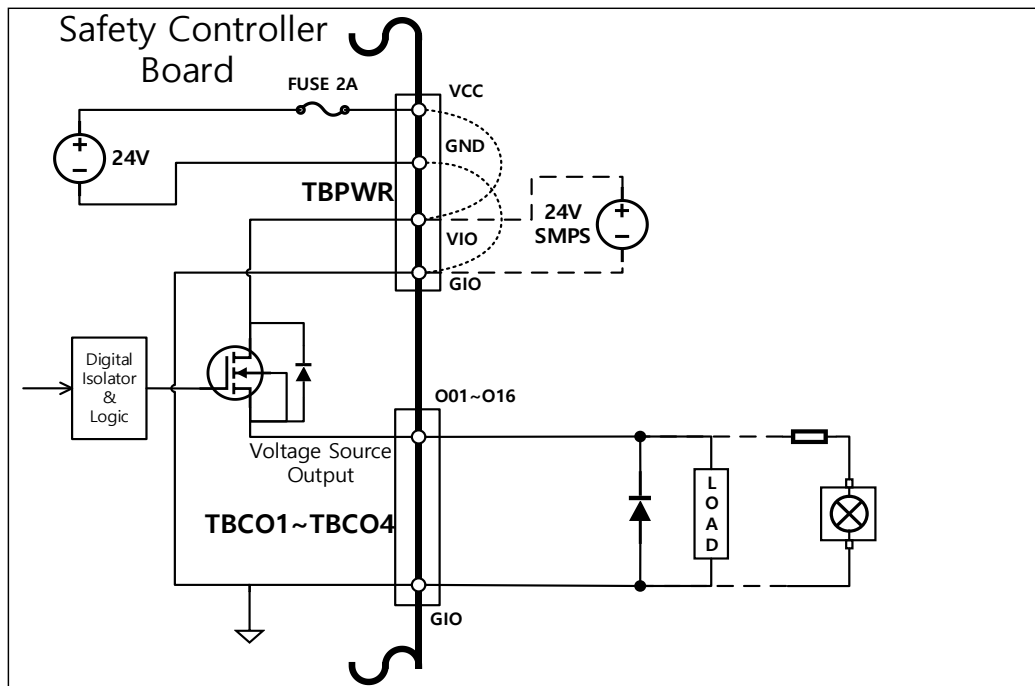


- If a simple load is operated

This is a method of connecting loads between the O01-O16 terminals of the TBCO1-TBCO4 terminal blocks and the GIO terminal.

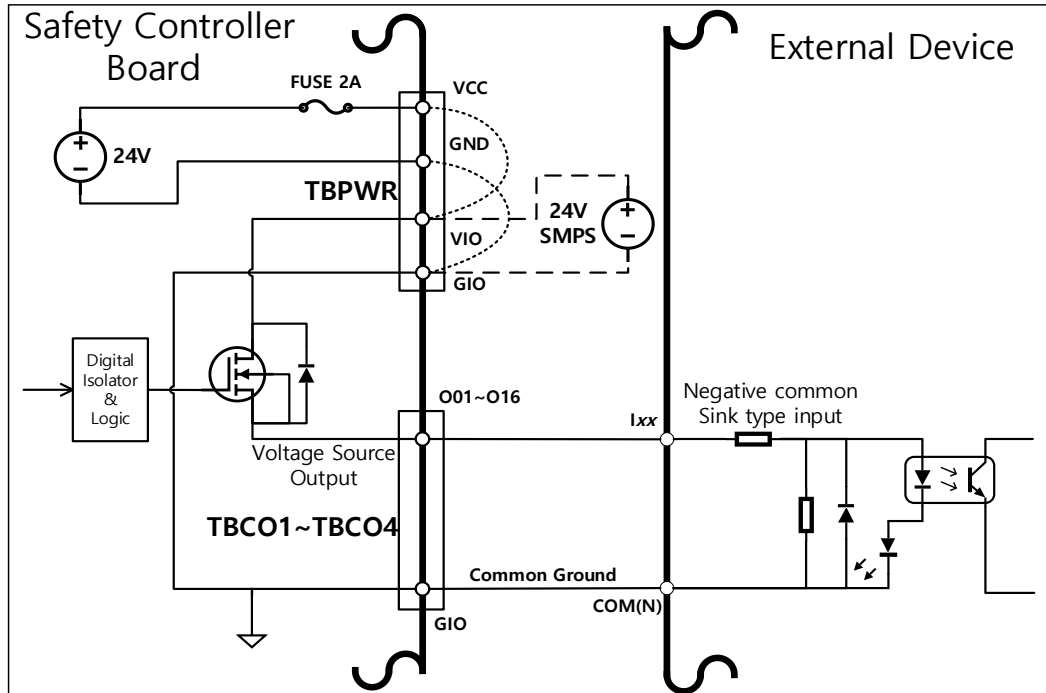
Each terminal is capable of outputting a maximum of 1A, but the overall current may be limited according to the calorific value and load.

If digital I/O power (VIO/GIO) is supplied through the internal power supply as in the factory default setting, up to 2A of VIO current can be used. If a total current greater than 2A is required, remove the connection between the digital I/O power supply (VIO/GIO) of the Terminal Block for Digital I/O Power (TBPWR) and the internal power supply (VCC/GND), and an external power supply must be connected.



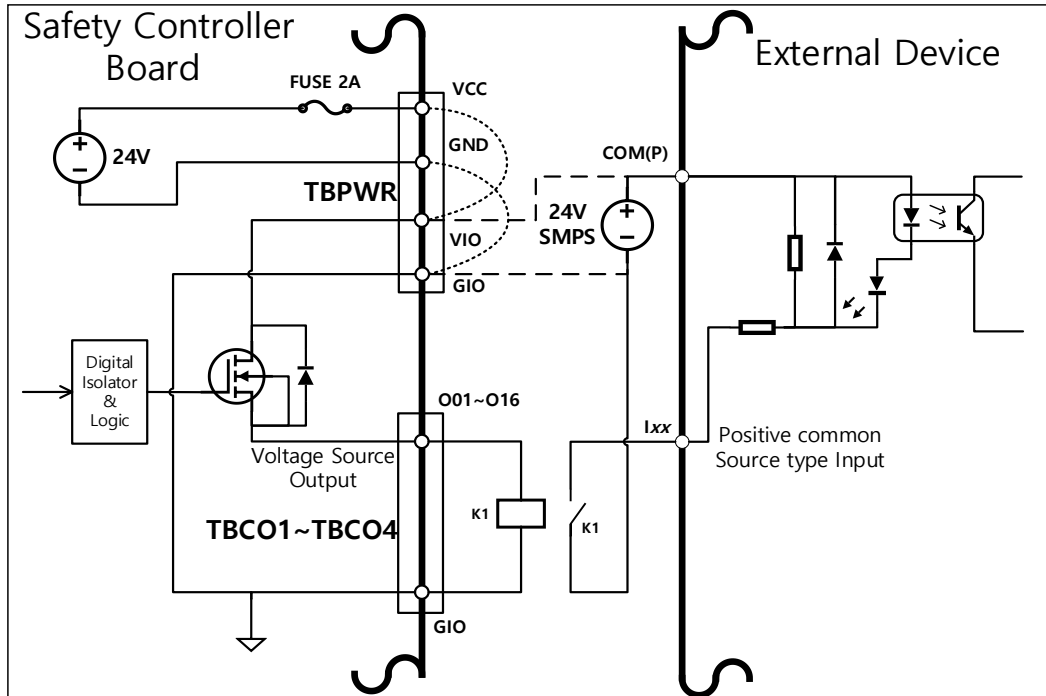
- If a negative common & sink type input device is connected

If digital I/O output is connected to a sink type input device, connect the Oxx terminals of TBCO1-TBCO4 terminal blocks to the input terminal of the external device, and connect the GIO to the negative common of the external device to establish a common ground.



- If a positive common & source type input device is connected

Connect a relay between the Oxx terminal of TBCO1-TBCO4 terminal blocks and GIO terminal to supply input signals as contacts to the external device. If necessary, an external power supply can be connected to the external device.



Caution

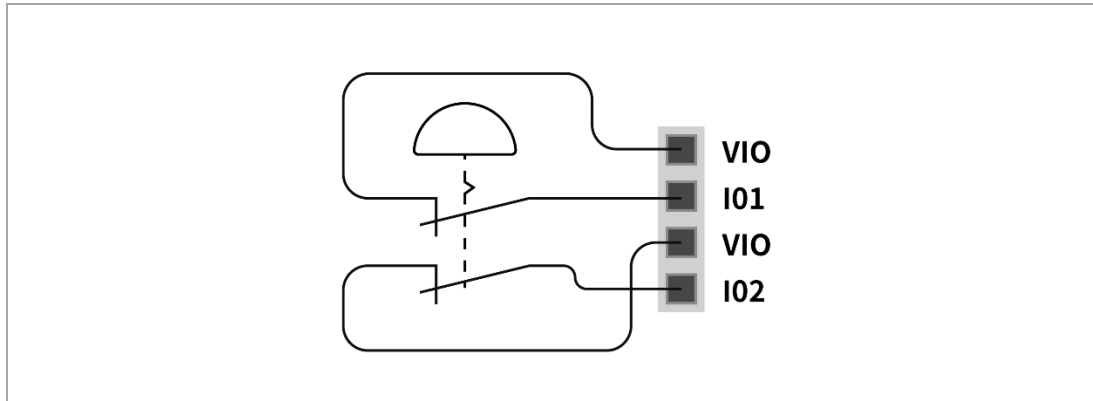
- General digital I/O devices can stop at any time due to a controller power shortage, self-diagnosis error detection and work program settings. Therefore, perform risk assessment before setting up a robot workcell, and if additional risks such as a workpiece falling, ignoring digital input or synchronization error due to incorrect recognition, make sure to implement additional safety measures.
- The general digital I/O is a single connection type I/O and any short circuits or breakdown can result in the loss of safety functions, so it cannot be used for safety purposes. If the connection of a safety device or safety-related I/O is required, make sure to set the corresponding terminal as a dual safety I/O on the teach pendant.

If the configurable digital I/O is used as safety I/O, two neighboring I/O terminals, such as O01 & O02, ... , O15 & O16, I01 & I02, ... I15 & I16, can use identical safety signals to form a dual safety I/O.

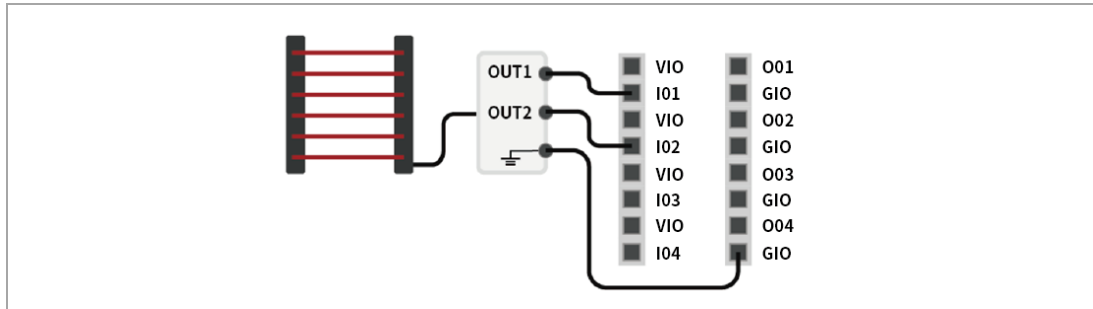
While the Safety Contact Output Terminal (TBSFT) can only be connected with dry contact type signals, input set as safety I/O can connect with both contact and voltage type signals. Output set as safety I/O outputs voltage signals, but it can also output contact type signals by adding an external relay.

The following is an example of connecting a safety device for operation.

- Connecting an emergency switch (contact signal) as a safety input terminal



- Connecting a light curtain (voltage signal) as a safety input terminal (common ground)



4.2.4 Setting Analog I/O Terminal (TBAIO)

The controller features two analog I/O terminals that can be set to voltage mode or current mode. It can output voltage/current through an external device operated using analog I/O or receive signals from sensors outputting analog voltage/current.

To ensure maximum input accuracy, observe the following:

- Use shielded or twisted pair cables.
- Connect the cable shield to the ground terminal inside the controller.
- Current signal is relatively less sensitive to interference, so use devices operating in current mode for analog I/O terminals. Current/voltage input mode can be set by the software.

