OMRON

i4L

Robots with EtherCAT

User's Manual

i4-350L
i4-450L
i4-550L

Introduction

Thank you for purchasing the i4L robot.

This manual is OMRON's original instructions describing the setup, operations, and user maintenance of the i4L robot (herein also referred to as robot).

Please read this manual and make sure you understand the functionality and performance of the robot before attempting to use it.

Keep this manual in a safe place where it will be available for reference during operation.

Intended Audience

This manual is intended for the following personnel, who must also have knowledge of factory automation (FA) systems and robotic control methods.

- Personnel in charge of introducing FA systems.
- Personnel in charge of designing FA systems.
- Personnel in charge of installing and maintaining FA systems.
- Personnel in charge of managing FA systems and facilities.

Applicable i4L Robot Models

This manual provides information for all i4L-series robot models..

When information varies between different robot models, details are provided. When information is common to all robot models, an illustration of a single robot model is typically shown.

Units

Unless otherwise noted, length dimensions are in millimeters and all units are metric.

Manual Information

Page Structure

The following page structure is used in this manual.
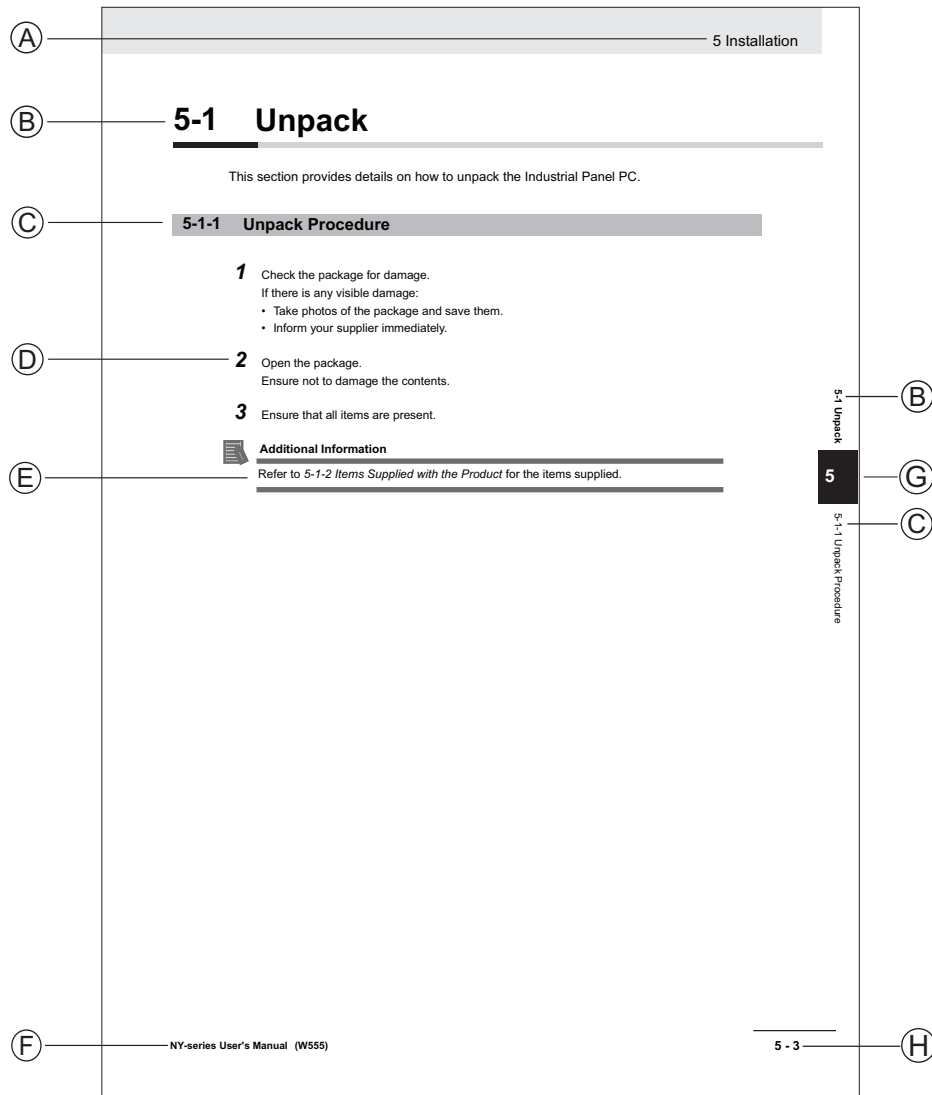
Note: This illustration is provided as a sample. It will not literally appear in this manual.

Item	Explanation	Item	Explanation
A	Level 1 heading	E	Special Information
B	Level 2 heading	F	Manual name
C	Level 3 heading	G	Page tab with the number of the main section
D	Step in a procedure	H	Page number

Special Information

Special information in this manual is classified as follows:

Precautions for Safe Use

Precautions on what to do and what not to do to ensure safe usage of the product.

Precautions for Correct Use

Precautions on what to do and what not to do to ensure proper operation and performance.

Additional Information

Additional information to read as required.
This information is provided to increase understanding or make operation easier.

Version Information

Information on differences in specifications and functionality between different versions.

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Terms and Conditions Agreement

Warranty and Limitations of Liability

Warranty

● **Exclusive Warranty**

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NEVER USE THE PRODUCT FOR AN APPLICATION INVOLVING SERIOUS RISK TO LIFE OR PROPERTY WITHOUT ENSURING THAT THE SYSTEM AS A WHOLE HAS BEEN DESIGNED TO ADDRESS THE RISKS, AND THAT THE OMRON PRODUCT(S) IS PROPERLY RATED AND INSTALLED FOR THE INTENDED USE WITHIN THE OVERALL EQUIPMENT OR SYSTEM.

Programmable Products

- Omron Companies shall not be responsible for the user's programming of a programmable Product, or any consequence thereof.
- Omron Companies shall not be responsible for the operation of the user accessible operating system (e.g. Windows, Linux), or any consequence thereof.

Disclaimers

Performance Data

Data presented in Omron Company websites, catalogs and other materials is provided as a guide for the user in determining suitability and does not constitute a warranty. It may represent the result of Omron's test conditions, and the user must correlate it to actual application requirements. Actual performance is subject to the Omron's Warranty and Limitations of Liability.

Change in Specifications

Product specifications and accessories may be changed at any time based on improvements and other reasons. It is our practice to change part numbers when published ratings or features are changed, or when significant construction changes are made. However, some specifications of the Product may be changed without any notice. When in doubt, special part numbers may be assigned to fix or establish key specifications for your application. Please consult with your Omron's representative at any time to confirm actual specifications of purchased Product.

Errors and Omissions

Information presented by Omron Companies has been checked and is believed to be accurate; how-ever, no responsibility is assumed for clerical, typographical or proofreading errors or omissions.

Safety Precautions

Definition of Precautionary Information

The following notation is used in this manual to provide precautions required to ensure safe usage of the i4L robot. The safety precautions that are provided are extremely important to safety.
Always read and heed the information provided in all safety precautions.
The following notation is used.

⚠ DANGER	Identifies an imminently hazardous situation which, if not avoided, is likely to result in serious injury, and might result in fatality or severe property damage.
⚠ WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury. Additionally, there may be severe property damage.
⚠ CAUTION	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury, or property damage.

Symbols

🚫	The circle and slash symbol indicates operations that you must not do. The specific operation is shown in the circle and explained in text. This example indicates prohibiting disassembly.
⚡	The triangle symbol indicates precautions (including warnings). The specific operation is shown in the triangle and explained in text. This example indicates a precaution for electric shock.
⚠	The triangle symbol indicates precautions (including warnings). The specific operation is shown in the triangle and explained in text. This example indicates a general precaution.
❗	The filled circle symbol indicates operations that you must do. The specific operation is shown in the circle and explained in text. This example shows a general precaution for something that you must do.
🔥	The triangle symbol indicates precautions (including warnings). The specific operation is shown in the triangle and explained in text. This example indicates a precaution for high temperatures.

Dangers

⚠ DANGER

General

An i4L robot can cause serious injury or death, or damage to itself and other equipment, if the following safety precautions are not observed:

- All personnel who install, operate, teach, program, or maintain the system must read this guide, read the *Robot Safety Guide (Cat. No. I590)*, and complete a training course for their responsibilities in regard to the robot.
- All personnel who design the robot system must read this guide, read the *Robot Safety Guide (Cat. No. I590)*, and must comply with all local and national safety regulations for the location in which the robot is installed.
- The robot system must not be used for purposes other than described in *1-1 Intended Use* on page 1-2. Contact your local Omron support if you are not sure of the suitability for your application.
- The user is responsible for providing safety barriers around the robot to prevent anyone from accidentally coming into contact with the robot when it is in motion.
- Power to the robot and its power supply must be locked out and tagged out before any maintenance is performed.
- When the robot or robotic equipment is not investigated in conjunction with a system work cell, the instructions shall call attention to the following: the interlocked portion of barrier shall be installed, applied, and maintained so that it has the capability of being easily unlocked from the inside of the safeguarded space, with or without power available, when the possibility of full body access exists.

i4L robots are not collaborative robots. They require a dedicated work area that will prevent personnel from coming into contact with them during operation.

The normal and intended use of these robots does not create hazards.

These robots have been designed and constructed in accordance with the relevant requirements of IEC 60204-1.

These robots are intended for use in parts assembly and material handling for payloads up to 5.0 kg.

Refer to the *Robot Safety Guide (Cat. No. I590)* for details on the intended use of our robots.

These robots are intended for industrial use only.

Perform a risk assessment before using.

These robots are not intended for:

- Use in the presence of ionizing or non-ionizing radiation.
- Use in potentially explosive atmospheres.
- Use in medical or life saving applications.
- Use in a residential setting.

Installation

The robot system must be installed with user-supplied interlock barriers. The interlocked barriers must open the E-Stop circuit in the event of personnel attempting to enter the work cell when High Power is enabled. Failure to install suitable guarding or interlocks could result in injury or death. We strictly prohibit installation, commissioning, or operation of any robot without adequate safeguards. These must be compliant with applicable local and national standards.

The placement of safety controls shall avoid requiring a person to enter a hazardous area to actuate them.

Controls shall be located outside of the safeguarded space, except for certain controls such as emergency stops or a teach pendant, where based on a risk assessment they may be located within the safeguarded space.

After installing the robot, you must test it before you use it for the first time. Failure to do this could cause death, serious injury, or equipment damage.

Failure to ground robot-mounted equipment or tooling that uses hazardous voltages could lead to injury or fatality of a person touching the end-effector during an electrical fault.

Any High Power push-buttons must be installed outside of the robot's workspace.

Warnings

⚠ WARNING

General

The instructions for operation, installation, and maintenance given in this document must be strictly observed.

If air pressure is present, disconnect it from the robot when servicing end-of-arm tooling or other pneumatic components to prevent unsecured pneumatic air lines from accidentally injuring personnel.

Do not move the robot links if the robot is not secured. Failure to comply could result in the robot falling and causing either personnel injury or property damage.

Installation

Ensure that installation and post-installation checks of the product are performed by personnel in charge who possess a thorough understanding of the machinery to be installed.

Ensure compliance with all local and national safety and electrical codes for the installation and operation of the robot system.

Provide appropriately-sized Branch Circuit Protection and Lockout / Tagout Capability in accordance with the National Electrical Code and any local codes.	
Always use proper lifting technique when lifting the robot. Failure to comply could result in the robot falling and causing either personnel injury or equipment damage.	
If you supply your own Front Panel, its design must comply with the requirements of IEC 60204-1 and ISO 13849. The E-Stop's push button must comply with ISO 13850 (Clause 5.5.2).	
Disabling the High Power button violates IEC 60204-1. Do not alter its functionality.	
If a robot is mounted to a surface with inadequate stiffness, damage to the z-axis quill or other mechanical components can result from excessive oscillation during operation.	
The robot's center of mass can cause the robot to fall over if the robot is not properly secured with the mounting bolts.	
The robot must be installed to avoid interference with buildings, structures, utilities, other machines and equipment that may create trapping or pinch points. It must be installed in accordance with Standard for Robots and Robotic Devices – Safety Requirements for Industrial Robots – Part 2: Robot Systems and Integration, ISO 10218-2.	
Ensure that interconnecting cables or pneumatic lines are routed away from the robot workspace.	
To reduce the risk of fire or electric shock, install the robot in a controlled environment relatively free of contaminants.	

Operation

Before starting the operation of equipment, always confirm that the safety equipment of the robot works properly. If a malfunction of the safety equipment is detected, follow the troubleshooting procedure.	
Use the total weight of the end-of-arm tooling and the payload to stay within the payload rating of the robot. Ensure that the system never exceeds that maximum payload.	
Perform a full risk assessment which includes the end-of-arm tooling and any payload to prevent crushing, shearing, payload ejection, entanglement, stabbing or puncture hazard.	
Releasing a brake may cause the quill, tool flange, end-of-arm tooling, and payload to drop. To prevent possible injury to personnel or damage to the equipment, make sure that the equipment is supported when releasing the brake and verify that the end-of-arm tooling and payload are clear of all obstructions.	
All signals that pass-through the USER connectors are not associated with any robot controls, emergency stop circuits, or robot power. Implement appropriate safety measures to ensure that these signals are not active during emergency stop conditions or while the robot is powered OFF.	

In Automatic mode, the robot can move unexpectedly. Ensure all personnel remain clear of the cell when Automatic mode is enabled.

If an operator is going to be in the work cell with the switch in Manual mode, the operator must carry an enabling device such as the T20 pendant.

Whenever possible, perform Manual mode operations with all personnel outside the workspace.

The stopping time and distance, or angle, of a robot joint from initiation of a stop signal is not negligible and must be taken into account when designing and applying safeguarding devices.

Never connect or disconnect system cables while power is applied to the robot. Failure to comply may cause unexpected behavior and can result in personnel injury and equipment damage.

Never run a robot system with all jumpers installed. This would leave the system with no E-Stops.

Do not use the robot in hazardous environments (explosive gas, and oil mist).

The robot shall be operated within its specified temperature range to ensure proper operation.

The robot's physical hardstop devices are not intended to withstand repeated use and if this occurs, the hardstop may become damaged. Implement proper programming and configuration of joint range limits to prevent hardstop impacts.

Maintenance

Do not use organic solvents to clean any part of the robot unless directed in the cleaning instructions. Organic solvents might damage electronics resulting in an unsafe operating state that could cause injury or damage to equipment.

You must perform the Lockout and tagout procedure prior to servicing the robot.

The access covers on the robot are not interlocked. You must turn OFF and disconnect the power before the covers of the robot are removed.

The procedures and replacement of the parts mentioned in this manual must be performed only by the skilled or instructed persons.

Cautions

⚠ CAUTION

The design and installation of the complete system must comply with the safety standards and regulations in the country of use. The integrators of the robot should understand the safety laws and regulations in their countries and prevent major hazards from occurring in the complete system.

Precautions for Safe Use

- The Joint 3 quill and the tool flange are not grounded to protective earth. If hazardous voltages are present at any user-supplied robot-mounted equipment or tooling, you must install a ground connection from that equipment or tooling to the ground point on the robot base.
- This equipment must be shipped and stored in a temperature-controlled environment, within the range –25 to +55°C. The recommended humidity range is 5 to 90%, non-condensing. It should be shipped and stored in the supplied packaging, which is designed to prevent damage from normal shock and vibration.
- Output 8 can be assigned to indicate the robot's High Power state. When High Power is enabled, this output will turn ON. When High Power is not enabled, this output will be OFF. This is not a safety-rated means of indicating a High Power state and should only be used for monitoring the robot status. Use the Sysmac Studio to make this configuration if needed.
- Do not apply 48 VDC power until all installation steps are complete and verified and all safety measures are in place.
- High power cannot be enabled unless all safety circuits are satisfied.
- The LED indicator does not reflect the robot's High Power status. To see the robot's High Power status, use the Front Panel indicator or a user-supplied indicator connected to the XFP connector.
- The braking mechanism operates passively. If 24 VDC Control Power is removed from the system, the brake mechanism will automatically activate. 24 VDC Control Power must be supplied to release the brake. To prevent possible damage to the equipment, remove any payload from the end-of-arm tooling, make sure that Joint 3 is supported while releasing the brake, and verify that the end-of-arm tooling or other installed equipment is clear of all obstructions.
- The High Power indicator must be operational to satisfy safety requirements.
- You can contribute to resource conservation and protecting the environment by the proper disposal of Waste Electronics and Electrical Equipment (WEEE). All electrical and electronic products should be disposed of separately from the municipal waste system according to local ordinances using designated collection facilities.

- The product contains lithium batteries with a perchlorate content of 6ppb or higher. When exporting an end product containing the product to or shipping through California, USA, label all packing and shipping containers appropriately. Special handling may apply. Refer to https://dtsc.ca.gov for more information.
- Dispose of any battery that has been dropped or otherwise subjected to excessive shock. Batteries that have been subjected to shock may leak if they are used.
- Batteries may leak, rupture, heat, or ignite. Never short-circuit, charge, disassemble, heat, or incinerate a battery or subject it to strong shock.
- Any person who programs, teaches, operates, maintains, or repairs robots or robot systems shall be trained and can demonstrate competence to safely perform the assigned task.
- Any person who programs, teaches, operates, maintains, or repairs robots or robot systems shall be trained on responding to emergency or abnormal situations.
- Do not connect user-supplied Manual / Automatic contacts or other control signals in parallel with the Front Panel switch contact. This would violate the Single Point of Control principle and might allow Automatic mode to be selected while an operator is in the cell.

- Acoustic emission from these robots may be up to 70 dB (A) at 1 m distance under worst-case conditions. Typical values will be lower, depending on payload, speed, acceleration, and mounting. Appropriate safety measures should be taken, such as ear protection and display of a warning sign.
- Any moving robot requires some distance to stop. This requires more distance at high operating speeds or heavier payloads. When stopping a robot, make sure that there is no interference with other equipment.
- Do not expose the shipping container to excessive shock and vibration. This could damage the robot.
- Using improper lubrication products on the robot may damage it.
- After an operator places the robot in Manual mode using the Front Panel key switch, they should remove the key for safety purposes.
- If the supplied Front Panel is not used, a High Power indicator light must be present in the system. This indicator light must be amber in color. It must be either mounted to the robot or integrated into the work cell where it is visible from all approaches or entry points.
- If a supplementary audible means of robot operation is provided, it shall exceed the ambient noise at the end-use application.
- You can burn yourself. Do not touch the robot after it has been running at high ambient temperatures or at fast cycle times (over 60 cycles per minute). The robot surface temperature can exceed 85° C.
- During manual operation, ensure all persons are a safe distance away from the robot work envelope.
- The robot can be lifted by hand. Only use the base and inner link when lifting the robot. Never maneuver the robot using the quill or flyover assemblies.
- To stop the robot in an emergency, press any E-stop button and then follow the internal procedures of your company or organization defined for an emergency situation.
- If a fire occurs on the robot, use a CO_2 type fire extinguisher.
- In case of entrapment of a person by the robot or any other emergency or abnormal situation, you can manually move the inner and outer links to a safe position while 48 VDC High Power is disabled. A brake device prevents Joints 3 and 4 from moving when High Power is disabled and can only be released while 24 VDC Control Power is present.
- Prior to placing the robot in Automatic Mode, all safeguards must be returned to their safe state.
- After the robot is placed in Manual mode using the Front Panel key switch, the key should be removed for safety purposes.

Precautions for Correct Use

- Robot motion is not possible until High Power is supplied and has been enabled.
- Control power must be present before High Power can be enabled.
- The T20 pendant can only control the robot it is directly connected to.
- Either a Front Panel or equivalent circuits are required to enable High Power to the robot.
- If the Front Panel High Power ON / OFF indicator fails, you might incorrectly assume that High Power is OFF, and the robot is safe. To prevent this, a failed indicator causes an error (-924) *Front panel HIGH POWER lamp failure* and locks out the High Power enabling until you replace the indicator.
- It is recommended to use a properly secured, 18 mm (minimum) thick steel plate with a maximum surface roughness of 25 μm as a robot mounting surface.
- The mounting surface should be clean and prepared according to the information provided in this document before attempting to mount the robot.
- Do not over-tighten the tool flange setscrew. This will cause off-center alignment of the tool flange on the quill.
- Always reduce joint motion limits with software settings in the robot configuration area when hard-stops are used to restrict range of motion.
- Never loosen or remove the quill clamp collar while the z-axis brake is released.
- If Teach Pendant cabling is installed, the jumper plug or the Teach Pendant must be connected to satisfy safety circuits and allow High Power to be enabled.
- Do not disable or bypass the High Power button. This will violate IEC 60204-1.
- Operating the robot outside of the payload and speed constraints described in this document can damage or reduce the service life of the z-axis quill.
- If a Front Panel is not present, the High Power indicator and High Power button signals can be accessed with the XFP system cable connector.
- Attempting to release the brake while High Power is ON will automatically disable High Power. If the robot is moving, this will cause it to stop abruptly.
- If no controller(s) is detected, check the Ethernet network and cables and ensure that a network connection is available to the robot and the PC.
- Only replace items on the robot system with the parts supplied by OMRON.
- Only use the recommended grease on the joint 3 quill. Use THK AFF Grease (part number 20950-000). Refer to the provided Safety Data Sheet for proper handling.
- When removing and replacing the tool flange, you must reinstall it in the same position to avoid losing the calibration for the robot.
- Use surge suppression when switching inductive loads such as relays to prevent damage to the output circuits.
- Any externally mounted equipment is considered robot payload. Consideration to the payload attached to the Tool Flange should be made when mounting external equipment to the robot.
- If the robot has a bottom Primary Interface Panel orientation, do not temporarily set the robot upright on a flat surface because this can damage the Primary Interface Panel connectors.
- Avoid rotating the quill / Joint 4 when the brake is released. This could result in an out-of-range condition and may prevent program execution.
- All fastener torque values provided must be applied within ±5%.
- Keep a minimum of 300 mm clearance from the Primary Interface Panel to allow for switch and cable connection access.
- Never loosen or remove the quill clamp collar while the z-axis brake is released.

- The z-axis stroke is reduced when bellows are present. Bellows reduce the travel by 27 mm (180 mm quill length) / 53 mm (350 mm quill length) in the z-axis retracted position and 27 mm (180 mm quill length) / 53 mm (350 mm quill length) in the z-axis extended position. Always adjust joint motion limits with software settings in the robot configuration area when bellows are installed to restrict range of motion.

Regulations and Standards

Conformance to EU Directives

The robot complies with the following EN Directives.

Directives

- 2006/42/EC
  Machinery Directive
- 2014/30/EU
  EMC Directive

EN Harmonized Standards

The robot system conforms to the following EN standards.
- EN ISO 12100
  Safety of Machinery
  General Principles for Design
  Risk Assessment and Reduction
- EN ISO 13849-1
  Safety of Machinery
  Safety Related Parts of Control Systems SRP/CS – Part 1
- EN ISO 10218-1
  Robots for industrial environments
  Safety requirements, Part 1: Robot
- EN 60204-1
  Safety of Machinery
  Electrical equipment of machines, Part 1 General Requirements
- EN 61000-6-4
  EMC, Part 6-4: Emissions Standard for Industrial Environments
- EN 61000-6-2
  EMC, Part 6-2: Immunity Emissions Standard for Industrial Environments

Conformance to KC Certification

When you use this product in South Korea, observe the following precautions.

사 용 자 안 내 문
이 기기는 업무용 환경에서 사용할 목적으로 적합성평가를 받은 기기로서 가정용 환경에서 사용하는 경우 전파간섭의 우려가 있습니다.

This product meets the electromagnetic compatibility requirements for business use. There is a risk of radio interference when this product is used in home.

Software Licenses and Copyrights

This product incorporates certain third party software. The license and copyright information associated with this software is available at http://www.fa.omron.co.jp/nj_info_e/.

Related Manuals

Use the following related manuals for reference.

Manual Title	Description
IPC Application Controller User's Manual (Cat. No. I632)	Describes the IPC Application Controller.
NJ-series Robot Integrated CPU Unit User's Manual (Cat. No. O037)	Describes the settings and operation of the CPU Unit and programming concepts for OMRON robot control.
NJ/NX-series Troubleshooting Manual (Cat. No. W503)	Concepts on managing errors that may be detected in an NJ/NX-series Controller and information on individual errors are described.
Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)	Describes the operating procedures of the Sysmac Studio for Robot Integrated CPU Unit.
Sysmac Studio Version 1 Operation Manual (Cat. No. W504)	Describes the operating procedures of the Sysmac Studio.
Sysmac Studio 3D Simulation Function Operation Manual (Cat. No. W618)	Describes an outline, execution procedures, and operating procedures for the 3D simulation function of the Sysmac Studio.
T20 Pendant User's Manual (Cat. No. I601)	Describes the setup, operation, and user maintenance for the Teaching Pendant T20.
Robot Safety Guide (Cat. No. I590)	Describes how to use the OMRON robot safely.
V+ User's Manual (Cat. No. I671)	Provides a description of the V+ programming language and functionality.
V+ Keyword Reference Manual (Cat. No. I672)	Provides reference to V+ Keyword use and functionality.

Glossary

Term / Abbreviation	Description
Application Controller	Industrial PC that provides additional functionality to the robot to execute PackManager and Robot Vision Manager applications.
Automatic Mode	Operating state of the robot during normal conditions. In this mode, program execution will control the robot up to the maximum allowable speed.
Control Power	24 VDC supply that energizes control and other non-servo motor circuits.
End-of-arm Tooling	Any device mounted to the robot's tool flange intended for performing work during robot operation.
Emergency Stop	An action or device used to immediately stop the robot. This may be referred to as emergency stop, E-stop, or ESTOP.
Flyover	The cable assembly that connects the robot base to the outer link.
Hardstop	Physical limit that restricts the range of motion for a robot axis.
High Power	48 VDC supply that energizes all internal servo motors to allow robot motion.
Joint	Mechanical robot component that connects its moving parts.
LED Indicator	Multi-colored light on top of the outer link that provides a visual indication of the robot operating state.
Link	Mechanical robot component that moves in a radial motion.
Manual Mode	Operating state of the robot during commissioning, position teaching, and other setup operations.
SCARA	Selective Compliance Assembly Robot Arm
T20 Pendant	Optional, handheld device used to manually jog the robot, teach locations, and debug programs without a PC. This is also referred to as a Teach Pendant or a pendant.
Quill	Mechanical robot component that provides motion in the z-axis and rotary motion for the tool flange. This is a ball-screw mechanism.
Work Envelope	Working area that is accessible by the robot considering any end-of-arm tooling and part shapes that are attached.
Workspace	Total area that the robot occupies considering all capable range of motion.

1

Overview

This section provides general information about the robot.

1-1   Intended Use

The i4L robot is a selective compliance assembly robot arm (SCARA) for use within factory environ-
ments. It is designed to perform automated motion control typically used with material handling opera-
tions.
The i4L robot is capable of high speed, high-precision motion for payloads up to 5 kg. Its compact de-
sign and flexible programmability make it ideal for a wide variety of robotic applications.

1-2 Robot Features

This section provides information about the hardware features of the i4L robot.

- The robot can be mounted on a horizontal surface (table mount) or a vertical surface (wall mount) without the need for additional adapters or brackets.
- EtherCAT communications are built-in for easy integration with other networked devices.
- Cable connections can be arranged so that they exit through the mounting surface or parallel to the mounting surface.
- A highly visible, multi-colored LED light dome provides convenient indication of the robot status.
- The multi-colored LED light dome has an integrated brake release button built-in.
- A small and compact form factor is achieved with advanced internal controls and circuitry.
- Mounting points are available on the exterior of the robot for items such as cameras and solenoid valves.
- Pass through electrical and pneumatic ports are available from the base of the robot to the outer link.
- The Primary Interface Panel provides a central location for all cable connections and a Secondary Interface Panel on the outer link provides connections for end-of-arm tooling and other hardware.
- Built-in, optically isolated I/O provides 17 inputs and 12 outputs. I/O is expandable with optional I/O Blox units.
- Work envelope limits can be adjusted with configurable hard-stop points for robot joints 1, 2, and 3.

1-2-1 Robot Integrated System

The Robot Integrated CPU Unit provides the functionality of previous OMRON PLCs and also the functionality that is required for robot control. Control of I/O devices on high-speed EtherCAT can be applied to robots, safety devices, vision systems, motion equipment, discrete I/O, and more.
Built-in EtherCAT communications allow this robot to operate together with EtherCAT slaves, other Sysmac products, and the Sysmac Studio software to achieve optimal functionality and ease of operation.

Precautions for Correct Use

The NJ501 Robot Integrated CPU Unit must be connected to the robot for normal operation.
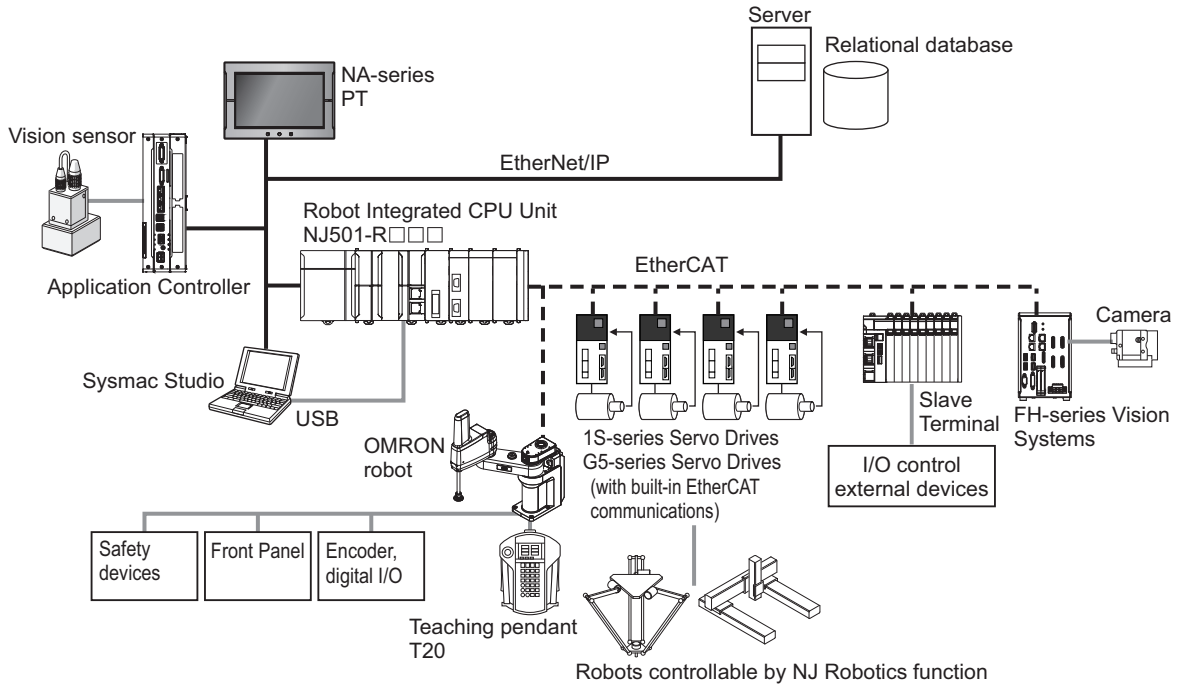
1-2-2 Basic Robot Components

The robot consists of the following components that are referred to throughout this manual. Use the information below to identify the robot's basic components.

Mechanical Components

Use the image below to identify the robot's mechanical components.
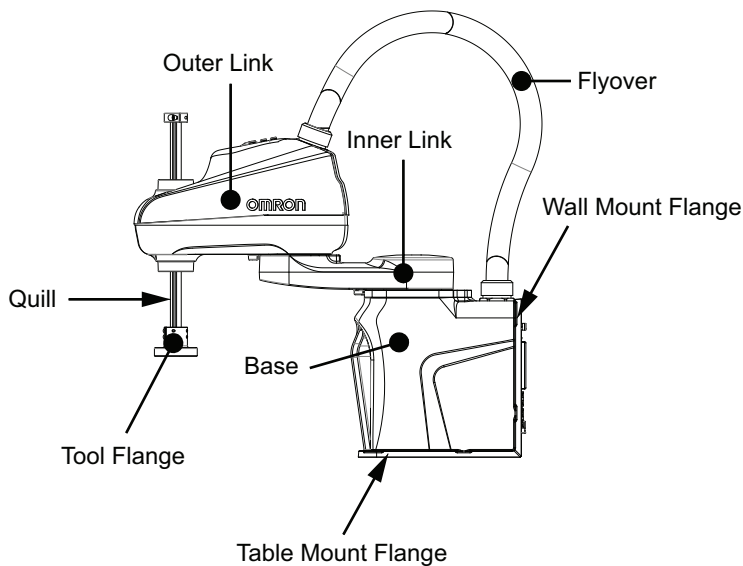
Axes of Motion

Use the following diagrams to understand the robot's 4 axes of motion.
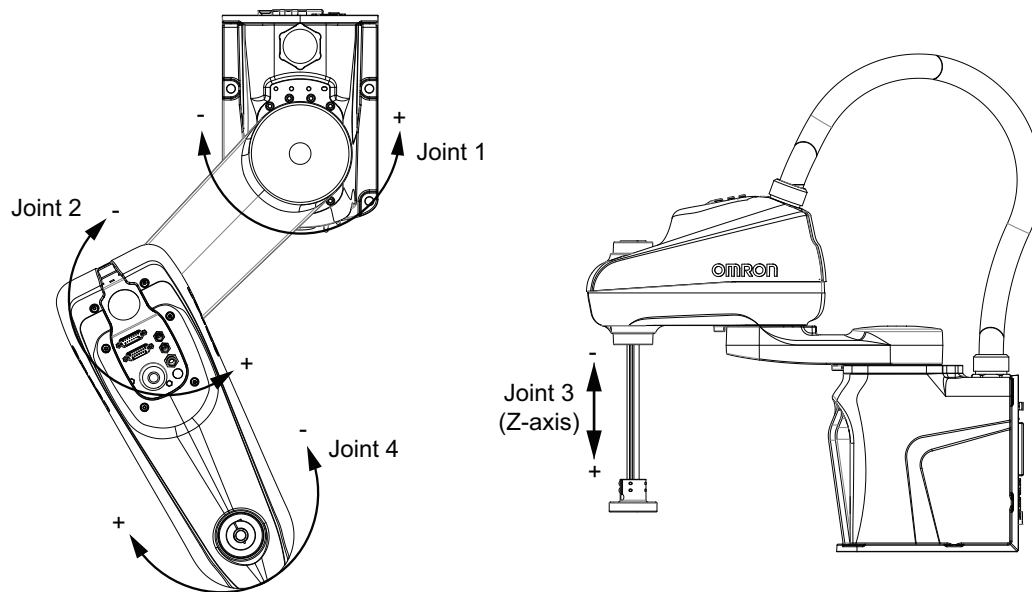
Interface Panels

Use the information below to identify the robot's interface panels and their functions.
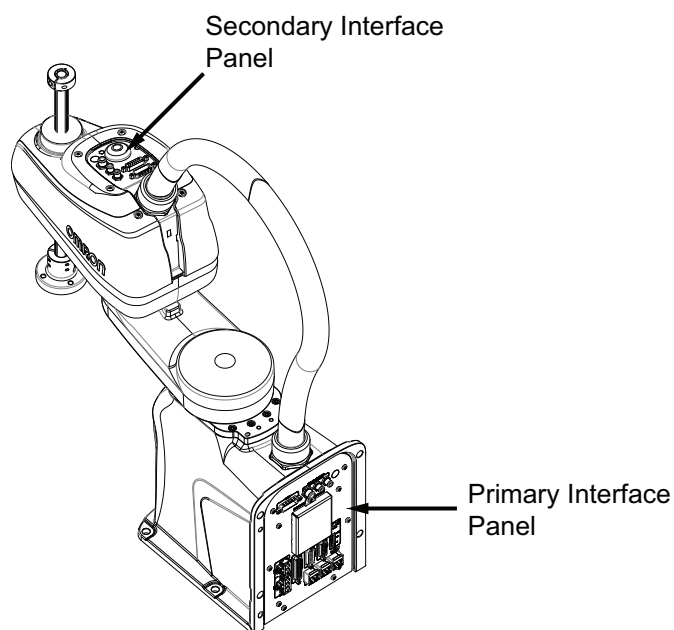
● Primary Interface Panel

The Primary Interface Panel is located on the base of the robot and provides access to the following items.

