Adept Quattro s650H Robot

User's Guide

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1.1 Product Description

Adept Quattro s650H Robot

The Adept Quattro s650H robot is a four-axis parallel robot. The four identical axis motors control movement of the robot tool in X, Y, and Z directions, as well as Theta rotation. See **Figure 1-1**.

The Adept Quattro s650H robot requires an Adept SmartController CX for operation. The robot is user-programmed and controlled using the SmartController.

> **NOTE:** The Adept SmartController CX must be installed inside a NEMA-1 rated enclosure.

The robot servo code runs on an Adept SmartServo distributed-motion control platform embedded in the robot base.

Mechanical specifications for the Adept Quattro s650H robot are provided in **Chapter 7**.

Figure 1-1. Adept Quattro s650H Robot

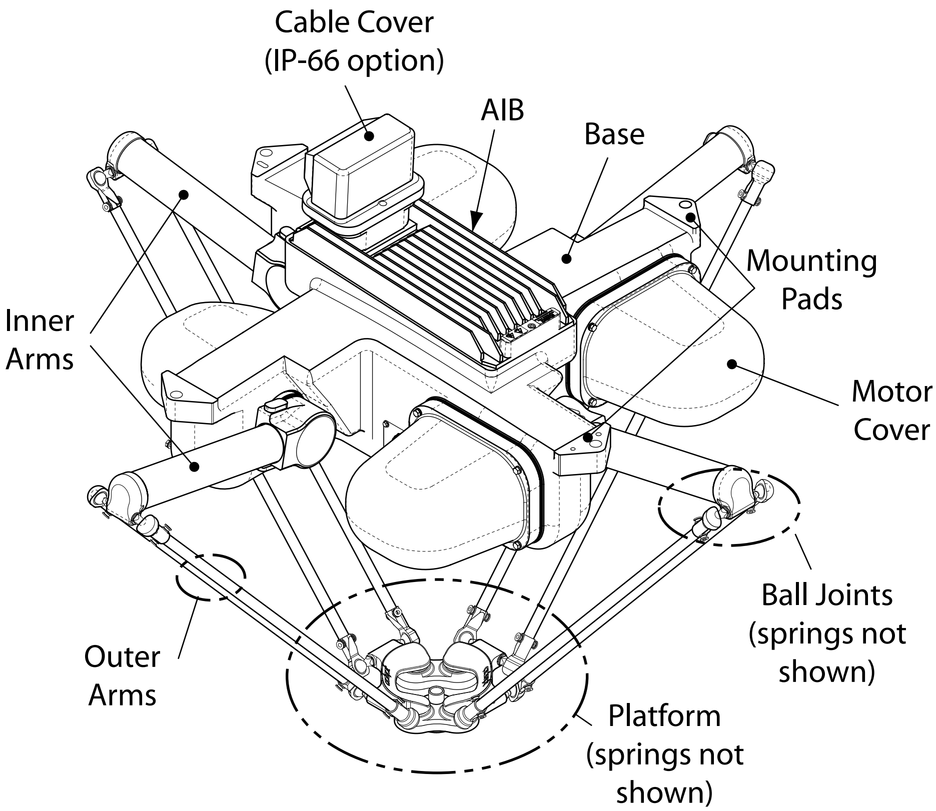


Figure 1-2. Major Robot Components, Isometric View

Quattro Robot Base

The Adept Quattro s650H robot base is an aluminum casting that houses the four drive motors, and supports the AIB (Amplifiers-In-Base). It provides four mounting pads for attaching the base to a rigid support frame. The Status Display Panel is mounted on the side of the robot base.

Adept AIB

The power amplifiers for the Adept Quattro s650H robot are embedded in the base of the robot. This amplifier section is known as the AIB distributed motion control platform, and provides closed-loop servo control of the robot amplifiers, as well as robot I/O.

Adept AIB features:

- On-board digital I/O: 12 inputs, 8 outputs
- Low EMI for use with noise-sensitive equipment
- No external fan
- 8 kHz servo rate
- Sine-wave commutation
- Digital feed-forward design
- Temperature sensors on all amplifiers and motors

Figure 1-3. Adept AIB

Inner Arms

The four robot motors attach directly to the inner arms through a high-performance gear reducer. Other than optional, user-supplied hardware mounted on the platform, these are the only drive motors in the Quattro. **Figure 1-4** shows a precision carbon fiber assembly of an inner arm. The RIA-compliant hard stops limit the inner arm motion to -52° and +124°.