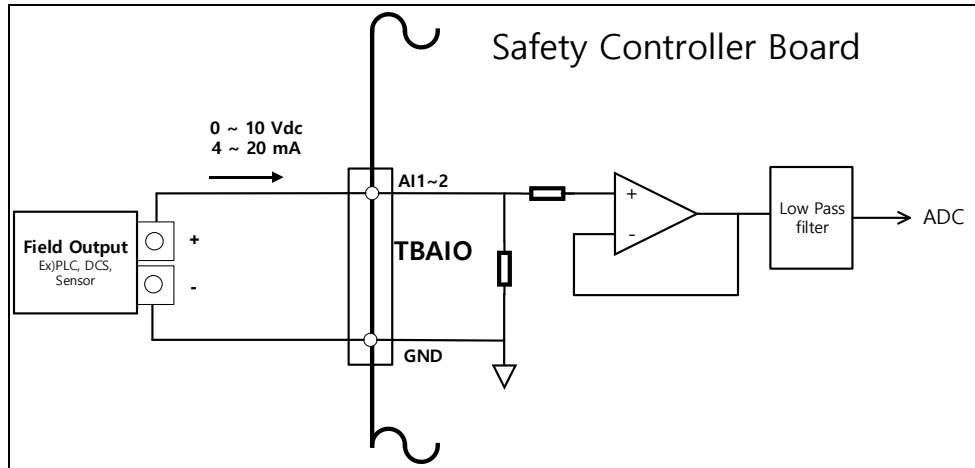
The electrical specifications of the analog I/O terminal are as follows:

Terminal		Parameter	Specifications
Current mode analog input	[AIx-GND]	Voltage	-
	[AIx-GND]	Current	4 - 20 mA
	[AIx-GND]	Resistance	250 ohm
	[AIx-GND]	Resolution	12 bit
Voltage mode analog input	[AIx-GND]	Voltage	0 - 10 V
	[AIx-GND]	Current	-
	[AIx-GND]	Resistance	1M ohm
	[AIx-GND]	Resolution	12 bit
Current mode analog output	[AOx-GND]	Voltage	-
	[AOx-GND]	Current	4 - 20 mA
	[AOx-GND]	Resistance	50M ohm
	[AOx-GND]	Resolution	16 bit
Voltage mode analog output	[AOx-GND]	Voltage	0 - 10 V
	[AOx-GND]	Current	-
	[AOx-GND]	Resistance	1 ohm
	[AOx-GND]	Resolution	16 bit

- Voltage/current input

It receives voltage or current signals from an external device between the AIx terminal of the TBAIO terminal block and GND terminal. If the output of the device is a voltage signal, it receives a signal of 0-10Vdc. If the output of the device is a current signal, it receives a signal of 4-20mA.

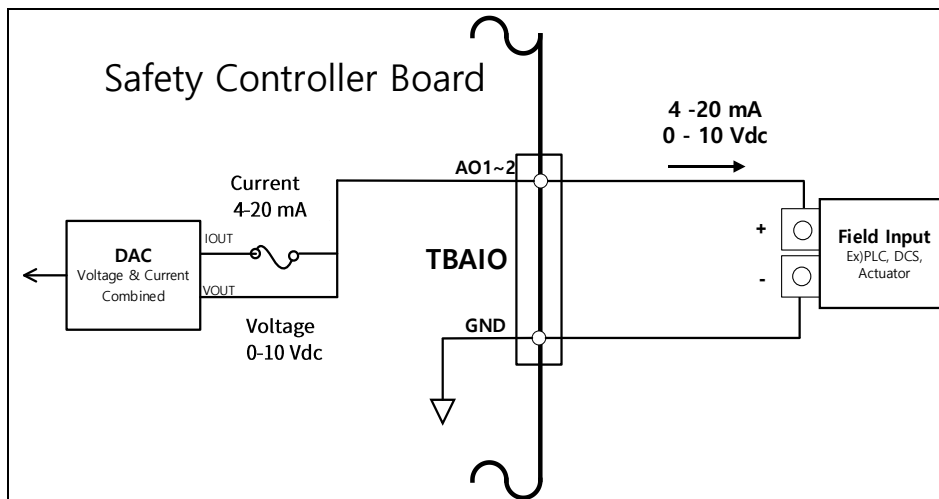
※ Depending on the output signal (voltage/current) of the device, it is necessary to set the controller analog input as “Voltage” or “Current” on the teach pendant.



- Voltage/current output

It supplies voltage or current signals to an external device between the AOx terminal of the TBAIO terminal block and GND terminal. If the input of the device is a voltage signal, it supplies a signal of 0-10Vdc. If the input of the device is a current signal, it supplies a signal of 4-20mA.

※ Depending on the input signal (voltage/current) of the device, it is necessary to set the controller analog output as “Voltage” or “Current” on the teach pendant.



4.2.5 Setting Encoder Input Terminal (TBEN1, TBEN2)

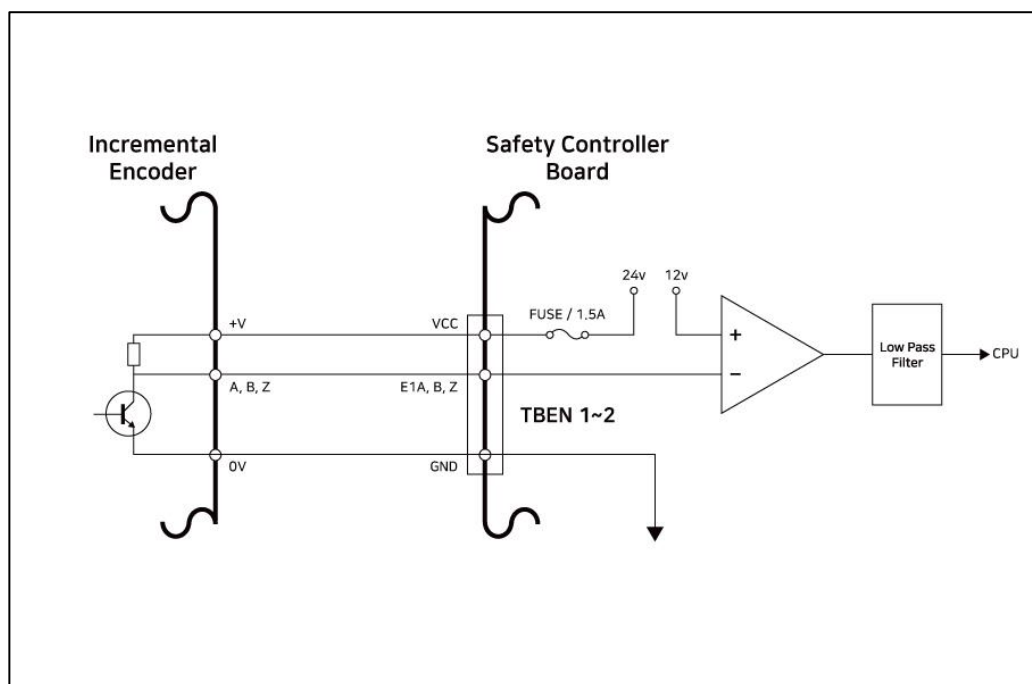
The controller has two TBEN terminals that allow the input of external encoders.

They support A, B and Z phases as inputs, and perform counts based on 12Vdc.

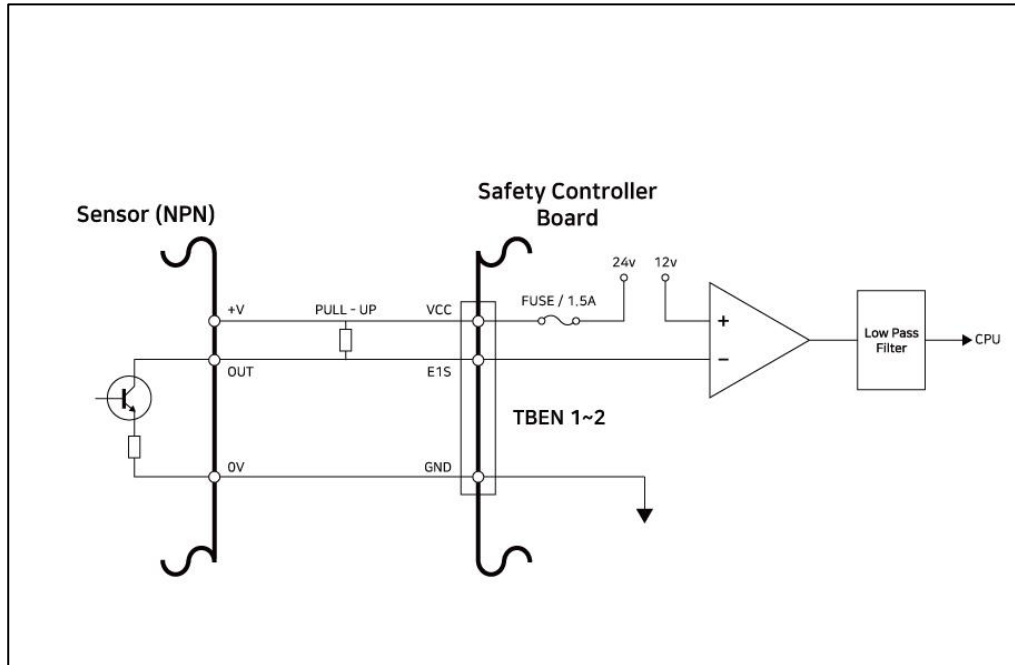
In addition, S phase can be used as the conveyor's Start sensor.

The figure below shows a sample encoder and sensor configuration, so refer to it while establishing connections.

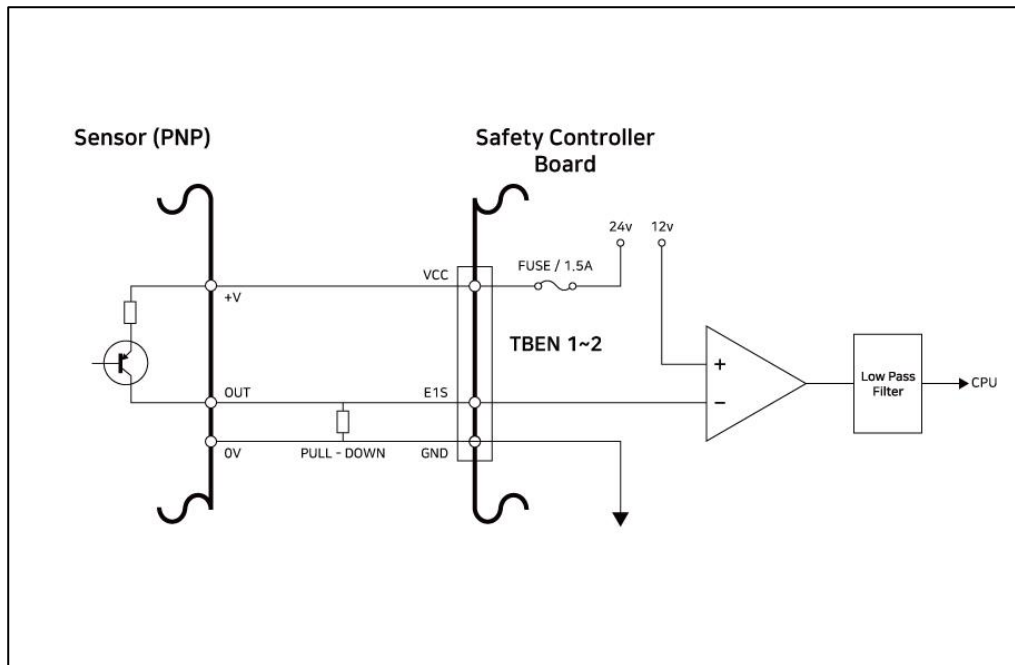
- To ensure maximum input accuracy, observe the following: Use shielded, twisted pair cables to reduce noise.
- Connect the cable shield to the ground terminal inside the controller.
- Connecting Incremental Encoder A, B, Z phase



- In the case of S phase inputs, connect a pull-up or pull-down resistance according to the sensor type to prevent floating.
- Connecting NPN Sensor



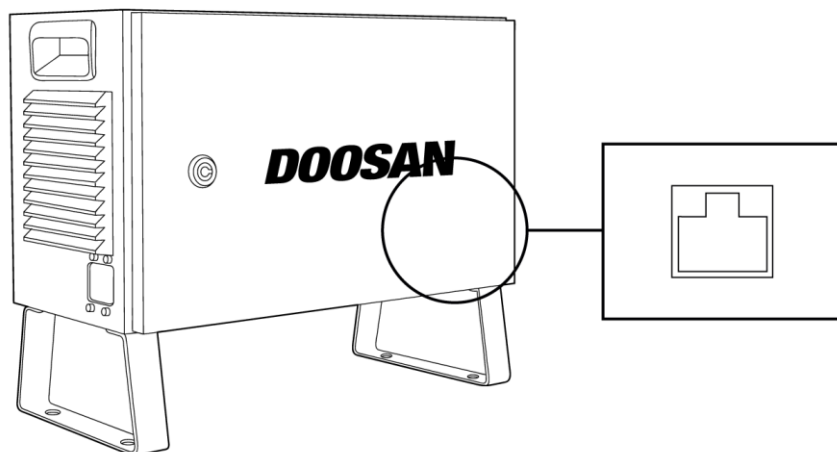
- Connecting PNP Sensor



4.3 Network Connection

Laptops, TCP/IP equipment, Modbus equipment and vision sensors can be connected to the network connector terminal inside the controller.