Pneumatic Pass-through Ports

USER Connector

Encoder Backup Battery Access

Control Power Connector

High Power Connector

Mode Switches

EtherCAT Node Switches

Ethernet Interface Port

XSYSTEM Connector

XBELTIO Connector

XIO Connector

EtherCAT Ports
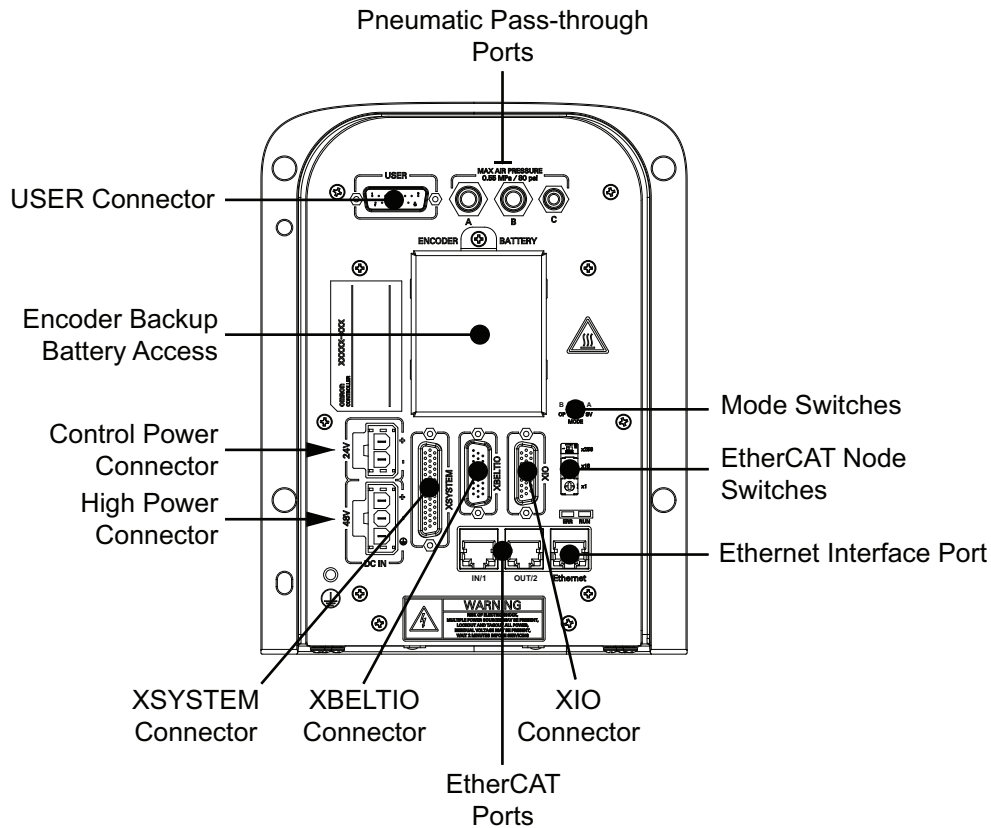
● **Secondary Interface Panel**

The Secondary Interface Panel is located on top of the outer link and provides access to the following items.

USER Connector

TIO Connector

LED Indicator / Brake Release

Pneumatic Pass-through Ports
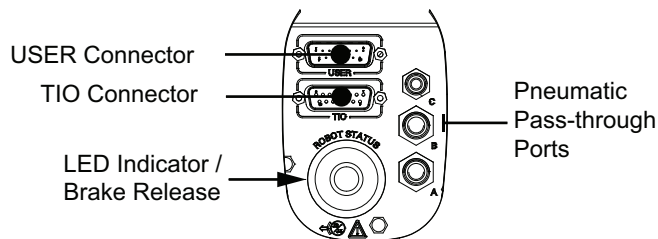
1-2-3 Front Panel

The Front Panel is a device that provides remote control and status functions when mounted a safe distance outside of the robot workspace. The Front Panel provides the following functions.

- Setting the robot mode to Manual or Automatic mode. Refer to *4-3 Robot Control Modes* on page 4-5 for more information.
- Indicating the robot High Power and Control Power state.
- Enabling robot High Power. Refer to *4-4-1 Robot High Power Operations* on page 4-8 for more information.
- Activating an emergency stop and disabling robot High Power.

If Front Panel signals need to be relocated, refer to *XFP Wiring Diagram* on page 3-38 for internal circuit details.

Precautions for Safe Use

If the supplied Front Panel is not used, a High Power indicator light must be present in the system. This indicator light must be amber in color. It must be either mounted to the robot or integrated into the work cell where it is visible from all approaches or entry points.

Precautions for Correct Use

- Either a Front Panel or equivalent circuits are required to enable High Power to the robot. Refer to *XFP Wiring Diagram* on page 3-38 for more information.
- If the Front Panel High Power ON / OFF indicator fails, you might incorrectly assume that High Power is OFF, and the robot is safe. To prevent this, a failed indicator causes an error (-924) *Front panel HIGH POWER lamp failure* and locks out the High Power enabling until you replace the indicator. Refer to the *V+ User's Manual (Cat. No. I671)* for more information about error handling. Refer to *High Power Indicator Check Procedure* on page 3-48 for information about High Power indicator operation verification.

Additional Information

- The Front Panel is supplied with an extension cable that must be used to connect it to the XFP connector on the XSYSTEM cable. Refer to *3-8-1 Installing the Front Panel* on page 3-34 for more information.
- Design of the factory-supplied Front Panel E-Stop is in accordance with the requirements of IEC 60204-1 and ISO 13849.

⚠ WARNING

- If you supply your own Front Panel, its design must comply with the requirements of IEC 60204-1 and ISO 13849. The E-Stop's push button must comply with ISO 13850 (Clause 5.5.2).
- If an operator is going to be in the work cell with the switch in Manual mode, the operator must carry an enabling device such as the T20 pendant.
- Whenever possible, perform Manual mode operations with all personnel outside the workspace.
- Disabling the High Power button violates IEC 60204-1. Do not alter its functionality.
- In Automatic mode, the robot can move unexpectedly. Ensure all personnel remain clear of the cell when Automatic mode is enabled.
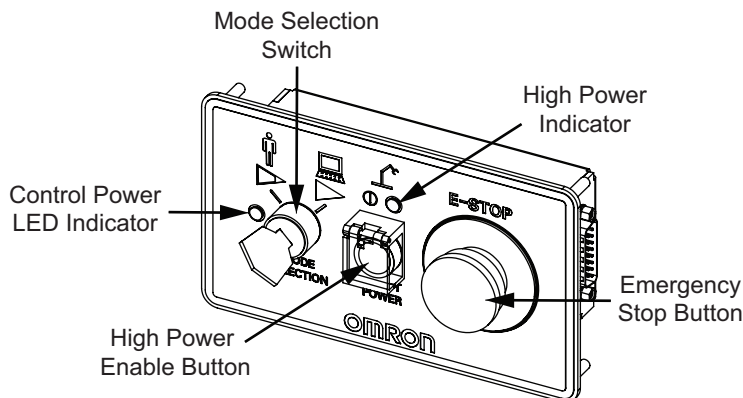
Use the information in the table below to understand Front Panel item details.

Item	Description
Control Power LED Indicator	Provides an indication that the robot is receiving 24 VDC Control Power with a green LED.

Item	Description
Mode Selection Switch	Controls the robot's operating mode. The left position selects Manual mode. The right position selects Automatic mode. Refer to *4-3 Robot Control Modes* on page 4-5 for more information.
High Power Indicator	Provides an indication of the robot's High Power state with an amber LED. Refer to *4-4 Enabling and Disabling the Robot* on page 4-8 for more information.
High Power Enable Button	Button to request robot High Power.
Emergency Stop Button[*1]	Button for emergency stopping of the robot.

*1. This switch is a dual-channel, passive E-stop device that supports Category 3 CE safety requirements.

1-2-4 Connectors and Ports

This section describes all connectors and ports on the robot.

USER Connectors

The USER connectors provide pass-through electrical signals from the Primary Interface Panel to the Secondary Interface Panel.

Pass-through electrical signals are typically used for end-of-arm tooling sensing and control.

All USER connector pin associations between the Primary Interface Panel and the Secondary Interface Panel are one-to-one. For example, pins 1 through pins 15 of the USER connector on the Primary Interface Panel are directly connected to pins 1 through 15 of the USER connector on the Secondary Interface Panel.

There are no twisted-pair conductors between the USER connectors on the Primary Interface Panel and the Secondary Interface Panel. Data communication is not recommended for these connectors.

> ### ⚠ CAUTION
>
> All signals that pass-through the USER connectors are not associated with any robot controls, emergency stop circuits, or robot power. Implement appropriate safety measures to ensure these signals are not active during emergency stop conditions or while the robot is powered OFF. ⚠

> **Additional Information**
>
> Refer to the following sections for more information.
> • *2-5-2 Connector and Port Specifications* on page 2-16
> • *3-4-2 USER Connector Wiring* on page 3-8

Control Power Connector

The Control Power connector is used to supply 24 VDC to the robot logic circuits. When power is supplied to this connector, the robot will boot up and control functions such as programming and configuration are possible.

A mating connector is supplied with the robot. Control power is user-supplied.

> **Precautions for Correct Use**
>
> Robot motion is not possible until High Power is supplied and has been enabled. Refer to *4-4 Enabling and Disabling the Robot* on page 4-8 for more information.

> **Additional Information**
>
> Refer to the following sections for more information.
> - *2-3-1 Power Supply Specifications* on page 2-13
> - *3-10-2 24 VDC Connections* on page 3-45

High Power Connector

The High Power connector is used to supply 48 VDC to the internal servo amplifiers.

When power is supplied to this connector and High Power has been enabled, the robot is ready to move.

A mating connector is supplied with the robot.

> **Precautions for Correct Use**
>
> - Robot motion is not possible until High Power is supplied and has been enabled.
> - Control Power must be present before High Power can be enabled.

> **Additional Information**
>
> Refer to the following sections for more information.
> - *2-3-1 Power Supply Specifications* on page 2-13
> - *3-10-3 48 VDC Connections* on page 3-45

XSYSTEM Connector

The XSYSTEM connector provides connections to external equipment such as a Front Panel, Teach Pendant, and user-supplied safety devices.

The robot is supplied with an XSYSTEM cable and jumper plugs. This cable provides connections for a Front Panel, Teach Pendant, and other user-supplied safety devices.

> **Additional Information**
>
> Refer to the following sections for more information.
> - *2-5-2 Connector and Port Specifications* on page 2-16
> - *Standard Connections* on page 3-23
> - *A-5 Cable Pinouts* on page A-9

XBELTIO Connector

The XBELTIO connector provides access to the following signals.

- Belt encoder inputs 1 and 2
- Expansion I/O
- RS-232

Additional Information

Refer to the following sections for more information.
- *XBELTIO Adapter Cable* on page 1-19
- *2-5-2 Connector and Port Specifications* on page 2-16
- *Optional Connections* on page 3-24
- *A-5 Cable Pinouts* on page A-9

XIO Connector

The XIO connector provides access to built-in I/O of the robot (12 inputs, 8 outputs).

Additional Information

Refer to the following sections for more information.
- *2-5-2 Connector and Port Specifications* on page 2-16
- *XIO Breakout Cable* on page 1-20
- *XIO Cable* on page 1-20
-

Ethernet Interface Port

The Ethernet interface port is used for service operations. Contact your local OMRON representative for more information.

Pneumatic Pass-through Ports

The pneumatic pass-through ports provide pass-through air lines from the Primary Interface Panel to the Secondary Interface Panel.
Pneumatic pass-through ports are typically used for end-of-arm tooling control.

Additional Information

Refer to *2-5-2 Connector and Port Specifications* on page 2-16 for more information.

TIO Connector

The TIO connector provides 5 digital inputs and 4 digital outputs for use with end-of-arm tooling. These signals are fully programmable for integration with robot motion, part sensing, and other robot functions.

Additional Information

- Refer to *3-7-2 TIO Connector Signals and Wiring* on page 3-30 for more information.
- Refer to *2-5-2 Connector and Port Specifications* on page 2-16 for more information.

1-3   Information Labels

The information labels contain relevant information about the robot and the controller.
The following examples will be different from your product label.

1-3-1   Robot Label

The robot label is described below.

Item	Name	Description
1	Part number [1]	The robot part number is displayed.
2	Product type	The product type is displayed.
3	Alerts and compliance	General alerts and compliance information is displayed.
4	Robot information	The robot model, weight, maximum payload, and maximum reach is displayed.
5	Electrical information	General electrical power supply information about the robot is displayed.
6	Production information	The following information is provided. • M/N indicates the model number and revision level. • SN indicates the serial number. • Lot. No. indicates the lot number in the format of DDMYYFF. Month number 1 to 9 for January to September, X for October, Y for November, and Z for December. FF is reserved for internal use. • Product origin information is displayed.

[1]   Refer to *1-5 Model Numbers* on page 1-15 for model information.

1-3-2   Controller Label

The controller label is described below.

Item	Name	Description
1	Part number *1	The controller part number is displayed.
2	Product type	The product type is displayed.
3	Alerts and compliance	General alerts and compliance information is displayed.
4	Controller information	The controller model and general electrical power supply information is displayed.
5	MAC Address	Reserved for future use.
6	Production information	The following information is provided. • SN indicates the serial number. • Lot. No. indicates the lot number in the format of DDMYYFF. Month number 1 to 9 for January to September, X for October, Y for November, and Z for December. FF is reserved for internal use. • Product origin information is displayed.

*1.   Refer to *1-5 Model Numbers* on page 1-15 for model information.

1-4   Robot Configurations

The i4L robot is offered in a variety of configurations with different work envelopes and z-axis stroke lengths.

1-4-1   i4-350L

The i4-350L configuration has a reach of 350 mm and a z-axis stroke of 180 mm.
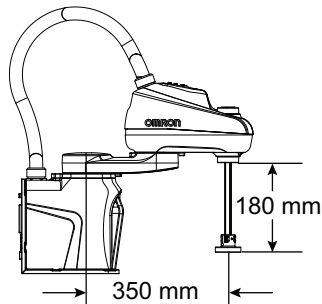
1-4-2   i4-450L

The i4-450L configuration has a reach of 450 mm and a z-axis stroke of 180 mm.
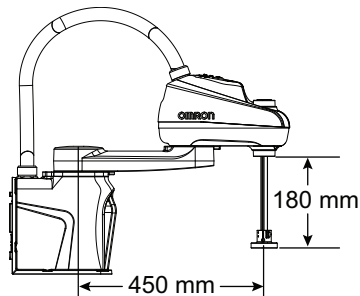
1-4-3   i4-550L

The i4-550L configuration has a reach of 550 mm and a z-axis stroke of 180 mm.
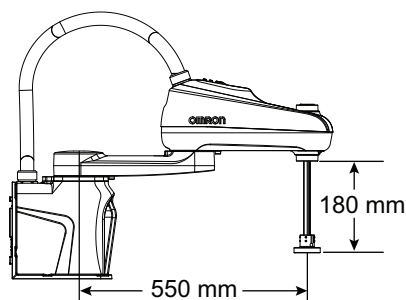
1-4-4   i4-550L (350 mm Z)

The i4-550L (350 mm Z) configuration has a reach of 550 mm and a z-axis stroke of 350 mm.
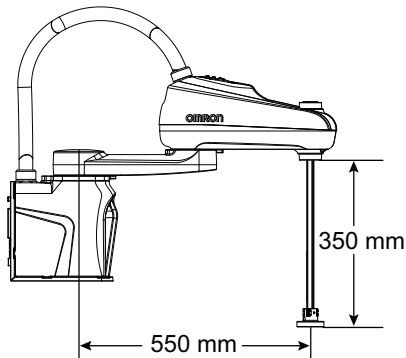
1-4-5   Mounting and Cabling Options

The robot has a table mount flange and a wall mount flange integrated into the base. This allows the robot to be table-mounted or wall-mounted without the need for additional brackets or adapters.
The rear / bottom Primary Interface Panel orientation options allow cables to exit through the mounting surface or parallel to the mounting surface as shown below.
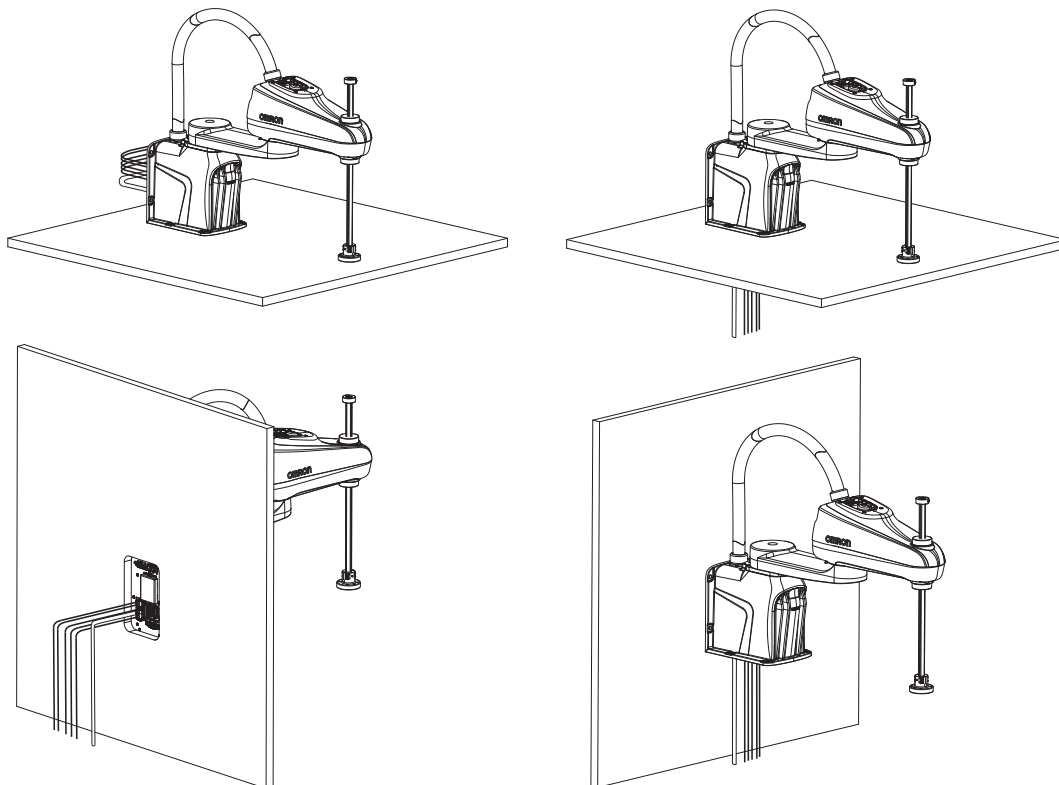
1-5   Model Numbers

Models numbers and descriptions associated with the robot are provided below.

1-5-1   Robot Model Numbers

The table below provides all robot model numbers and descriptions.

Model Number	Reach	Z-axis Stroke	Primary Interface Panel Orientation
RS4-2063002	350 mm	180 mm	Rear
RS4-2064002	450 mm		
RS4-2065002	550 mm		
RS4-2065004	550 mm	350 mm	
RS4-2063102	350 mm	180 mm	Bottom
RS4-2064102	450 mm		
RS4-2065102	550 mm		
RS4-2065104	550 mm	350 mm	

1-5-2   Controller Model Numbers

The table below provides all robot controller model numbers and descriptions.

Model Number	Description
i4L-iCS	Internal controller for the robot..

1-6   Optional Hardware

The following optional hardware is available for the robot.

1-6-1   IO Blox

IO Blox units are available to expand the I/O capacity of the robot. Each unit offers 8 inputs and 8 outputs. Up to 4 IO Blox units can be added to the robot.
- The part number for an IO Blox unit connected directly to the robot is 90356-30200.
- The part number for IO Blox units connected to another IO Blox unit is 90356-30100.

> **Additional Information**
>
> Refer to the following areas for more information.
> - *3-7-3 IO Blox Connections* on page 3-32
> - Omron Adept IO Blox User's Guide (04638-000)
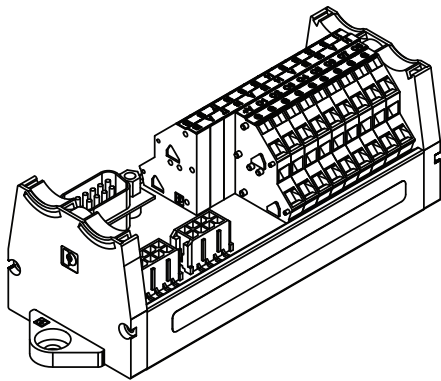
1-6-2   T20 Pendant

The T20 pendant is an optional handheld device that allows you to manually jog the robot, teach locations, and view V+ programs without a PC.
- The part number for the pendant kit is 10046-010. This kit includes the T20 pendant, an adapter cable (3 m), and a jumper plug.
- The adapter cable includes a round, 17-pin connector that can be panel-mounted. It can be mounted to a surface with up to 6.5 mm of thickness and requires an M23 hole.

> **Precautions for Correct Use**
>
> The T20 pendant can only control the robot it is directly connected to.

> **Additional Information**
>
> Refer to the following areas for more information.
> - *3-6-1 System Cable Overview* on page 3-23
> - *T20 Pendant User's Manual (Cat. No. I601)*
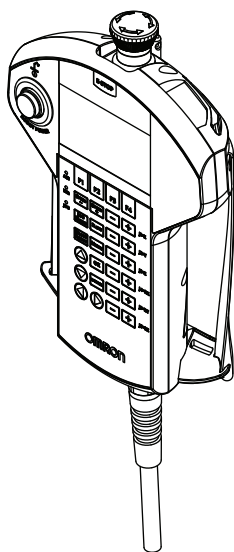
1-6-3 IPC Application Controller

The IPC Application Controller can be added to your system to execute PackManager and Robot Vision Manager applications.

The Pack Manager application controls automated pick-and-place systems with cameras, conveyors, and robots based on the data that you set up in the Sysmac Studio. It is executed on the IPC Application Controller to control the process data and recipe data.

The Robot Vision Manager application processes images captured by cameras based on the data that you set up in the Sysmac Studio. It is executed on the IPC Application Controller.

Additional Information

Refer to the following areas for more information.
- *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)*
- *IPC Application Controller User's Manual (Cat. No. I632)*
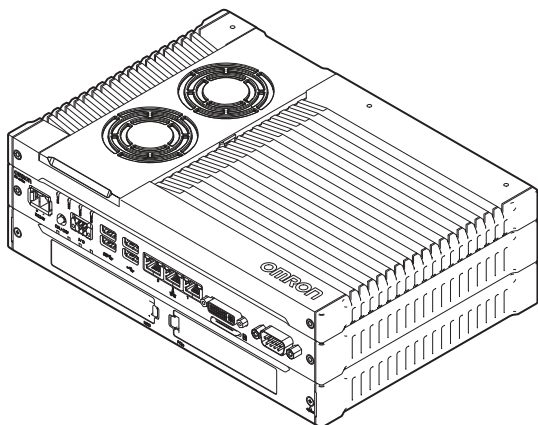
1-6-4 XIO Termination Block

The XIO Termination Block is used to connect digital I/O devices to the robot. This unit provides terminal block connection points for 12 inputs and 8 outputs. LED indicators are provided to indicate

ON/OFF status. Each input has a switch to simulate input signals for troubleshooting or testing purposes.

Use the XIO cable to connect the XIO Termination block to the robot.

The part number for the XIO Termination Block is 90356-40100 (2 m cable included).

> **Additional Information**
>
> Refer to the following areas for more information.
> - *XIO Cable* on page 1-20
> - *Adept XIO Termination Block Installation Guide (00340-000)*
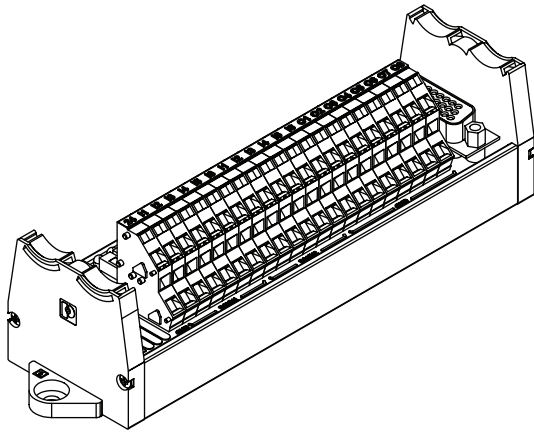
1-6-5   Optional Cables

This section provides information about optional cables that are available.

XIO Cable
XIO Breakout Cable
EXPIO to IO Blox Cable
XBELTIO Adapter Cable
Belt Encoder Y-adapter Cable
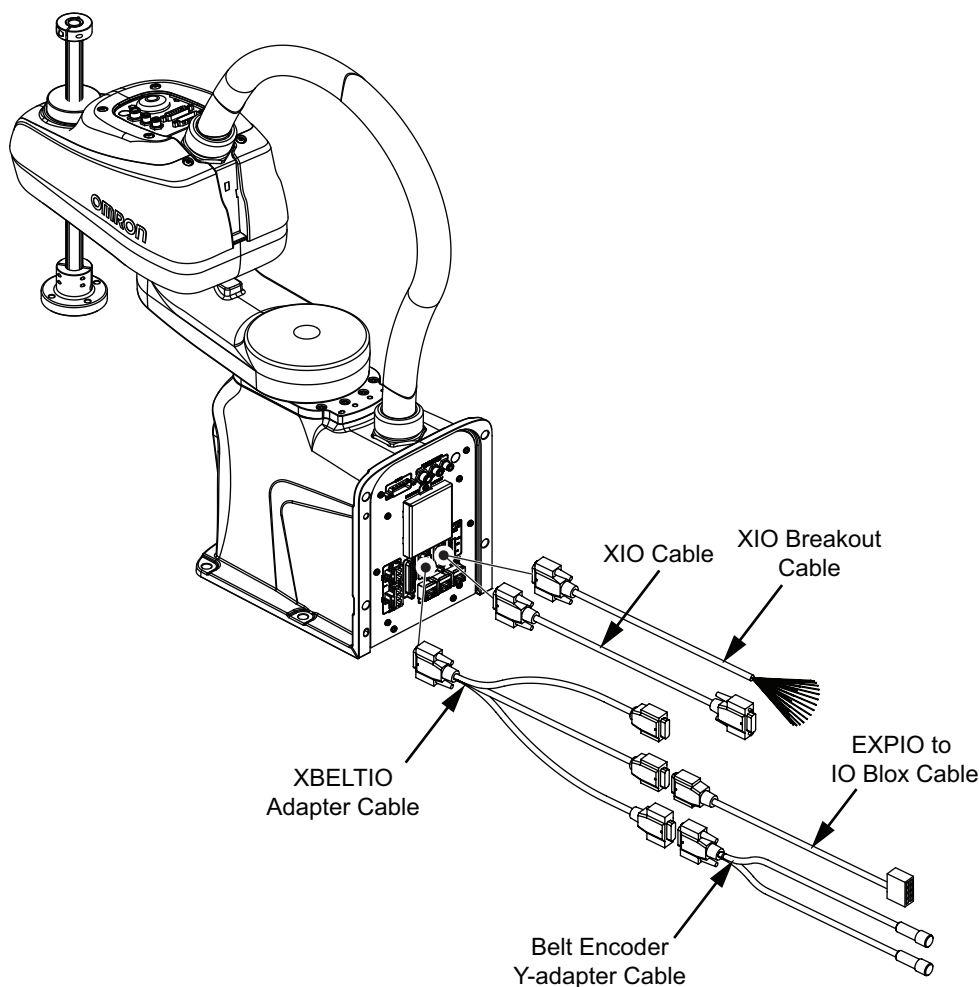
XBELTIO Adapter Cable

The optional XBELTIO adapter cable connects to the XBELTIO connector on the Primary Interface Panel. It provides connections for belt encoder, force sensor, RS-232, and IO Blox signals.

- The part number for this cable is 13463-000.
- The length of this cable is 600 mm.

Additional Information

Refer to *A-5-2 XBELTIO Adapter Cable Pinouts* on page A-10 for more information.

Belt Encoder Y-adapter Cable

The optional belt encoder Y-adapter cable connects to the XBELTIO adapter cable's BELT ENCODER connector. This cable provides individual connections for two belt encoder input signals.

- The part number for this cable is 09443-000.
- The length of this cable is 3 m.

Additional Information

Refer to *A-5-3 Belt Encoder Y-adapter Cable Pinouts* on page A-11 for more information.

XIO Breakout Cable

The optional XIO breakout cable connects to the XIO connector on the Primary Interface Panel and provides a method to connect I/O devices directly to the robot without using an XIO Termination Block unit.
- This cable is not compatible with the XIO Termination Block.
- This cable cannot be used together with an XIO cable.
- The part number for this cable is 04465-000.
- The length of this cable is 5 m.

Additional Information

Refer to *3-7-1 XIO Connector Signals and Wiring* on page 3-26 for more information.

XIO Cable

The optional XIO cable connects to the XIO connector on the Primary Interface Panel. It is used to connect an XIO Termination Block to the system.
- This cable cannot be used together with the XIO Breakout cable.
- The part number for this cable is 03695-000.
- The length of this cable is 2 m.

Additional Information

Refer to the following areas for more information.
- *1-6-4 XIO Termination Block* on page 1-17
-

EXPIO to IO Blox Cable

The optional EXPIO to IO Blox cable connects to the XBELTIO adapter cable's FORCE/EXPIO connector. It allows a direct connection between this connector and optional IO Blox units.
- The part number for this cable is 04677-030.
- The length of this cable is 3 m.

Additional Information

Refer to the following areas for more information.
- *3-7-3 IO Blox Connections* on page 3-32
- *Omron Adept IO Blox User's Guide (04638-000)*

1-6-6 Camera Mounting Bracket Kit

A camera mounting bracket can be used to attach a Basler or Sentech camera to the robot outer link. This is fastened to the bottom of the outer link, near the z-axis quill exit.

The part number of the camera mounting bracket kit is 23693-000. This kit includes all hardware and fasteners to attach a Basler or Sentech camera to the robot outer link as shown below.
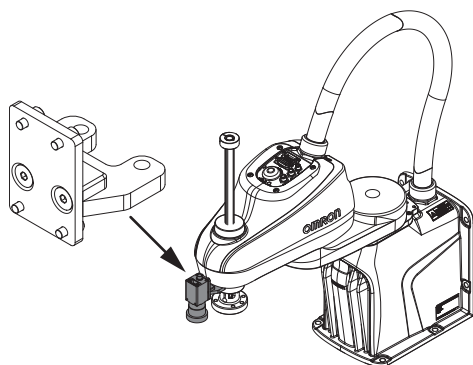
Apply Loctite 222 or equivalent thread locking compound to all screws. Apply the following torque values when tightening the screws.

- 51120-67010: 2.9 N-m
- 04221001184-0006: 1.3 N-m
- 51006-69012: 5.7 N-m
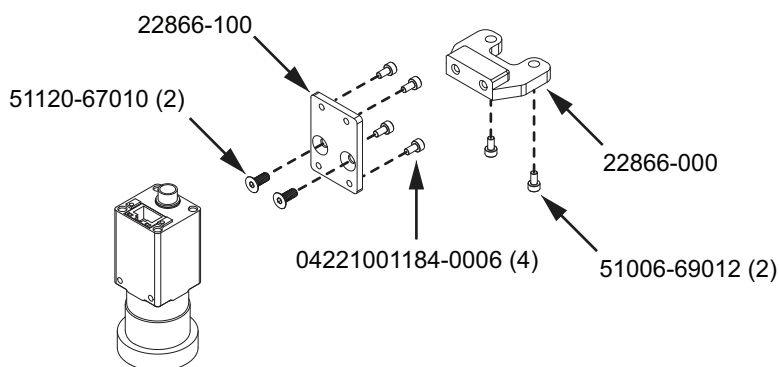
The following items are included in the camera mounting bracket kit for cable management.

- 23681-000 (2)
- 27300-00024 (4)

Item 23681-000 can be installed for cable management. Remove the outer link cover, drill 0.25 inch holes in the locations shown below, and then insert the cable tie mounts. Refer to *3-4-4 Pneumatic Valve Kit Installation Procedure* on page 3-15 for more information about outer link cover removal and replacement.
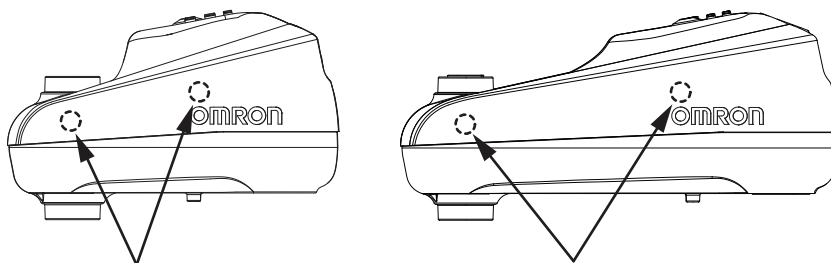
1-6-7   Bellows Kit

Bellows are an optional item that can be placed on upper and lower exposed portions of the Joint 3 quill for additional environmental protection. Bellows prevent debris or liquid from entering the internal compartment of the outer link, protect the Joint 3 quill, and prevent contamination of items external to the robot.

A hole is present at the top of the bellows assembly that can be used for a user-supplied seal fitting if cabling or tubing needs to pass through the Joint 3 quill.

The part number for bellows kits are provided below. All components are supplied for installation.