Figure 1-4. Robot Inner Arm

Ball Joints, Outer Arms

The inner arm motion is transmitted to the platform through the outer arms, which are connected between the inner arms and platform with precision ball-joints. The outer arms are carbon fiber epoxied assemblies with identical ball-joint sockets at each end. A bearing insert at each socket accepts the ball-joint studs on the inner arms and platform, and allows for ± 60° of relative motion. No ball-joint lubrication is required. See the following figure. Refer also to **“Ball Joints” on page 112**.

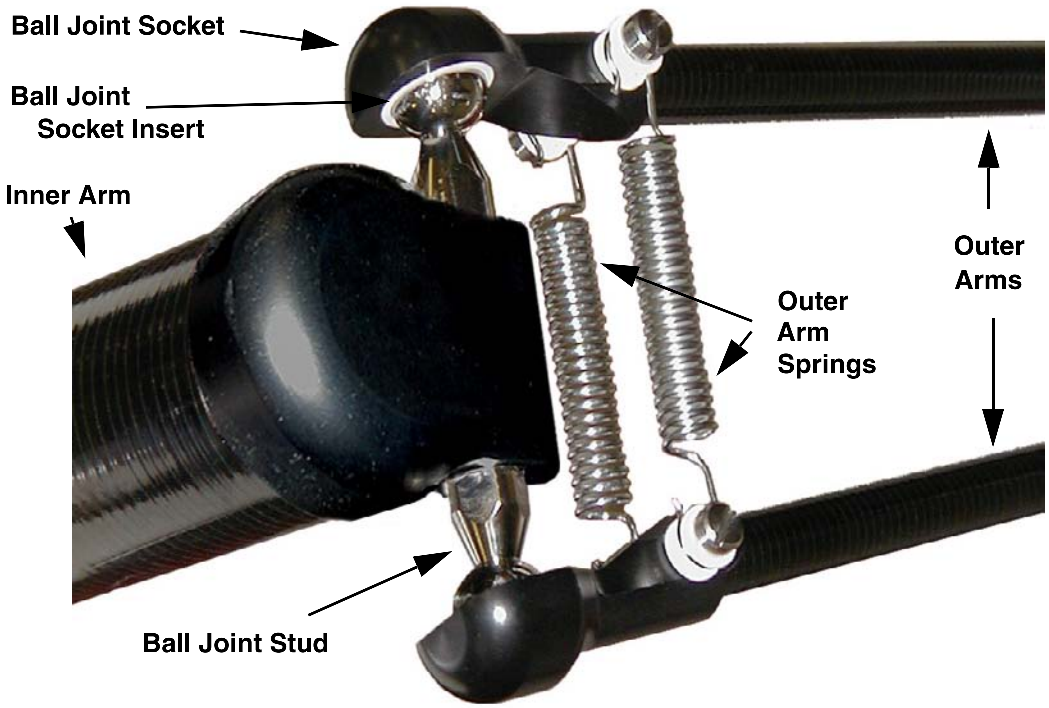


Figure 1-5. Ball Joints between Inner and Outer Arms

Each pair of outer arms is held together with springs that pre-tension the ball joint assemblies. The outer arms can be installed and removed without tools.

Platform

The platform converts the motion of the four Quattro motors into Cartesian motion and Theta rotation of the robot tool.

Platform articulation is achieved by differentially driving the four motors. Tool rotation is implemented with either a gear-drive mechanism, or with direct-drive, for applications needing higher rotation force but less rotation range.

The Adept Quattro s650H robot currently supports two types of platforms, depending on the amount of Theta rotation and inertia needed.

> **NOTE:** The two platforms require different robot parameters. The 185° platform is the default. If you have a 60° platform, contact your Adept representative.

The 185° platform (P/N 09068-000) has a rotation range of ±185°, achieved with a gear drive. This is illustrated in **Figure 1-6** and **Figure 1-7**.

The 60° platform (P/N 09023-000) has a rotation range of ± 60°. The tool flange is mounted directly to the pivot link. It does not rotate in relation to the pivot link, so there are no gears involved. This is illustrated in **Figure 1-8** and **Figure 1-9**.

> **NOTE:** The 60° platform flange is 27.1 mm higher, in Z, than the previous 1:1 and 4:1 platform flanges. An optional spacer of this thickness is available, from Adept, as P/N 02906-000. The 185° platform is 9.78 mm higher, in Z. The optional spacer for it is P/N 09266-000.