Connecting the cable to the network connection terminal will connect the network (refer to the figure below).



4.3.1 Connecting External Devices - Vision Sensor

The robot can be connected with a vision sensor (2D camera for object position measurement), and vision sensor measurements can be transferred to the robot through a network to link with commands of the robot.

• Vision Sensor Setting

■ Communication Connection Setting

Connect the LAN ports of the devices and apply TCP/IP communication to transfer vision sensor measurements to the robot. (Refer to LAN port connection 4.3 Network Connection) Set the IP address of the vision sensor to the TCP/IP 192.168.137.xxx band to allow TCP/IP communication.

■ Vision Work Setting

To perform object position measurement, it is necessary to have an image input and vision teaching of the target object using the vision sensor. Refer to the dedicated vision work setting program provided by the vision sensor manufacturer.

■ Measurement Data Format Setting

To use vision sensor measurement data in robot work, it is necessary to perform vision- robot coordinate calibration, and this must be performed using the vision sensor setting program before initiating work. The vision sensor measurement data must be transferred using the following format setting:

Format	pos	,	x	,	y	,	angle	,	var1	,	var2	,	...
--------	-----	---	---	---	---	---	-------	---	------	---	------	---	-----

- pos: Separator indicating the start of measurement data (prefix)
- x: X coordinate value of the object measured using vision sensor
- y: Y coordinate value of the object measured using vision sensor
- angle: Rotation angle value of the object measured using vision sensor
- var1...varN: Information measured using vision sensor (e.g., object dimension / defect check value)

Example) pos,254.5,-38.1,45.3,1,50.1 (description: x=254.5, y=-38.1, angle=145.3, var1=1, var2=50.1)

• Robot Program Setting

Once the physical communication connection between the vision sensor and robot is completed and the vision sensor itself is set up, a program must be set up to allow the vision sensor and robot program to be linked. The Doosan Robot Language (DRL) enables the connection, communication and control of the external vision sensor, and it is possible to set up the program in Task Writer.

Details and comprehensive examples of Doosan Robot Language (DRL) external vision sensor functions are provided in the programming manual.

4.3.2 Connecting External Device – DART Platform

The DART Platform is software that runs on a Windows OS base desktop or laptop. Once you execute the DART Platform after connecting the controller and desktop/laptop through the LAN Port, all functions of the teach pendant can be used without a teach pendant. To establish a connection with sub-controllers within the controller, the following setup procedure is required.

- **IP Address Search and Connection Setting**

- **Communication Connection Setting**

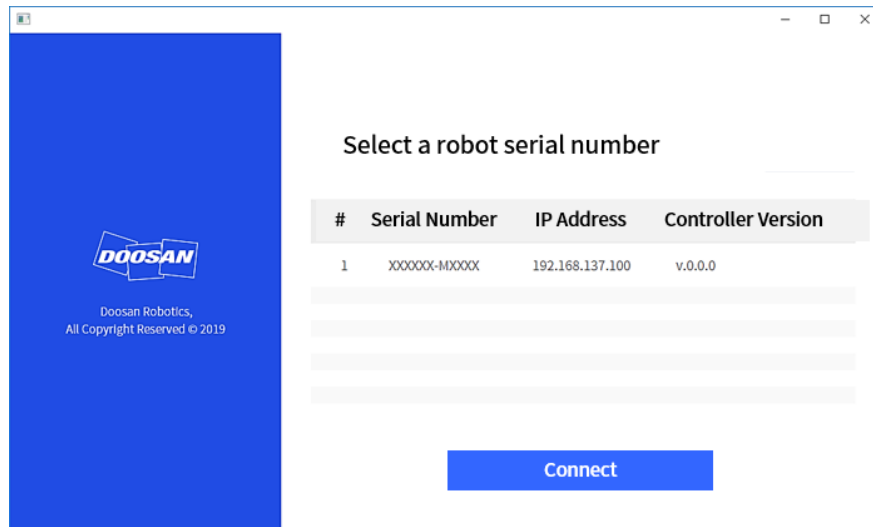
When a laptop is connected to the LAN port of the controller and the DART Platform is executed, the controller IP address, sub-controller version information and robot serial number required for establishing a connection are automatically searched.

Selecting the serial number of the robot to connect will connect the DART Platform and a sub-controller, allowing the robot to be operated normally.

If there is an issue with the connection, implement the process below. If the issue is not resolved, contact the sales or service staff for assistance.

1. If the connectible controller IP address, sub-controller version information and robot serial number search results are not displayed: Press the refresh button to search again and try to connect again according to the procedure above.
2. If information is not found even after pressing the refresh button, press and hold the F3 and F4 key of the smart pendant* simultaneously for more than 3 seconds to reset to the default IP address and try to connect again according to the procedure above.

* Purchased separately as an option



4.3.3 ModbusTCP Slave Setup

The ModbusTCP Slave function of Doosan Robotics supports robot parameter monitoring, General Purpose Register (GPR) (refer to **4.3.7 Using General Purpose Register (GPR)**) function. This function starts automatically when the robot controller boots up normally. Therefore, the user can use it after matching the Master IP of the robot controller with the same bandwidth.

 **Note**

- The related I/O Table is provided as a separate file.
- Please refer to the Programming Manual for DRL to use the GPR function.

4.3.4 Expanded Protocol - PROFINET IO Device (PNIO device) Setup

The robot controllers of Doosan Robotics support the PROFINET IO Device (Slave) function, which allows data modification after reading the Parameters of the robot from an external device (PROFINET IO Controller/Master). (e.g., Robot parameter monitoring, General Purpose Register (Bit, Int, Float) – refer to **4.3.7 Using General Purpose Register (GPR)**). For more information about PROFINET refer to www.profinet.com.

4.3.5 Expanded Protocol - EtherNet/IP Adapter (EIP adapter) Setup

The robot controllers of Doosan Robotics support the EtherNet/IP Adapter (Slave) function, which allows data modification after reading the Parameters of the robot from an external device (EtherNet/IP Scanner / Master). (e.g., Robot parameter monitoring, General Purpose Register (Bit, Int, Float) – refer to **4.3.7 Using General Purpose Register (GPR)**). For more information about EtherNet/IP, refer to www.odva.org.

4.3.6 Using Expanded Protocol

The PROFINET IO Device (PNIO device) and EtherNet/IP Adapter (EIP adapter) functions start together at controller startup, and are in connection standby state with the Master device. Therefore, in order to use the function, it is necessary to connect and set up the Master. Each Master device has different characteristics, so it is necessary to check them out.

 **Note**

The following are descriptions of implementation characteristics of general functions for Industrial Ethernet.

- The Industrial Ethernet function of Doosan Robotics controllers does not use a separate ASIC, but implements its function based on TCP/IP, so it does not support real-time performance.
- Data output to external devices has identical markings (PNIO, EIP), but data input to the robot only has identical structures and does not link. Therefore, data output from the PNIO controller does not synchronize with output data from the EIP scanner.
- For the I/O table of PNIO and EIP, please refer to a separate document (or attachment).

4.3.7 Using General Purpose Register (GPR)

The GPR function is the memory of the PNIO device and the EIP adapter predefined by the user for use. It allows the exchange of user data between external devices and the robot.

 **Note**

The GPR function is only provided through DRL, and the DRLs used are as follows: For more information about DRL, please refer to the Programming Manual.

- `set_output_register_bit(address, val)`
- `set_output_register_int(address, val)`
- `set_output_register_float(address, val)`
- `get_output_register_bit(address)`
- `get_output_register_int(address)`
- `get_output_register_float(address)`
- `get_input_register_bit(address)`
- `get_input_register_int(address)`
- `get_input_register_float(address)`

5. Robot Mode and State

The operation modes of the robot consist of Manual Mode, where the user controls the robot directly, and Automatic mode, where the robot operates without direct user control.

5.1 Manual Mode

This is the mode in which the robot operates according to direct user control. The robot only operates when a button related to an action is pressed, and releasing the button results in stopping the corresponding action.

- In Manual Mode, the TCP movement speed is limited to less than 250 mm/s according to the Robot Safety Regulations. However, during Handguiding, the TCP speed and joint speed are limited to less than the thresholds of Reduced status set in **WCM > Robot > Robot Limits**
- If risk assessment results indicate that a 3-position Enable Switch is necessary, the 3-position Enable Switch can be connected through the I/O by the setting in the **WCM > Robot > Safety I/O**. In this case, the Enable Switch must be placed in the center-enable position to allow robot operation in Manual Mode and Servo On.

In Manual Mode, it is possible to configure robot peripherals in the Workcell Manager or to program robot tasks in Task Builder and Task Writer, and if the robot cannot be operated normally for reasons such as the robot exceeding the safety threshold, the Recovery function can be performed to restore normal operation.

5.2 Automatic Mode

This is the mode in which the robot operates without direct user control. The robot will execute the programmed task or predefined sequence with a simple operation command and without additional user input.

Task Builder or **Task Writer** can verify the programmed task in virtual mode, execute it in actual operation, and perform robot tool weight and auto weight center measurement functions.

- If risk assessment results indicate that a 3-position Enable Switch is necessary, the 3-position Enable Switch can be connected through the I/O by the setting in the **WCM > Robot > Safety I/O**. In this case, the Enable Switch must be placed in the center-enable position to allow Play or Start, Resume and Servo On in Automatic Mode.

5.3 Other Mode

Unlike normal modes such as manual mode and automatic mode, this is exceptional mode.

This mode includes special states such as controller booting, initializing and states related to Backdrive at which you can push robot by hand without drive power..

5.4 State and Flange LED Color for Each Mode

Mode	State	Description	Flange and/or Base LED
Manual	Manual Standby	<ul style="list-style-type: none"> This is the default status of teaching. Workcell Manager, Task Builder and Task Writer can be used to configure the work condition or perform task programming. It monitors the stop status with Safe Operating Stop (SOS). 	Blue
	Manual Jogging	<ul style="list-style-type: none"> The jog function is used to operate the robot. 	Blue Blinking
	Manual Handguiding	<ul style="list-style-type: none"> The robot can be operated directly by hand during teaching. 	Cyan Blinking
	Recovery Standby	<ul style="list-style-type: none"> Recovery in progress. All safety monitoring functions except for axis and TCP speed monitoring are disabled during recovery. It monitors the stop status with Safe Operating Stop (SOS). 	Yellow Blinking
	Recovery Jogging	<ul style="list-style-type: none"> The jogs of each axis can be used to correct the exceeded safety threshold. 	Yellow Blinking
	Recovery Handguiding	<ul style="list-style-type: none"> The robot can be moved directly by hand to correct the exceeded safety threshold. 	Yellow Blinking
	Safety Stop	<ul style="list-style-type: none"> The system stopped due to protective stop or exceeding the safety threshold. It monitors the stop status with Safe Operating Stop (SOS). 	Yellow

Mode	State	Description	Flange and/or Base LED
Auto	Auto Standby	<ul style="list-style-type: none"> The Teach Pendant UI is in the actual mode execution screen in a single workspace. Pressing the "Execute" button will execute the task program. White is displayed for a Standalone Zone, green is displayed for a Collaborative Zone.. 	White/Green
	Auto Running	<ul style="list-style-type: none"> The task program is being executed. White is displayed for a Standalone Zone, green is displayed for a Collaborative Zone., and white and yellow are displayed by turns for a High Priority Zone 	White Blinking / Green Blinking / White and yellow Flashing alternately
	HGC (HandGuide Control) Standby	<ul style="list-style-type: none"> The Handguiding command is executed during task program execution. The system waits until the user presses the "Handguiding" button. It monitors the stop status with Safe Operating Stop (SOS). 	Cyan
	HGC Running	<ul style="list-style-type: none"> The robot pose can be changed by pressing the "Handguiding" button. After the robot stops, enter HGC End & Resume signal through the Safety IO to set Auto Running and then 	Cyan Blinking

Mode	State	Description	Flange and/or Base LED
		continue executing the task program.	
	Auto-measure	<ul style="list-style-type: none"> The weight and center of gravity point of the end effector are measured automatically. Please note that the safety monitoring functions of the robot are disabled during auto-measuring. 	Yellow Blinking
	Safety Stop	<ul style="list-style-type: none"> The system stopped due to protective stop or exceeding the safety threshold. It monitors the stop status with Safe Operating Stop (SOS). 	Yellow
	Servo Off	<ul style="list-style-type: none"> The servo is off due to protective stop, emergency stop or exceeded safety threshold. It is identical to Safe Torque Off (STO). 	Red (M/H-Series) LED Off (A-Series)

Mode	State	Description	Flange and/or Base LED
	Backdrive Hold	<ul style="list-style-type: none"> All brakes of 6 joints are engaged, and Backdrive motion is locked. 	Yellow Blinking
	Backdrive Release	<ul style="list-style-type: none"> Break of one or more joint(s) is released due to the selection of brake release. The brake(s) will not lock by itself. Use caution as the robot and/or end-effector may fall unless all brakes are engaged again. 	Yellow Blinking
	Backdrive Servo Off	<ul style="list-style-type: none"> The servo is off due to emergency stop or exceeded joint speed threshold during Backdrive Motion. It is identical to Safe Torque Off (STO). 	Red (M/H-Series) LED Off (A-Series)
	Initializing	<ul style="list-style-type: none"> The controller is booting and the robot is initialized. 	Red Blinking

6. Safety Functions

6.1 Introduction

Robot's from Doosan Robotics use various safety-rated monitoring and safety-related electrical interfaces to protect users and devices, and it allows the integration of other devices and additional protection devices. The performance of each safety-rated monitoring function and interface satisfies Category 3, Performance Level d(PL d) defined by ISO 13849-1 and Hardware Fault Tolerance 1, Safety Integrity Level 2 (SIL 2) defined by IEC 62061.