• Bellows Kit (180 mm quill): 22839-000
• Bellows Kit (350 mm quill): 22868-000
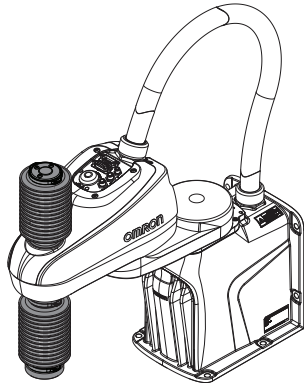
Precautions for Correct Use

The z-axis stroke is reduced when bellows are present. Bellows reduce the travel by 27 mm (180 mm quill length) / 53 mm (350 mm quill length) in the z-axis retracted position and 27 mm (180 mm quill length) / 53 mm (350 mm quill length) in the z-axis extended position. Always adjust joint motion limits with software settings in the robot configuration area when bellows are installed to restrict range of motion. Refer to the *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* for more information.

Additional Information

Refer to *3-4-3 Bellows Kit Installation Procedure* on page 3-9 for more information.

1-6-8 Pneumatic Valve Kit

Three pneumatic valves can be mounted to the outside of the outer link to control devices such as grippers or end-effectors. The valves are connected to the TIO connector on the Secondary Interface Panel and controlled with V+ signals.

The part number of the pneumatic valve kit is 22872-000.

The pneumatic valve kit includes all necessary hardware to mount and electrically connect the valves to the robot.
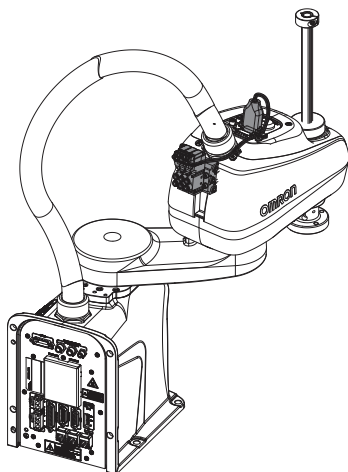
> **Additional Information**
>
> - When the pneumatic valve kit is installed, TIO signals are allocated for valve solenoid control. Refer to *Pneumatic Valve Kit Signals* on page 3-32 for more information.
> - Valve types are SMC type VQZ1121-5MO1-C4-Q.
> - Refer to *3-4-4 Pneumatic Valve Kit Installation Procedure* on page 3-15 for more information.

1-6-9 Power Supply Kits

Optional power supply kits are available to provide Control Power and High Power to the robot.

Control Power Kit

The Control Power Kit provides 24 VDC power to the robot. This kit consists of a power supply and the required DC connector and cable. The connector is pre-installed on the cable.

- The Control Power Kit part number is 23916-000.
- The power supply part number is S8VK-G24024.
- The length of the cable from the power supply to the robot is 5 m.

> **Additional Information**
>
> Refer to the following areas for more information.
> - *3-4-5 Control Power Kit Connections* on page 3-19
> - *S8VK-G Series Switch Mode Power Supply Datasheet (Cat. No. T056)*
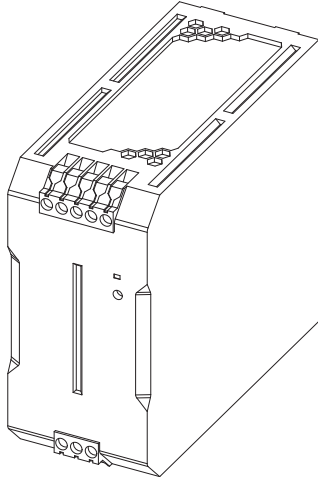
High Power Kit

The High Power Kit provides 48 VDC power to the robot. This kit contains two 48 VDC power supplies, a redundancy unit, and all required DC cables and connectors. All connectors are pre-installed on the cables.

• The High Power Kit part number is 23913-000.
• The power supply part number is S8VK-G48048.
• The redundancy unit part number is S8VK-R20.
• The length of the cable from the power supply to the robot is 5 m.

> **Additional Information**
>
> Refer to the following sections for more information.
> • *3-4-6 High Power Kit Connections* on page 3-19
> • *S8VK-G Series Switch Mode Power Supply Datasheet (Cat. No. T056)*
> • *S8VK-R Series Redundancy Unit Datasheet (Cat. No. T059)*

48 VDC Power
Supplies

Redundancy
Unit
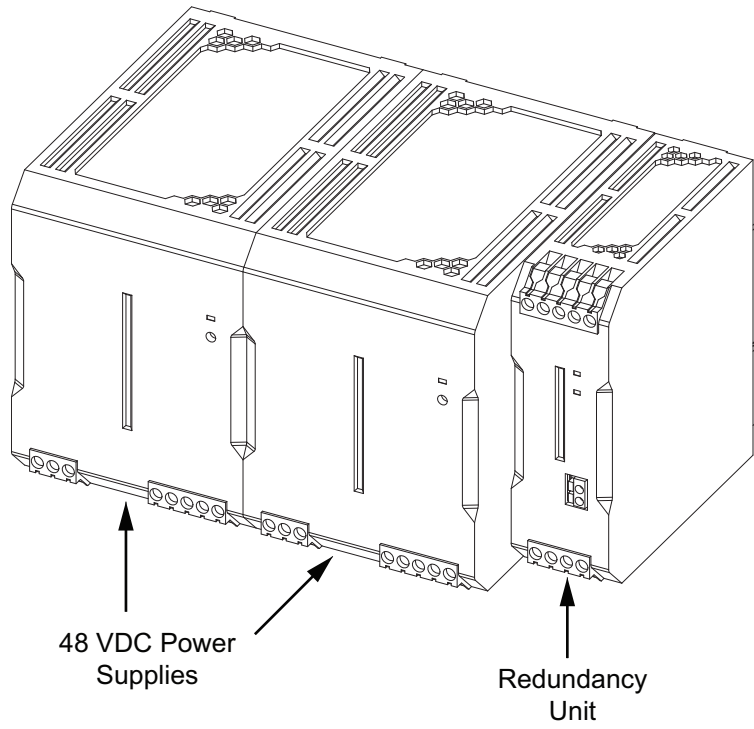
2

Specifications

This section provides specifications for the robot's hardware, performance, electrical connections, installation environment, and other technical aspects of the system.

2-1 Physical Specifications

This section provides physical specifications for the i4L robot.

2-1-1 Robot Overall Dimensions

Use the diagrams below to understand the robot's overall physical dimensions.

i4-350L Dimensions

Overall dimensions for the i4-350L are provided below.
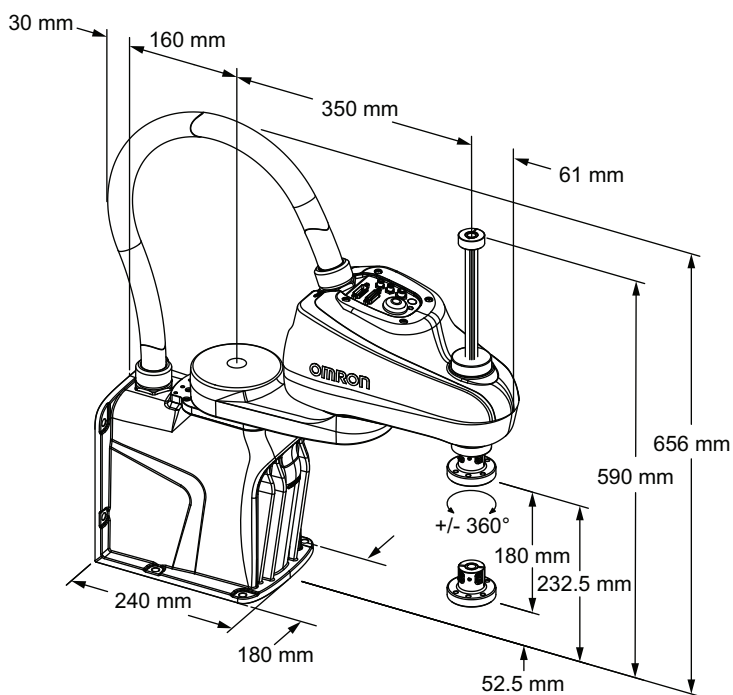
i4-450L Dimensions

Overall dimensions for the i4-450L are provided below.

160 mm
450 mm
61 mm
642 mm
600 mm
+/- 360°
180 mm
242.5 mm
240 mm
180 mm
62.5 mm
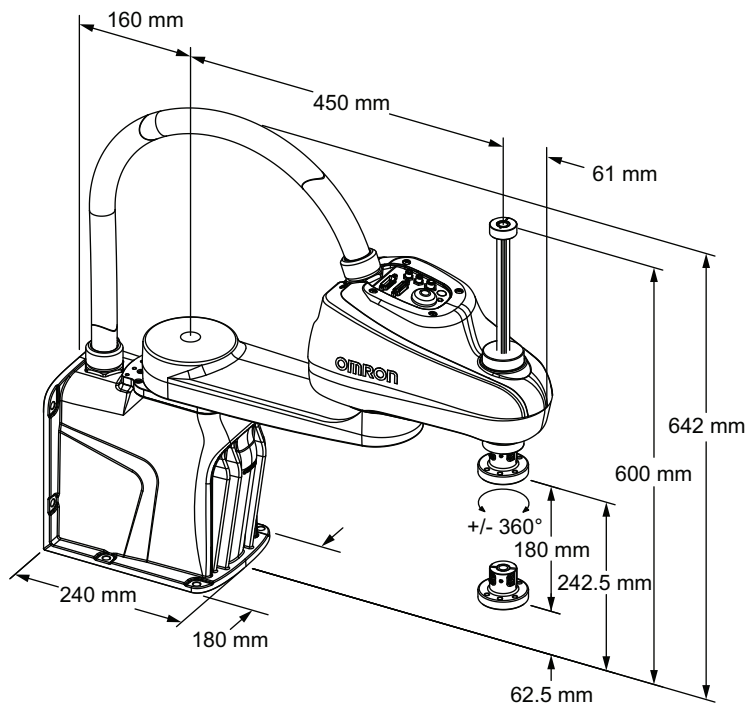
i4-550L Dimensions

Overall dimensions for the i4-550L are provided below.

160 mm
550 mm
61 mm
642 mm
600 mm
+/- 360°
180 mm
242.5 mm
240 mm
180 mm
62.5 mm
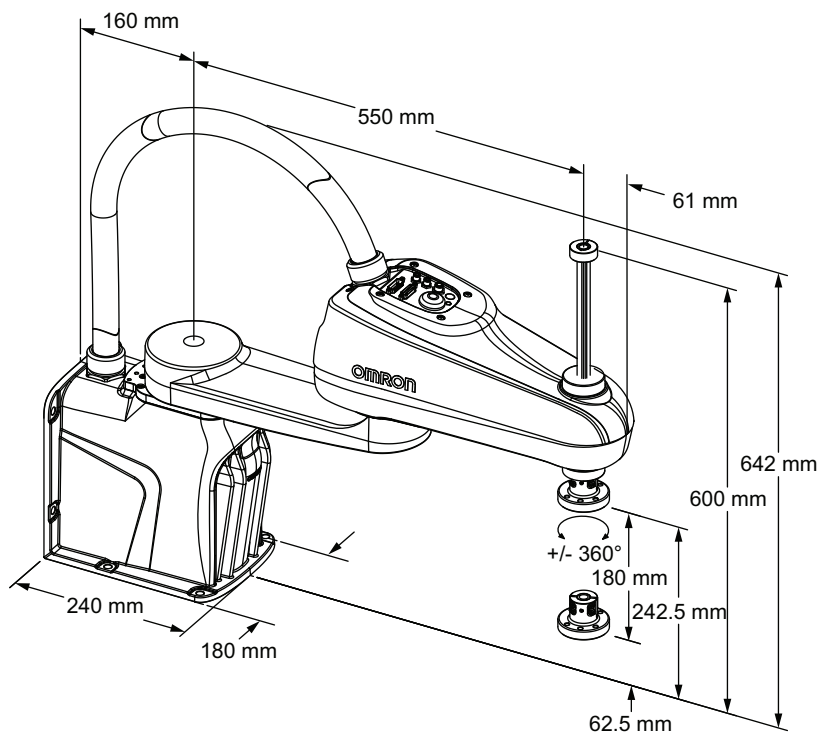
i4-550L (350 mm Z) Dimensions

Overall dimensions for the i4-550L (350 mm Z) are provided below.
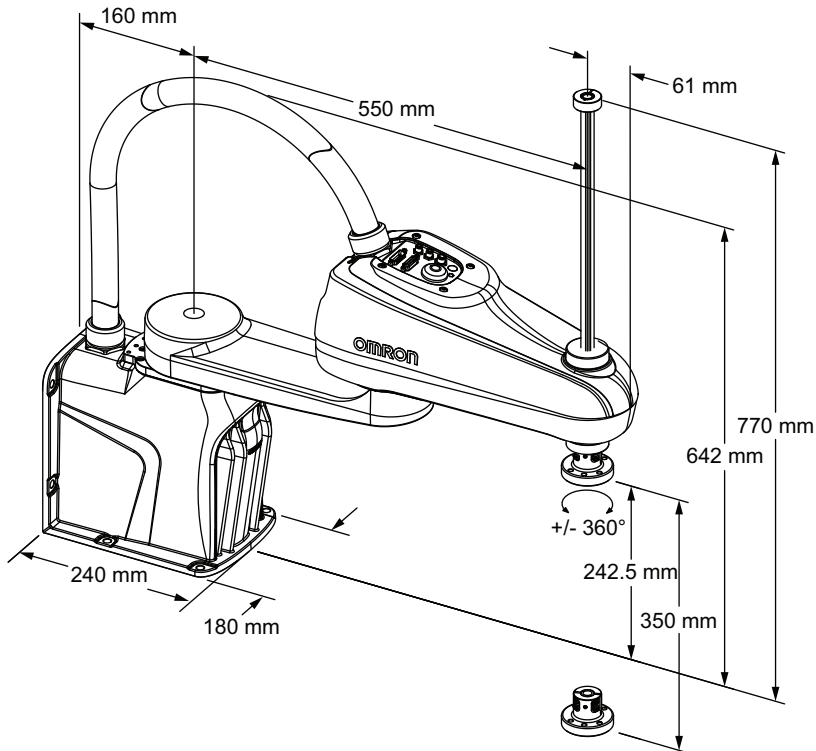
Cable Clearances

There must be at least 183 mm of clearance from the Primary Interface Panel connectors to provide adequate space for cables. These clearances apply to all robot models.

2-1-2   Mounting Flange Dimensions

The robot's mounting flange dimensions are provided below.
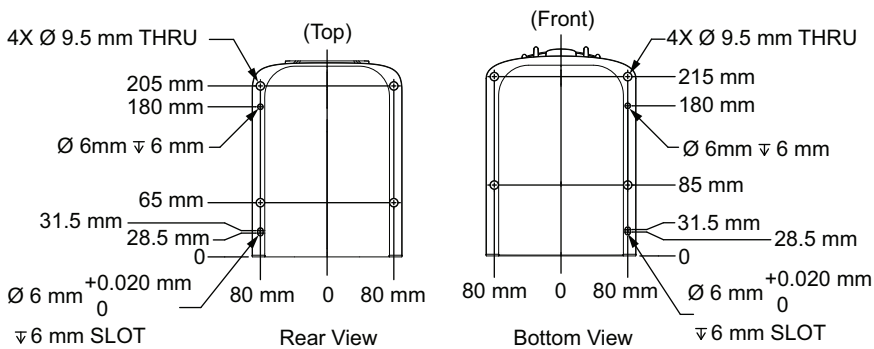
Cable Exit Cutout Dimensions

Use the cutout dimensions provided below when cables exit the mounting surface.

Top

220 mm

59 mm

Mounting Holes (x4)

R 20 mm

20 mm

120 mm

Front

220 mm

79 mm

Mounting Holes (x4)

R 20 mm

20 mm

120 mm
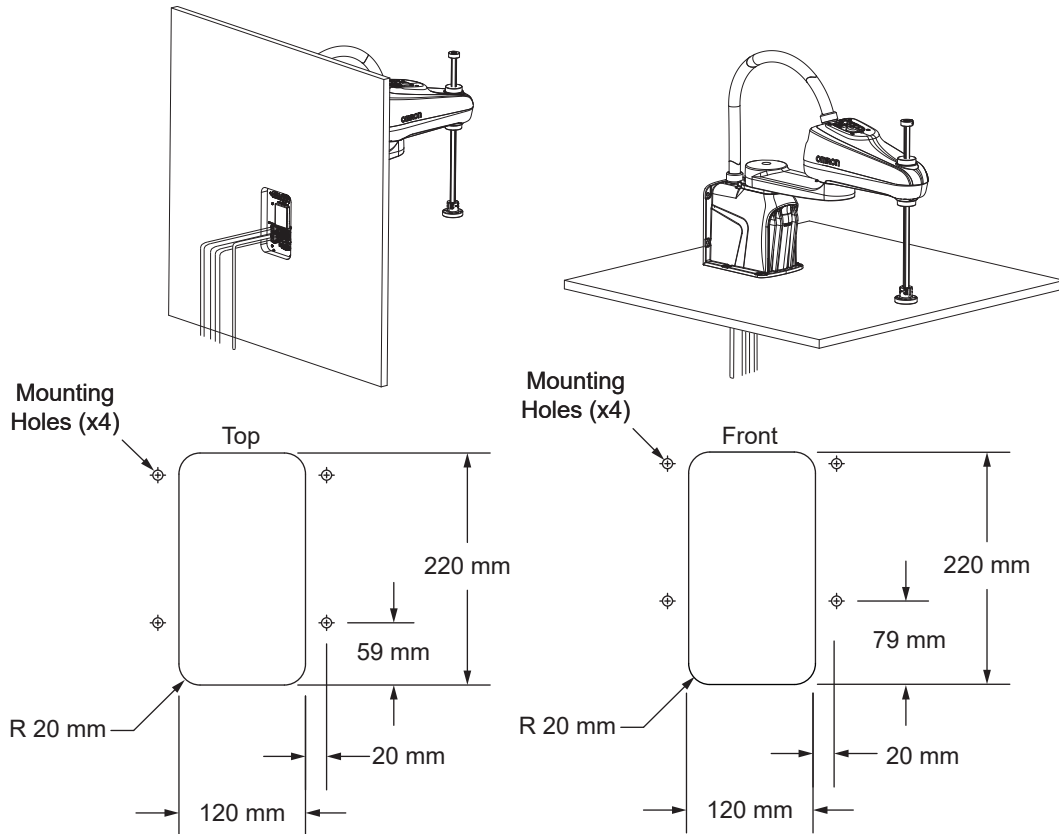
2-1-3 Tool Flange Dimensions

The robot's tool flange dimensions are provided below. Geometry and tolerances meet ISO-9409-1-50-4-M6 (2004) requirements for manipulating industrial robots.

SECTION A-A
SCALE 1:1

13 mm
6.8 mm
0
1 mm x 45°

R 0.3 mm
1 mm x 45°

b | 0.02 | B

A

B

$\varnothing$ 31.5 mm $^{+0.025}_{0}$
H7

$\varnothing$ 63 mm $^{0}_{-0.046}$
H8

r | n 0.02 | A | B

45°

C

$\varnothing$ 6 mm $^{+0.015}_{0}$ THRU

j | n 0.040 | A | B

$\varnothing$ 50 mm

90°

A

A

4 X $\varnothing$ 5.5 mm THRU
M6 x 1.0 6H THRU

j | n 0.2 | A | B | C
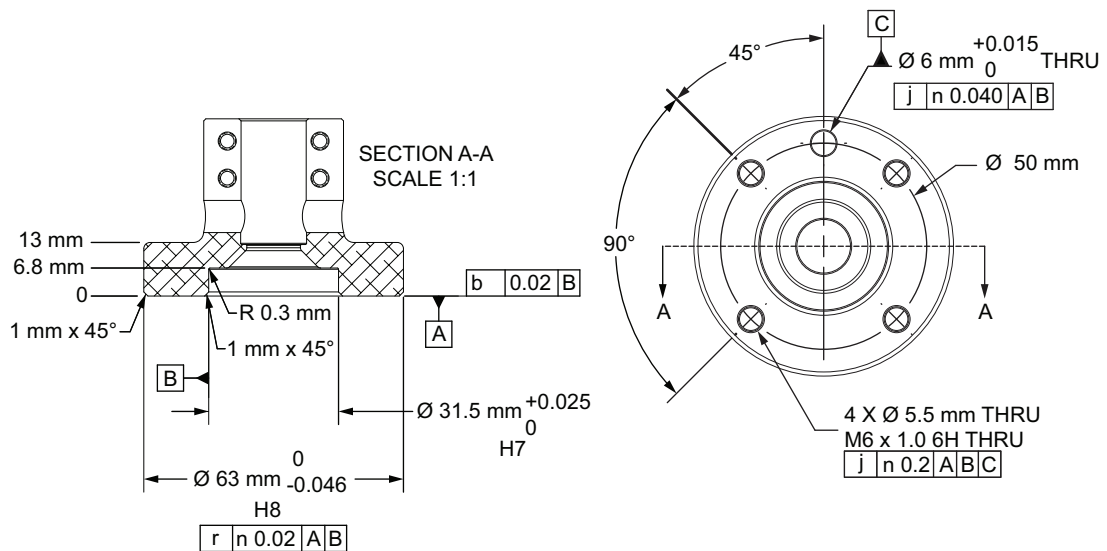
2-1-4 Front Panel Dimensions

The Front Panel dimensions are provided below.
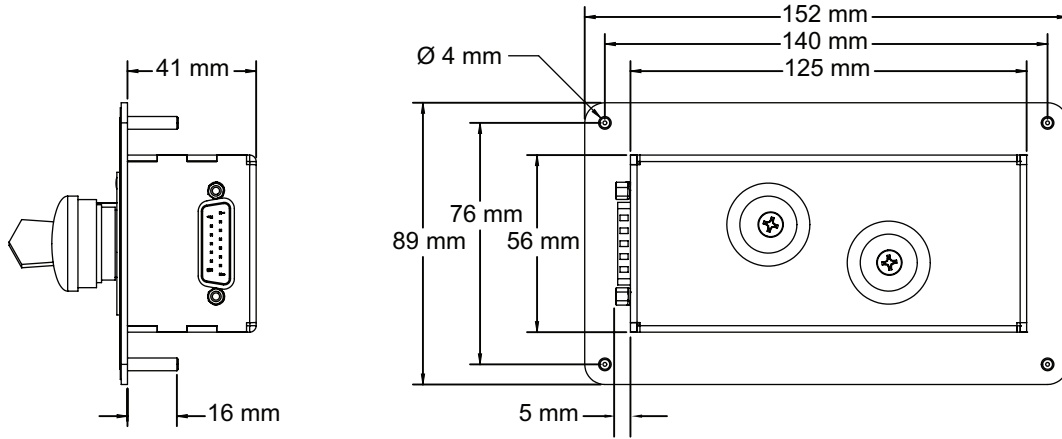
2-1-5   Camera Mounting Bracket Dimensions

The camera mounting bracket dimensions are provided below.
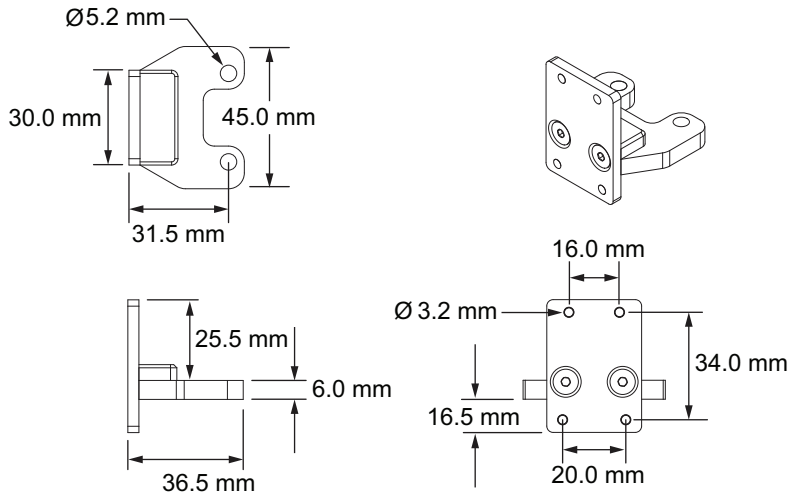
2-1-6   Robot Work Envelope Dimensions

Use the diagrams below to understand the robot's working envelope dimensions.

i4-350L Work Envelope
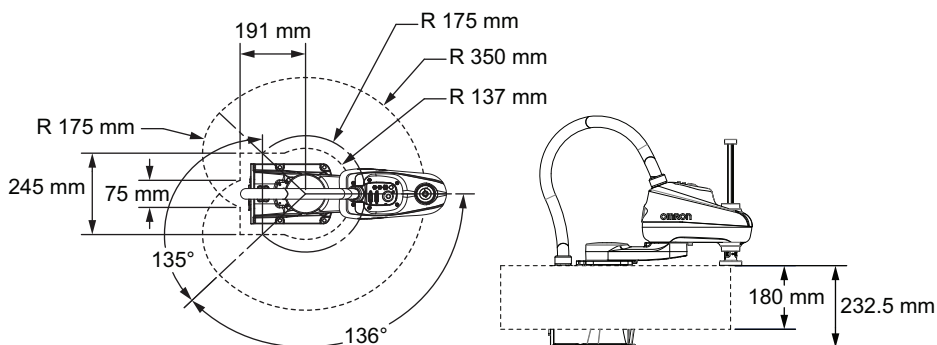
Work envelope dimensions are provided below.

i4-450L Work Envelope

Work envelope dimensions are provided below.

191 mm
R 275 mm
R 450 mm
R 156.5 mm
R 175 mm
245 mm
148°
136°
180 mm
242.5 mm

i4-550L Work Envelope

Work envelope dimensions are provided below.

20 mm
191 mm
R 275 mm
R 550 mm
R 150 mm
R 275 mm
245 mm
79 mm
148°
136°
180 mm
242.5 mm
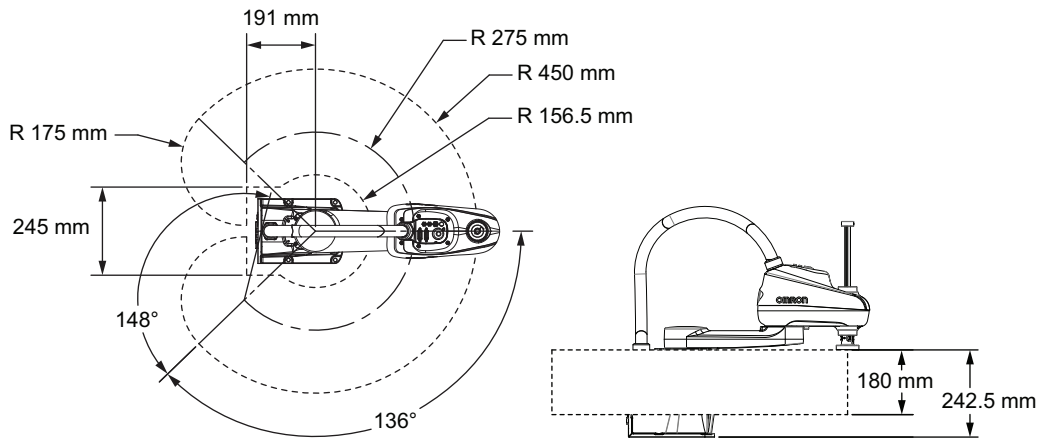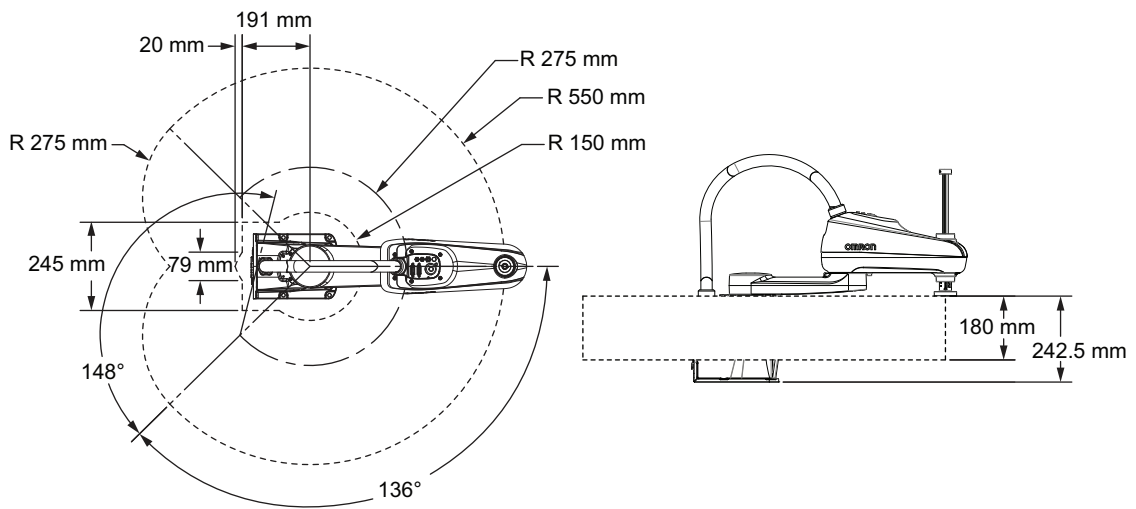
i4-550L (350 mm Z) Work Envelope

Work envelope dimensions are provided below.
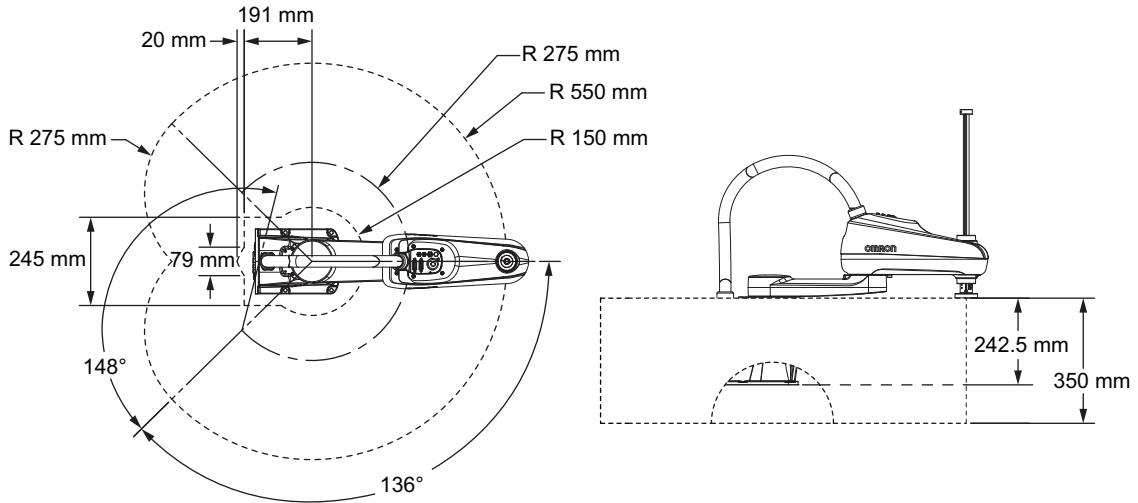
2-1-7   Robot Weights

Weights for the different robot models are provided in the following table.

📰 **Additional Information**

Weights provided do not include optional accessories.

Robot Model	Weight
i4-350L	15.1 kg
i4-450L	15.9 kg
i4-550L	16.4 kg
i4-550L (350 mm Z)	16.5 kg

2-2 Performance Specifications

The following sections provide robot performance specifications.

2-2-1 General Performance Information

The following table provides general performance information for the robot.

Item		i4-350L	i4-450L	i4-550L	i4-550L (350 mm Z)
Payload[*1]		2 kg rated 5 kg maximum			
Reach		350 mm	450 mm	550 mm	
Joint Range	Joint 1	±136°			
	Joint 2	±136°	±148°		
	Joint 3	180 mm			350 mm
	Joint 4	±360°			
Joint 4 Moment of Inertia		0.05 kg-m^2 maximum			
Cycle Time[*2]		0.57 s		0.54 s	
Downward Push Force burst with no load[*3]		150 N			
Repeatability at 100% speed		X, Y: 0.01 mm Joint 3: 0.01 mm Joint 4: 0.01°			
Joint speeds (maximum)	Joint 1	456 degrees/s			
	Joint 2	456 degrees/s			
	Joint 3	800 mm/s			
	Joint 4	6000 degrees/s			

*1. Payload is considered as any object(s) attached to a robot link or tool flange including items such as end effectors, tooling, valves, grippers, and objects being handled by the robot.

*2. Cycle time is defined as a continuous path with straight-line motion cycle in which the robot tool moves up 25 mm, over 305 mm, down 25 mm, and then back along the same path (not achievable over all paths in the robot working envelope). Values listed are for sustained motion, no joint 4 rotation, with a 2 kg payload, at 20° C ambient temperature.

*3. At a duty cycle of 1 second pushing and then 3 seconds not pushing.

Z-axis Quill Bending Moments

When the robot is operating at high payloads with high acceleration / deceleration, the z-axis quill may be subject to excessive bending moments. Careful considerations must be made under these conditions. Refer to *4-2 Payload and Acceleration Considerations* on page 4-4 for more information.

2-2-2 Stopping Distances and Times

The following graphs present information required by Clause 7.2 n of ISO 10218-1. This information should be used to calculate the safe distance needed when designing and installing safeguarding devices.

⚠ **WARNING**

The stopping time and distance, or angle, of a robot joint from initiation of a stop signal is not negligible and must be taken into account when designing and applying safeguarding devices.

⚠

The graphs show the time elapsed and distances traveled between the initiation of a stop signal and the cessation of all robot motion.

For stop category 1, the stopping time and distance values depend on the speed, load, and extension of the robot, stated for 33%, 66% and 100% of the maximum payload (5 kg). Data provided is for the three joints of greatest displacement (J1, J2, and J3).