Refer to **“Torque and Rotation Limits” on page 90** for details on rotation and inertial loading of the platforms.

Both platforms are constructed such that the clocking of the platform relative to the robot base is critical. This is detailed in **“Clocking the Platform to the Base” on page 45**.

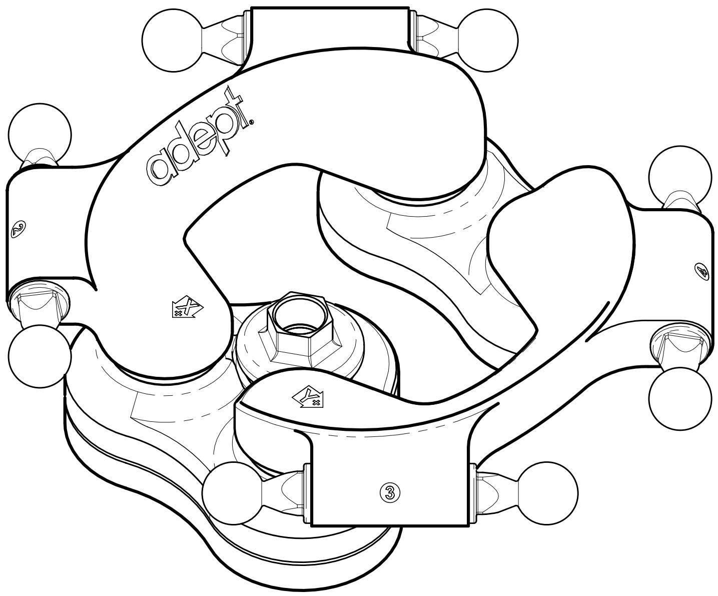


Figure 1-6. 185° Platform, Top View

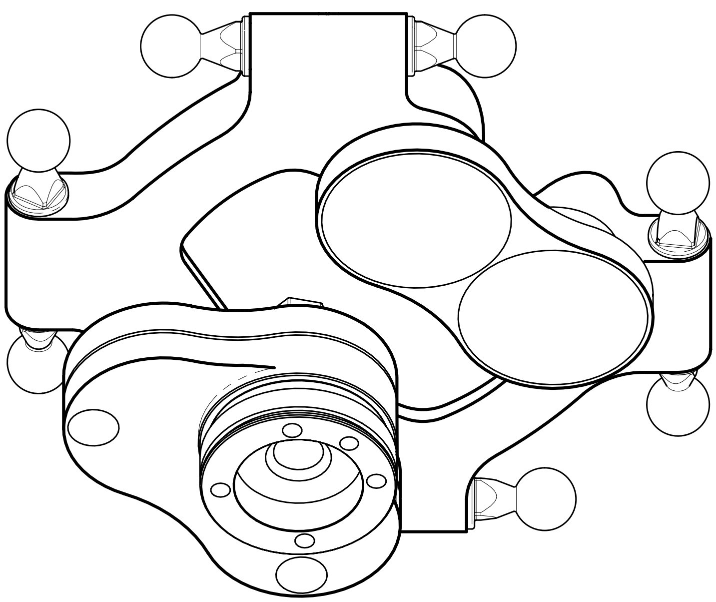


Figure 1-7. 185° Platform, Bottom View

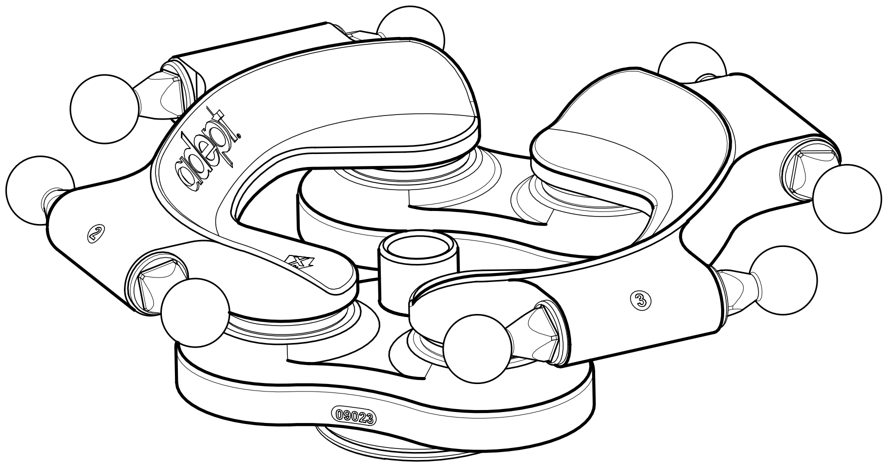


Figure 1-8. 60° Platform, Top View

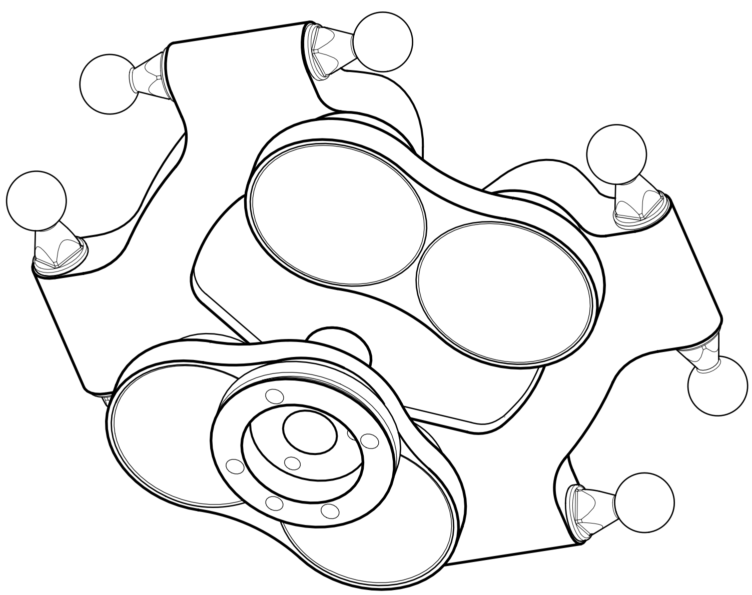


Figure 1-9. 60° Platform, Bottom View

For shipping:

- The platform and outer arms are removed.
- The platform is shipped pre-assembled as a unit.
  You will need to connect the outer arms between the inner arms and the platform to reassemble the robot. The outer-arm assemblies are interchangeable.

Any end-effectors and their air lines and wiring are user-supplied.

Adept SmartController

The SmartController is the foundation of Adept's family of high-performance, distributed-motion and vision controllers. The SmartController is designed for use with:

- Adept Quattro robots
- Adept Cobra s-series robots
- Adept Viper s-series robots
- Adept Python linear modules
- Adept MotionBlox-10
- Adept sMI6 (SmartMotion)