Note

- Work cells must be set using the safety functions and interface according to the risk assessment performed on the corresponding robot application by the system integrator, and refer to this manual for information required for this.
- If the safety systems of the robot detect system defects such as hardware defects including emergency stop circuit shortage, position sensor damage or control communication error, stop category 0 is immediately initiated. Meanwhile, if the safety systems of the robot detect violations during safety monitoring such as pressing the emergency stop switch, protective stop signal input, detection of external impact, or physical parameters (robot position, speed, momentum) exceeding set parameters, the system stops the robot using the mode set as the stop mode setting in the safety setting menu. (select one from stop category 0, 1, 2)
- In special cases (collision detection, TCP Force Violation), a special mode that stops the robot after accepting the external force for 0.25 seconds after event occurrence can be used to avoid clamping situations where limbs are jammed between the fixated jig/workpiece and the robot. (RS1 stop mode)
- For information on the time and stopping distance until the robot comes to a full stop from the moment the above error or violation occurs, refer to **Annex C Stop Distance and Stop Time**. This time must be considered as part of the risk assessment performed by the system integrator.
- The safety setting menu can set various safety functions to limit the movement of joints, robot and TCP. Here, TCP means the location of the output flange center point added by the TCP offset.

6.2 Safety-Rated Stop Function

This is the stop function and stop monitoring function of Doosan Robotics, and it uses the safety function defined in IEC 61800-5-2.

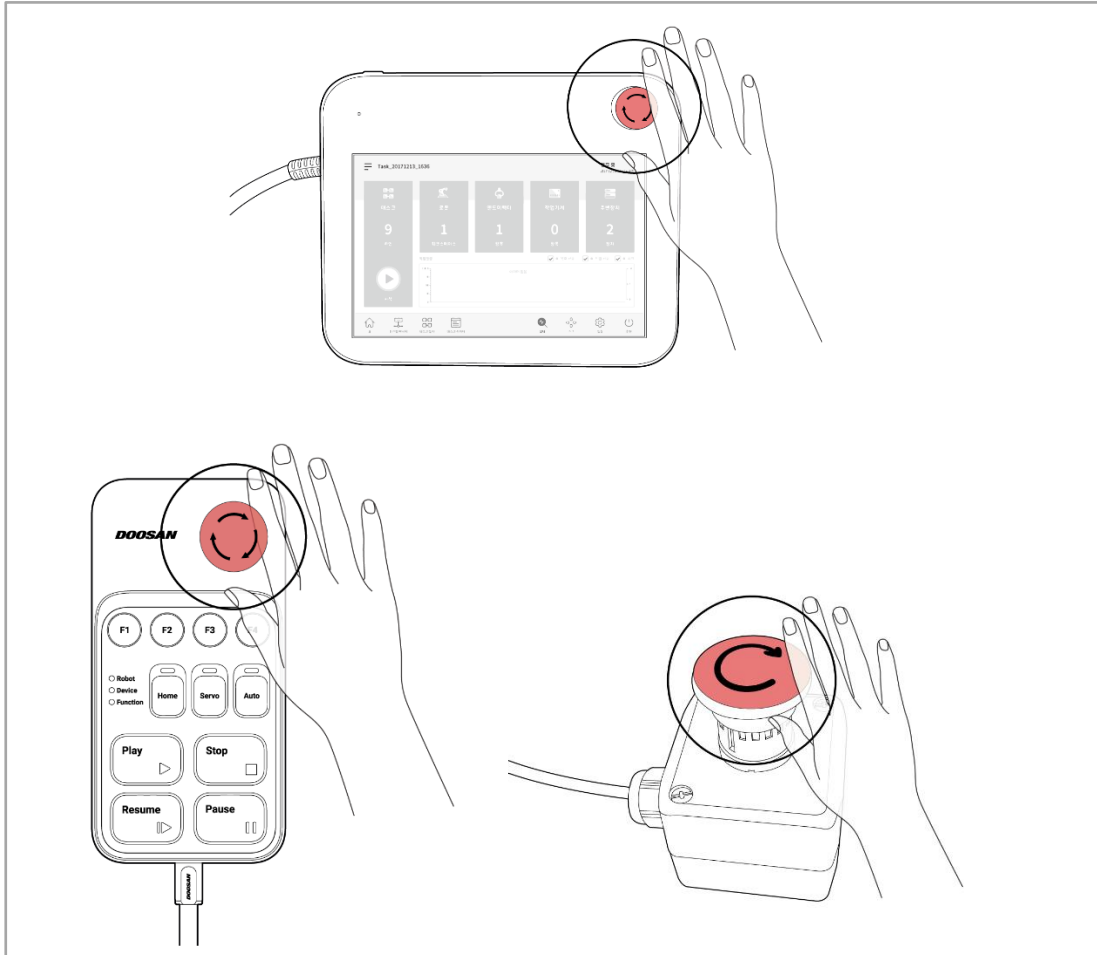
Safety Function Name	Function Description and Failure Detection	PFHd	PL, SIL
STO (Safe Torque Off)	Immediately cuts off the power supply to all joint module motors, and brake engagement forces the operation to stop. (Servo Off)	2.64E-8 /h	PL e Cat. 4 SIL 3
SS1 (Safe Stop 1)	All joints are stopped with the maximum deceleration possible, the power supply to the motor is cut off, and the brake is engaged to stop. (Servo Off) If deceleration is not sufficient during stopping, the method is set to STO stop.	3.90E-7 /h	PL d Cat. 3 SIL 2
SS2 (Safe Stop 2)	All joints are stopped with the maximum deceleration possible, and the SOS stop monitoring function is set. If deceleration is not sufficient during stopping, the method is set to STO stop.	3.90E-7 /h	PL d Cat. 3 SIL 2
SOS (Safe Operating Stop)	The current position is maintained with power supplied to the motor and the brake disengaged (Servo ON). If abnormal position change is detected, STO is set.	3.90E-7 /h	PL d Cat. 3 SIL 2

Safety Function Name	Stop Triggering Event	Stop Mode	PFHd	PL, SIL
Emergency Stop	If the Emergency Stop switch of the teach pendant is pressed If the Emergency Stop switch connected to the TBSFT EM terminal is pressed	STO or SS1	2.6E-8 /h	PL e Cat. 4 SIL 3
Protective Stop	If the protective device connected to the TBSFT PR terminal is activated	STO, SS1 or SS2	3.90E-7 /h	PL d Cat. 3 SIL 2

6.2.1 Emergency Stop Function

The user can make use of the emergency stop button to stop the system in emergency situations.

In emergency situations, press the Emergency Stop button or the Emergency Stop located on the top right of the teach pendant or smart pendant to immediately stop the system.



Note

- SS1 stop mode is set as the default setting of the emergency stop button.
- Turning the emergency stop button clockwise can release emergency stop function engagement.
- If additional Emergency Stop buttons are needed, a button can be added to the controller after a risk assessment.
- Emergency stop must not be used as a risk reduction method, but as a secondary protection device.
- If additional emergency stop buttons need to be connected, this must be determined with a robot application risk assessment. The Emergency Stop button must comply with IEC 60947-5-5.

6.2.2 Protective Stop

The robot features a protective stop function to stop the robot according to signals sent by protective devices.

For information about the protective device connection, refer to sections **4.2.1 Setting the Terminal Block for Contact Input (TBSFT)** and **4.2.3 Setting the Configurable Digital I/O (TBC11 - 4, TBCO1 - 4)**.

6.3 Safety-Rated Monitoring Function

Doosan robot's feature various safety-rated monitoring functions that can be used as a risk reduction measure through risk assessment. The threshold of each monitoring function that triggers stop can be configured in the WCM>Robot>Robot Limit of the teach pendant UI.

- Joint Position Monitoring (SLP): Limits the maximum rotation angle of a joint
- Joint Speed Monitoring (SLS): Limits the maximum rotation speed of a joint
- TCP Position/Direction Monitoring: Limits and monitors TCP position/direction in an orthogonal space, Operating Space, Standalone Workspace, Collaborative Workspace, Protected Zone, Tool orientation limit zone, collision detection mute zone
- TCP Speed Monitoring: Limits the maximum TCP movement speed of TCP
- TCP External Force Monitoring: Limits the external force applied to TCP
- Collision Detection: Limits the external torque applied to the manipulator arm and each joint
- Momentum Monitoring: Limits the maximum momentum of the manipulator arm
- Mechanical Power Monitoring: Limits the maximum power applied to the manipulator arm.

Note

- The safety threshold used for each monitoring function can be configured in the WCM>Robot>Robot Limit of the teach pendant UI.
- Safety limits is the condition where the safety-rated monitoring function triggers the stop function. When stop is completed, the position of the robot and force applied externally may differ from the configured safety threshold.

Safety Function Name	Stop Triggering Event	Stop Mode	PFHd	PL, SIL
Joint Position Limit (SLP)	If the angle of each axis exceeds the configured threshold	STO, SS1 or SS2	3.90E-7 /h	PL d Cat. 3 SIL 2
Joint Speed Limit (SLS)	If the speed of each axis exceeds the configured threshold	STO, SS1 or SS2	3.90E-7 /h	PL d Cat. 3 SIL 2
Joint Torque Limit (SLT)	If the torque applied to each axis exceeds the predefined threshold	STO	3.92E-7 /h	PL d Cat. 3 SIL 2
Collision Detection	If the external applied to each axis exceeds the thresholds for the configured sensitivity	STO, SS1 or SS2	3.92E-7 /h	PL d Cat. 3 SIL 2
TCP/Robot Position Limit	If the TCP/Robot leaves the operating space If the TCP enters the protected space	STO, SS1 or SS2	3.90E-7 /h	PL d Cat. 3 SIL 2
TCP Orientation Limit	If the difference between the set direction within the Tool Orientation Limit Zone and the TCP orientation deviation exceeds the configured threshold	STO, SS1 or SS2	3.90E-7 /h	PL d Cat. 3 SIL 2
TCP Speed Limit	If the TCP speed exceeds the configured threshold	STO, SS1 or SS2	3.90E-7 /h	PL d Cat. 3 SIL 2
TCP Force Limit	If the external force applied to the TCP exceeds the configured threshold	STO, SS1 or SS2	3.92E-7 /h	PL d Cat. 3 SIL 2

Safety Function Name	Stop Triggering Event	Stop Mode	PFHd	PL, SIL
Robot Momentum Limit	If the momentum of the robot exceeds the configured threshold	STO, SS1 or SS2	3.90E-7 /h	PL d Cat. 3 SIL 2
Robot Power Limit	If the mechanical power of the robot exceeds the configured threshold	STO, SS1 or SS2	3.90E-7 /h	PL d Cat. 3 SIL 2

6.4 Safety-Rated I/O

The robot's of Doosan Robotics feature a safety-rated input interface capable of connecting protective stop signals from safety protective devices, external emergency stop signal input and 3-position Enable Switch. They also feature a safety-rated output interface capable of outputting internal status and area information.