Joint 1 Stopping Time
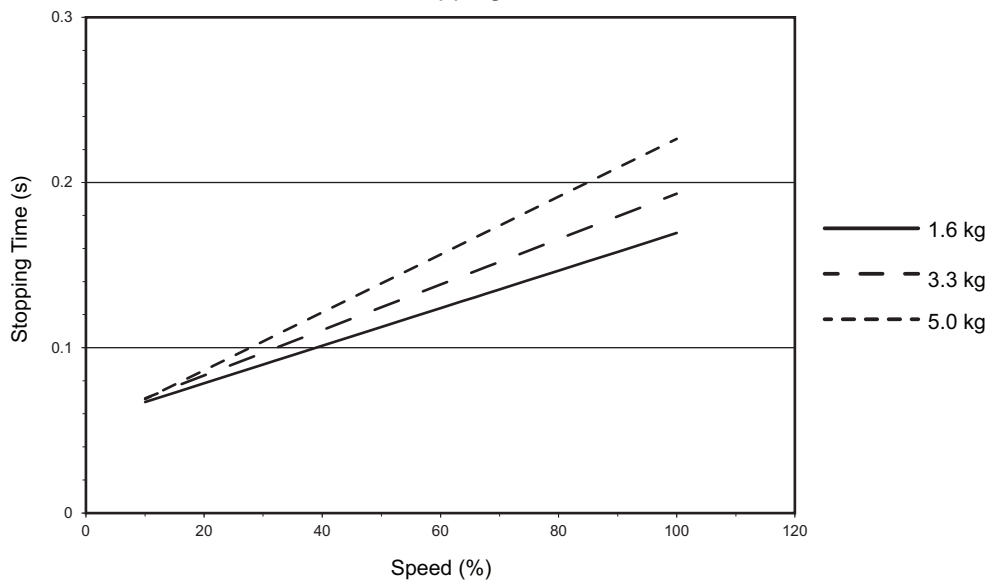
Joint 1 Stopping Distance
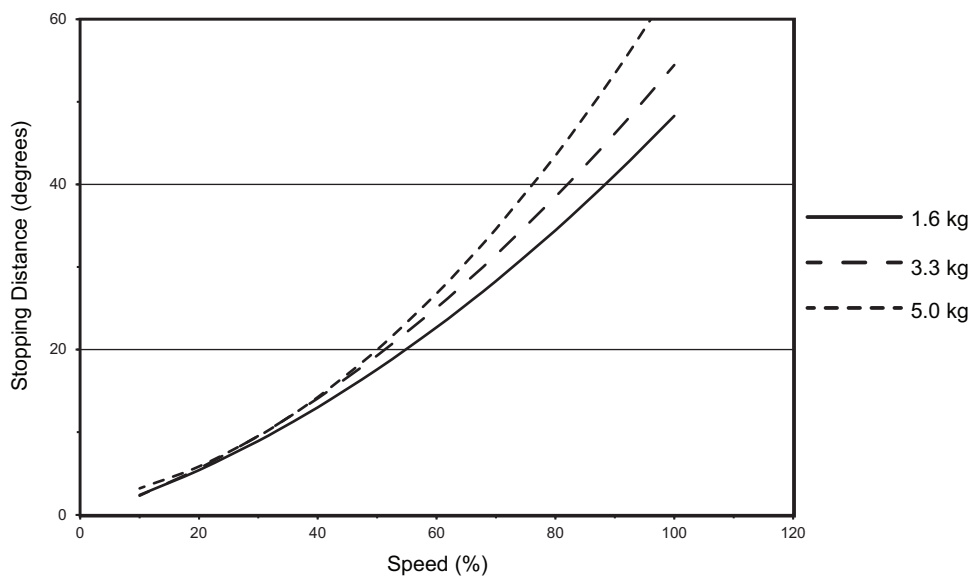
Joint 2 Stopping Time (all payloads)
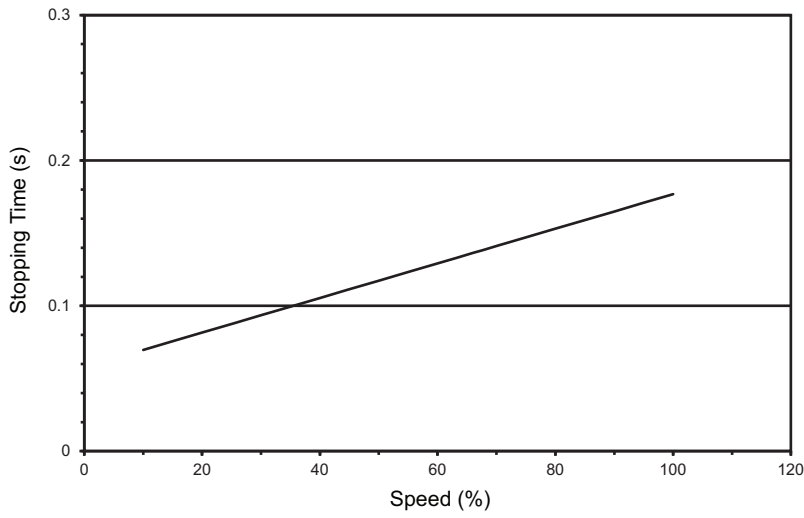
Joint 2 Stopping Distance (all payloads)
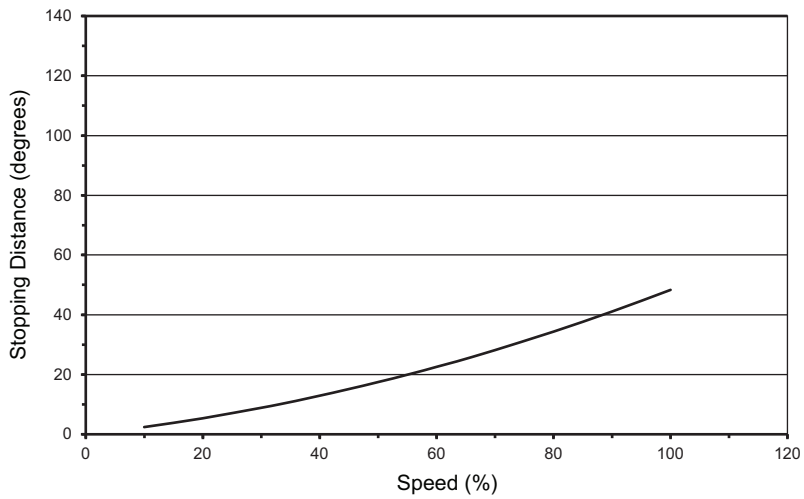
Joint 3 Stopping Time (all payloads)

Joint 3 Stopping Distance (all payloads)

i4L Robots with EtherCAT User's Manual (I659)
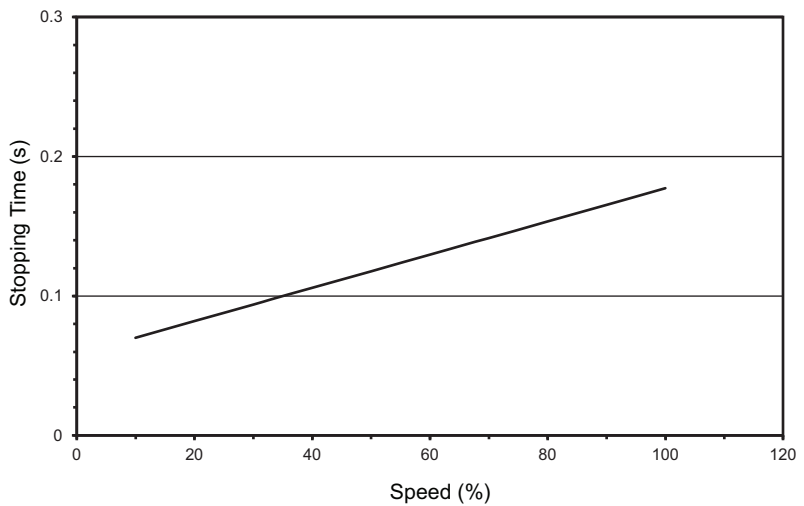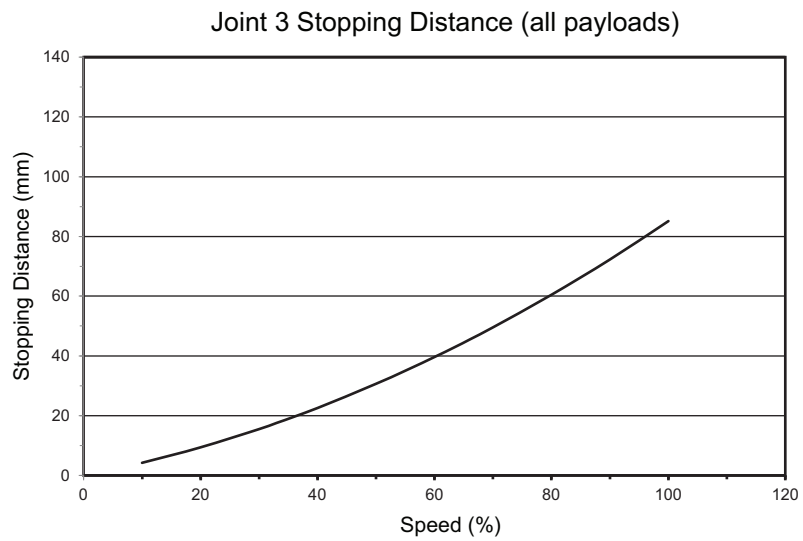
2-3 Electrical Specifications

Electrical specifications are provided in the sections below.

2-3-1 Power Supply Specifications

Specifications for user-supplied 24 VDC and 48 VDC power supplies are provided below.

> **Additional Information**
>
> Refer to the following documents for Control Power Kit and High Power Kit equipment specifications.
> - *S8VK-G Series Switch Mode Power Supply Datasheet (Cat. No. T056)*
> - *S8VK-R Series Redundancy Unit Datasheet (Cat. No. T059)*

User-supplied Control Power Specifications

Item	Specification
Supply voltage range	24 VDC ±10%
Current / power requirements	5 A / 120 W maximum
Circuit protection	User-supplied 5 A in-line fuse
Wire size	0.75 mm^2 to 2.5 mm^2
Shielding	User-supplied connection from power supply cable shield to robot ground point.

User-supplied High Power Specifications

Item	Specification
Supply voltage range	48 VDC ±10%
Current / power requirements	15A / 720 W rated 20 A / 960 W maximum
Wire size	2.5 mm^2
Shielding	User-supplied connection from power supply cable shield to robot ground point

2-3-2 XIO and TIO Connector I/O Specifications

Specifications for the XIO and TIO connector input and output circuits are provided below.

Type	Item	Specification
Input circuits	Type	Sinking / Sourcing
	Operational voltage range	0 to 30 VDC
	OFF state voltage range	0 to 3 VDC
	ON state voltage range	10 to 30 VDC
	Typical threshold voltage	8 VDC
	Operational current range	0 to 7.5 mA
	OFF state current range	0 to 0.5 mA
	ON state current range	2.5 to 6 mA
	Typical threshold current	2.0 mA
	Impedance (V_{in} / I_{in})	39 kΩ
	Current at 24 VDC	< 6 mA
Output circuits	Type	Sourcing
	Output voltage range	24 VDC ±10%
	Total current output for all XIO circuits	1.0 A maximum at 50° C ambient temperature 1.5 A maximum at 25° C ambient temperature
	Total current output for all TIO circuits	1.0 A maximum at 50° C ambient temperature 1.5 A maximum at 25° C ambient temperature
	ON state resistance at 0.5A	0.14Ω maximum at 85° C
	Output leakage current	5 µA maximum
	Short circuit current limit	0.7 to 2.5 A
	Output voltage at inductive load (turn OFF)	$(+V - 52) \leq V_{demag} \leq (+V - 41)$ where I_{out} = 0.5 A and load ≥ 1 mH

2-3-3　Belt Encoder Specifications

Specifications for the XBELTIO connections are provided below.

Item	Specification
Pulse input method	Line driver
Input signals	A, B, and Z
Counting unit	Pulses
Counter range	-8388607 to 8388608
ON voltage/current	2 to 5 VDC
OFF voltage/current	0 to 0.8 VDC
Input current	100 µA
5 VDC output rating	5 VDC ±10% 1 A max.

2-4   Environmental Specifications

Environmental specifications are provided below.

⚠ WARNING

To reduce the risk of fire or electric shock, install the robot in a controlled environment relatively free of contaminants.

Item	Specification
Ambient operating temperature[1]	5 to 40°C
Storage temperature	–25 to 55°C
Humidity	5 to 90%, non-condensing
Altitude	2000 m maximum
Pollution degree	2
Protection class	IP20 / NEMA Type 1

*1.   A warm-up is required at low temperatures.

2-5   Other Specifications

Other specifications for associated equipment are provided below.

2-5-1   EtherCAT Communication Specifications

EtherCAT communication specifications are provided below.

Item	Specification
Synchronization	DC (Distributed Clock)
Physical Layer	100BASE-TX
Modulation	Baseband
Baud rate	100 Mbits/s
Topology[*1]	Line, daisy chain, and branching
Transmission media	Twisted-pair cable of category 5 or higher Recommended cable: straight, double-shielded cable with aluminum tape and braiding
Maximum transmission distance between nodes	100 m
Communications cycle	2 ms, 4 ms

*1.   Wiring in a ring configuration is not possible.

2-5-2   Connector and Port Specifications

Robot connector specifications are provided below.

> **Additional Information**
>
> Refer to *Section 3 Installation* on page 3-1 for more information about connector wiring and pin diagrams.

Connector	Specification
Pneumatic pass-through ports	Push-connect type fittings with a maximum air pressure of 0.55 MPa • Port A and B fittings: 6 mm • Port C fitting: 4 mm
USER connectors	15 pin, D-sub, male Rated current: 3 A
Control Power connector	Molex 2-wire receptacle Part number: 43160-2102
High Power connector	Molex 3-wire receptacle Part number: 43160-2103
XSYSTEM connector	44 pin, D-sub HD, female
XBELTIO connector	26 pin, D-sub HD, male
XIO connector	26 pin, D-sub HD, female
Ethernet interface port	RJ-45
TIO connector	15 pin, D-sub, female

2-5-3 Mounting Hardware and Torques

The following bolt types, washers, and torque is required for mounting the robot.

Type	Quantity	Size	Class	Torque
Socket Head Cap Screw	4	• M8 x 1.25 mm • DIN 912 or ISO 4782	10.9 or 12.9	30-32 N-m
Flat Washer	4	• M8 • DIN 125 or ISO 7089	8.8	---

⚠ WARNING

The robot's center of mass can cause the robot to fall over if the robot is not properly secured with the mounting bolts.

3

Installation

This section provides information about installing the robot and other necessary equipment.

3-1 Robot Installation Procedure

The basic installation steps are provided below.

> ## ⚠ WARNING
>
> • Ensure that installation and post-installation checks of the product are performed by personnel in charge who possess a thorough understanding of the machinery to be installed.
> • The robot must be installed to avoid interference with buildings, structures, utilities, other machines and equipment that may create trapping or pinch points. It must be installed in accordance with Standard for Robots and Robotic Devices – Safety Requirements for Industrial Robots – Part 2: Robot Systems and Integration, ISO 10218-2.

Additional Information

Refer to *A-1 Unpacking and Inspecting the Robot* on page A-2 for more information.

1 Mount the robot.
Refer to *3-2 Mounting the Robot* on page 3-5 for more information.

2 Install the end-of-arm tooling.
Refer to *3-3 Installing End-of-Arm Tooling* on page 3-7 for more information.

3 Install any equipment such as cameras, solenoid valves, a Front Panel, or bellows.
Refer to *3-4 Installing Optional Equipment* on page 3-8 for more information.

4 Connect any necessary pneumatic air lines using the pass-through ports.
Refer to *2-5-2 Connector and Port Specifications* on page 2-16 for more information.

5 Make any necessary adjustments to hardstops.
Refer to *3-5 Adjustable Hardstops* on page 3-20 for more information.

6 Connect all required system cables.
Refer to *3-6 System Cable Installation* on page 3-23 and *3-7 Connecting Digital I/O* on page 3-26 for more information.

7 Connect all required safety equipment.
Refer to *3-8 Installing Safety Equipment* on page 3-34 for more information.

8 Set the EtherCAT node ID and robot operation mode.
Refer to *3-9 Setting the EtherCAT Node ID* on page 3-42 and *4-3 Robot Control Modes* on page 4-5 for more information.

9 Make power and ground connections.
Refer to *3-10 Supplying Power and Ground* on page 3-44 for more information.

10 Verify the robot installation.

Refer to *3-11 Verifying Installation* on page 3-47 for more information.

3-2 Mounting the Robot

Use the information in the following sections to mount the robot.

3-2-1 Robot Mounting Surface

The following considerations must be made when preparing a robot mounting surface.

- It must be smooth and flat.
- It must be rigid enough to prevent vibration and flexing that is caused by reactionary forces during fast robot motion.
- It must be designed to support the weight of the robot with payload.
- Table-mounted robots must be placed on a level, horizontal surface.
- Wall-mounted robots must be fastened to a 90° vertical surface.
- When the robot is mounted to a vertical surface, considerations for preventing a collision with the mounting surface should be made.

⚠ WARNING

If a robot is mounted to a surface with inadequate stiffness, damage to the z-axis quill or other mechanical components can result from excessive oscillation during operation.

Precautions for Correct Use

- It is recommended to use a properly secured, 18 mm (minimum) thick steel plate with a maximum surface roughness of 25 μm as a robot mounting surface.
- Keep a minimum of 300 mm clearance from the Primary Interface Panel to allow for switch and cable connection access.

3-2-2 Mounting Procedure

Use the following procedure to mount the robot.

⚠ WARNING

- Always use proper lifting technique when lifting the robot. Failure to comply could result in the robot falling and causing either personnel injury or equipment damage.
- The robot's center of mass can cause the robot to fall over if the robot is not properly secured with the mounting bolts.

Precautions for Safe Use

The robot can be lifted by hand. Only use the base and inner link when lifting the robot. Never maneuver the robot using the quill or flyover assemblies.

Precautions for Correct Use

The mounting surface should be clean and prepared according to the information provided in *3-2-1 Robot Mounting Surface* on page 3-5 before attempting to mount the robot.

Before beginning the mounting procedure, have the following tools and resources available. Prepare the mounting holes before beginning the mounting procedure.

• Prepare the mounting holes.
• A torque wrench for proper tightening of the mounting bolts.
• Assistance to lift and maneuver the robot into the mounting position.
• Four socket-head cap screws with flat washers. Refer to *2-5-3 Mounting Hardware and Torques* on page 2-17 for more information.

1 Using the dimensions provided in *2-1-2 Mounting Flange Dimensions* on page 2-4, prepare four holes in the mounting surface to accommodate the user-supplied machine bolts (specified above). A slot and hole are provided in the mounting flange for dowel pins.

2 Maneuver the robot into position on the mounting surface.

3 Align the holes in the mounting flange with the prepared mounting holes in the mounting surface.

4 Insert all four bolts with washers to secure the robot to the mounting surface.

5 Tighten the four bolts to 31 N-m of torque.

Additional Information

After mounting the robot, check the mounting bolt torque after 72 hours of initial operation and then recheck every 3 months thereafter. Refer to *6-1 Periodic Maintenance* on page 6-2 for more information.

6 After all four bolts have been tightened to the specified torque, the mounting procedure is complete.

3-3 Installing End-of-Arm Tooling

You must provide, install, and ground (if necessary) end-of-arm tooling to the tool flange.
Use the following details when designing and installing end-of-arm tooling.

- Hole diameters and placement on the tool flange comply with ISO-9409-1-50-4-M6 (2004) standards.
- End-of-arm tooling is attached to the tool flange using M6 x 1.0 (Class 10.9 or higher) screws with a minimum of 10 mm thread engagement into the tool flange.
- Apply Loctite 243 thread lock (or equivalent) to secure the screws.
- Apply a torque of 7.5 N-m when tightening tooling screws.

> **Additional Information**
>
> Refer to *2-1-3 Tool Flange Dimensions* on page 2-5 for more information.

If the end-of-arm tooling requires pneumatic or electrical connections, use the pass-through connections from the Primary Interface Panel to the Secondary Interface Panel. Refer to *1-2-4 Connectors and Ports* on page 1-8 for more information.

> **Precautions for Safe Use**
>
> The Joint 3 quill and the tool flange are not grounded to protective earth. If hazardous voltages are present at any user-supplied robot-mounted equipment or tooling, you must install a ground connection from that equipment or tooling to the ground point on the robot base.
> Refer to *3-10-1 Grounding the System* on page 3-44 for more information about grounding the tool flange.

⚠ DANGER

Failure to ground robot-mounted equipment or tooling that uses hazardous voltages could lead to injury or fatality of a person touching the end-effector during an electrical fault.

3-4   Installing Optional Equipment

This section provides information about installing the following optional equipment.

3-4-1   Mounting External Equipment to the Robot

The robot body has accommodations to mount external equipment such as a camera or solenoid valves. Use the information below to understand how to mount external equipment to the robot.
4 mounting holes are provided on the bottom of the outer link between joint 2 and joint 4.
2 mounting holes are provided on the bottom and near the end of the outer link.
The following considerations should be made when mounting external equipment to the robot.
• Do not mount equipment that will interfere with robot motion or other objects in the work cell.
• Do not mount equipment in a way that can induce excessive inertia to the outer link.
• Mounting holes are thru-type and the robot body is 6.5 mm thick. Do not use fasteners that can extend into the body of the robot. This can interfere with internal components.

> **Precautions for Correct Use**
>
> Any externally mounted equipment is considered robot payload. Consideration to the payload attached to the Tool Flange should be made when mounting external equipment to the robot.

Apply a torque of 2.5 N-m to the user-supplied fasteners when mounting equipment to the 4 mounting holes between joint 2 and joint 4. Apply Loctite thread lock type 222 or equivalent.
Apply a toque of 4.5 N-m to the user-supplied fasteners when mounting equipment to the 2 mounting holes at the end of the outer link. Apply Loctite thread lock type 243 or equivalent.
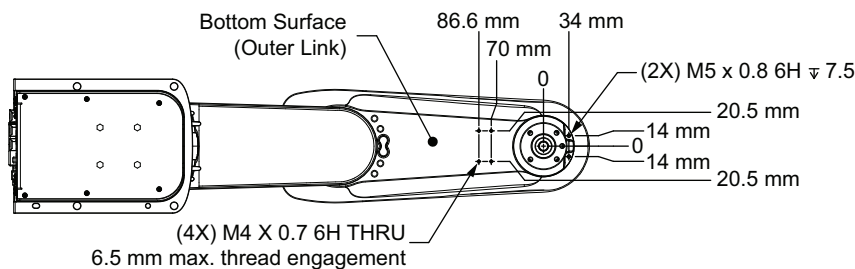
3-4-2   USER Connector Wiring

Use the information below to make connections to the USER connectors on the Primary Interface Panel and the Secondary Interface Panel.

> **Additional Information**
>
> Refer to *2-5-2 Connector and Port Specifications* on page 2-16 for more information about the USER connector type.

PIN 1   PIN 8

PIN 9   PIN 15
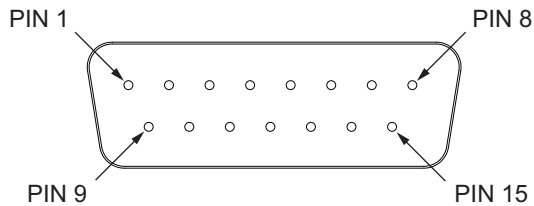
3-4-3   Bellows Kit Installation Procedure

Use the following procedure to install bellows.

📝 **Precautions for Correct Use**

- Never loosen or remove the quill clamp collar while the z-axis brake is released.
- The z-axis stroke is reduced when bellows are present. Bellows reduce the travel by 27 mm (180 mm quill length) / 53 mm (350 mm quill length) in the z-axis retracted position and 27 mm (180 mm quill length) / 53 mm (350 mm quill length) in the z-axis extended position. Always adjust joint motion limits with software settings in the robot configuration area when bellows are installed to restrict range of motion. Refer to the *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* for more information.

The following items are required for this procedure.
- Bellows kit. Refer to *1-6-7 Bellows Kit* on page 1-21 for more information.
- Torque wrench.
- 2.5 mm, 3 mm, 4 mm hex bits.
- T8 torx bit.

Make the following considerations before installing the bellows.
- If cables or tubing are routed through the center of the quill, they must be removed before beginning this procedure.
- The tool flange must be removed. Make all necessary preparations and considerations before removing the tool flange.
- The outer link cover must be removed. Make all necessary preparations and considerations before removing the outer link cover.
- This procedure installs the upper bellows first and then the lower bellows next.
- To simplify installation, the Joint 3 quill should be positioned in approximately the middle position before beginning this procedure.
- The upper and lower bellows are identical and interchangeable.

The bellows kit includes the following main components.

Lower Bellows   Upper Bellows

Tool Flange Bearing Adapter   Clamps   Upper Bearing Adapter   Plug
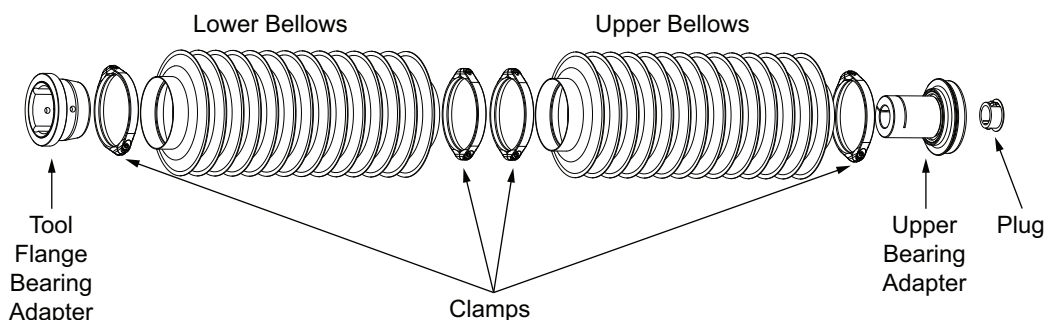
1. Begin the upper bellows installation by removing the quill clamp collar at the top of the Joint 3 quill and the tool flange using 3 and 4 mm hex bits.

   The quill clamp collar will be replaced by the upper bearing adapter provided in the bellows installation kit.
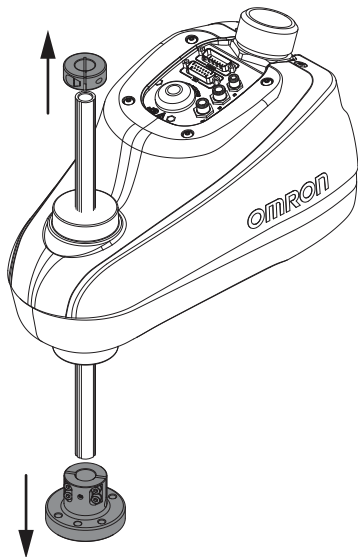
2. Slide the bellows (22861-000) down the quill and then wrap it around the exterior of the robot housing.

   Orientation of the bellows must be correct. Ensure the taller bellows collar is mated with the robot housing.

   Take care to ensure the bellows is wrapped evenly and completely around the robot housing.
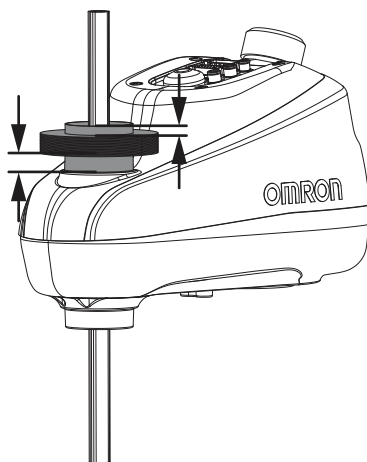
3. Place the two halves of the clamp (22852-000) around the robot housing.

   Orient the clamp so that the clamp fasteners (22919-000) can be inserted as shown in the image below.
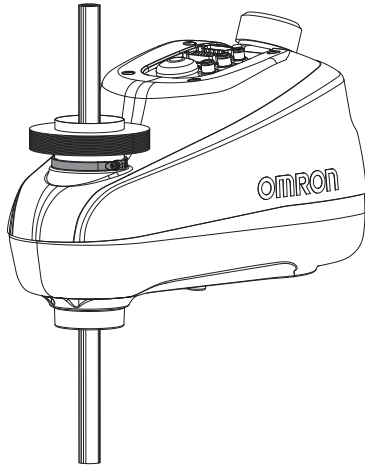
4   Apply thread lock (87002-00680) to the clamp fasteners, insert, and tighten using an T8 torx bit while ensuring that the bellows are completely seated and positioned between the small clamp and the robot housing. Tighten to a torque of 2.4 N-m.

5   Place the upper bearing adapter on the top of the quill.
Ensure the upper bearing adapter is completely seated on top of the quill.
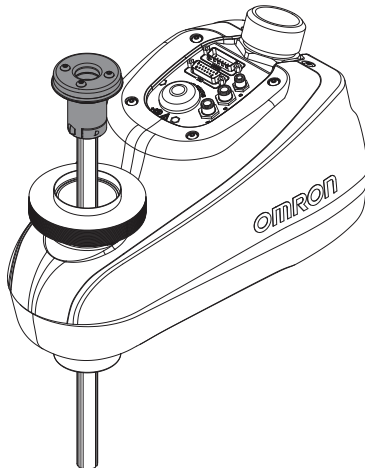
6   Apply thread lock to the upper bearing adapter clamp screw (51000-67016), insert, and tighten using a 3 mm hex bit to a torque of 1.3 N-m.

7   Lift the bellows upward and wrap it over the outer circumference of the upper bearing adapter. This may require stretching the bellows slightly so it can be positioned over the upper bearing adapter lip.
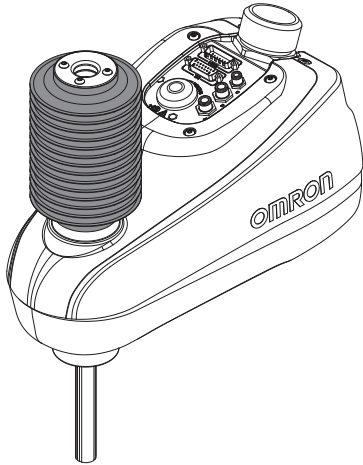
8 Place the two halves of the clamp on the upper bearing adapter.
The bellows should be evenly positioned between the upper bearing adapter and the clamp.
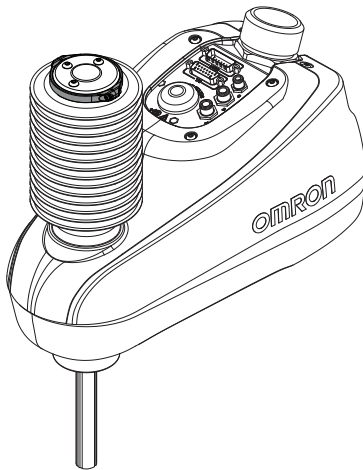
9 Apply thread lock to the clamp fasteners, insert, and tighten using an T8 torx bit while ensuring that the bellows are completely seated and positioned between the clamp and the upper bearing adapter. Tighten to a torque of 2.4 N-m.

10 If routing cables or lines through the center of the quill is not required, insert the plug (22921-000) into the upper bearing adapter to complete the installation of the upper bellows.

11 Begin the lower bellows installation by sliding the bellows up the quill and then wrap it around the exterior of the robot housing.
Orientation of the bellows must be correct. Ensure the taller bellows collar is mated with the robot housing (refer to step 2 above).
Take care to ensure the bellows is wrapped evenly and completely around the robot housing.
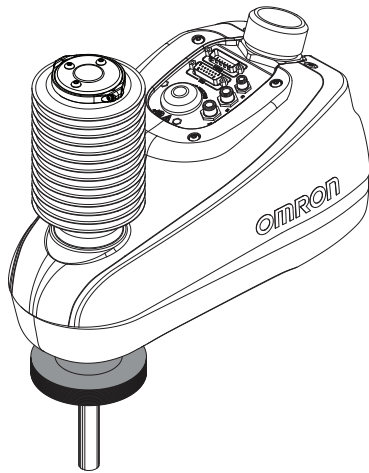
12 Place the two halves of the clamp around the robot housing.
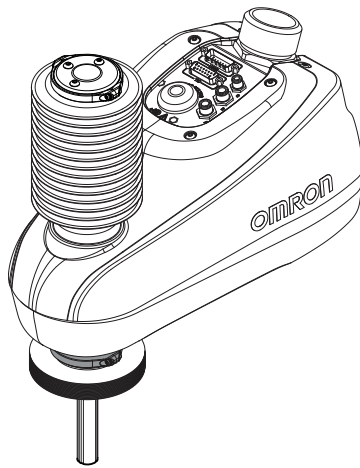
13 Apply thread lock to the clamp fasteners, insert, and tighten using an T8 torx bit while ensuring that the bellows are completely seated and positioned between the clamp and the robot housing. Tighten to a torque of 2.4 N-m.

14 Slide the tool flange bearing adapter (1) up the quill and then move the tool flange into its original position (2).
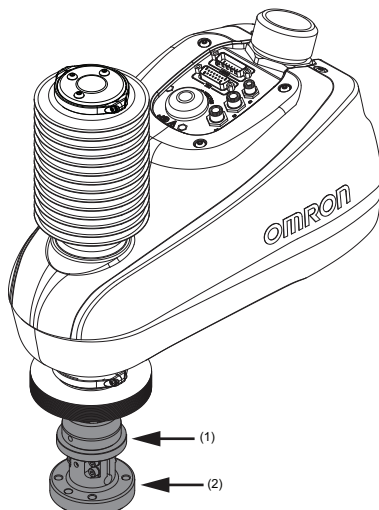
15 Apply thread lock to the tool flange setscrew and then tighten to a torque of 1.1 N-m using a 2.5 mm hex bit..
Do not over-tighten the tool flange setscrew. This will cause off-center alignment of the tool flange on the quill.

16 Apply thread lock to the tool flange socket-head screws and then use a torque wrench with a 4 mm hex bit to tighten one of the socket-head screws to 1 N-m. Then, apply the same torque to the other socket-head screws. Finally, tighten each socket-head screw to 2.5 N-m torque.

17 Position the tool flange bearing adapter on the tool flange.
Ensure the bearing adapter is completely mated to the tool flange.
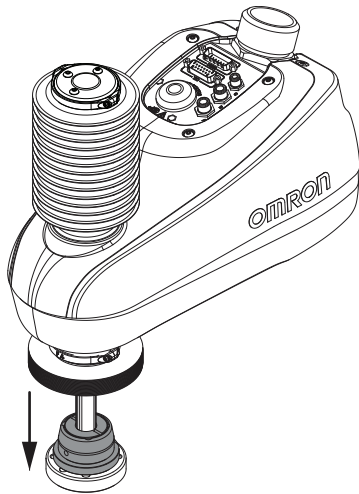
18 Rotate the tool flange bearing adapter to ensure that the setscrews will make contact with a flush surface of the tool flange.
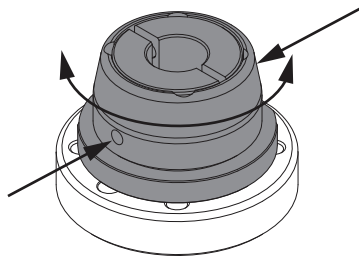
19 Apply thread lock to the tool flange bearing adapter setscrews (51410-000), insert them, and then tighten using a 2.5 mm hex bit to a toque of 1.1 N-m.
Ensure the tool flange bearing adapter is completely mated to the tool flange before tightening the setscrews.

20 Wrap the bellows over the outer circumference of the tool flange bearing adapter.
This may require stretching the bellows slightly so it can be positioned over the tool flange bearing adapter lip.
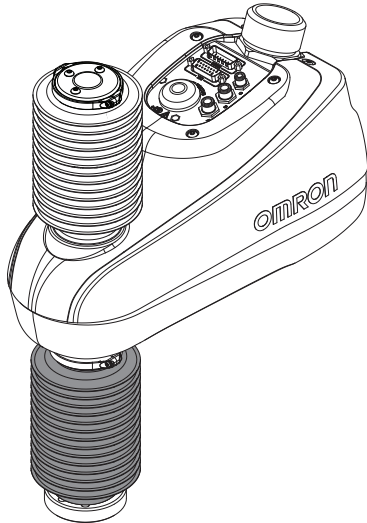
21 Place the clamp on the tool flange bearing adapter.
The bellows should be evenly positioned between the tool flange bearing adapter and the clamp.
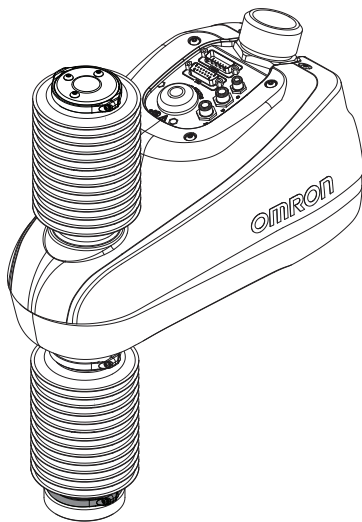
22 Apply thread lock to the clamp fasteners, insert, and tighten using an T8 torx bit while ensuring that the bellows are completely seated and positioned between the clamp and the tool flange bearing adapter. Tighten to a torque of 2.4 N-m.