Safety Function Name	Function description and Failure detection	PFHd	PL, SIL
Safety IO	The redundant interface for I/O of safety-rated signals. The system stops the robot and displays error messages if a mismatch is detected between the redundant input signals or if the feedback on the redundant output signals detects a mismatch.	2.50E-8 /h	PL d Cat. 3 SIL 2

7. Transportation

7.1 Cautions during Transportation



Caution

- If the robot is transported by packaging it with packaging materials, store the robot in a dry location. If the robot is stored in a location with high humidity, condensation may occur, resulting in robot defects.
- When relocating the robot, have two or more individuals hold the link area of the robot.
- The controller is moved by grasping the side handle.
- When transporting the robot or controller, make sure to maintain the proper posture. Failure to do so may result in back injury or other physical injuries.
- When transporting the robot using lifting equipment, make sure to observe all related national and regional regulations.
- Doosan Robotics does not assume responsibility for any damages or losses that occur during transportation, so make sure to transport the robot safely according to the user manual.

7.2 Pose for Robot Transportation

Set the following poses to transport the robot:

Model	J1	J2	J3	J4	J5	J6
A0509(S)	-180°	0°	150°	0°	25°	0°
A0912(S)	-180°	0°	160°	0°	20°	0°

7.3 Package Specifications

The box specifications for transport are as follows:

Model	Length	Width	Height
A0509(S)	755 mm	450 mm	545 mm
A0912(S)	986 mm	452 mm	545 mm

8. Maintenance

System maintenance must be performed by Doosan Robotics or a company designated by Doosan Robotics. Maintenance covers maintaining system operability and recovering system operability in the event of an issue, and it includes repair work and system diagnosis of potential issues.

When maintenance work is completed, risk assessment must be performed to confirm whether the system satisfies required safety levels. Corresponding national and regional regulations must be observed during inspection, and all possibilities related to safety must be tested.

When performing work on the manipulator arm or controller, the following safety procedures and warnings must be observed.

- Maintain the safety settings of the software during maintenance work.
- If a defect in a particular part occurs, replace the part with a new identical part or part approved by Doosan Robotics.
- The replaced part must be returned to Doosan Robotics.
- After completing work, resume the safety function.
- Document the repair history of the robot system and manage related technical documents.
- Disconnect the power cable and make sure other power sources connected to the manipulator or controller do not supply power.
- Do not connect the system to a power source during maintenance.
- Check the ground connection before supplying power to the system.
- Observe ESD regulations when disassembling manipulator arm or controller parts.
- Do not disassemble areas that supply power from within the controller. Power supply areas may still be charged with high voltage (up to 600V) even after the controller is turned off.
- Use caution to prevent water or dust from entering the system during maintenance.

9. Disposal and Environment

Since this system contains industrial waste materials, improper disposal can cause environmental pollution. Therefore, do not dispose of the system along with general industrial or home waste.

When disposing of all or part of the system, the relevant laws and legislation must be complied with, and contact Doosan Robotics for detailed information related to the disposal of the system.

10. Product Warranty and Responsibility

Doosan Robotics (hereinafter referred to as “Doosan” or “Manufacturer”) offers a restricted warranty as stipulated in this warranty certificate for all robot systems (collectively “robot”) and parts of the system (excluding parts that are exceptions or restricted according to the terms and conditions below) sold through Doosan or official sales agents. The warranty stipulated by this warranty certificate is a restricted warranty, and it is the only warranty provided by the Manufacturer. All warranty items shall be handled according to the conditions listed below.

10.1 Scope of Warranty

Material and manufacturing defects of each robot and its parts (collectively, “Doosan Products”) are subject to the warranty provided by the Manufacturer. This warranty is only offered to the end user (hereinafter referred to as “Customer”). The warranty period is 1 year starting from the date the robot was installed.

The only responsibility the Manufacturer offers and the only measure the Customer can receive in terms of Doosan Products within the scope of this warranty is restricted to repairing or replacing Doosan Products with defects.

Doosan does not compensate any or all financial, operation or productions losses, any or all indirect losses such as damage to other equipment, and any or all deliberate, special or consequential losses that occur due to defects of Doosan Products.

10.2 Restrictions and Exceptions of Warranty

To maintain the warranty, thorough maintenance procedures stipulated by the Manufacturer must be observed and recorded. This warranty is void if the Manufacturer determines the following due to the user's failure to observe the stipulated procedures.

- If a Doosan Product is inappropriately handled or used by the user
- If parts or S/W not provided by Doosan are installed
- If a Doosan Product is incorrectly repaired or maintained by an unofficial repair technician or unauthorized individuals
- If the user has modified a Doosan Product without prior approval from the Manufacturer
- If a Doosan Product is used for non-industrial or personal purposes
- If the life cycle of consumables has ended
- If the warranty claim is made after the warranty period
- If the breakdown is caused by natural disasters (fire, flood, abnormal power, etc.)

This warranty does not apply to damages caused by external circumstances the Manufacturer does not have any control over such as theft, intentional destruction, fire, natural disasters, war or acts of terrorism.

Notwithstanding the exceptions or restrictions in this warranty, this warranty does not include any warranty that Doosan Product satisfies the buyer's production standards or miscellaneous requirements, or operates without any errors or without any interruption. The Manufacturer does not assume responsibility for any uses by the buyer, and the Manufacturer does not assume any responsibility for defects other than repair or replacement, such as defects in design, production, operation and performance.

10.3 Transfer

This warranty is included in the warranty period, and if a Doosan robot is sold to a different individual through a private transaction, the warranty can also be transferred. However, the warranty is only valid if the Manufacturer is notified of such a transaction, and the warranty period is still in effect. The assignee of this warranty must observe all conditions stipulated in this warranty.

11. Indemnification

Doosan Robotics continues to upgrade its product reliability and performance, and has the right to upgrade the product without notification. Doosan Robotics endeavors to ensure that all contents in this manual are accurate. However, it does not assume responsibility for errors or missing information.

Annex A System Specifications

A.1 Manipulator

A.1.1 A0509(S)

Classification	Item	Specifications
Performance	Axis Structure	6
	Payload	5 kg
	Max. Radius	A0509 : 900 mm / A0509S : 903 mm
	TCP Speed	Over 1m/s
	Repeatability	± 0.03mm
Joint Movement	J1 Range / Speed	±360° / 180°/s
	J2 Range / Speed	±360° / 180°/s
	J3 Range / Speed	±160° / 180°/s
	J4 Range / Speed	±360° / 360°/s
	J5 Range / Speed	±360° / 360°/s
	J6 Range / Speed	±360° / 360°/s
Operating Environment	Operating Temperature	-5 °C ~ 45 °C (268K-318K)
	Storage Temperature	-5 °C ~ 50 °C (268K-323K)
	Humidity	90% RH (non-condensing)
Tool Flange & Connector	Digital I/O - X1	IN-2ch / Out-2ch
	Power Supply	DC 24V / Max. 3A
	RS 485	Support
	(-) Connector	1414229 (PHOENIX)
Cable		Teach Pendant-Controller (4.5m) / Controller_ Robot (6.0m) / Smart Pendant (6.0m)
Weight		21 kg
Mounting		Floor, Ceiling, Wall, Any
IP Rating		IP 54
Noise		< 65 dB

A.1.2 A0912(S)

Classification	Item	Specifications
Performance	Axis Structure	6
	Payload	9 kg
	Max. Radius	A0912 : 1200 mm / A0912S : 1203 mm
	TCP Speed	Over 1m/s
	Repeatability	± 0.05mm
Joint Movement	J1 Range / Speed	±360° / 180°/s
	J2 Range / Speed	±360° / 180°/s
	J3 Range / Speed	±160° / 180°/s
	J4 Range / Speed	±360° / 360°/s
	J5 Range / Speed	±360° / 360°/s
	J6 Range / Speed	±360° / 360°/s
Operating Environment	Operating Temperature	-5 °C ~ 45 °C (273K-318K)
	Storage Temperature	-5 °C ~ 50 °C (268K-323K)
	Humidity	90% RH (non-condensing)
Tool Flange & Connector	Digital I/O - X1	IN-2ch / Out-2ch
	Power Supply	DC 24V / Max. 3A
	RS 485	Support
	(-) Connector	1414229 (PHONIX)
Cable		Teach pendant (4.5 m) / Robot (6.0 m) Smart pendant (6.0 m) / Emergency stop button (6.0 m)
Weight		31 kg
Mounting		Floor, Ceiling, Wall, Any
IP Rating		IP 54
Noise		< 65 dB

A.2 Controller

A.2.1 CS-01 (AC Controller)

Item	Specifications
Weight	13 kg
Dimensions	450x210x265 mm + Stand 100mm
Protection Rating	IP 40
Interfaces	Ethernet / USB / RS-232
I/O Port – Digital I/O	16/16
I/O Port – Analog I/O	2/2
I/O power supply	DC24V
Industrial Network	ModbusTCP Master/Slave, ModbusRTU Master, PROFINET IO Device, EtherNet/IP Adapter
Rated supply voltage	100-240VAC 47-63 Hz

A.3 Emergency Stop Button

A.3.1 CS-01

Item	Specifications
Weight	0.2 kg
Dimensions	68 x 91.5 x 68 mm
Protection Rating	IP 65

A.4 Smart Pendant (Option)

A.4.1 CS-01

Item	Specifications
Weight	0.3 kg
Dimensions	180 x 90 x 26.5 mm
Protection Rating	IP 40
Cable Length	6 m

A.5 Teach Pendant (Option)

A.5.1 TP-01

Item	Specifications
Weight	0.8 kg
Dimensions	264 x 218 x 42 mm
Protection Rating	IP 30
Screen Size	10.1 inches i
Cable Length	4.5 m

A.6 FTS (A0509S, A0912S only)

Item	Specifications	
Load Capacity	Fx	110 N
	Fy	110 N
	Fz	110 N
	Tx	11 Nm
	Ty	11 Nm
	Tz	11 Nm
Overload Capacity 150%L.C.(Load Capacity)	Fx	165 N
	Fy	165 N
	Fz	165 N
	Tx	16.5 Nm
	Ty	16.5 Nm
	Tz	16.5 Nm
Data Rate	1000 Hz	
Operating Temperature	0 - 45 °C (273K-318K)	

 **Caution**

- Make sure to use Quick Guide provided by Doosan Robotics as a reference.

A.7 DART Platform Installation Requirement (minimum, recommended)

The minimum installation requirements for the DART Platform are as follows:


- OS: Windows 7 Enterprise Service pack1 (64 bit) or higher
- CPU: 2.20 GHz or higher
- GPU: GMA 4500 and GMA HD (Intel) or equivalent specification
- Memory: 4 GB
- Java SDK: jdk1.8.0_152 (64 bit)

The recommended installation requirements for the DART Platform are as follows:

- OS: Windows 10 Enterprise (64 bit)
- CPU: 2.80 GHz or higher
- GPU: GMA 4500 higher and GMA HD higher
- Memory: 16 GB
- Java SDK: jdk1.8.0_152 (64 bit)

Annex B Declaration and Certification

B.1 Europe Declaration of Incorporation (Original)

DECLARATION OF INCORPORATION	
according to EC Machinery Directive 2006/42/EC Annex II Part 1 Section B	
We,	
Doosan Robotics Inc.	
79, Saneop-ro 156beon-gil, Gwonseon-gu, Suwon-si, Gyeonggi-do, 16648, Republic of Korea	
declare under our sole responsibility that the following product:	
Product :	Industrial Robot (Manipulator & Controller)
Model :	Manipulator : A0509, A0509S, A0912, A0912S Controller : CS-03
conform to the essential safety requirements of the Directive 2006/42/EC	
The product as the partly completed machinery must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of the Directive 2006/42/EC and with the regulations transposing it into national law.	
The following requirements of Annex I have been fulfilled	
Clause 1.1.2, 1.1.3, 1.1.5, 1.3.4, 1.3.8.1, 1.5.2, 1.5.10, 1.7.3, 1.7.4	
The product is based on following standards	
<i>Standard</i>	<i>Description</i>
EN ISO 12100:2010	Safety of machinery —General principles for design — Risk assessment and risk reduction
EN ISO 13849-1:2015	Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design
EN 60204-1:2006/A1:2009	Safety of machinery — Electrical equipment of machines — Part 1: General requirements
EN ISO 10218-1:2011	Robots and robotic devices — Safety requirements for industrial robots — Part 1: Robots
ISO TS 15066	Robots and robotic devices — Collaborative robots
Relevant technical documentations are compiled in accordance with Annex VII, part B of the Directive, and available in electronic form to national authorities upon legitimate request.	
Additionally, the product declares in conformity with the following directives, according to which the product is CE marked:	
2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility Directive (EMC)
Suwon, 9 th July, 2020 R&D Center	 DOOSAN Junhyun Jang Chief Technical Officer

B.2 Europe Machinery Directive Attestation of Conformity

ZERTIFIKAT ◆ CERTIFICATE ◆ 認 證 證 書 ◆ CERTIFICADO ◆ CERTIFICAT



Attestation of Conformity

M8A 004249 0019 Rev. 01

Holder of Certificate: Doosan Robotics Inc
79, Saneop-ro 156beon-gil, Gwonseon-gu
Suwon-si, Gyeonggi-do 16648
REPUBLIC OF KOREA

Product: Industrial Robot
(Manipulator & Controller)

Model(s): Manipulator: A0509, A0912, A0509S, A0912S
Controller: CS-03

Parameters:	Manipulator:	A0509	A0912	A0509S	A0912S
Payload:		5 kg	9 kg	5 kg	9 kg
Degrees of freedom:		6 Axis	6 Axis	6 Axis	6 Axis
Weight:		21 kg	27 kg	21 kg	27 kg
Controller: CS-03					
Rated input voltage:		100-240 Va.c., 1 Phase			
Rated Frequency:		50/60 Hz			
Rated input current:		10 A			
Weight:		13 kg			

Tested according to: EN ISO 10218-1:2011
EN ISO 12100:2010
EN 60204-1:2006/A1:2009

This Attestation of Conformity is issued on a voluntary basis according to Council Directive 2006/42/EC relating to machinery. It confirms that the listed equipment (not Annex IV equipment) complies with the principal protection requirements of the directive. It refers only to the sample submitted to TÜV SÜD Product Service GmbH for testing and certification. For details see: www.tuvsud.com/ps-cert

Test report no.: MAEB01220220

Date, 2020-07-29


(Ro-Hyun Park)

Page 1 of 1

After preparation of the necessary technical documentation as well as the EC declaration of conformity the required CE marking can be affixed on the product. Other relevant directives have to be observed.