23 Reduce joint motion limits with software settings in the robot configuration area when bellows are installed to restrict range of motion. Refer to the *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* for more information.
After the joint limits are reduced, the bellows installation procedure is complete.

3-4-4   Pneumatic Valve Kit Installation Procedure

Use the following procedure to install the pneumatic valve kit.
The following items are required for this procedure.

• 2.5 mm, 3 mm hex bit.

- 6 mm socket.
- Slotted screw driver.
- Cutters.

Make the following considerations before installing the pneumatic valve kit.

- The outer link cover must be removed. If bellows are installed, the upper assembly must be removed before beginning this procedure. Refer to *3-4-3 Bellows Kit Installation Procedure* on page 3-9 and reverse installation steps to remove and replace the upper bellows assembly.

The pneumatic valve kit includes the following main components.
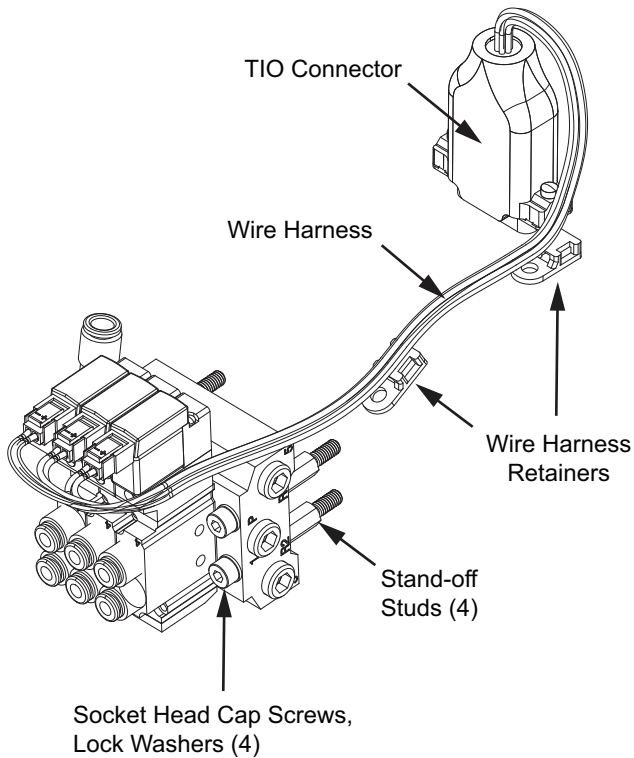
1 Remove six outer link cover fastening screws using a 2.5 mm hex bit and then remove the outer link cover.
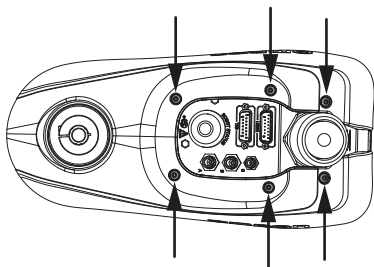
2 Drill four 8 mm diameter holes in the back of the outer link.

Drill from the inside of the cover. Use the indentations shown below for the hole locations.
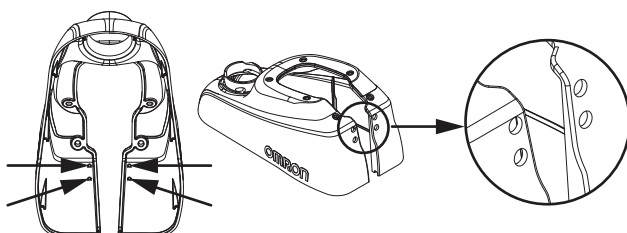
3 Place the outer link cover on the robot in its original position.

4 Replace four of the outer link cover fastening screws as indicated below.
Apply thread lock to the screws and tighten using a 2.5 mm hex bit to a torque of 2.9 N-m.
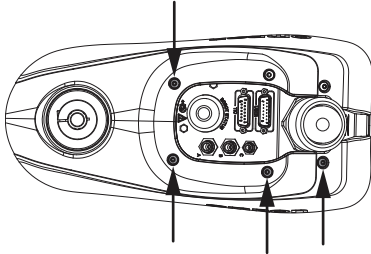
5 Fasten two wire harness retaining clips (23477-000) to the outer link using two screws that were previously removed in the locations shown below.
Apply thread lock to the screws and tighten using a 2.5 mm hex bit to a torque of 2.9 N-m.
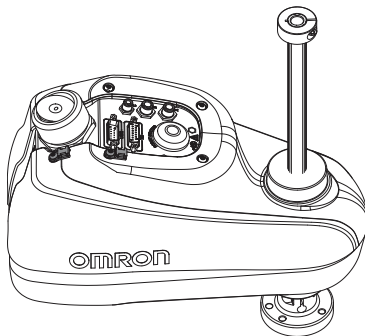
6 Screw the stand-off studs (22873-000) into the inner bracket.
Apply thread lock to the stand-off studs and tighten using a 6 mm socket to a torque of 2.9 N-m.
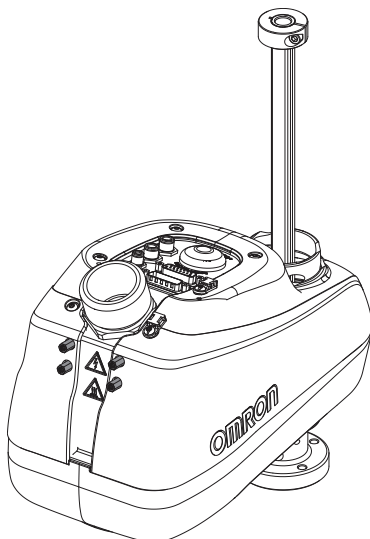
7 Place the pneumatic valve assembly near the stand-off studs and then insert four socket head cap screws (51006-67025) with lock washers (18913-000) into the valve manifold to secure it to the robot in the orientation shown below.
Apply thread lock to the socket head cap screws and tighten using a 3 mm hex bit to a torque of 2.9 N-m.
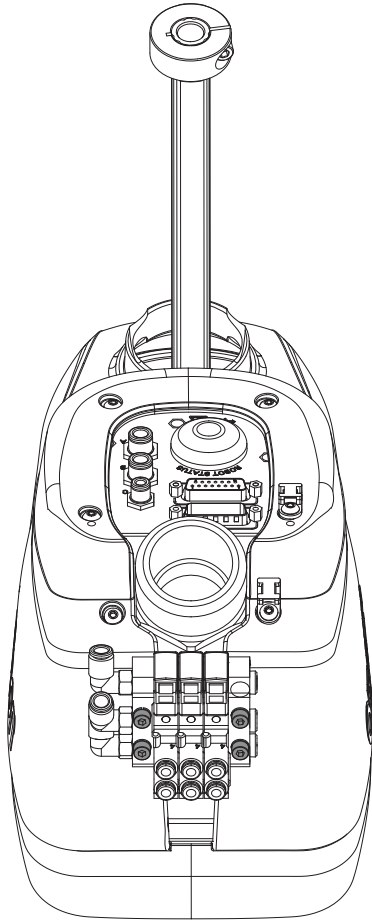
8 Connect the wire harness as shown below.

SNLD 3
SNLD 2
SNLD 1
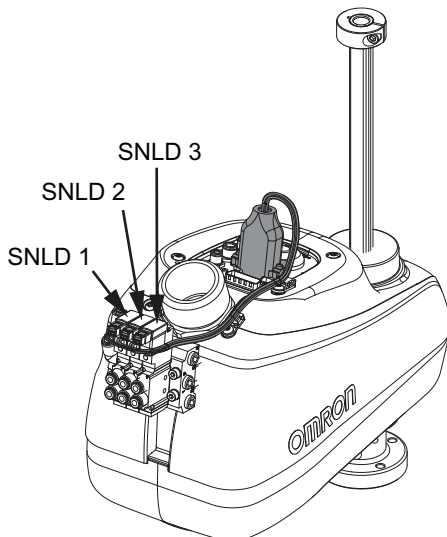
9 Tighten the wire harness TIO connector retaining screws using a slotted screwdriver.

10 Secure the wire harness to the robot by inserting two cable ties (27300-00024) through the wire harness retaining clips and then around the wire harness.
Trim excess cable tie material placement using cutters to complete this procedure.

3-4-5　　Control Power Kit Connections

Use the following diagram to connect the Control Power Kit to the robot.
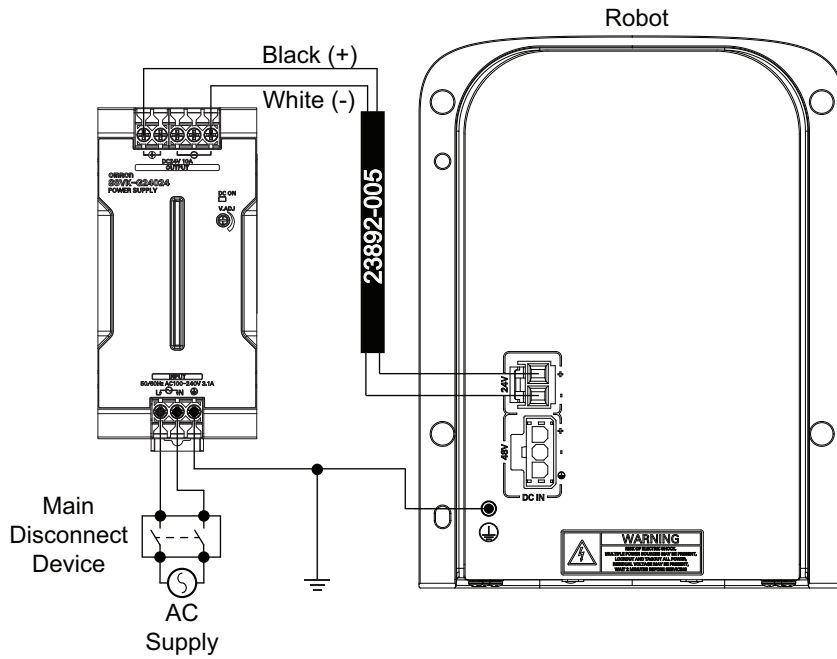
3-4-6　　High Power Kit Connections

Use the following diagram to connect the High Power Kit to the robot.

① Black Wire
② Gray Wire
③ Green Wire
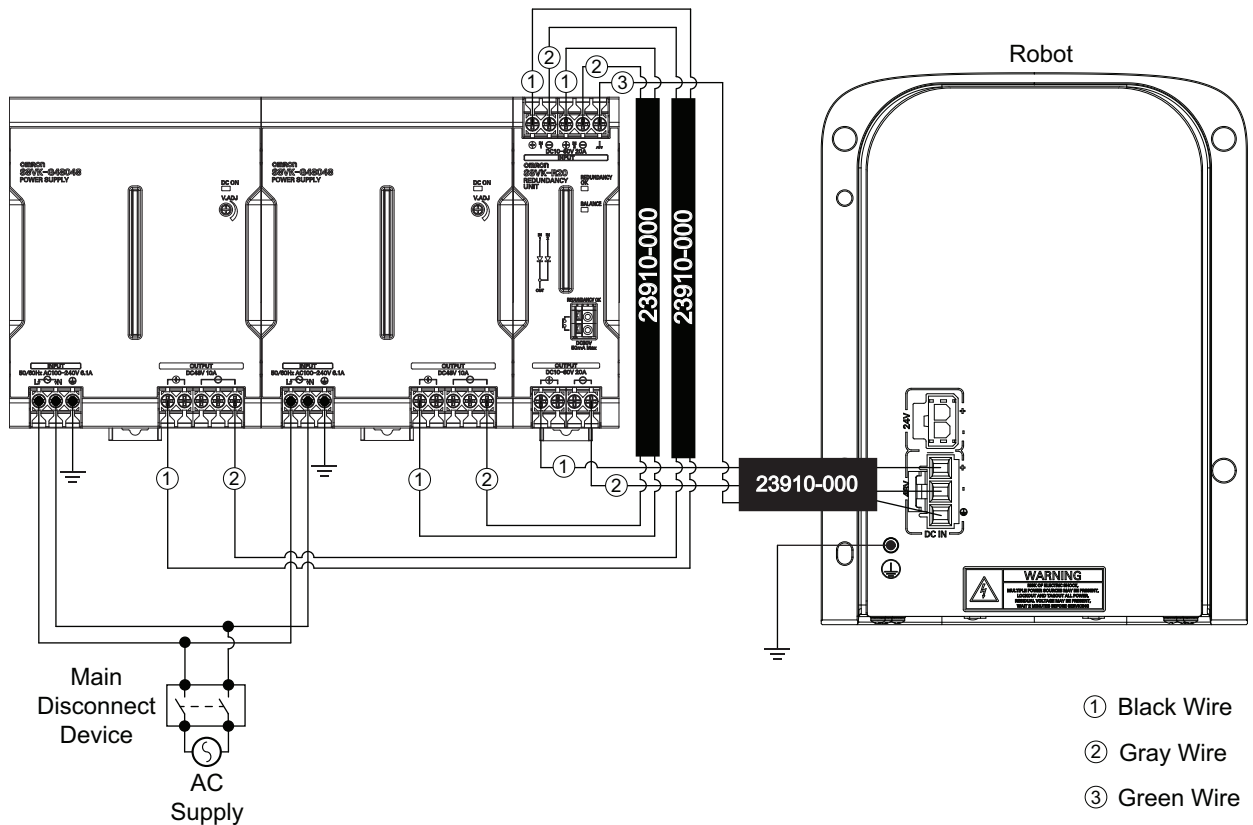
3-5 Adjustable Hardstops

The robot is equipped with several mechanical hardstop adjustment points for joints 1, 2, and 3 as described in the following sections. Adjust these mechanical hardstops to restrict the robot's range of motion in order to prevent collisions within the workspace if necessary.

> ## ⚠ WARNING
>
> The robot's physical hardstop devices are not intended to withstand repeated use and if this occurs, the hardstop may become damaged. Implement proper programming and configuration of joint range limits to prevent hardstop impacts.

Precautions for Correct Use

Always reduce joint motion limits with software settings in the robot configuration area when hardstops are used to restrict range of motion. Refer to the *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* for more information.

Additional Information

- Obstacles may be defined with software configuration to restrict the robot tool-tip from entering specified volumes of the work envelope. Refer to the *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* for more information.
- Refer to *2-1-6 Robot Work Envelope Dimensions* on page 2-6 for full range of motion values.
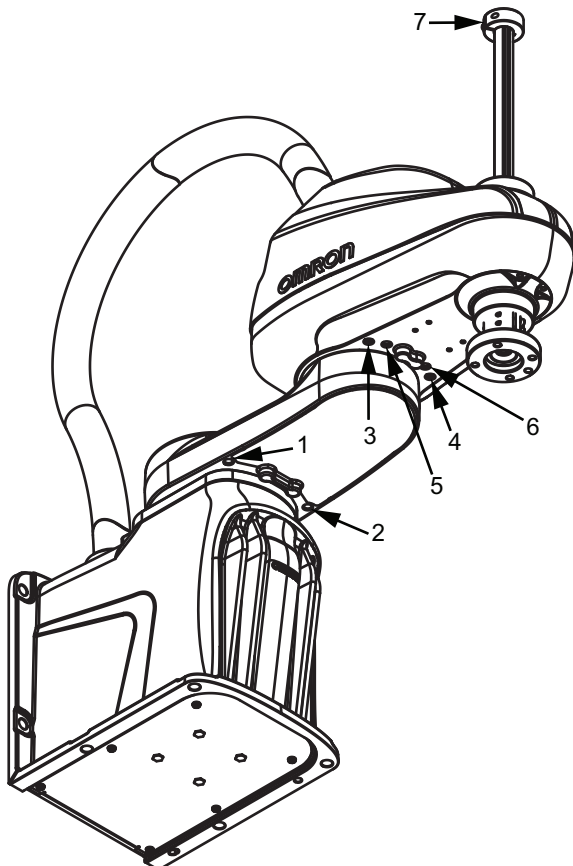
Joint Hardstop Position	Joint Limitation	Range of Motion Software Limit Setting		
		i4-350L	i4-450L	i4-550L / i4-550L (350 mm Z)
1	Joint 1	-109.5°		
2		+109.5°		
3	Joint 2	-124°	-118°	
4		+124°	+118°	
5		See note*1	-133°	
6			+133°	
7	Joint 3	5 mm from end of travel.		

*1. The i4-350L model includes pre-installed hardstop screws in positions 5 and 6 to prevent base interference with the quill. Do not remove these pre-installed hardstop screws.

3-5-1 Joint 1 Adjustable Hardstops

Use the following information when making joint 1 hardstop adjustments.
- Four M8 X 10 socket head cap screws, class 12.9 are supplied with the robot for use as Joint 1 and Joint 2 adjustable hardstops.
- Apply Loctite thread lock type 243 or equivalent.
- Apply a torque of 17 N-m when tightening the hardstop screws.

3-5-2 Joint 2 Adjustable Hardstops

Use the following information when making joint 2 hardstop adjustments.
- Four M8 X 10 socket head cap screws, class 12.9 are supplied with the robot for use as Joint 1 and Joint 2 adjustable hardstops.
- Apply Loctite thread lock type 243 or equivalent.
- Apply a torque of 17 N-m when tightening the hardstop screws.

3-5-3 Joint 3 Adjustable Hardstop

The joint 3 down stroke can be limited by sliding the clamp collar down the z-axis quill to a lower position.
The following tools are required when adjusting the joint 3 hardstop.
- 4 mm hex bit
- Torque wrench
- Loctite thread lock type 243 or equivalent

Precautions for Correct Use

Never loosen or remove the quill clamp collar while the z-axis brake is released.

Clamp Collar → Socket-head Screw
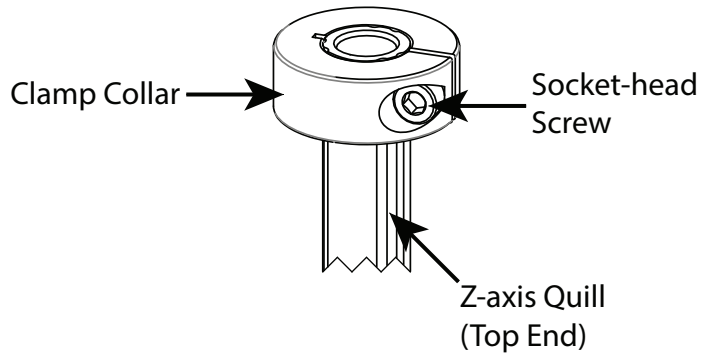
Z-axis Quill
(Top End)

Loosen the clamp collar socket-head screw and slide the clamp to the appropriate location to limit the down stroke of the z-axis quill. When the clamp is in the desired location, apply thread lock and tighten the socket-head screw to a torque of 4.5 N-m.

3-6 System Cable Installation

This section provides information about installing the robot system cables.

⚠ WARNING

- Never connect or disconnect system cables while power is applied to the robot. Failure to comply may cause unexpected behavior and can result in personnel injury and equipment damage.
- Provide appropriately-sized Branch Circuit Protection and Lockout / Tagout Capability in accordance with the National Electrical Code and any local codes.
- Ensure that interconnecting cables or pneumatic lines are routed away from the robot workspace.

3-6-1 System Cable Overview

Standard and optional cable connections are provided below.

Standard Connections

The following figure shows standard connections with the XSYSTEM cable. This cable is supplied with the robot.

> 📝 **Additional Information**
>
> Refer to *3-8 Installing Safety Equipment* on page 3-34 for more information about XFP, XUSR, and XMCP connections.
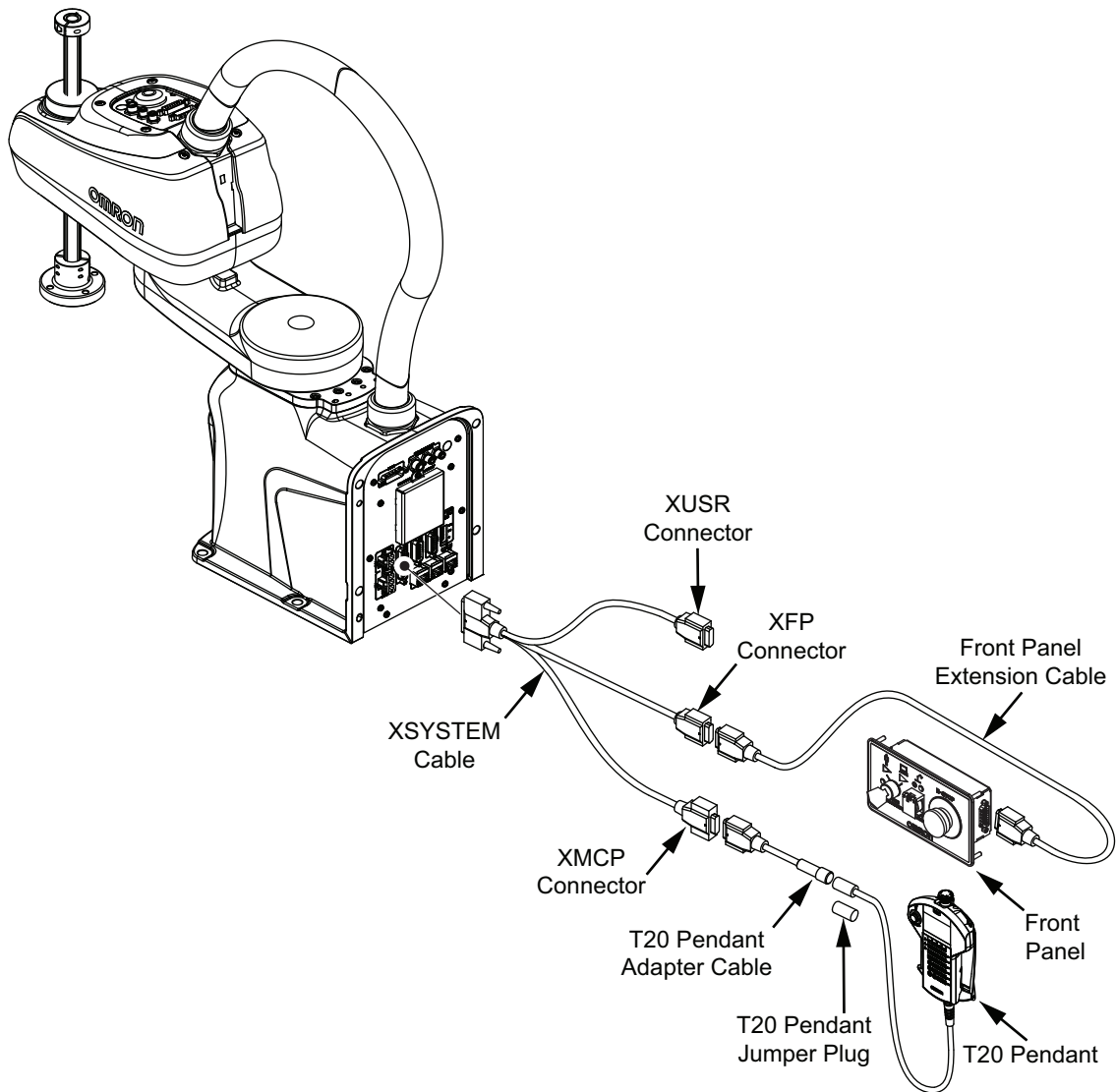
Optional Connections

The following figure shows optional connections to the robot.

📝 **Additional Information**

Refer to *3-7 Connecting Digital I/O* on page 3-26 for more information about connecting I/O with IO Blox Units or with the XIO connector.

XIO Cable

XIO Breakout Cable

EXPIO to IO Blox Cable

XBELTIO Adapter Cable

Belt Encoder Y-adapter Cable
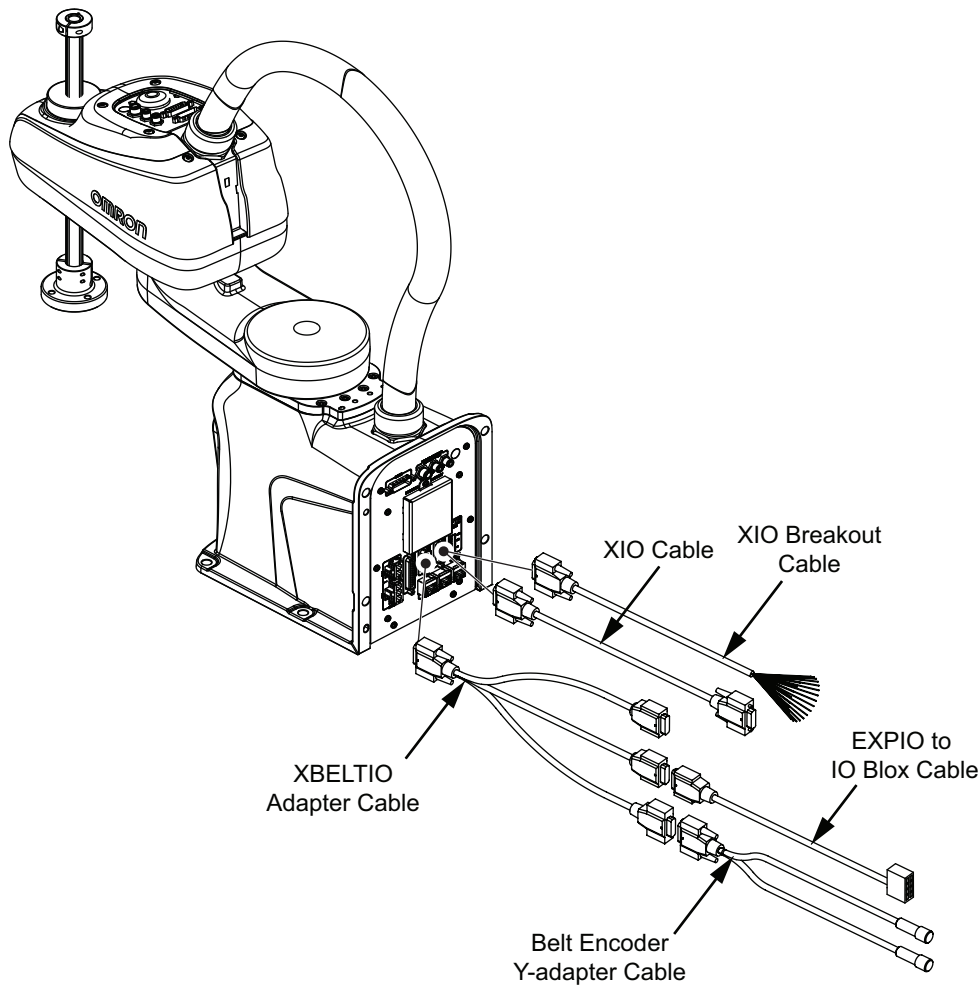
3-6-2   System Cable Installation Procedure

The following procedure provides details about system cable installation.
The robot must be mounted before following the steps below. Refer to *3-2 Mounting the Robot* on page 3-5 for more information.

1   Connect the XSYSTEM cable to the Primary Interface Panel XSYSTEM connector and route the XFP, XUSR, and XMCP connectors to their appropriate locations.

2   Connect any digital I/O to the XIO and TIO connectors.
Refer to *3-7 Connecting Digital I/O* on page 3-26 for more information.

3   Connect external equipment such as the Front Panel and Teach Pendant to the XSYSTEM cable XFP and XMCP connectors.
Refer to *3-6-1 System Cable Overview* on page 3-23 for more information.

4   Connect all user-supplied safety equipment to the XUSR connector on the XSYSTEM cable.
Refer to *3-8 Installing Safety Equipment* on page 3-34 for more information.

5   If applicable, connect devices to the XBELTIO connector and the USER connectors.
Refer to *Optional Connections* on page 3-24 for more information.

3-7 Connecting Digital I/O

The following sections describe the various methods to connect digital I/O to the robot.

3-7-1 XIO Connector Signals and Wiring

The XIO connector on the Primary Interface Panel provides access to 12 built-in digital inputs and 8 built-in digital outputs.

V+ signal number assignments vary based on the Robot Number setting. The Robot Number is designated with the Robot Device Assignment in Sysmac Studio.

Refer to the following areas for more information about V+ signal number assignments.

• *A-4 I/O Signal Numbering* on page A-6
• *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)*

> **Additional Information**
>
> Refer to the following sections for more information.
> • *2-3-2 XIO and TIO Connector I/O Specifications* on page 2-13
> • *2-5-2 Connector and Port Specifications* on page 2-16

PIN 9 — PIN 1
PIN 18 — PIN 10
PIN 26 — PIN 19
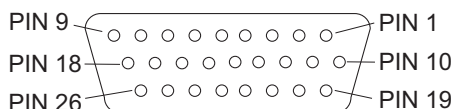
The XIO connector pin assignments are provided in the table below.

Pin Number	Designation	Signal Bank[1]
1	Ground	-––
2	24 VDC	
3	Common 1	1
4	Input 1.1	
5	Input 2.1	
6	Input 3.1	
7	Input 4.1	
8	Input 5.1	
9	Input 6.1	
10	Ground	--
11	24 VDC	
12	Common 2	2
13	Input 1.2	
14	Input 2.2	
15	Input 3.2	
16	Input 4.2	
17	Input 5.2	
18	Input 6.2	

Pin Number	Designation	Signal Bank[1]
19	Output 1	--
20	Output 2	
21	Output 3	
22	Output 4	
23	Output 5	
24	Output 6	
25	Output 7	
26	Output 8	

[1].   Only applies when using an XIO Termination Block.

XIO Internal Circuits

Use the following information to understand the XIO internal circuits.

● XIO Input Signals

The twelve inputs are arranged in two banks of six. Each bank is electrically isolated from the other bank. Each input is optically isolated. The six inputs within each bank share a common source / sink line.
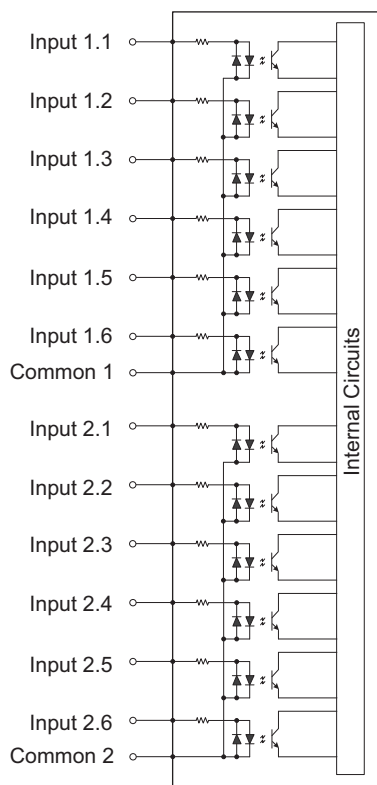
● XIO Output Signals

The eight outputs share a common, sourcing driver integrated circuit. The driver is designed to supply a load with one side connected to ground. Each channel is capable of switching up to 0.7 A of current. This driver has over-temperature protection, shorted load protection, and is current limiting. The driver draws power from the 24 VDC Control Power supplied to the robot through a self-resetting polyfuse.

Precautions for Safe Use

Output 8 can be assigned to indicate the robot's High Power state. When High Power is ena-
bled, this output will turn ON. When High Power is not enabled, this output will be OFF. This is
not a safety-rated means of indicating a High Power state and should only be used for monitor-
ing the robot status. Use the Sysmac Studio to make this configuration if needed.

Precautions for Correct Use

Use surge suppression when switching inductive loads such as relays to prevent damage to the
output circuits.

Additional Information

If there is an output short or other over-current condition, the affected output of the driver inte-
grated circuit turns OFF until the condition is removed.
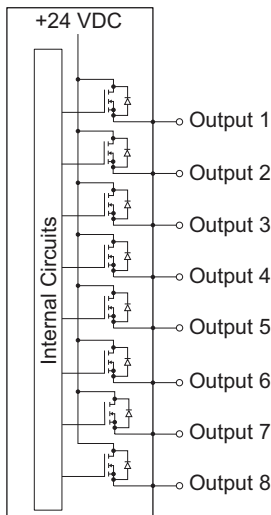
XIO Breakout Cable Pinouts

Use the following diagrams for XIO Breakout cable pinout information.
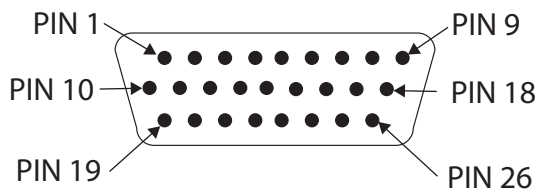
Pin Number	Signal	Wire Color
1	GND	White
2	24 VDC	White / Black
3	Common 1	Red
4	Input 1.1	Red / Black

Pin Number	Signal	Wire Color
5	Input 2.1	Yellow
6	Input 3.1	Yellow / Black
7	Input 4.1	Green
8	Input 5.1	Green / Black
9	Input 6.1	Blue
10	GND	Blue / White
11	24 VDC	Brown
12	Common 2	Brown / White
13	Input 1.2	Orange
14	Input 2.2	Orange / Black
15	Input 3.2	Gray
16	Input 4.2	Gray / Black
17	Input 5.2	Violet
18	Input 6.2	Violet / White
19	Output 1	Pink
20	Output 2	Pink / Black
21	Output 3	Light blue
22	Output 4	Light blue / Black
23	Output 5	Light green
24	Output 6	Light green / Black
25	Output 7	White / Red
26	Output 8	White / Blue
Shell	Shield	

XIO Termination Block

An XIO termination block can be connected directly to the XIO connector to provide simple wiring and access to the built-in I/O.

Additional Information

Refer to the *Adept XIO Termination Block Installation Guide (00340-000)* for more information.
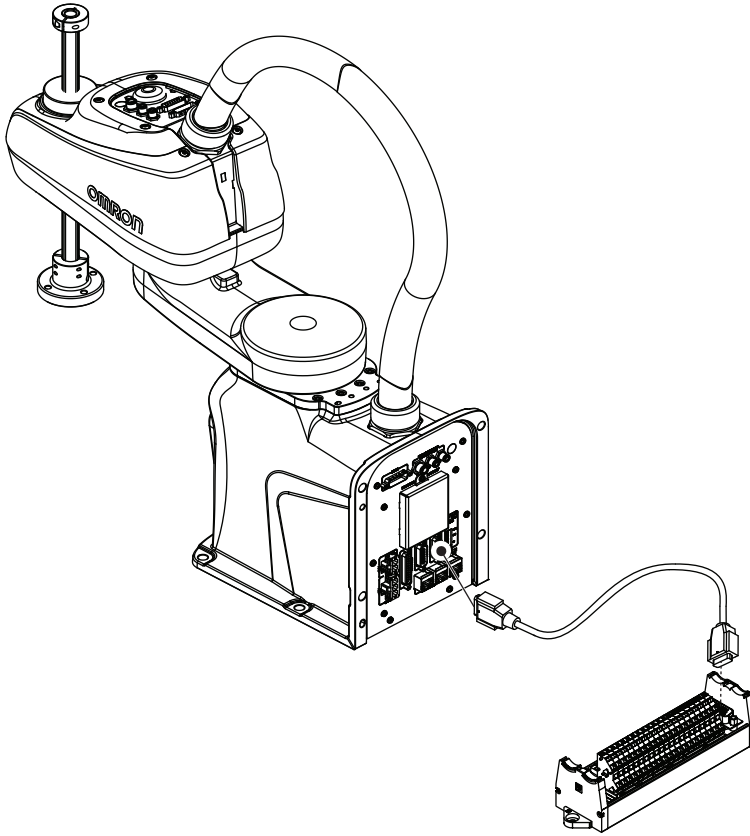
3-7-2 TIO Connector Signals and Wiring

The TIO connector on the Secondary Interface Panel provides access to built-in digital I/O.

V+ signal number assignments vary based on the Robot Number setting. The Robot Number is designated with the Robot Device Assignment in Sysmac Studio.

Refer to the following areas for more information about V+ signal number assignments.

📑 **Additional Information**

Refer to the following areas for more information.
- *2-3-2 XIO and TIO Connector I/O Specifications* on page 2-13
- *2-5-2 Connector and Port Specifications* on page 2-16
- *A-4 I/O Signal Numbering* on page A-6
- *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)*
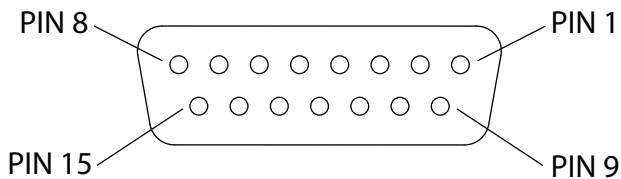
The TIO connector pin assignments provided below.

Pin Number	Designation
1	Common
2	Input 5

Pin Number	Designation
3	Input 2
4	Input 4
5	24 VDC
6	Output 3
7	Output 4
8	Ground
9	Input 1
10	Input 3
11	Ground
12	Output 1
13	Output 2
14	Ground
15	

TIO Internal Circuits

Use the following diagram to understand the TIO internal circuits.

● TIO Input Signals

The 5 input channels are optically isolated and share a common source / sink line.
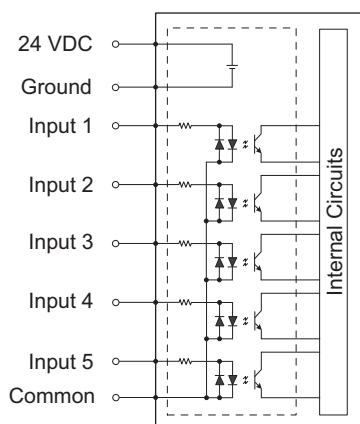
● TIO Output Signals

The 4 outputs share a common, sourcing driver integrated circuit. The driver is designed to supply a load with one side connected to ground. Each channel is capable of switching up to 0.7 A of current. This driver has over-temperature protection, shorted load protection, and is current limiting. The driver draws power from the primary 24 VDC input to the robot through a self-resetting poly-fuse.

Precautions for Correct Use

Use surge suppression when switching inductive loads such as relays to prevent damage to the output circuits.

Additional Information

If there is an output short or other over-current condition, the affected output of the driver integrated circuit turns OFF until the condition is removed.
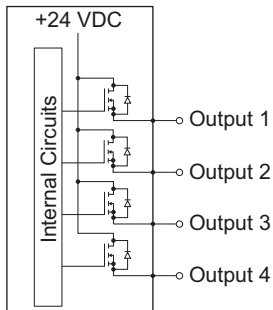
Pneumatic Valve Kit Signals

Use the following signal designations to control solenoids on the pneumatic valve kit.

- Output 1: SNLD 1
- Output 2: SNLD 2
- Output 3: SNLD 3

Additional Information

Valve types are SMC type VQZ1121-5MO1-C4-Q.

3-7-3   IO Blox Connections

IO Blox units can be connected to the XBELTIO connector using the XBELTIO adapter cable. Up to 4 IO Blox units can be connected as shown below.

V+ signal number assignments vary based on the Robot Number setting. The Robot Number is designated with the Robot Device Assignment in Sysmac Studio.

Refer to the following areas for more information about V+ signal number assignments.

- *A-4 I/O Signal Numbering* on page A-6
- *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)*

Additional Information

Refer to the for more information.

XBELTIO
Adapter Cable

EXPIO to
IO Blox Cable
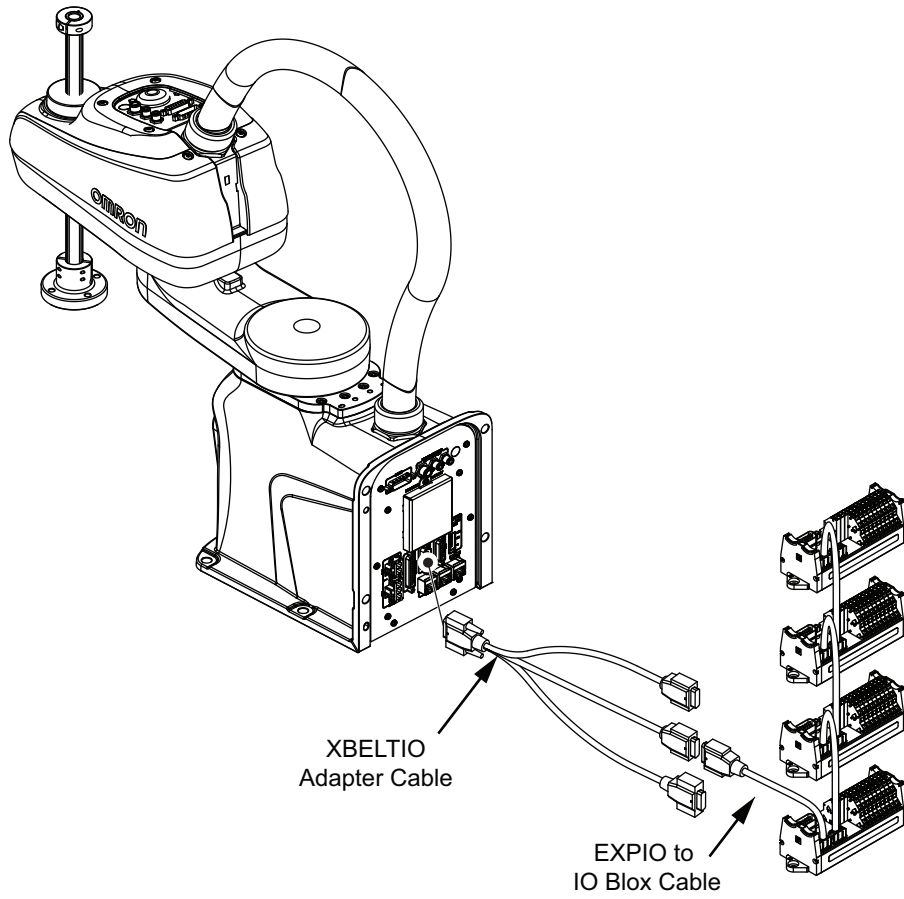
3-8 Installing Safety Equipment

The user-supplied safety equipment connects to the system through the XMCP, XUSR and XFP connectors on the XSYSTEM cable. Refer to the following sections for safety equipment connection details.

⚠ DANGER	
• The robot system must be installed with user-supplied interlock barriers. The interlocked barriers must open the E-Stop circuit in the event of personnel attempting to enter the work cell when High Power is enabled. Failure to install suitable guarding or interlocks could result in injury or death. We strictly prohibit installation, commissioning, or operation of any robot without adequate safeguards. These must be compliant with applicable local and national standards. • The placement of safety controls shall avoid requiring a person to enter a hazardous area to actuate them. • Controls shall be located outside of the safeguarded space, except for certain controls such as emergency stops or a teach pendant, where based on a risk assessment they may be located within the safeguarded space.	❗

⚠ WARNING	
Before starting the operation of equipment, always confirm that the safety equipment of the robot works properly. If a malfunction of the safety equipment is detected, follow the procedure for abnormal conditions.	❗

⚠ CAUTION	
The design and installation of the complete system must comply with the safety standards and regulations in the country of use. The integrators of the robot should understand the safety laws and regulations in their countries and prevent major hazards from occurring in the complete system.	⚠

Additional Information

Refer to the *Robot Safety Guide (Cat. No. I590)* for more information.

3-8-1 Installing the Front Panel

Use the dimensions below to install the Front Panel in a suitable location outside of the robot's workspace where it can be easily accessed for emergency stops.

The length of the XSYSTEM cable (1.8 m) and the length of the Front Panel extension cable (3 m) should also be considered when choosing an installation location. If you need to extend the Front Panel beyond the supplied cable distance, contact your local OMRON representative for more information.

⚠ DANGER	
Any High Power push-buttons must be installed outside of the robot's workspace.	❗
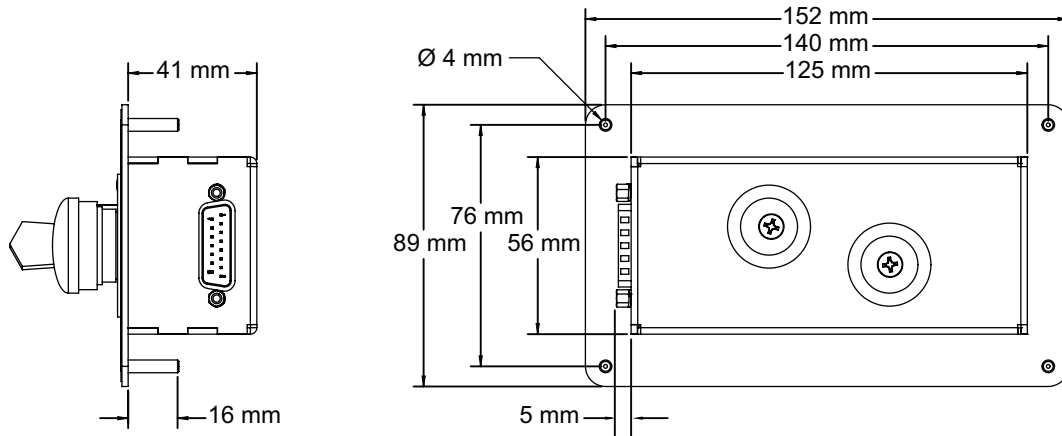
Front Panel Connections

The Front Panel is connected directly to the XFP connector on the XSYSTEM cable with the 3 m extension cable supplied with the Front Panel.
- The part number of the extension cable is 10356-10500.
- The length of the extension cable is 3 m.

> **Additional Information**
>
> Refer to *XFP Connections* on page 3-37 for more information.

3-8-2 Safety Circuits

The XSYSTEM cable provides connections for all emergency stop circuits. All emergency stop circuits are dual-channel and voltage-free. These voltage-free contacts are provided by a redundant, cyclically-checked, positive-drive, safety relay circuit for Category 3 PL-d per ISO 13849 operation.

The XUSR connector provides access to the following safety circuits.
- Dual channel emergency stop inputs.
- Dual channel emergency stop status outputs.
- Dual channel muted safety gate inputs.
- Dual channel Automatic / Manual mode status outputs.

The XFP connector provides access to the following safety circuits that are typically used with the Front Panel.
- Dual channel emergency stop inputs.
- Dual channel Automatic / Manual mode selection inputs.
- High power indicator output.
- High power enable input.
- Control power indicator output.

The XMCP connector provides access to the following safety circuits that are use with a connected Teach Pendant.
- Dual channel E-stop button inputs.
- Dual channel pendant enable switch inputs.

Use the diagram below to understand safety circuits.
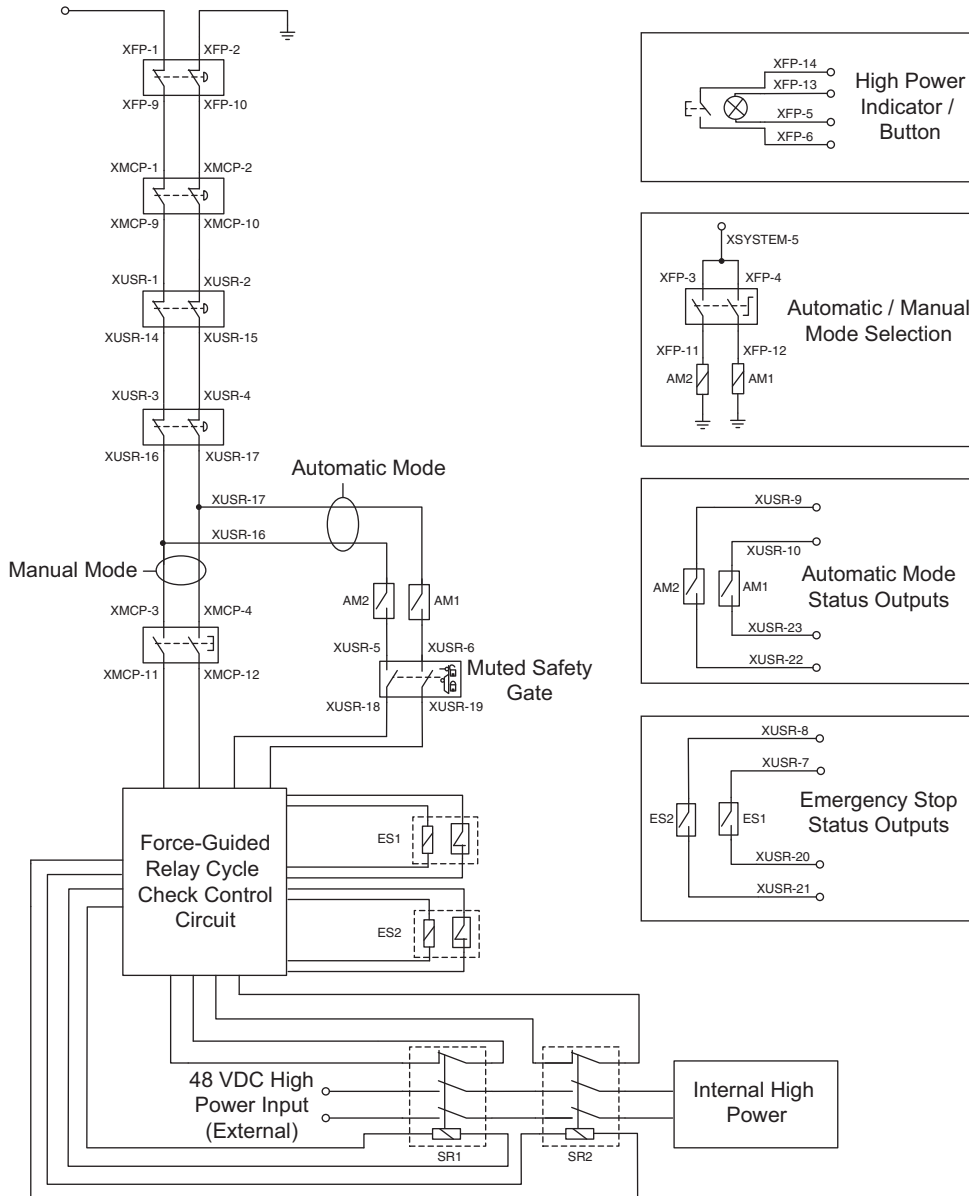
XUSR Connections

Use the information in the following table to understand the signals provided on the XUSR connector.
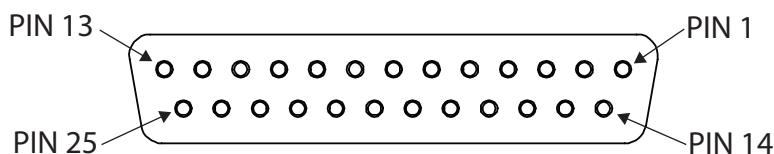
Pins	Description	Additional Information
1, 14	Emergency stop channel 1 input	Typically connected to normally closed contacts on user-supplied safety devices such as E-stop buttons, safety switches, or safety relays.
2, 15	Emergency stop channel 2 input	

Pins	Description	Additional Information
3, 16	Line emergency stop inputs	Normally closed contacts on user-supplied safety devices typically used for other robot or line emergency stop interconnection. This does not affect emergency stop indication signals on pins 7, 20.
4, 17		
5, 18	Muted safety gate channel 1 input	Causes emergency stop in Automatic mode only.
6, 19	Muted safety gate channel 2 input	
7, 20	Emergency stop status channel 1 output	Internal contacts are closed when Front Panel, Teach Pendant, and user-supplied safety devices are not enabled / activated.
8, 21	Emergency stop status channel 2 output	
9, 22	Automatic mode status channel 1	Internal contacts are closed when the robot is in automatic mode.
10, 23	Automatic mode status channel 2	
11, 12, 13, 24, 25	Reserved for future use.	

● **XUSR Jumper Plug**

The XUSR jumper plug is provided for safety equipment troubleshooting only.
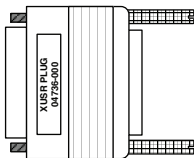
⚠ WARNING

Never run a robot system with all jumpers installed. This would leave the system with no E-Stops.

📓 **Additional Information**

The XUSR jumper plug is supplied with the robot.
The part number for the XUSR jumper plug is 04736-000.

XFP Connections

Use the information in the following table to understand the signals provided on the XFP connector.
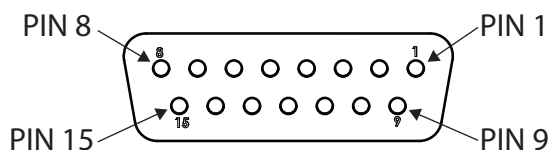
📓 **Additional Information**

Refer to *Front Panel Connections* on page 3-35 for more information.

Pins	Description	Additional Information
1, 9	Front panel E-stop button channel 1 input	Typically connected to normally closed contacts on the E-stop button used with the Front Panel.
2, 10	Front panel E-stop button channel 2 input	
3, 11	Automatic / Manual mode selection channel 1 input	Typically connected to the selector switch used with the front panel. An open circuit selects Manual mode. A closed circuit selects Automatic mode.
4, 12	Automatic / Manual mode selection channel 2 input	
5, 13	System-supplied 5 VDC output (pin 5) and common (pin 13) for High Power indicator lamp.	If lamp is user-supplied, it must draw between 10 mA to 500 mA to satisfy the internal High Power lamp monitoring function.[1]
6, 14	High Power ON / OFF	Typically connected to a momentary push-button that enables High Power when all safety circuits are satisfied.
7, 15	System-supplied 5 VDC output (pin 7) and common (pin 15) for Control Power indicator.	If indicator is user-supplied, the recommended load is between 20 to 500 mA.
8	Reserved for future use	

*1. Lamps that illuminate with a low current (10 mA to 25 mA) may appear dim when the High Power is OFF due to leakage current. If this occurs, add additional resistance to ensure the lamp is OFF when High Power is not enabled.

● **XFP Wiring Diagram**

Use the following diagram to understand XFP electrical connections.

⚠ WARNING

If you supply your own Front Panel E-Stop, its design must comply with the requirements of IEC 60204-1 and ISO 13849. The E-Stop's push button must comply with ISO 13850.

Precautions for Correct Use

Do not disable or bypass the High Power button. This will violate IEC 60204-1.
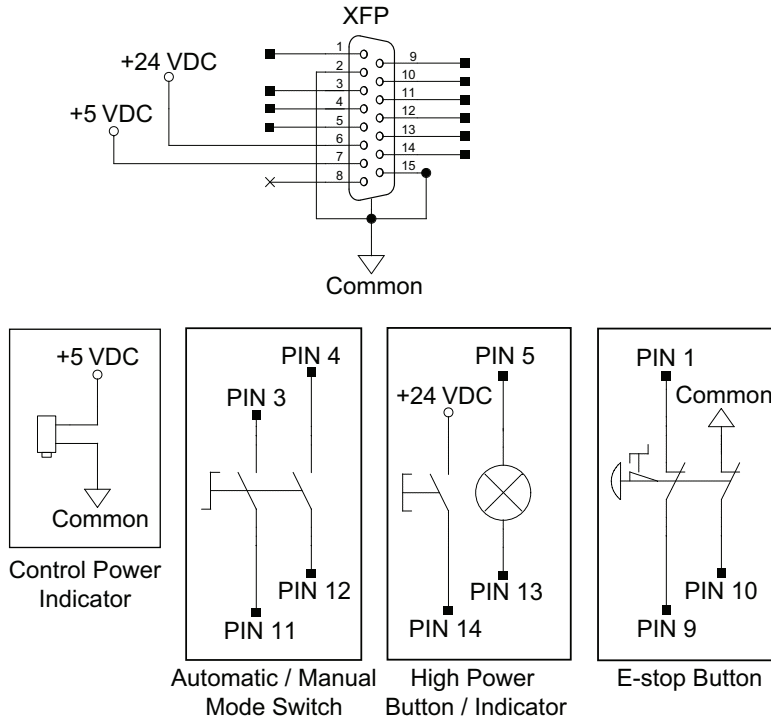
● **XFP Jumper Plug**

The XFP jumper plug is provided for safety equipment troubleshooting.
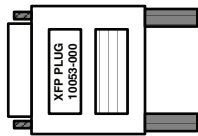
⚠ WARNING

Never run a robot system with all jumpers installed. This would leave the system with no E-Stops.

🚫

📝 **Additional Information**

- The XFP jumper plug is supplied with the robot.
- The part number for the XFP jumper plug is 10053-000.

XMCP Connections

Use the information in the following table to understand the signals provided on the XMCP connector.
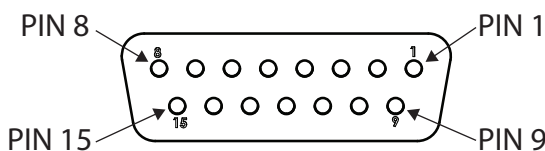
Additional Information

Refer to the *T20 Pendant User's Manual (Cat. No. I601)* for additional information.

Precautions for Correct Use

If Teach Pendant cabling is installed, the jumper plug or the Teach Pendant must be connected to satisfy safety circuits and allow High Power to be enabled.

Pins	Description	Additional Information
1, 9	Pendant E-stop button channel 1	Connected to the pendant's integrated E-stop button.
2, 10	Pendant E-stop button channel 2	
3, 11	Pendant enable switch channel 1	Connected to the pendant's integrated enable switch.
4, 12	Pendant enable switch channel 2	
6	24 VDC pendant supply	
7	Serial communications TXD	Pendant serial communications transmit signal.
8	Serial communications RXD	Pendant serial communications receive signal.
13	Serial communications GND	Pendant serial communications ground signal.
Shield	Ground shield	
5, 14, 15	Reserved for future use.	

● **XMCP Jumper Plug**

The XMCP jumper plug is used when there is no T20 pendant adapter cable connected.
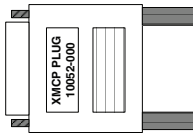
⚠ WARNING

Never run a robot system with all jumpers installed. This would leave the system with no E-Stops.

Additional Information

• The XMCP jumper plug is supplied with the robot.
• The part number for the XMCP jumper plug is 10052-000.

● **Teach Pendant Jumper Plug**

The Teach Pendant jumper plug is provided to allow the system to operate when Teach Pendant cabling is installed, but the Teach Pendant is not connected. This plugs into the Teach Pendant adapter cable when the pendant is not in use.
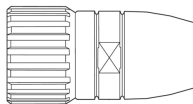
Additional Information

- The jumper plug is supplied with the Teach Pendant kit.
- The part number for the Teach Pendant jumper plug is 10048-000.

3-9 Setting the EtherCAT Node ID

The EtherCAT node ID / address can be set with two methods as described below.

* Use Hardware Switches on the Robot.
  Use the hardware switches on the robot interface panel to set an explicit EtherCAT node ID for the robot. Refer to *3-9-1 EtherCAT Node ID Setting Example* on page 3-42 for more information.
  Switch positions are only evaluated during the power-up procedure after 24 VDC Control Power is applied. Changing switch positions while the robot Control Power is ON will have no effect until the power is cycled.
  Use Sysmac Studio to verify the EtherCAT node ID setting after adjusting the switches.

* Use Sysmac Studio
  When using Sysmac Studio to set the EtherCAT node ID, ensure the switches are set to the default 0 positions. If the switches are set to a non-zero value, the switch positions will dictate the EtherCAT node ID and software adjustment of this value is not possible. Switches should be in the following positions when using Sysmac Studioto set the EtherCAT node ID.
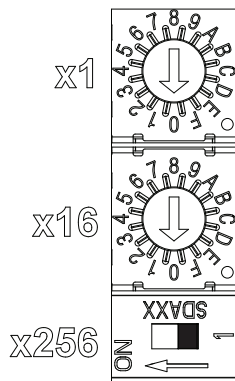
When the EtherCAT node ID is set with Sysmac Studio, it is retained in non-volatile memory and will persist after subsequent power cycles.

> **Additional Information**
>
> Refer to the *Sysmac Studio Version 1 Operation Manual (Cat. No. W504)* for more information about setting the EtherCAT node ID with software.

3-9-1 EtherCAT Node ID Setting Example

In the following example, an EtherCAT node ID of 196 is used to demonstrate how to make the switch settings.

1 Begin by converting the desired node ID into a hexadecimal format. In this example, 196 is converted to 0x0C4.

2 Set the x256 dip switch to the OFF position.

3 Set the x16 rotary switch to position C.

4 Set the x1 rotary switch to position 4.

·

5 Confirm that the switches are in the following positions.
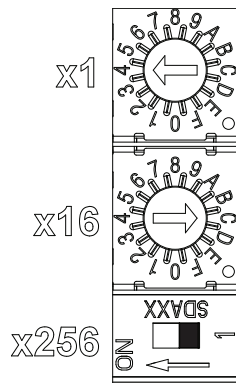
6 Apply or cycle Control Power to implement the new node ID setting.

7 Confirm the correct EtherCAT node ID of 196 with Sysmac Studio..

3-10 Supplying Power and Ground

The robot requires separate 24 VDC and 48 VDC power supplies. The 24 VDC supply provides Control Power and the 48 VDC supply provides power to the internal servo amplifiers.

A lockout tagout main disconnect device must be installed on the AC supply to the 24 VDC and 48 VDC power supplies. These devices are user-supplied. Disconnect devices shall be accessible and conveniently located to facilitate application of lockout devices during service and maintenance.

Use the information below to make all power supply connections to the robot.

> **Additional Information**
>
> Refer to *2-3-1 Power Supply Specifications* on page 2-13 for information about power supply requirements and other wiring details.

3-10-1 Grounding the System

The system should be grounded properly to avoid transient voltages or other electrical noise. There are two primary ground points on the system as described below.

- High Power ground
- Chassis ground

> **Precautions for Safe Use**
>
> The Joint 3 quill and the tool flange are not grounded to protective earth. If hazardous voltages are present at any user-supplied robot-mounted equipment or tooling, you must install a ground connection from that equipment or tooling to the ground point on the robot base.
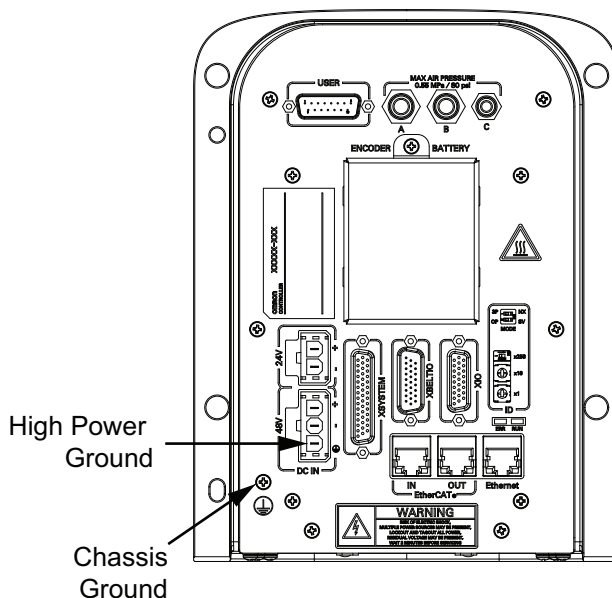
Ground Circuit

Use the following diagram to understand the recommended grounding circuit.
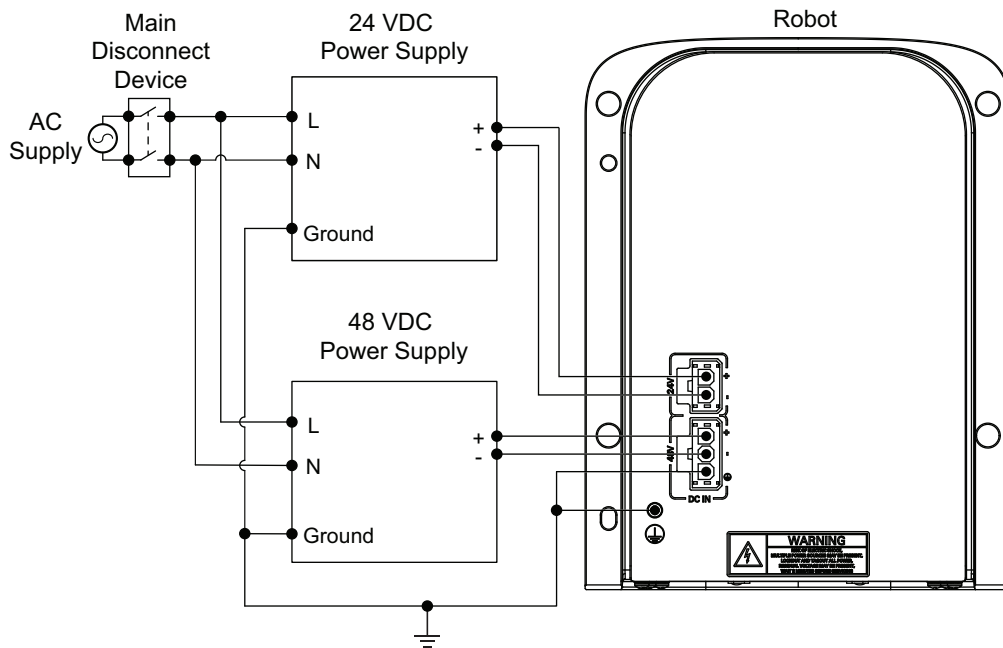
3-10-2   24 VDC Connections

The 24 VDC Control Power connector is located on the Primary Interface Panel. A 24 VDC power supply mating connector is provided with the robot.

Use the illustration below to understand the polarity of the mating connector.

> **Additional Information**
>
> • The connector and pins are provided with the robot and require assembly with user-supplied wires. The connector part number is 02708-000. The pin part number is 02709-000.
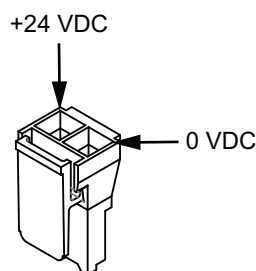
> • Refer to *3-4-5 Control Power Kit Connections* on page 3-19 for more information.

3-10-3   48 VDC Connections

The 48 VDC High Power connector is located on the Primary Interface Panel. A 48 VDC power supply mating connector is provided with the robot.

Use the illustration below to understand the polarity and ground terminals of the mating connector.

> **Additional Information**
>
> • The connector and pins are provided with the robot and require assembly with user-supplied wires. The connector part number is 22009-000L. The pin part number is 02709-000.

0 VDC

+48 VDC

GND
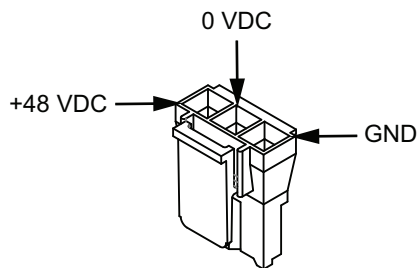
> • Refer to *3-4-6 High Power Kit Connections* on page 3-19 for more information.

3-11 Verifying Installation

If any modifications have been made to the robot during installation or other actions, make the following checks before operation.

3-11-1 Mechanical Checks

Make the following mechanical checks after any hardware adjustments have been made to the system.
- Check that the robot mounting surface is secure and adequate.
- Check all mounting bolts and other fasteners for proper torque.
- Check the tool flange and end-of-arm tooling for correct installation and grounding (when necessary).
- Check any equipment that is mounted to the robot to make sure it is securely fastened.

3-11-2 System Cable Checks

Make the following system cable checks after any adjustments have been made to cable connections.
- Check all cables and connectors to ensure that they are securely fastened and free of damage.
- Check the system ground and power supply connections to make sure that they are connected properly.
- Check that all cables are adequately supported and not strained near the connectors.

3-11-3 Safety Equipment Checks

Make the following checks to all user-supplied safety equipment to ensure emergency stops are properly installed and other safety systems are functioning correctly.
When checking safety equipment, the following prerequisites are necessary.
- Sysmac Studio must be installed and available.
- The Front Panel operating mode switch must be in the Automatic position.
- All emergency stop devices must be able to be activated and deactivated easily.

Use the following utilities in the Sysmac Studio to confirm safety operations controlled by robot software.

Safety Setting Function	Description
Configure Teach Restrict	The objective of the Teach Restrict feature is to comply with safety regulations which require that the speed be limited while the robot is in Manual mode.
Verify Teach Restrict Auto	
Verify Teach Restrict Manual	This is hardware-based safety functionality to prevent rapid robot motion in Manual mode even in the unexpected event of software error attempting to move a robot faster than allowed. While jogging the robot in Manual mode, if any joint exceeds its configured speed limit, the system will disable High Power. Configuration will set predetermined speed limits for each robot motor. Verification will verify that Teach Restrict operations are functioning properly in Automatic and Manual modes.

Safety Setting Function	Description
Configure E-stop Hardware Delay	The objective of the ESTOP hardware delay feature is to comply with safety regulations which require the robot to have the capability of disabling High Power without software intervention in an emergency stop situation. Configuration will set the delay for the emergency stop timer circuit. Verification will verify that High Power is disabled without software intervention in an emergency stop situation.
Verify E-stop Hardware Delay	

Additional Information

Refer to the *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* for more information about using the Safety Setting functions.

Emergency Stop Check Procedure

Use the following procedure to check for correct emergency stop operation.

1 If a pendant is present in the system, connect it to the XSYSTEM cable.

2 Prepare all emergency stop devices for enabling the robot High Power.

3 Enable the robot High Power with one of the methods described in *4-4-1 Robot High Power Operations* on page 4-8.

4 Confirm that robot High Power is enabled using the High Power indicator. If robot High Power is not enabled, refer to *Section 5 Troubleshooting* on page 5-1 for more information.