TÜV SÜD Product Service GmbH • Certification Body • Ridlerstraße 65 • 80339 Munich • Germany

TUV®

B.3 Europe EMC Directive Attestation of Conformity

ZERTIFIKAT ◆ CERTIFICATE ◆ 認 證 證 書 ◆ CERTIFICADO ◆ CERTIFICAT



Product Service

Attestation of Conformity

No. E8A 004249 0026 Rev. 01

Holder of Certificate: **Doosan Robotics Inc**
79, Saneop-ro 156beon-gil, Gwonseon-gu
Suwon-si, Gyeonggi-do 16648
REPUBLIC OF KOREA

Name of Object: **Industrial Robot
(Manipulator & Controller)**

Model(s): **Manipulator: A0509, A0912, A0509S, A0912S
Controller: CS-03**

Description of Object: Rated input voltage: 100-240 V a.c., 1 Phase
Rated input frequency: 50/60 Hz
Rated input current: 10 A

Tested according to: EN 61000-6-4:2007/A1:2011
EN 61000-6-2:2005
EN 61000-3-2:2014
EN 61000-3-3:2013

This Attestation of Conformity is issued on a voluntary basis according to the Directive 2014/30/EU relating to electromagnetic compatibility. It confirms that the listed apparatus complies with all essential requirements of the directive and is based on the technical specifications applicable at the time of issuance. It refers only to the particular sample submitted for testing and certification. For details see: www.tuvsud.com/ps-cert

Test report no.: CPSC01387420

Date, 2020-08-10


(Byung-Soo Kang)

Page 1 of 1

After preparation of the necessary technical documentation as well as the EU Declaration of conformity the required CE marking can be affixed on the product. That Declaration of conformity is issued under the sole responsibility of the manufacturer. Other relevant EU-directives have to be observed.

TÜV SÜD Product Service GmbH • Certification Body • Ridlerstraße 65 • 80339 Munich • Germany

TÜV®

B.4 U.S. NRTL Certification (U.S., CANADA)

ZERTIFIKAT ◆ CERTIFICATE ◆ 認 證 證 書 ◆ CERTIFICADO ◆ CERTIFICAT



CERTIFICATE

No. U8 004249 0020 Rev. 01

Holder of Certificate: Doosan Robotics Inc
79, Saneop-ro 156beon-gil, Gwonseon-gu
Suwon-si, Gyeonggi-do 16648
REPUBLIC OF KOREA

Certification Mark:



Product: Industrial Robot
(Manipulator & Controller)

This product was voluntarily tested to the relevant safety requirements referenced on this certificate. It can be marked with the certification mark above. The mark must not be altered in any way. This product certification system operated by TÜV SÜD America Inc. most closely resembles system 3 as defined in ISO/IEC 17067. Certification is based on the TÜV SÜD "Testing and Certification Regulations". TÜV SÜD America Inc. is an OSHA recognized NRTL and a Standards Council of Canada accredited Certification body.

Test report no.: MAEA07221020

Date, 2020-07-29

(Ro-Hyun Park)



America

CERTIFICATE

No. U8 004249 0020 Rev. 01

Model(s): Manipulator: A0509, A0912, A0509S, A0912S
Controller: CS-03

Tested according to: UL 1740:2018
CAN/CSA-Z434-14

Production Facility(ies): 004249

Parameters:	Manipulator:	A0509	A0912	A0509S	A0912S
	Payload:	5 kg	9 kg	5 kg	9 kg
	Degrees of freedom:	6 Axis	6 Axis	6 Axis	6 Axis
	Weight:	21 kg	27 kg	21 kg	27 kg
	Controller:	CS-03			
	Rated input voltage:	100-240 V.a.c., 1 Phase			
	Rated frequency:	50/60 Hz			
	Rated input current:	10 A			
	Weight:	13 kg			

Additionally tested to: ANSI/NFPA 79:2018

B.5 Voluntary Safety Confirmation Declaration (KCs)



자율안전확인 신고증명서

신청인	사업장명	두산로보틱스주식회사	사업장관리번호	257-88-001280
	사업자등록번호	257-88-00128	대표자 성명	이병서
	소재지	(16648) 경기도 수원시 권선구 산업로156번길 79		
자율안전인증대상 기계·기구명		산업용로봇		
형식(규격)	A0509	용량(등급)	6 axis	
자율안전확인번호	19-AE1EQ-12468			
제조사	두산로보틱스주식회사			
소재지	(16648) 경기도 수원시 권선구 산업로156번길 79			

「산업안전보건법」 제35조제1항 및 같은 법 시행규칙 제61조제3항에 따라
자율안전확인 신고증명서를 발급합니다.

2019년 12월 24일

한국산업안전보건공단 이사장





자율안전확인 신고증명서

신청인	사업장명	두산로보틱스(주)	사업장관리번호	257-88-001280
	사업자등록번호	257-88-00128	대표자 성명	곽상철
	소재지	(16648) 경기도 수원시 권선구 산업로156번길 79(고색동)		
자율안전인증대상 기계·기구명		산업용로봇		
형식(규격)	A0912	용량(등급)	6 axis	
자율안전확인번호	20-AE1EQ-00833			
제조사	두산로보틱스(주)			
소재지	(16648) 경기도 수원시 권선구 산업로156번길 79(고색동)			

「산업안전보건법」 제89조제1항 및 같은 법 시행규칙 제120조제3항에 따라
자율안전확인 신고증명서를 발급합니다.

2020년 02월 28일

한국산업안전보건공단 이사장





자율안전확인 신고증명서

신청인	사업장명	두산로보틱스(주)	사업장관리번호	257-88-001280
	사업자등록번호	257-88-00128	대표자 성명	곽상철
	소재지	(16648) 경기도 수원시 권선구 산업로156번길 79(고색동)		
자율안전인증대상 기계·기구명		산업용로봇		
형식(규격)	A0509S	용량(등급)	6 axis	
자율안전확인번호	20-AE1EQ-02816			
제조사	두산로보틱스(주)			
소재지	(16648) 경기도 수원시 권선구 산업로156번길 79(고색동)			

『산업안전보건법』 제89조제1항 및 같은 법 시행규칙 제120조제3항에 따라
자율안전확인 신고증명서를 발급합니다.

2020년 08월 22일

한국산업안전보건공단 이사장





자율안전확인 신고증명서

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자율안전인증대상 기계·기구명		산업용로봇		
형식(규격)	A0912S	용량(등급)	6 axis	
자율안전확인번호	20-AE1EQ-02817			
제조사	두산로보틱스(주)			
소재지	(16648) 경기도 수원시 권선구 산업로156번길 79(고색동)			

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Annex C Stop Distance and Stop Time

C.1 Measurement Methods and Conditions

C.1.1 General Information

- Stop distance is the angle traveled from the moment a stop signal is generated to the moment all manipulator stop operation.
- Stop time is the time from the moment a stop signal is generated to the moment all manipulator stop operation.
- Stop distance and stop time data are provided for Joint 1, Joint 2 and Joint 3, which have large travel distances.
- The movement of an overlapping axis can cause a longer stop distance.
- Stop distance and stop time data are defined according to ISO 10218-1:2011 Annex B.

C.1.2 Stop Category:

- Stop Category 1

The stop distance and stop time of Joint 1 (Base) and Joint 2 (Shoulder) are measured at 33%, 66% and 100% of the maximum speed, stretch level and load, respectively. The stop distance and stop time of Joint 3 (elbow) is measured at 33%, 66% and 100% of maximum speed and load. The stretch level during Joint 3 measurement is locked at maximum because of the lower arm length and completely flat wrist.

- Stop Category 0

The stop distance and stop time of Joint 1 (Base), Joint 2 (Shoulder) and Joint 3 (Elbow) are measured at maximum speed, stretch level and load. The axes of Joint 2 and Joint 3 are parallel to each other, so an impact caused by forced stop on one part may cause a slip on the other side. The angle deviation is also measured.



Note

- The measurements are the result of the worst case. Measurement may vary according to circumstances.

Joint 1 measurement is performed with the rotating axis perpendicular to the ground and during horizontal movement. Joint 2 and Joint 3 measurements are performed with the rotating axis parallel to the ground and when the robot is stopped in a downward movement vertical to the ground.

C.1.3 Pose and condition for measurements:

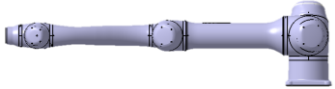
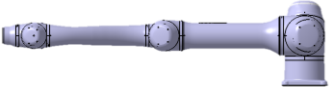
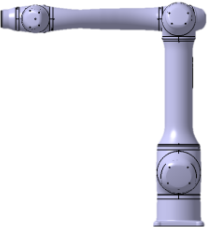
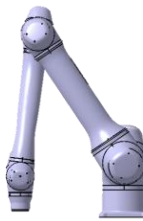
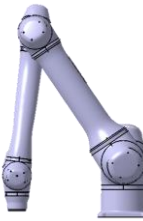
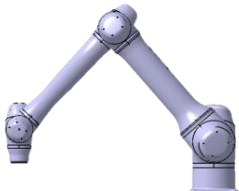
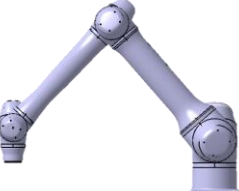
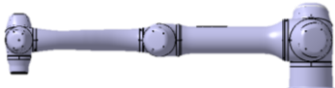
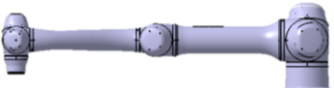
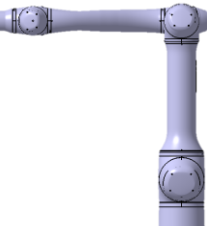
	Joint 1	Joint 2	Joint 3
100% extension Stop category 0			
33% extension Stop category 1			-
66% extension Stop category 1			-
100% extension Stop category 1			