5 Activate each and every emergency stop device connected to the system to check that High Power is disable for all safety equipment. This includes pendant safety devices, Front Panel safety devices, and any other safety equipment wired to the XUSR connector. After one safety device check is made, deactivate it, enable High Power again, and make a check for the next safety device. Repeat 2 to 5 until all safety device functionality is confirmed to be working properly.

High Power Indicator Check

When High Power is enabled, an amber indicator lamp must turn ON to alert personnel that the robot is capable of motion to satisfy safety requirements.

● High Power Indicator Check Procedure

Use the following procedure to verify that the High Power indicator is working correctly.

1 Apply Control Power to the robot and disable High Power.

2 Make a High Power request using one of the methods described in *High Power Control Methods* on page 4-9.

3 Check that the High Power indicator flashes. After the High Power request is made and the in-
dicator is checked, the procedure is complete.

3-11-4 Switch Position Checks

Check the following switch positions on the Primary Interface Panel to make sure they are set correct-
ly. The following settings are required for normal operation.
- Mode switches
  Dip switch 1: B
  Dip switch 2: OP
- EtherCAT node ID switches
  Dip switch and rotary switches: set to 0 if node ID is set with Sysmac Studio. Set to desired node ID
  if setting an explicit node ID.

4

Operation

This section provides information necessary to operate the robot.

4-1   Configuration Procedure Overview

The following procedure provides an overview for configuring the robot.

1   Create a new project for the Robot Integrated CPU Unit in the Sysmac Studio.
Refer to the *Sysmac Studio Version 1 Operation Manual (Cat. No. W504)* for more information.

2   Make the settings for the Robot Integrated CPU Unit.
Refer to *NJ-series Robot Integrated CPU Unit User's Manual (Cat. No. O037)* for more information.

3   Add the EtherCAT slaves including the OMRON robots and make the EtherCAT network settings.
Refer to *NJ-series Robot Integrated CPU Unit User's Manual (Cat. No. O037)* for more information.

4   Make the robot control parameter settings.
Refer to *NJ-series Robot Integrated CPU Unit User's Manual (Cat. No. O037)* for more information.

5   Make settings to control I/O from the user program.
Refer to *NJ-series Robot Integrated CPU Unit User's Manual (Cat. No. O037)* for more information.

6   Write the user program for OMRON robots and peripheral devices with the sequence control program and the V+ program.
Refer to *NJ-series Robot Integrated CPU Unit User's Manual (Cat. No. O037)* for more information.

7   Perform teaching in the simulation operation.
Refer to the following manuals for more information.
- *NJ-series Robot Integrated CPU Unit User's Manual (Cat. No. O037)*
- *Sysmac Studio 3D Simulation Function Operation Manual (Cat. No. W618)*
- *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)*

8   Transfer the settings and program from the Sysmac Studio to the Robot Integrated CPU Unit and the EtherCAT slaves.
Refer to *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* for more information.

9   Check the operations for the program and the teaching position on the physical Controller and make changes as required.
Refer to the following manuals for more information.
- *NJ-series Robot Integrated CPU Unit User's Manual (Cat. No. O037)*
- *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)*

- *T20 Pendant User's Manual (Cat. No. I601)*

10 Operate the Controller and the machine.

11 Perform the troubleshooting for the error, periodic inspections, and maintenance.

Refer to the following manuals for more information.

- *NJ-series Robot Integrated CPU Unit User's Manual (Cat. No. O037)*
- *NJ/NX-series Troubleshooting Manual (Cat. No. W503)*

4-2 Payload and Acceleration Considerations

Careful considerations must be made when using high payloads, high accelerations, or a combination of both.

If non-linear moves such as joint moves or arc moves are required with high speeds or high payloads, contact your local OMRON representative for more information about acceleration and payload limitations.

Use the following chart to understand the limitations to acceleration and payload when making linear moves. Some linear moves are not achievable over all paths in the working envelope.

Precautions for Correct Use

Operating the robot outside of the payload and speed constraints described in this document can damage or reduce the service life of the z-axis quill.

Payload Z-Location vs. Acceleration at 100% Speed
(Linear Moves Only)

Payload Z-Location (mm) = Joint 3 Position + Payload Center of Gravity
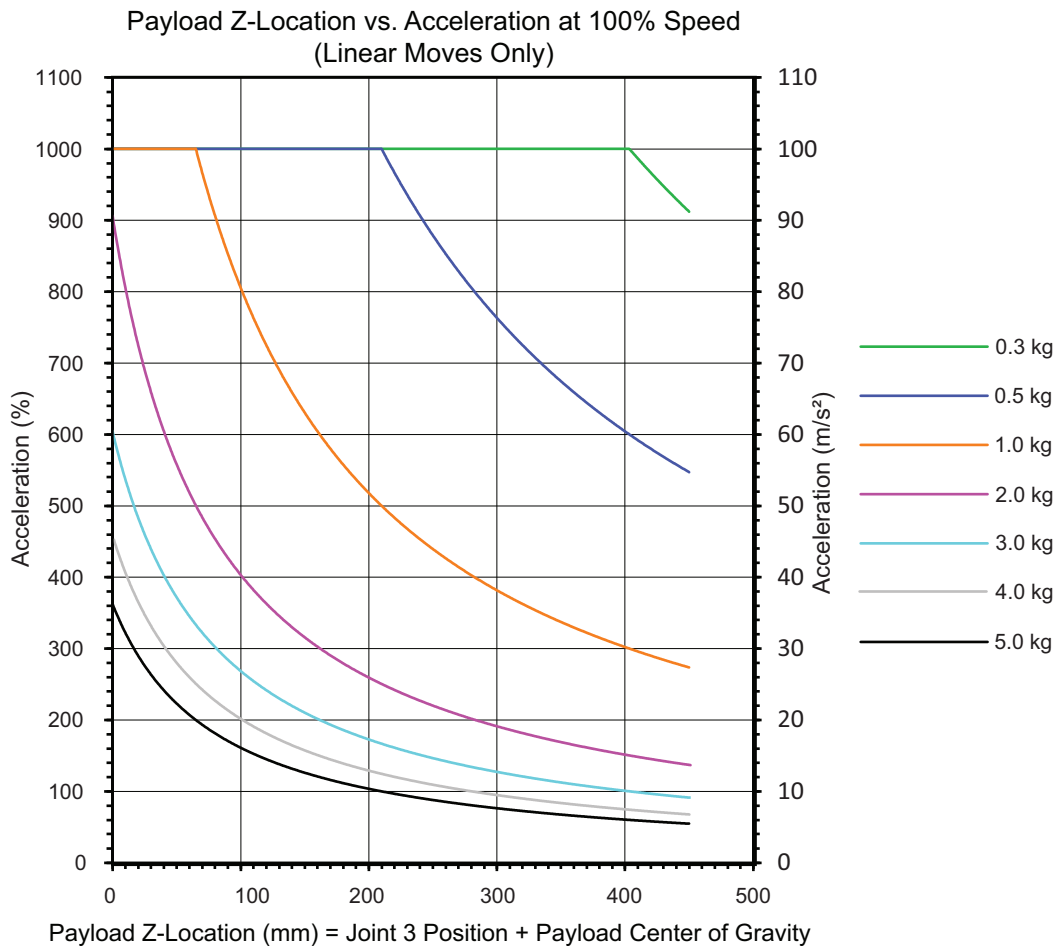
4-3 Robot Control Modes

The robot can operate in Automatic or Manual control modes. These modes are described in the following sections.

4-3-1 Manual Mode

Manual mode is typically used during functions of commissioning, position teaching, and other setup operations. In this mode, the robot will respond to the control signals issued by the connected pendant.

When the robot is placed in Manual mode, robot motion speed is limited to 250 mm/sec and servo torque is limited so an operator can safely work inside the cell. Programs can execute from the pendant in STEP mode.

Precautions for Safe Use

• After the robot is placed in Manual mode using the Front Panel key switch, the key should be removed for safety purposes.
• During manual operation, ensure all persons are a safe distance away from the robot work envelope.

Additional Information

Refer to the *T20 Pendant User's Manual (Cat. No. I601)* for more information.

To place the robot in Manual mode, use the Front Panel key switch and rotate it to the left position as indicated below. Changing the robot control mode will automatically disable High Power.
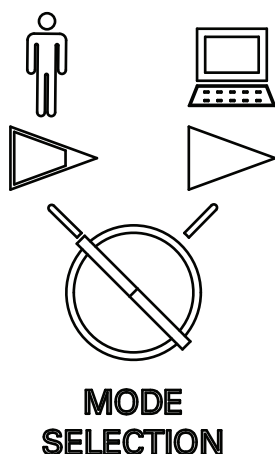
4-3-2 Automatic Mode

Automatic mode is used when the robot is operating under normal conditions.

When the robot is placed in Automatic mode, program execution will control the robot up to the maximum speed.

Precautions for Safe Use

Prior to placing the robot in Automatic Mode, all safeguards must be returned to their safe state.

To place the robot in Automatic mode, use the Front Panel key switch and rotate it to the right position as indicated below. Changing the robot control mode will automatically disable High Power.
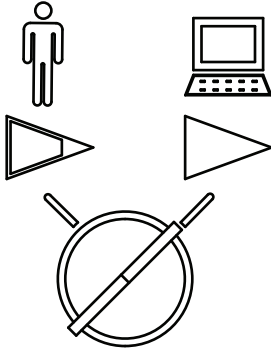
MODE
SELECTION

⚠ WARNING

In Automatic mode, the robot can move unexpectedly. Ensure all personnel remain clear of the cell when Automatic mode is enabled.

4-3-3 Operation Mode

Operation mode should be used when the robot is operating under normal conditions and is being controlled by the with EtherCAT communications.

Additional Information

The position of the operation mode dip switch is checked during power-up only. Changing this switch position while 24 VDC Control Power is supplied will not change the mode of the robot until power is cycled. It is recommended to remove all robot power before changing the position of this switch.

To place the robot in operation mode, set dip switch 2 on the Primary Interface Panel to the OP position as shown in the figure below and then apply Control Power to the robot.

Service Mode

Service mode is used for special conditions when the robot must be accessed with methods other than EtherCAT communications.

Dip switch 2 on the Primary Interface Panel should remain in the OFF / OP position during normal operation.

If any of the following conditions are present on your robot, contact your local OMRON representative for support using service mode.

- The license mode of the robot needs to be changed.
- EtherCAT communications cannot be achieved.
- The robot has an unrecoverable fault or error.
- Factory recalibration is required.

> **Additional Information**
>
> The position of the operation mode dip switch is checked during power-up only. Changing this switch position while 24 VDC Control Power is supplied will not change the mode of the robot until power is cycled. It is recommended to remove all robot power before changing the position of this switch.

4-3-4   Host Mode

Dip switch 1 on the Primary Interface Panel is used to control the host mode of the robot.

Dip switch 1 on the Primary Interface Panel should remain in the NX position during normal operation as shown in the figure below.

The switch position 3P is reserved for future use.
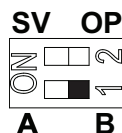
4-4 Enabling and Disabling the Robot

Enabling the robot energizes all robot servo motors with the 48 VDC power supply. This is also referred to as enabling High Power. When the robot is enabled, it is capable of moving.

Program execution and I/O control functions are still operational when High Power is disabled. However, ATTACH or other motion commands may return errors or delay program execution if High Power is disabled. Refer to the *V+ Keyword Reference Manual (Cat. No. I672)* for more information.

Disabling the robot de-energizes all robot servo motors.

> **Additional Information**
>
> When High Power is enabled, the brake is automatically released. When High Power is disabled, the brake is automatically activated to prevent downward motion of the quill due to gravity.

> **Precautions for Safe Use**
>
> • The LED indicator does not reflect the robot's High Power status. To see the robot's High Power status, use the Front Panel indicator or a user-supplied indicator connected to the XFP connector.
> • High Power cannot be enabled unless all safety circuits are satisfied.

4-4-1 Robot High Power Operations

Robot High Power operations are described below.

High Power Safety Timeout

If the safety timeout function is enabled in the robot configuration, the High Power indicator on the Front Panel will flash for a specified amount of time after a High Power request is made. If the High Power button is not pressed within the specified amount of time, a safety timeout occurs and High Power is not applied.

The safety timeout function is enabled by default and has a duration set for 10 seconds. The safety timeout function configuration settings are accessed with the Sysmac Studio. Refer to the *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* for more information.

> **Precautions for Correct Use**
>
> If a Front Panel is not present, the High Power indicator and High Power button signals can be accessed with the XFP system cable connector. Refer to *XFP Connections* on page 3-37 for more information.

High Power and Faults

If a fault is present, the robot will not enter the High Power state.

The AUTO.POWER.OFF system switch controls if the robot prevents or disables High Power for specific errors. Refer to the *V+ Keyword Reference Manual (Cat. No. I672)* for more information.

High Power Control Methods

There are several methods to control robot High Power as described below.

● Front Panel

When a Front Panel is present in the system, the High Power button can be used to request High Power to the robot.

If High Power is enabled, pressing the button will disable High Power.

> **Additional Information**
>
> Refer to *Front Panel Connections* on page 3-35 for more information about connecting external devices to the High Power enable signal on the XFP connector.

● Connected PC

High Power can be controlled with the Sysmac Studio. Refer to the *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* more information.

● User Program

High Power can be controlled with a user program through the use of the POWER system switch keyword. Refer to the *V+ Keyword Reference Manual (Cat. No. I672)* for more information.

● Pendant

If a pendant is connected to the robot, it can be used to control High Power. Refer to the *T20 Pendant User's Manual (Cat. No. I601)* for more information.

● Faults and Emergency Stops

Robot faults and E-stop open circuit detection will disable High Power.

4-5   LED Indicator

The LED indicator on the top of the outer link provides a visual status of the robot. The LED indications and associated robot states are described below.

> **Precautions for Safe Use**
>
> The LED indicator does not reflect the robot's High Power status. To see the robot's High Power status, use the Front Panel indicator or a user-supplied indicator connected to the XFP connector.

LED Indication	Robot State
OFF	Control Power is not present.
Solid White	The robot is initializing.
Solid Blue	The robot is booting.
Slow Flashing Blue (0.25 Hz)	The robot is in an idle state with no errors present.
Fast Flashing Green (1 Hz)	The robot is in a normal operating state while in Automatic mode.
Slow Flashing Green (0.25 Hz)	The robot is in a normal operating state while in Manual mode.
Fast Flashing Red (1 Hz)	The robot is in an error state from an emergency stop or other condition.
Solid Red	The robot has a system error.

4-6 Brake Operation

The robot has a mechanical brake on joints 3 and 4. Releasing the brake is typically done when you need to manually position joint 3 or 4. The brake is controlled with the methods described below. The mechanical brake is capable of preventing the z-axis quill from lowering more than 5 mm when up to 100 N of downward force is applied.

> ## ⚠ WARNING
>
> Releasing a brake may cause the quill, tool flange, end-effector, and payload to drop. To prevent possible injury to personnel or damage to the equipment, make sure that the equipment is supported when releasing the brake and verify that the end-effector and payload are clear of all obstructions.

Precautions for Safe Use

- The braking mechanism operates passively. If 24 VDC Control Power is removed from the system, the brake mechanism will automatically activate. 24 VDC Control Power must be supplied to release the brake. To prevent possible damage to the equipment, remove any payload from the end-of-arm tooling, make sure that Joint 3 is supported while releasing the brake, and verify that the end-of-arm tooling or other installed equipment is clear of all obstructions.
- In case of entrapment of a person by the robot or any other emergency or abnormal situation, you can manually move the inner and outer links to a safe position while 48 VDC High Power is disabled. A brake device prevents Joints 3 and 4 from moving when High Power is disabled and can only be released while 24 VDC Control Power is present.

Precautions for Correct Use

- Attempting to release the brake while High Power is ON will automatically disable High Power. If the robot is moving, this will cause it to stop abruptly.
- Robot joints 1 and 2 have no brake mechanism and can be manually moved when power is not present.
- Avoid rotating the quill / Joint 4 when the brake is released. This could result in an out-of-range condition and may prevent program execution.

4-6-1 Built-in Brake Release Button

The brake release button is built-in and integrated into the LED indicator light on the top of the outer link. Pressing this button while the 24 VDC Control Power is ON and High Power is disabled will release the brake. The brake will remain released while the button is pressed. Releasing the button will re-enable the brake.
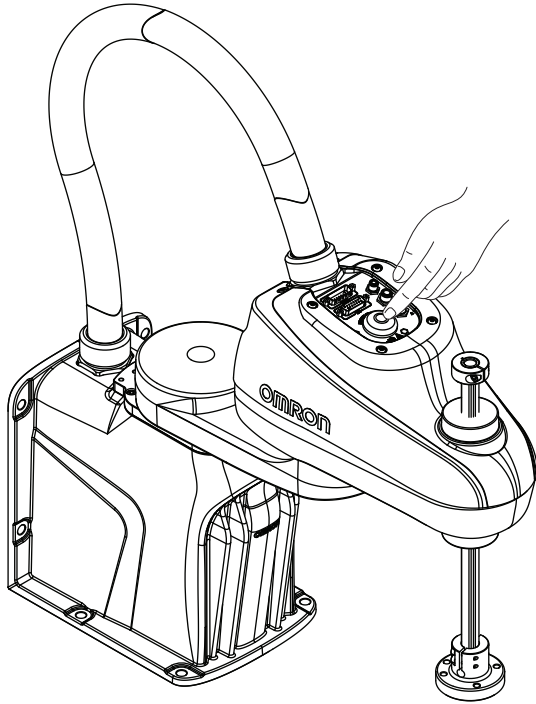
4-6-2   Remote Brake Release

The brake can be released with a signal connected to the XIO connector. This is typically used for re-
mote control of the brake.

Use the Sysmac Studio to configure the robot by selecting Enable Brake Release Input. This setting
will change the XIO input 6.2 (pin 18) for use as a brake release signal from another device such as a
remote pushbutton or an output from another control device. This setting does not affect the normal
functionality of the brake release button.

> **Additional Information**
>
> Refer to the *Sysmac Studio Robot Integrated System Building Function with Robot Integrated
> CPU Unit Operating Manual (Cat. No. W595)* for more information about the Enable Brake Re-
> lease Input robot configuration item.

> **Precautions for Safe Use**
>
> To comply with ISO 10218-1 when using a remote brake release button, ensure the brake re-
> lease button displays a warning label to indicate that the z-axis of the robot may fall due to grav-
> ity if the brake is released.

4-7   Manually Jogging the Robot

Manually jogging the robot is typically performed during setup or when teaching locations.

Precautions for Safe Use

During manual operation, ensure all persons are a safe distance away from the robot work envelope.

The following considerations should be made when jogging the robot.
- The jog speed and accelerations of the robot are reduced from normal operating speeds and accelerations.
- The jog speed of the robot can be adjusted.
- Robot motion can be incremented by specified amounts when extra precision is needed.
- Jogging can be executed in world, tool, or joint modes.
- The robot can be manually jogged with software or a pendant. Refer to the *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* or the *T20 Pendant User's Manual (Cat. No. I601)* for more information.
  - The robot can be jogged with the pendant while in Automatic mode or in Manual mode.
  - The robot can be jogged with the software while in Automatic mode. If the pendant is connected, it must be set to COMP to allow the software to jog the robot.

4-8   Robot Positioning

The information in this section describes important robot positions for typical operation.

4-8-1   Joint Zero Position

The robot is at the zero position under the following conditions. When the robot is properly calibrated and positioned at a precision point that consists of all zeros, the robot will have the following orientation.

• The inner link and outer link are fully extended.
• The quill is retracted in the up position.
• The 6 mm through hole on the tool flange is at the position shown below.

ø6 THRU
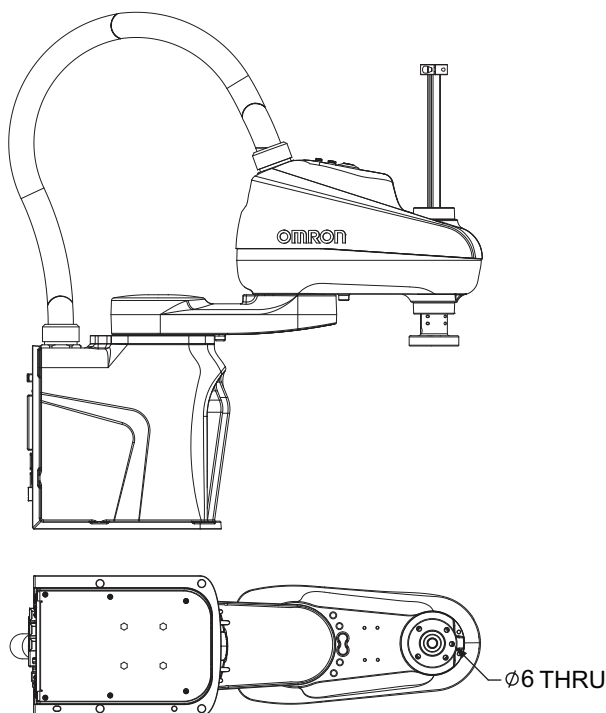
4-8-2   Ready Position

Use the READY keyword to place the robot in the ready position. Refer to the *V+ Keyword Reference Manual (Cat. No. I672)* for more information.

Ready positions provide below may vary slightly due to nulling tolerances.

Model	Joint 1 Position	Joint 2 Position	Joint 3 Position	Joint 4 Position
i4-350L	-44.42°	88.83°	10.00 mm	44.42°
i4-450L	-35.10°	99.72°	10.00	64.50°
i4-550Li4-550L (350 mm Z)	-50.48°	100.96°	10.00 mm	50.48°

4-8-3 Right-Left Arm Configurations

The robot can operate in a left-arm or right-arm configurations. Select an appropriate configuration for the work area based on your application requirements.

Use the RIGHTY/LEFTY keywords to set an arm configuration. Consider specifying the arm configuration before moving the robot to transformation locations. Moves to precision points are not affected by arm configurations because these points are unique joint positions. Refer to the *V+ Keyword Reference Manual (Cat. No. I672)* for more information.
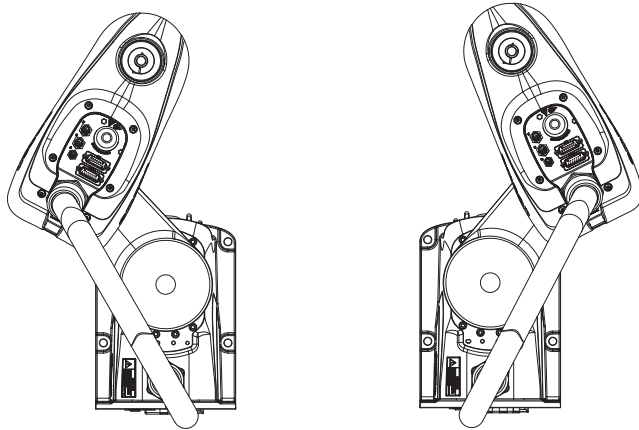
Left Arm
Configuration

Right Arm
Configuration

4-8-4 Collision Avoidance

Add and adjust obstacles to avoid collision with the robot base, flyover assembly, cables, connectors, wall, or other objects within the work envelope.

5
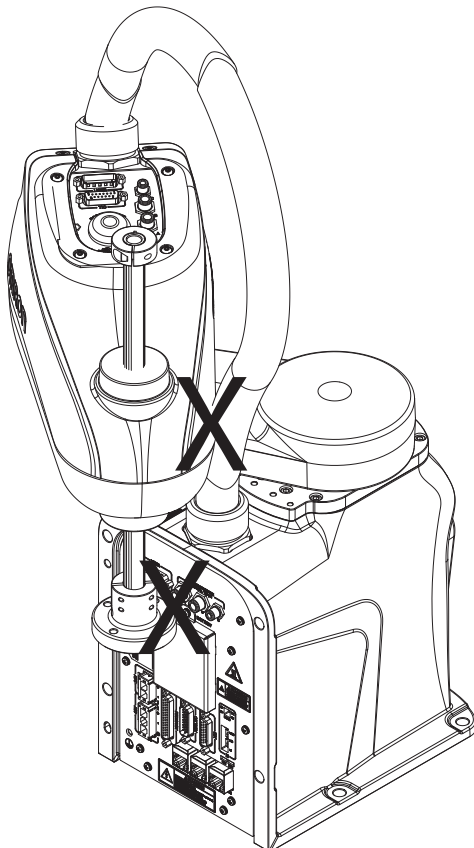
Troubleshooting

This section provides robot troubleshooting information.

5

5-1 Fault Detection

Robot faults can be detected with the following methods.

- Create a V+ program to change the state of an output signal when a fault is present. Refer to the *V+ User's Manual (Cat. No. I671)* for more information.
- Use the LED indicator to visually see when a fault is present. Refer to *4-5 LED Indicator* on page 4-10 for more information.
- Connect a PC running the Sysmac Studio.

5-2   Emergency Stop Troubleshooting

If the emergency stop circuit is not operating as expected, the following supplied jumper plugs can be used to troubleshoot the problem. These jumpers can be placed on the XSYSTEM cable to bypass and isolate safety devices. Refer to *3-6-1 System Cable Overview* on page 3-23 for jumper installation locations.

- XFP jumper plug (part number 10052-000)
- XUSR jumper plug (part number 04736-000)
- XMCP jumper plug (10052-000)

> ⚠ **WARNING**
>
> Never run a robot system with all jumpers installed. This would leave the system with no E-Stops.

5-3 Error Messages

The following table lists robot error messages. Use the Sysmac Studio to access robot status codes.

> **Additional Information**
>
> Other system messages may be present. Use the Sysmac Studio to check for these messages.

Error Code	V+ Error Message	Explanation	Corrective Action
-606	*Robot overheated*	The temperature sensor on the embedded processor board is at its temperature limit.	Try slowing the motion or insert pauses. Also, check for excessive ambient temperature, inadequate ventilation, and proper function of any cooling fans.
-643	*E-STOP detected by robot*	An E-STOP condition has been detected by the robot.	Remove the source of the E-STOP and re-enable High Power.
-648	*Safety System Not Commissioned*	The E-Stop Delay has not been commissioned and verified. The Teach Restrict has not been commissioned and verified.	Commission and verify the E-Stop Delay or Teach Restrict.
-651	*RSC communications failure*	There is a failure to communicate with the Robot Signature Card.	Contact your local OMRON support.
-670	*RSC power failure*	The 24 VDC input voltage is out of bounds (too high or low). The high-voltage DC bus for the amplifiers is out of bounds (too high or low). A loss of High Power was detected.	Check connections and voltage level from the user-supplied 24 VDC power supply. Check High Power connections for shorts or opens. Turn High Power back ON and restart the program. If the error persists, contact your local OMRON support.
-1007	*Motor stalled* Mtr #	A motor stall occurs when the maximum allowed torque was applied on a given motor for longer than the timeout period. Typically occurs when an obstacle is encountered.	Check for obstacles and free movement of all joints. Turn High Power back on and repeat the motion that failed.

Error Code	V+ Error Message	Explanation	Corrective Action
-1009	*Safety System Fault* Code 0	Robot hardware did not detect pressing the Front Panel High Power button before the servo system attempted to enable power.	Contact your local OMRON support.
	Safety System Fault Code 1	Contact your local OMRON support.	
	Safety System Fault Code 2	The safety system failed on channel 1 during the cyclic check of dual-channel power system. This may indicate a welded relay contact or other hardware failure.	Contact your local OMRON support.
	Safety System Fault Code 3	The safety system failed channel 2 during the cyclic check of dual-channel power system. May indicate hardware failure.	
	Safety System Fault Code 4	The internal E-STOP delay timer timed out and turned power off. Normally, software sequences the shutdown before the time-out.	
	Safety System Fault Code 5	The power system was improperly unlocked by software during a power sequence in manual mode.	
	Safety System Fault Code 6	CAT-3 hardware safety system detected an encoder OVERSPEED and turned power off. This circuit is active in Manual mode only on select robots which have the CAT-3 teach mode option.	Intentionally triggered during specific commissioning tests for the CAT-3 system. If during normal operation, contact your local OMRON support.
	Safety System Fault Code 9	Error reported by the watchdog circuit that cross-checks the clocks for the dual-channel safety system.	Contact your local OMRON support.
	Safety System Fault Code 10	An error was detected during a software self test of a secondary safety and monitoring circuit (SRV_DIRECT / SRV_ STAT).	
-1016	*Motor overheating* Mtr #	The motor encoder temperature sensor indicates an over temperature.	Reduce robot speed, acceleration and/or deceleration motions, or introduce delays in the application cycle to give the motor an opportunity to cool.
-1018	*Motor Amplifier Fault*	A power amplifier fault is indicated on axis #.	Check user motor power connections for shorts or opens. Turn High Power back ON and restart the program. If the error persists, contact your local OMRON support.

Error Code	V+ Error Message	Explanation	Corrective Action
-1021	*Duty-cycle exceeded* Mtr #	The indicated motor (#) has high power use for too long a period of time. The servo system has disabled power to protect the robot hardware.	• Turn High Power back ON and reduce the speed or acceleration for the motion that was in progress or for motions that preceded the message. • If the robot is operating at low temperatures when this error occurs, perform a warm-up operation at low speeds and acceleration and then resume normal operation. • If the robot is operating at high temperatures when this error occurs, reduce speed, acceleration, or provide additional cooling and then resume operation.
-1025	*Encoder Fault*	The servo system has detected an electrical or physical condition that resulted in an encoder fault.	Refer to the V+ User's Manual (Cat. No. I671) for more information.
-1027	*Hard envelope error* Mtr #	The indicated motor was not tracking the commanded position with sufficient accuracy as set by the configuration.	Turn on high power and try to perform the motion at a slower speed. Make sure that nothing is obstructing the robot's motion. If the error continues, contact your local OMRON support.
-1115	*Power system failure* Code 0	The dual-channel brake circuit has reported a cyclic check error.	Contact your local OMRON support.
	Power system failure Code 1	The power system has unexpectedly turned off power.	
	Power system failure Code 2	Overvoltage in the high voltage DC bus to the regenerative energy dump circuit.	
	Power system failure Code 3	The regenerative energy dump circuit has exceeded its max short term dump rating.	
	Power system failure Code 4	Contact your local OMRON support.	
	Power system failure Code 5	An inrush error was detected by the power sequencer. This means the high-voltage DC bus failed to rise at the expected rate when power was enabled.	This can occur if High Power is abruptly removed during the High Power enable sequence. If it occurs unexpectedly, contact your local OMRON support.

6

Maintenance

This section provides information for maintaining the robot.

6-1   Periodic Maintenance

This section lists when to perform periodic maintenance on your robots and the steps for checking each item to inspect.

> ## ⚠ WARNING
>
> - Never connect or disconnect system cables while power is applied to the robot. Failure to comply may cause unexpected behavior and can result in personnel injury and equipment damage.
> - You must perform the Lockout and Tagout procedure prior to servicing the robot.
> - The procedures and replacement of the parts mentioned in this manual must be performed only by the skilled or instructed persons.
> - The access covers on the robot are not interlocked. You should turn OFF and disconnect the power before the covers of the robot are removed.

6-1-1   Periodic Maintenance Overview

The following table gives a summary of the periodic maintenance procedures and guidelines on frequency.

Item	Period	Reference
Check E-Stop, enable and key switches, and barrier interlocks	6 months	Refer to *6-1-2 Checking Safety Functions* on page 6-2 for more information.
Check fastener torques	3 months	Refer to *6-1-3 Checking Fastener Torques* on page 6-3 for more information.
Check safety labels	1 week	Refer to *6-1-4 Checking Safety and Warning Labels* on page 6-4 for more information.
Check the High Power indicator operation	1 week	Refer to *High Power Indicator Check Procedure* on page 3-48 for more information.
Check for signs of oil around robot joints	3 months	Refer to *6-1-5 Checking for Oil Leaks* on page 6-4 for more information.
Lubricate the joint 3 quill	3 months or 150 km of travel	Refer to *6-1-6 Lubricating Joint 3* on page 6-5 for more information.
Replace the encoder backup batteries	2 to 4 years	Refer to *6-1-7 Replacing Encoder Backup Batteries* on page 6-6 for more information.
Clean the exterior of the robot	As needed	Refer to *6-1-8 Cleaning the Robot* on page 6-7 for more information.
Bellows inspection	1 week	Refer to *3-4-3 Bellows Kit Installation Procedure* on page 3-9 for more information.

6-1-2   Checking Safety Functions

All safety devices in the system should be checked regularly for proper functionality. Operating any of the following safety devices should disable robot High Power.

- E-stop button(s) on the Front Panel or connected to the XSYSTEM cable.
- E-stop button and enabling switch on the pendant (if connected).
- All other safety devices connected to the XSYSTEM cable.

Precautions for Safe Use

The High Power indicator must be operational to satisfy safety requirements.

Additional Information

Refer to *3-11-3 Safety Equipment Checks* on page 3-47 for more information.

High Power Indicator Check

The robot monitors current used by the High Power indicator. This is to ensure that a High Power indicator device is connected and functioning properly to satisfy safety requirements.
If the robot does not detect a current between 10 mA to 500 mA when High Power is requested, an error condition (-924) *Front panel HIGH POWER lamp failure* will be present and High Power will not be enabled.
The High Power indicator needs to be periodically checked for correct functionality.
The following considerations should be made before beginning the High Power indicator check procedure.

• Control power and High Power supplies need to be available.
• All connected safety devices must be capable of providing signals for a safe state.
• The robot High Power needs to be disabled and robot motions will not execute during this procedure.
• High Power safety timeout must be enabled to allow the indicator to flash after a High Power request is made. The recommended setting is 10 seconds. Refer to *Sysmac Studio Robot Integrated System Building Function with Robot Integrated CPU Unit Operating Manual (Cat. No. W595)* for more information.

● High Power Indicator Check Procedure

Use the following procedure to verify that the High Power indicator is working correctly.

1 Apply Control Power to the robot and disable High Power.

2 Make a High Power request using one of the methods described in *High Power Control Methods* on page 4-9.

3 Check that the High Power indicator flashes. After the High Power request is made and the indicator is checked, the procedure is complete.