Table C.1 the pose for 33%, 66%, and 100% of extension

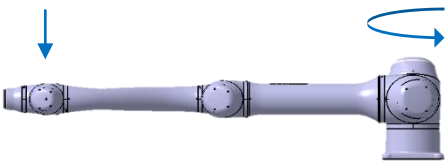
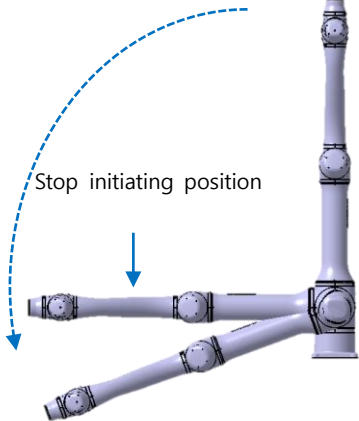
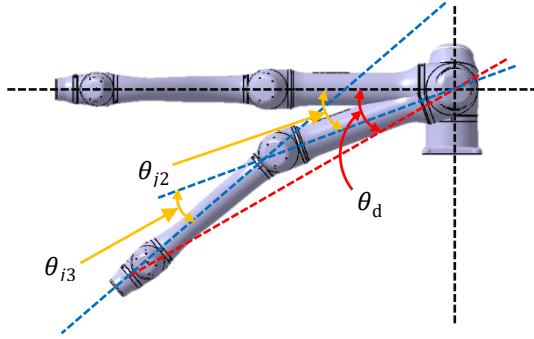
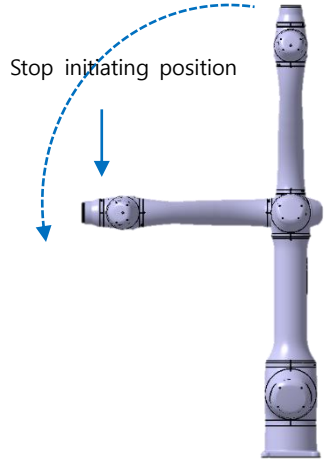
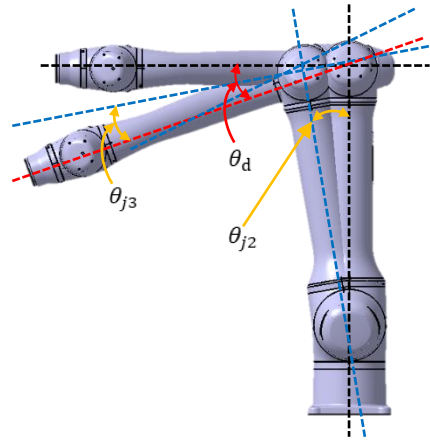
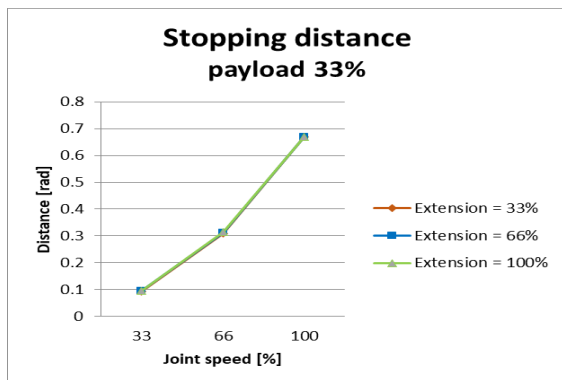
	Pose when the stop is initiated	Measured Angle
Joint1	<p>Stop initiating position</p> 	<p>No slip, $\theta_d = \theta_{j1}$</p>
Joint2	<p>Stop initiating position</p> 	
Joint3	<p>Stop initiating position</p> 	

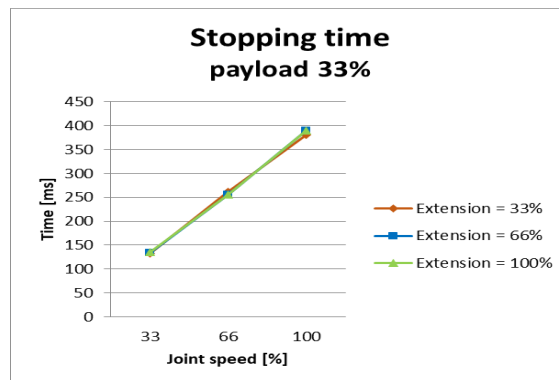
Table C.2 the pose when the stop is initiated and the measured angle (θ_d)

C.2 A0509(S)

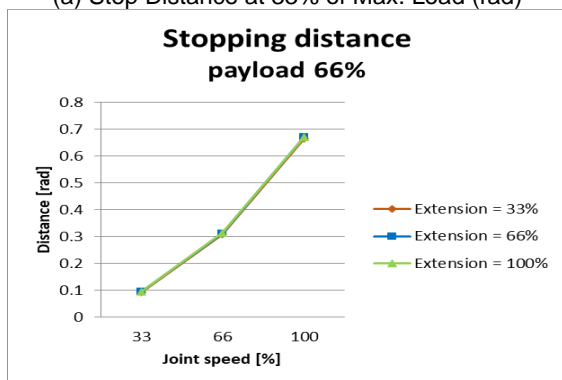
C.2.1 Stop Category 1



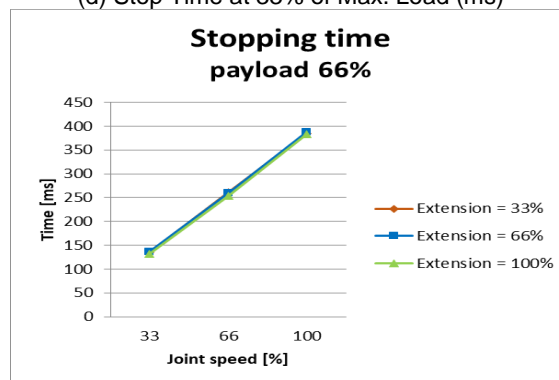
(a) Stop Distance at 33% of Max. Load (rad)



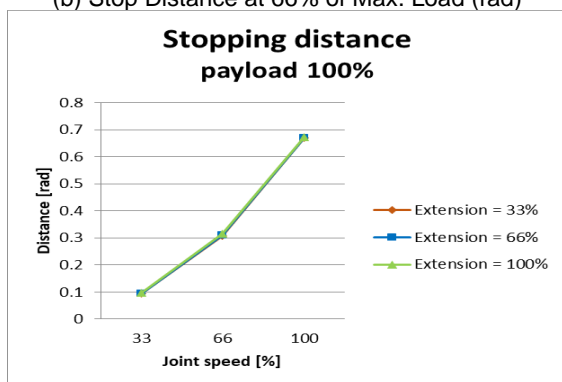
(d) Stop Time at 33% of Max. Load (ms)



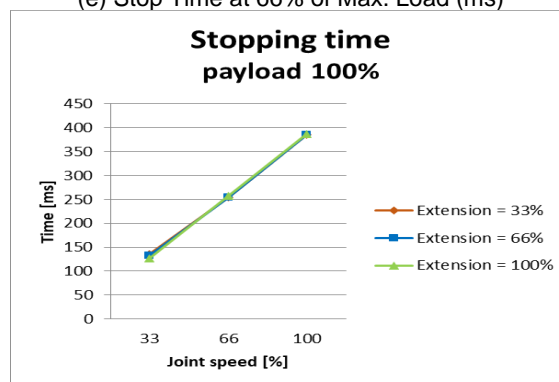
(b) Stop Distance at 66% of Max. Load (rad)



(e) Stop Time at 66% of Max. Load (ms)

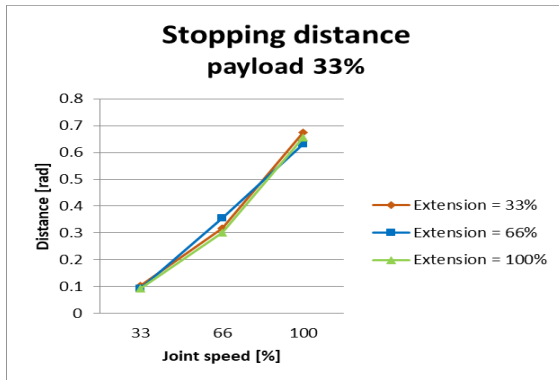


(c) Stop Distance at Max. Load (rad)

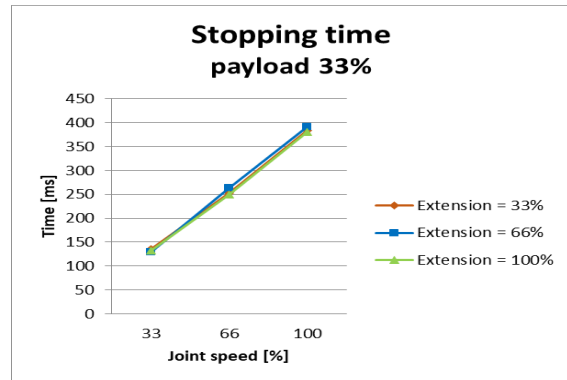


(f) Stop Time at Max. Load (ms)

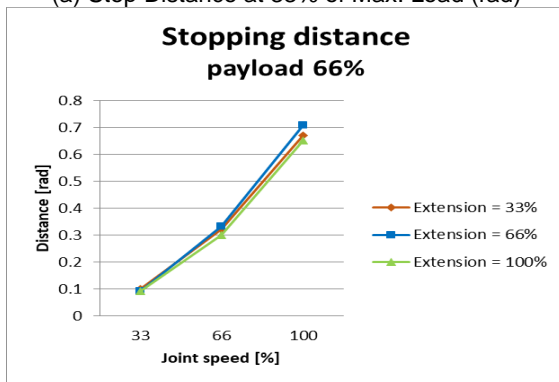
Figure C.1: Stop Distance and Stop Time of Joint 1 (Base)



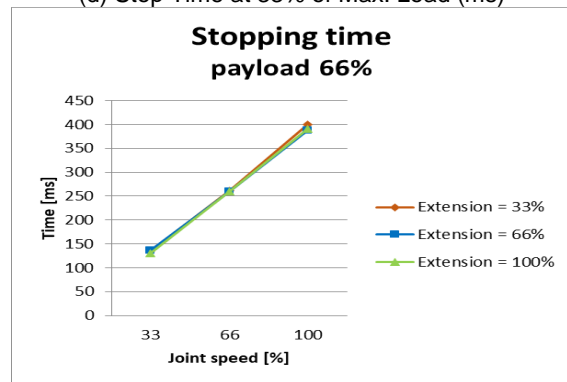
(a) Stop Distance at 33% of Max. Load (rad)



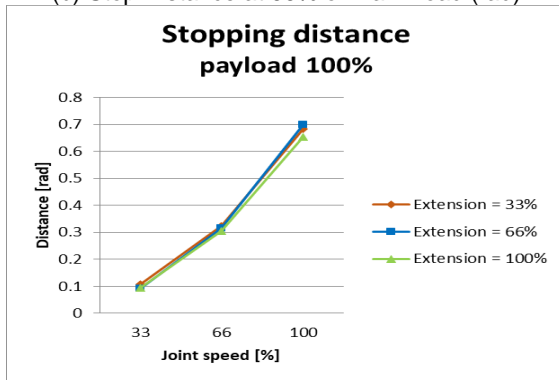
(d) Stop Time at 33% of Max. Load (ms)



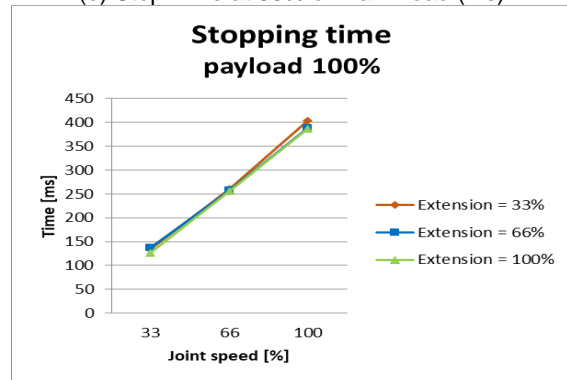
(b) Stop Distance at 66% of Max. Load (rad)



(e) Stop Time at 66% of Max. Load (ms)

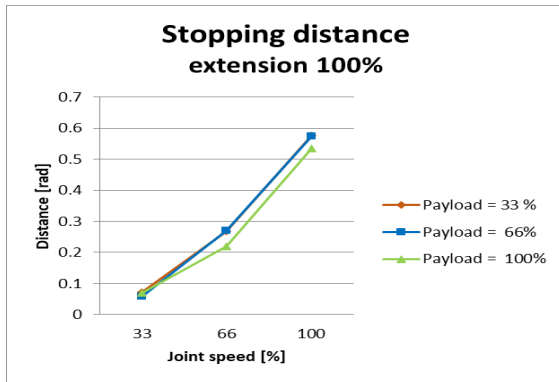


(c) Stop Distance at Max. Load (rad)

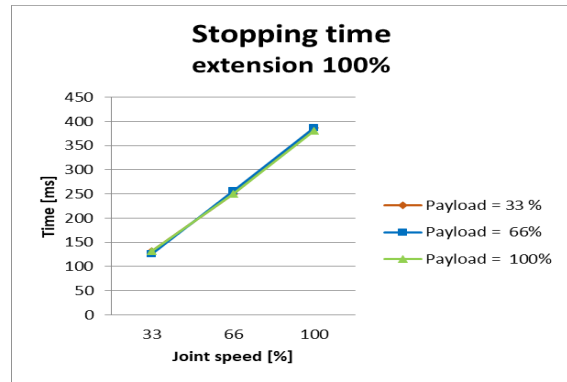


(f) Stop Time at Max. Load (ms)

Figure C.2: Stop Distance and Stop Time of Joint 2 (Shoulder)



(a) Stop Distance at Max. Stretch Level (rad)



(b) Stop Time at Max. stretch Level (ms)

Figure C.3: Stop Distance and Stop Time of Joint 3 (Elbow)

C.2.2 Stop Category 0

	Joint 1	
	Extension=100%, Speed=100%, Payload=100%	
	Stopping distance(rad)	Stopping time(ms)
Joint 1	0.286	166

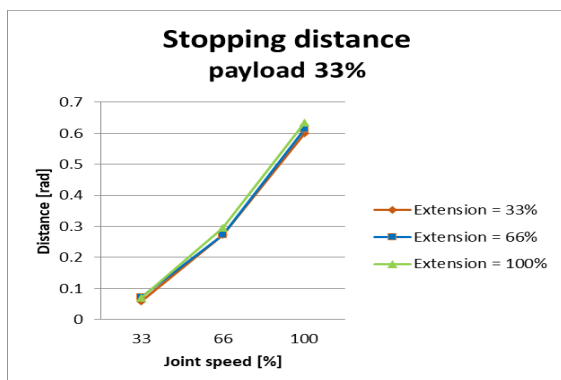
	Joint 2	
	Extension=100%, Speed=100%, Payload=100%	
	Stopping distance(rad)	Stopping time(ms)
Joint 2 (θ_{j2})	0.544	309
Joint 3 (θ_{j3})	0.0022	
Distance (θ_{jd})	0.545	

	Joint 3	
	Extension=100%, Speed=100%, Payload=100%	
	Stopping distance(rad)	Stopping time(ms)
Joint 2 (θ_{j2})	0.005	92
Joint 3 (θ_{j3})	0.163	
Distance (θ_{jd})	0.167	

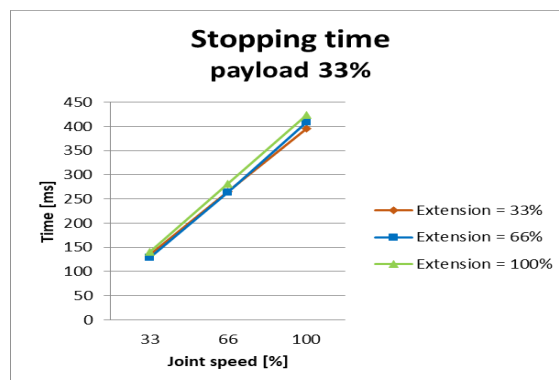
※ The joint 2 and joint 3 angles are refer to θ_{j2} , θ_{j3} , θ_d in table C.2

C.3 A0912(S)

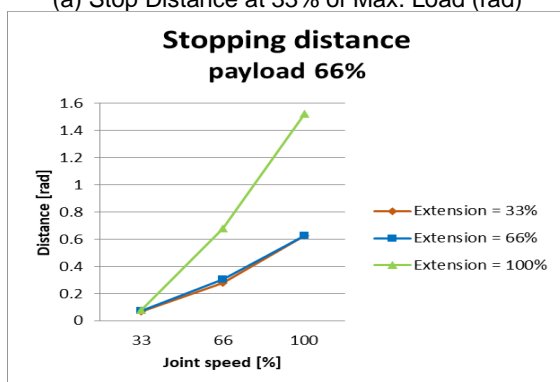
C.3.1 Stop Category 1



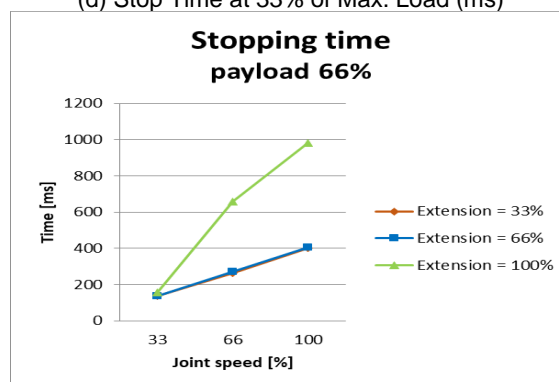
(a) Stop Distance at 33% of Max. Load (rad)



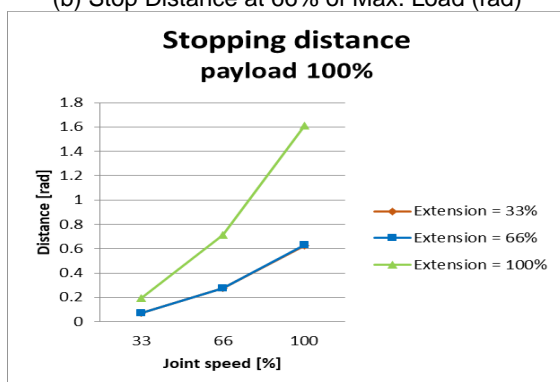
(d) Stop Time at 33% of Max. Load (ms)



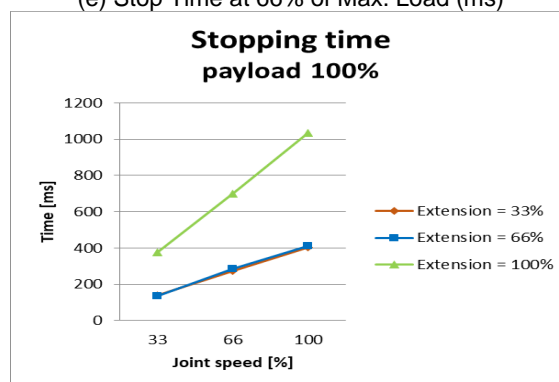
(b) Stop Distance at 66% of Max. Load (rad)



(e) Stop Time at 66% of Max. Load (ms)

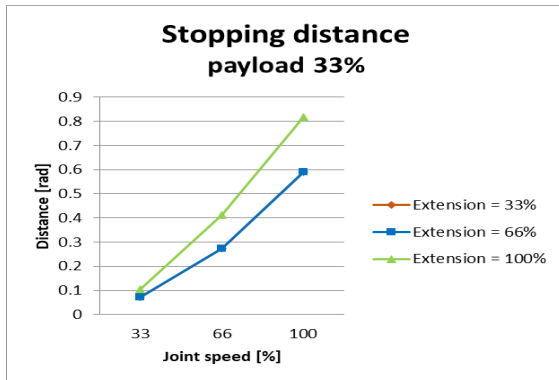


(c) Stop Distance at Max. Load (rad)

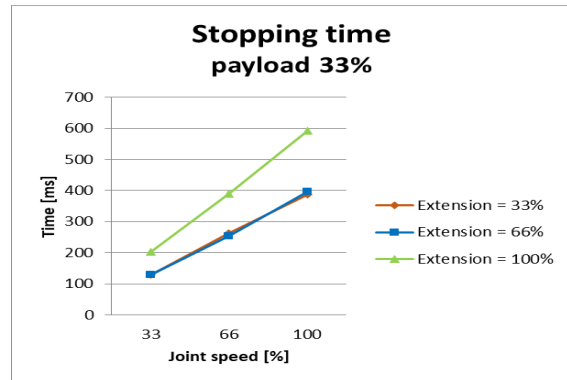


(f) Stop Time at Max. Load (ms)

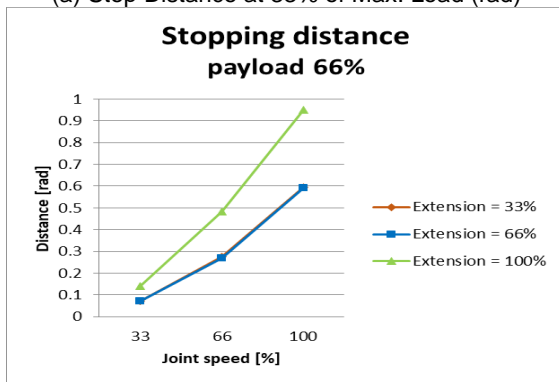
Figure C.4: Stop Distance and Stop Time of Joint 1 (Base)



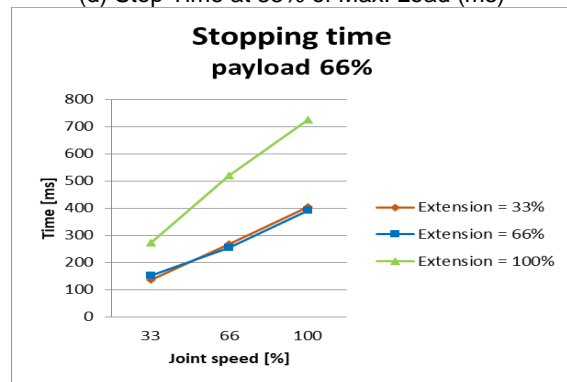
(a) Stop Distance at 33% of Max. Load (rad)



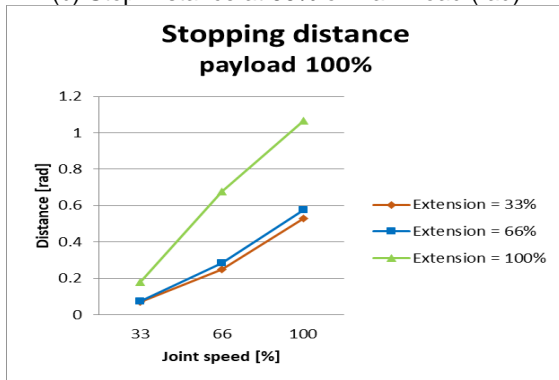
(d) Stop Time at 33% of Max. Load (ms)



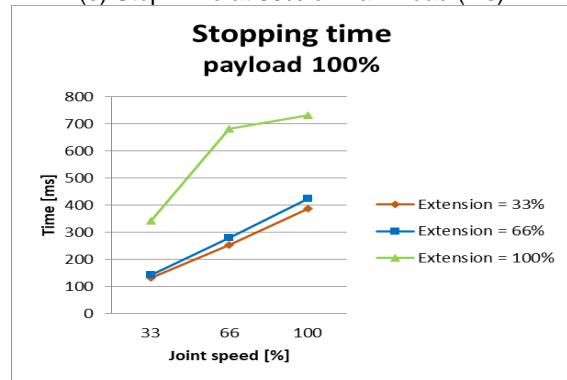
(b) Stop Distance at 66% of Max. Load (rad)



(e) Stop Time at 66% of Max. Load (ms)

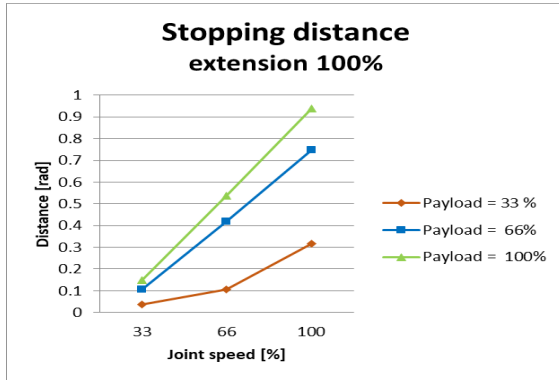


(c) Stop Distance at Max. Load (rad)

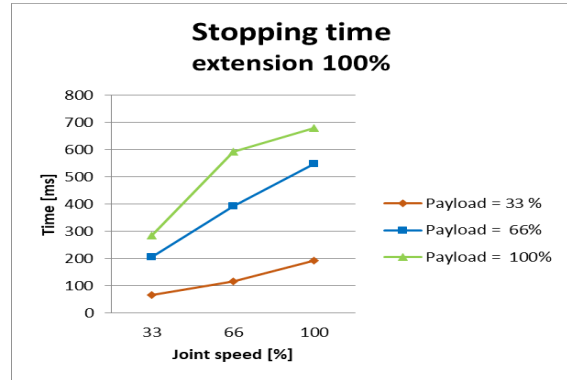


(f) Stop Time at Max. Load (ms)

Figure C.5: Stop Distance and Stop Time of Joint 2 (Shoulder)



(a) Stop Distance at Max. Stretch Level (rad)



(b) Stop Time at Max. stretch Level (ms)

Figure C.6: Stop Distance and Stop Time of Joint 3 (Elbow)

C.3.2 Stop Category 0

	Joint 1	
	Extension=100%, Speed=100%, Payload=100%	
	Stopping distance (rad)	Stopping time (ms)
Joint 1	0.4559	253

	Joint 2	
	Extension=100%, Speed=100%, Payload=100%	
	Stopping distance (rad)	Stopping time (ms)
Joint 2 (θ_{j_2})	0.950	412
Joint 3 (θ_{j_3})	0.001	
Distance (θ_{j_d})	0.950	

	Joint 3	
	Extension=100%, Speed=100%, Payload=100%	
	Stopping distance (rad)	Stopping time (ms)
Joint 2 (θ_{j_2})	0.018	187
Joint 3 (θ_{j_3})	0.318	
Distance (θ_{j_d})	0.329	

※ The joint 2 and joint 3 angles are refer to θ_{j_2} , θ_{j_3} , θ_d in table C.2



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