6-1-3   Checking Fastener Torques

The following fasteners must be periodically checked for proper torque.
• Mounting screws: 30 to 32 N-m
• External equipment mounting fasteners (if present): 2.5 N-m (M4 screws), 4.5 N-m (M5 screws)
• Hardstops:
  • Joint 1 hardstops: 17 N-m
  • Joint 2 hardstops: 17 N-m
  • Joint 3 hardstop (clamp collar socket-head screw): 4.5 N-m

- Cable D-sub connectors: finger tight
- Tool flange setscrew: 1.1 N-m
- Tool flange socket-head screws: 2.5 N-m
- Tool flange end-of-arm tooling mounting fasteners: 7.5 N-m

6-1-4 Checking Safety and Warning Labels

This section lists the various safety and warning labels and their placement on the robot. Use this information to perform periodic checks.
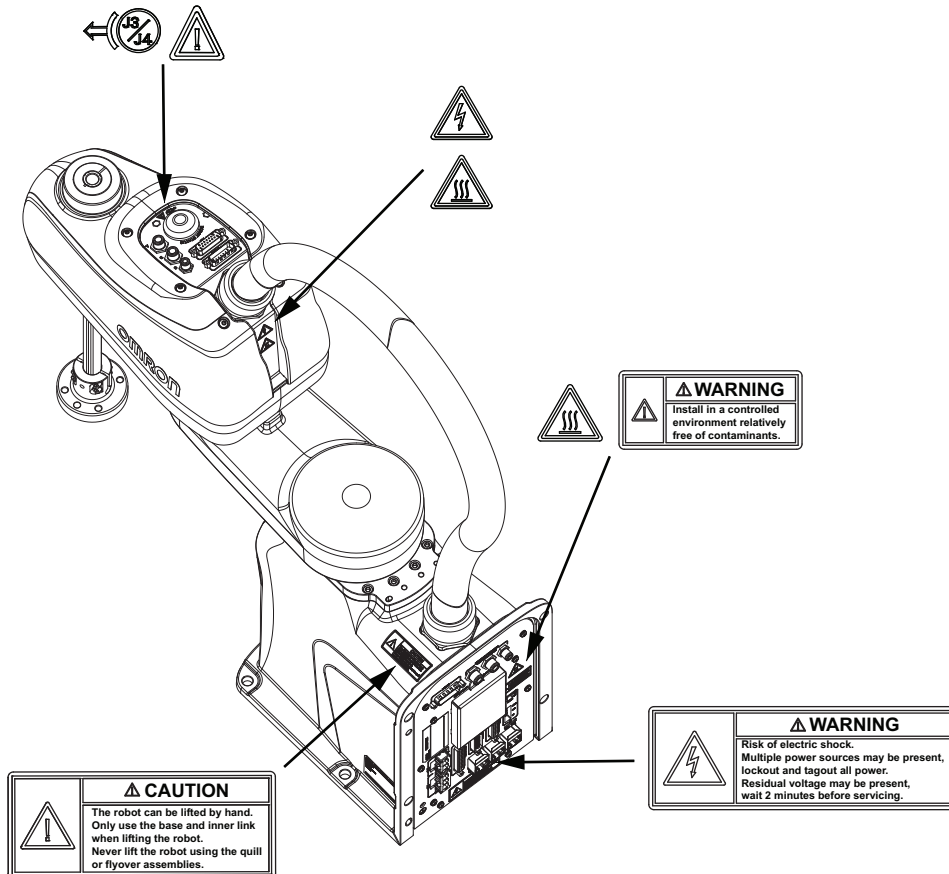

Additional Information

The label indicates the operation of the joint 3 and joint 4 brake.

6-1-5 Checking for Oil Leaks

Periodically check the robot for oil leaks. Carefully inspect the following points for oil or excessive debris accumulation. Oil and dirt should not be present. If oil or excessive debris accumulation is detected, contact your local OMRON support representative.
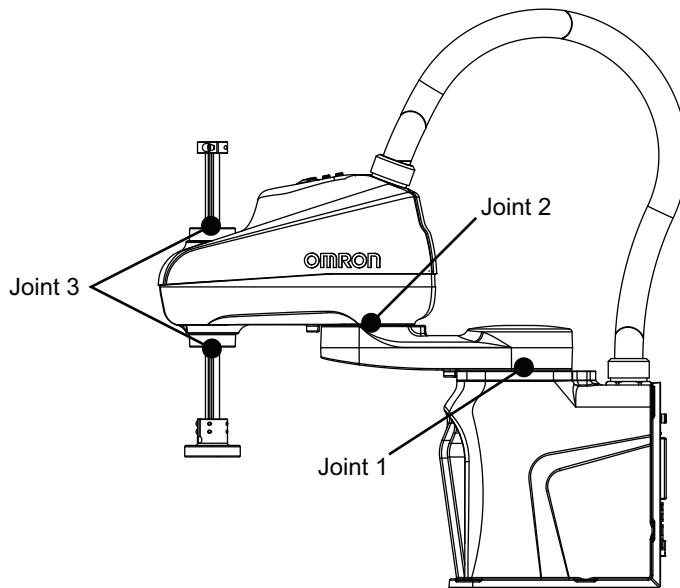
6-1-6　Lubricating Joint 3

The joint 3 quill needs to be lubricated on a periodic basis of 3 months or 150 km of linear travel, whichever comes first. 150 km of linear travel is approximately 2 weeks if a robot is operating 24 hours per day for 7 days per week.

Precautions for Correct Use

Only use the recommended grease on the joint 3 quill. Use THK AFF Grease (part number 20950-000). Refer to the provided Safety Data Sheet for proper handling.

Joint 3 Lubrication Procedure

Use the following procedure to lubricate joint 3.

Precautions for Safe Use

The braking mechanism operates passively. If 24 VDC Control Power is removed from the system, the brake mechanism will automatically activate. 24 VDC Control Power must be supplied to release the brake. To prevent possible damage to the equipment, remove any payload from the end-of-arm tooling, make sure that Joint 3 is supported while releasing the brake, and verify that the end-of-arm tooling or other installed equipment is clear of all obstructions.

Precautions for Correct Use

Avoid rotating the quill / Joint 4 when the brake is released. This could result in an out-of-range condition and may prevent program execution.

> 📋 **Additional Information**
>
> - If bellows are present on the robot, they must be removed before this procedure to access the Joint 3 and then reinstalled after this procedure is complete. Refer to *3-4-3 Bellows Kit Installation Procedure* on page 3-9 for more information.
> - Ensure there are no z-axis motion restrictions. The full operating stroke is required during this lubrication procedure.

1 Press the brake release button while moving the z-axis to the top of its stroke to expose the upper section of the quill.

2 Remove any existing grease or debris from the exposed quill with a clean, lint-free cloth.

3 Apply a small bead of grease to all grooves on the quill.

4 Press the brake release button while moving the z-axis to the bottom of its stroke to expose the lower section of the quill.

5 Remove any existing grease or debris from the newly exposed section of the quill with a clean, lint-free cloth.

6 Move the z-axis up and down to distribute the new grease. This can be accomplished manually with the brake release button or by jogging the z-axis. After this step is finished, the joint 3 lubrication procedure is complete.

6-1-7   Replacing Encoder Backup Batteries

Backup batteries maintain joint position data stored by internal encoders. This data is protected by 3 lithium backup batteries located in the Primary Interface Panel.

Encoder backup batteries need to be replaced on a periodic basis of 2 to 4 years or when a low battery alarm is present.

Before beginning the replacement procedure, have the following items available.
- Cross-head screwdriver, point size #1
- Three new replacement batteries (part number 20269-000F).

Encoder Backup Battery Replacement Procedure

Use the following procedure to replace encoder backup batteries.

Voltage must be maintained during the encoder backup battery replacement procedure to preserve joint position data. If 24 VDC Control Power is available, apply it to the robot during the battery replacement procedure. If 24 VDC Control Power is not available during the battery replacement procedure, replace one battery at a time and do not allow all three batteries to be absent from the compartment.

Precautions for Safe Use

- Batteries may leak, rupture, heat, or ignite. Never short-circuit, charge, disassemble, heat, or incinerate a battery or subject it to strong shock.
- Dispose of any battery that has been dropped or otherwise subjected to excessive shock. Batteries that have been subjected to shock may leak if they are used.
- Customers can contribute to resource conservation and protecting the environment by the proper disposal of WEEE (Waste Electronics and Electrical Equipment). All electrical and electronic products should be disposed of separately from the municipal waste system via designated collection facilities. For information about disposal of your old equipment, contact your local OMRON representative.
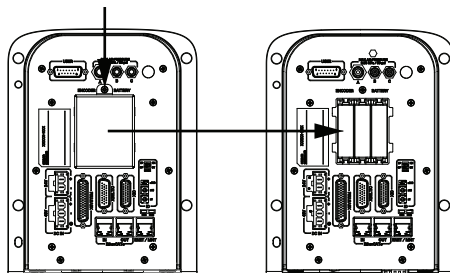
Precautions for Correct Use

Only replace items on the robot system with the parts supplied by OMRON.

1 Remove the encoder battery compartment cover fastener screw and then remove the cover.

Encoder Battery Compartment
Cover Fastener Screw

2 Remove and replace the batteries while observing orientation for correct polarity indicated in the battery compartment (upwards is positive).
- If 24 VDC Control Power is present, remove and replace all three batteries.
- If 24 VDC Control Power is not present, remove and replace only one battery at a time.

3 After all batteries have been replaced, fasten the battery compartment cover to the Primary Interface Panel to complete this procedure.

6-1-8 Cleaning the Robot

Clean the exterior of the robot as needed. Inspect the external surface of the robot frequently when used in a dirty environment.
Remove any dirt and debris from the exterior of the robot. Debris can accumulate around robot joints. Take extra effort to clean around these areas.

⚠ WARNING

Do not use organic solvents to clean any part of the robot. Organic solvents might damage electronics resulting in an unsafe operating state that could cause injury or damage to equipment. ⚠

6-1-9　Bellows Inspection

Check the bellows each week for cracks, wear, or damage and replace if necessary. Refer to the *3-4-3 Bellows Kit Installation Procedure* on page 3-9 for replacement and installation steps.

6-2 Non-periodic Maintenance

This section provides information and instructions for performing maintenance that does not occur at regular intervals.

> ### ⚠ WARNING
>
> - Never connect or disconnect system cables while power is applied to the robot. Failure to comply may cause unexpected behavior and can result in personnel injury and equipment damage.
> - You must perform the Lockout and Tagout procedure prior to servicing the robot.
> - The procedures and replacement of the parts mentioned in this manual must be performed only by the skilled or instructed persons.
> - The access covers on the robot are not interlocked. You should turn OFF and disconnect the power before the covers of the robot are removed.

6-2-1 Replacing the Tool Flange

Replace the tool flange if it gets damaged.

Before beginning the procedure, have the following tools available.

- 2.5 mm hex bit
- 3 mm hex bit
- Torque wrench
- Loctite thread lock type 243 or equivalent
- Loctite thread lock type 222MS or equivalent

> ### ⚠ DANGER
>
> Failure to ground robot-mounted equipment or tooling that uses hazardous voltages could lead to injury or fatality of a person touching the end-effector during an electrical fault.

> ### ⚠ WARNING
>
> If air pressure is present, disconnect it from the robot when servicing end-of-arm tooling or other pneumatic components to prevent unsecured pneumatic air lines from accidentally injuring personnel.

Precautions for Safe Use

The Joint 3 quill and the tool flange are not grounded to protective earth. If hazardous voltages are present at any user-supplied robot-mounted equipment or tooling, you must install a ground connection from that equipment or tooling to the ground point on the robot base.
Refer to *3-10-1 Grounding the System* on page 3-44 for more information about grounding the Tool Flange.

Precautions for Correct Use

When removing and replacing the tool flange, you must reinstall it in the same position to avoid losing the calibration for the robot.

Tool Flange Replacement Procedure

Use the following procedure to replace the tool flange on the z-axis quill if necessary.
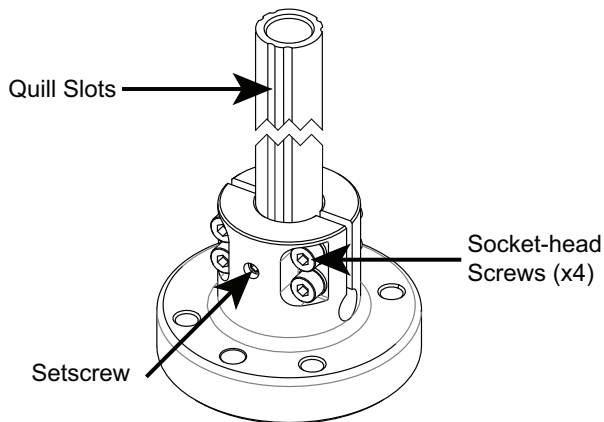
1 Take note of the old tool flange position and orientation on the quill.

2 Loosen the setscrew and socket-head screws while holding the old tool flange in place. This prevents it from falling off the z-axis quill.

3 Slide the tool flange off the z-axis quill.

4 Align the setscrew with the proper groove in the z-axis quill.

5 When the orientation is correct, slide the new tool flange up on the z-axis quill until it stops.

6 Apply thread lock (Loctite 243 or equivalent) to the setscrew and tighten to a torque of 1.1 N-m.

Precautions for Correct Use

Do not over-tighten the tool flange setscrew. This will cause off-center alignment of the tool flange on the quill.

7 Apply thread lock (Loctite 222MS or equivalent) to the socket-head screws and then use a torque wrench to tighten one of the socket-head screws to 1 N-m. Then, apply the same torque to the other socket-head screws. Finally, tighten each socket-head screw to the full 2.5 N-m torque.

8 When all socket-head screws are tight and the new tool flange is verified to be in the correct orientation, the replacement procedure is complete.

A

Appendices

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A-1 Unpacking and Inspecting the Robot

This section provides information about unpacking and inspecting the robot.

A-1-1 Before Unpacking the Robot

Before unpacking the robot, carefully inspect all shipping containers for evidence of damage during transit. Pay special attention to any tilt and shock indication labels on the exteriors of the containers.

Precautions for Correct Use

If any damage is detected before unpacking the robot, request that the carrier's agent be present when you unpack the container.

A-1-2 Unpacking the Robot

The robot ships fastened to a pallet with the following items included inside the container.

• Accessories box
• Documents
• Software

Use the following procedure to unpack the robot from its shipping container. The following tools are required:

• 6 mm hex key
• Cutting tools for securing straps and stretch wrap.

Additional Information

Retain all containers and packaging materials. These items may be necessary if there is any apparent damage or relocation becomes necessary at a later date.
Prepare the mounting surface and have all mounting items available before beginning this procedure so the robot can be mounted immediately after unpacking. Refer to *3-2-2 Mounting Procedure* on page 3-5 for more information.

Precautions for Safe Use

The robot can be lifted by hand. Only use the base and inner link when lifting the robot. Never maneuver the robot using the quill or flyover assemblies.

Precautions for Correct Use

If the robot has a bottom Primary Interface Panel orientation, do not temporarily set the robot upright on a flat surface because this can damage the Primary Interface Panel connectors.

1 Begin by placing the shipping container on a flat and level surface.

2 Remove the straps that secure the outer shell to the pallet.

3 Lift the outer shell up and off the pallet and set it aside.

4 Remove the straps that secure the accessory box to the pallet and set it aside.

5 Inspect the entire robot for damage before proceeding. If any damage is evident, contact your local OMRON representative.

6 Remove the 4 M8 X 50 screws that fasten the robot to the pallet.

⚠ WARNING

The robot's center of mass can cause the robot to fall over if the robot is not properly secured with the mounting bolts.

Do not reuse the screws to mount the robot. They are not sufficient grade.

7 Lift the robot and relocate it to the mounting surface.

8 Fasten the robot to the mounting surface using the *3-2-2 Mounting Procedure* on page 3-5. When the robot is fastened to the mounting surface, the unpacking procedure is complete. After the robot is fastened to the mounting surface, the stretch wrap and quill foam padding can be removed.

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A-2   Repacking the Robot for Transport

The robot must be carefully packed if it needs to be transported. Reuse all original packing containers and materials and follow all safety guidelines detailed in the installation section of this manual. Reverse the installation instructions and unpacking instructions provided in this manual to repack the robot.

A-3 Transportation and Storage Considerations

This section provides details about transporting and storing your robot.

Precautions for Safe Use

- This equipment must be shipped and stored in a temperature-controlled environment, within the range –25 to +55°C. The recommended humidity range is 5 to 90%, non-condensing. It should be shipped and stored in the supplied packaging, which is designed to prevent damage from normal shock and vibration.
- Do not expose the shipping container to excessive shock and vibration. This could damage the robot.

Always keep the ISO double-arrows on the sides of the shipping container oriented up.

A-4   I/O Signal Numbering

Digital I/O for the V+ programming language uses numeric signal numbers in the ranges provided below based on the I/O configuration of the system.

A-4-1   Input Signal Numbering

Use the table below to understand the digital input signal numbers.

Robot	Input Type	Switch Position	V+ Signal Numbers
1	XIO	--	1001 to 1012
	TIO		1017 to 1021
	IO Blox 1	OFF, OFF	1065 to 1072
	IO Blox 2	ON, OFF	1073 to 1080
	IO Blox 3	OFF, ON	1081 to 1088
	IO Blox 4	ON, ON	1089 to 1096
2	XIO	--	1101 to 1112
	TIO		1117 to 1121
	IO Blox 1	OFF, OFF	1165 to 1172
	IO Blox 2	ON, OFF	1173 to 1180
	IO Blox 3	OFF, ON	1181 to 1188
	IO Blox 4	ON, ON	1189 to 1196
3	XIO	--	1201 to 1212
	TIO		1217 to 1221
	IO Blox 1	OFF, OFF	1265 to 1272
	IO Blox 2	ON, OFF	1273 to 1280
	IO Blox 3	OFF, ON	1281 to 1288
	IO Blox 4	ON, ON	1289 to 1296
4	XIO	--	1301 to 1312
	TIO		1317 to 1321
	IO Blox 1	OFF, OFF	1365 to 1372
	IO Blox 2	ON, OFF	1373 to 1380
	IO Blox 3	OFF, ON	1381 to 1388
	IO Blox 4	ON, ON	1389 to 1396
5	XIO	--	1401 to 1412
	TIO		1417 to 1421
	IO Blox 1	OFF, OFF	1465 to 1472
	IO Blox 2	ON, OFF	1473 to 1480
	IO Blox 3	OFF, ON	1481 to 1488
	IO Blox 4	ON, ON	1489 to 1496
6	XIO	--	1501 to 1512
	TIO		1517 to 1521
	IO Blox 1	OFF, OFF	1565 to 1572
	IO Blox 2	ON, OFF	1573 to 1580
	IO Blox 3	OFF, ON	1581 to 1588
	IO Blox 4	ON, ON	1589 to 1596

Robot	Input Type	Switch Position	V+ Signal Numbers
7	XIO	--	1601 to 1612
	TIO		1617 to 1621
	IO Blox 1	OFF, OFF	1665 to 1672
	IO Blox 2	ON, OFF	1673 to 1680
	IO Blox 3	OFF, ON	1681 to 1688
	IO Blox 4	ON, ON	1689 to 1696
8	XIO	--	1701 to 1712
	TIO		1717 to 1721
	IO Blox 1	OFF, OFF	1765 to 1772
	IO Blox 2	ON, OFF	1773 to 1780
	IO Blox 3	OFF, ON	1781 to 1788
	IO Blox 4	ON, ON	1789 to 1796

A-4-2   Output Signal Numbering

Use the table below to understand the digital output signal numbers.

Robot	Output Type	Switch Position	V+ Signal Numbers
1	XIO	--	1 to 8
	TIO		17 to 20
	IO Blox 1	OFF, OFF	65 to 72
	IO Blox 2	ON, OFF	73 to 80
	IO Blox 3	OFF, ON	81 to 88
	IO Blox 4	ON, ON	89 to 96
2	XIO	--	101 to 108
	TIO		117 to 120
	IO Blox 1	OFF, OFF	165 to 172
	IO Blox 2	ON, OFF	173 to 180
	IO Blox 3	OFF, ON	181 to 188
	IO Blox 4	ON, ON	189 to 196
3	XIO	--	201 to 208
	TIO		217 to 220
	IO Blox 1	OFF, OFF	265 to 272
	IO Blox 2	ON, OFF	273 to 280
	IO Blox 3	OFF, ON	281 to 288
	IO Blox 4	ON, ON	289 to 296
4	XIO	--	301 to 308
	TIO		317 to 320
	IO Blox 1	OFF, OFF	365 to 372
	IO Blox 2	ON, OFF	373 to 380
	IO Blox 3	OFF, ON	381 to 388
	IO Blox 4	ON, ON	389 to 396

Robot	Output Type	Switch Position	V+ Signal Numbers
5	XIO	--	401 to 408
	TIO		417 to 420
	IO Blox 1	OFF, OFF	465 to 472
	IO Blox 2	ON, OFF	473 to 480
	IO Blox 3	OFF, ON	481 to 488
	IO Blox 4	ON, ON	489 to 496
6	XIO	--	501 to 508
	TIO		517 to 520
	IO Blox 1	OFF, OFF	565 to 572
	IO Blox 2	ON, OFF	573 to 580
	IO Blox 3	OFF, ON	581 to 588
	IO Blox 4	ON, ON	589 to 596
7	XIO	--	601 to 608
	TIO		617 to 620
	IO Blox 1	OFF, OFF	665 to 672
	IO Blox 2	ON, OFF	673 to 680
	IO Blox 3	OFF, ON	681 to 688
	IO Blox 4	ON, ON	689 to 696
8	XIO	--	701 to 708
	TIO		717 to 720
	IO Blox 1	OFF, OFF	765 to 772
	IO Blox 2	ON, OFF	773 to 780
	IO Blox 3	OFF, ON	781 to 788
	IO Blox 4	ON, ON	789 to 796

A-5   Cable Pinouts

Cable pinout information is provided below.

A-5-1   XSYSTEM Cable Pinouts

Use the following diagrams for XSYSTEM cable pinout information.
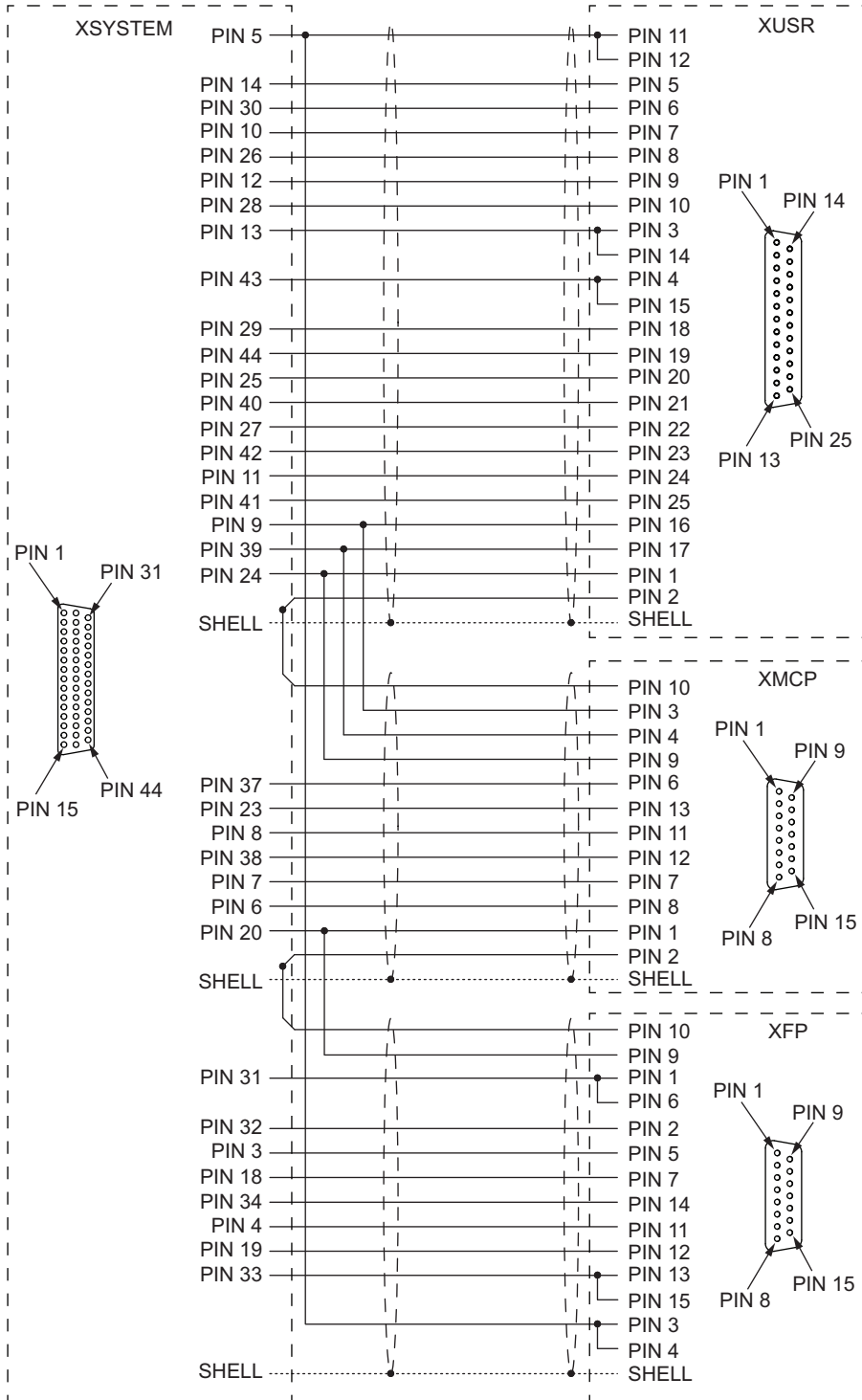
A-5-2   XBELTIO Adapter Cable Pinouts

Use the following diagrams for XBELTIO adapter cable pinout information.
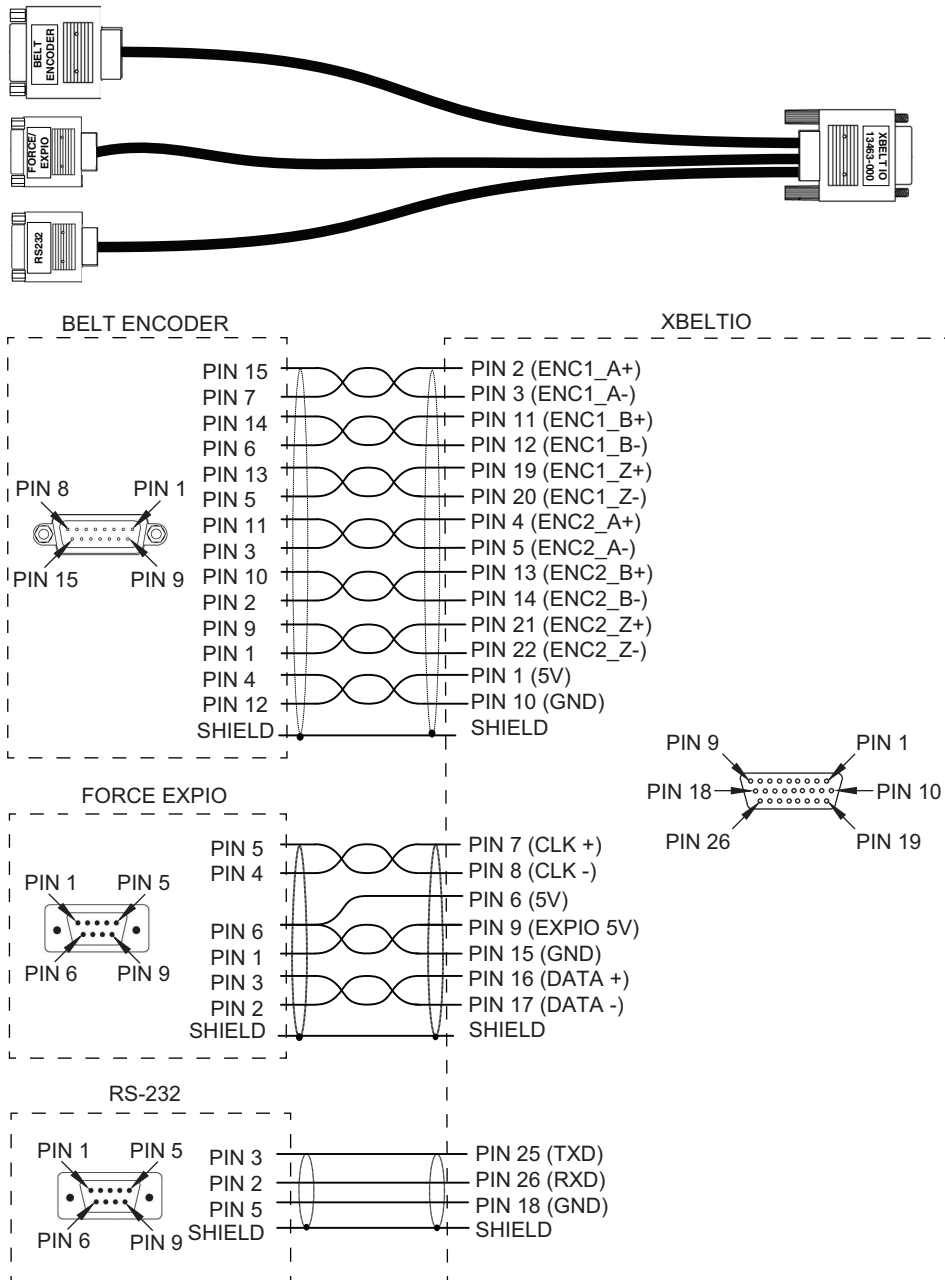
A-5-3 Belt Encoder Y-adapter Cable Pinouts

Use the following diagrams for Belt Encoder Y-adapter cable pinout information.

Encoder 1
(M12, Female, 8 PIN)

Encoder 2
(M12, Female, 8 PIN)

Encoder 1

BELT ENC.

PIN 1	—	PIN 15 (ENC1_A+)
PIN 3	—	PIN 7 (ENC1_A-)
PIN 4	—	PIN 14 (ENC1_B+)
PIN 5	—	PIN 6 (ENC1_B-)
PIN 6	—	PIN 13 (ENC1_I+)
PIN 8	—	PIN 5 (ENC1_I-)
PIN 2	—	PIN 4 (5V)
PIN 7	—	PIN 12 (GND)
SHIELD	—	SHIELD

Encoder 2

PIN 1	—	PIN 11 (ENC2_A+)
PIN 3	—	PIN 3 (ENC2_A-)
PIN 4	—	PIN 10 (ENC2_B+)
PIN 5	—	PIN 2 (ENC2_B-)
PIN 6	—	PIN 9 (ENC2_I+)
PIN 8	—	PIN 1 (ENC2_I-)
PIN 2	—	PIN 4 (5V)
PIN 7	—	PIN 12 (GND)
SHIELD	—	SHIELD
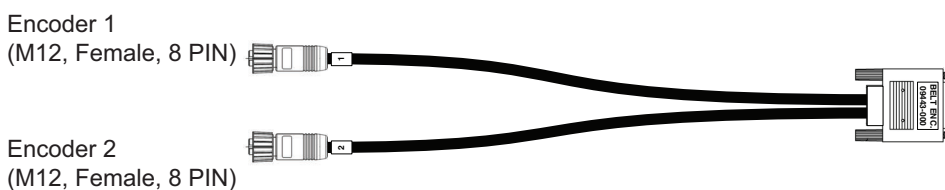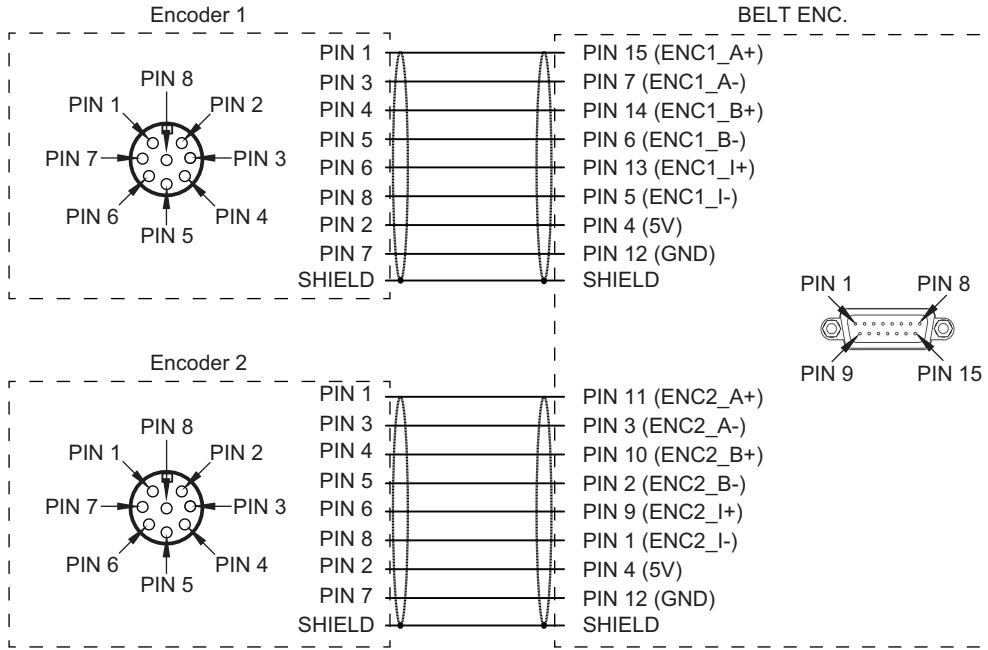
A-6   Parts List

Standard robot parts and accessories are provided in the following table.

Item		Part Number	Details	Included	Optional
Cables	XSYSTEM cable	13322-000		X	
	XBELTIO Cable	13463-000			X
	XIO Breakout Cable	04465-000			X
	IO Blox Extension Cable (to robot)	04677-030	Extends the connection between the IO Blox and the robot up to 3 m.		X
	IO Blox Extension Cable (between units)	04679-030	Extends the connection between IO Blox units up to 3 m.		X
	Encoder Extension Cable	09446-050	Replaces or extends encoder cable up to 5 m.		X
	Belt Encoder Y-adapter Cable	09443-000			X
Connectors / Jumpers	Power Connectors Kit	22008-000	Includes Control Power and High Power connectors, pins, and a grounding screw.	X	
	XFP Jumper Plug	10053-000		X	
	XUSR Jumper Plug	04736-000		X	
	XMCP Jumper Plug	10052-000		X	
	T20 Pendant Jumper Plug	10048-000			X

Item		Part Number	Details	Included	Optional
Other Items	Encoder Backup Batteries	20269-000F	3 batteries included.	X	
	Front Panel Kit	92546-10358	Kit includes front panel and 3 m cable.	X	
	Tool Flange	19360-016F		X	
	XIO Termination Block and Cable	90356-40100			X
	T20 Pendant Kit	10046-010	Kit includes the pendant, 3 m adapter cable, and a jumper plug.		X
	T20 Pendant Wall Bracket	10079-000			X
	IPC Application Controller	AC1-152000	Includes ACE software pre-installed.		X
	IO Blox Kit (robot connection)	90356-30200	Includes 300 mm cable to connect directly to the robot.		X
	IO Blox Kit (IO Blox connection)	90356-30100	Includes 200 mm cable to connect to another IO Blox unit.		X
	Joint 3 Quill Grease	20950-000	THK AFF type.		X
	Encoder Kit	09742-001	Includes encoder, mounting bracket, and 5 m cable.		X
	Camera Mounting Bracket Kit	23693-000	Includes all hardware to mount a Basler or Sentech Camera		X
	Bellows Kit (180 mm quill)	22839-000	Includes all hardware to install bellows.		X
	Bellows Kit (350 mm quill)	22868-000			X
	Pneumatic Valve Kit	22872-000	Includes valves, components, and hardware for installation.		X
	Control Power Kit	23916-000	Includes a power supply and DC cabling.		X
	High Power Kit	23913-000	Includes power supplies, redundancy unit, and DC cabling.		X

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