The Adept SmartController CX supports an integrated vision option and a conveyor tracking option, as well as other options. It offers scalability and support for IEEE 1394-based digital I/O and general motion expansion modules. The IEEE 1394 interface is the backbone of the Adept SmartServo distributed-servo network, which supports Adept products. The controller is commonly programmed through its Fast Ethernet port, which can be on a distributed network or directly connected to a PC for programming.

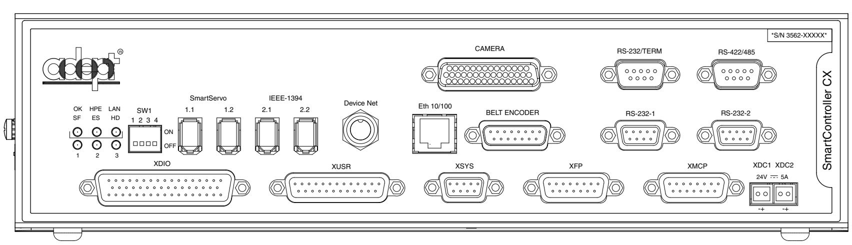


Figure 1-10. Adept SmartController CX

Refer to ***Adept SmartController User's Guide*** for SmartController specifications.

1.2 Installation Overview

The system installation process is summarized in the following table. Refer also to the system cable diagram in **Figure 4-1 on page 51**.

Table 1-1. Installation Overview

Task to be Performed	Reference Location
1. Mount the robot to a level, stable mounting frame.	Section 3.6 on page 40.
2. Attach the robot outer arms and platform.	Section 3.7 on page 45.
3. Install the SmartController, Front Panel, Pendant (if purchased), and AdeptWindows user interface.	Section 4.3 on page 52.
4. Install the IEEE 1394 and XSYS cables between the robot and SmartController.	Section 4.5 on page 54.

Table 1-1. Installation Overview

Task to be Performed	Reference Location
5. Create a 24 VDC cable and connect it between the robot and the user-supplied 24 VDC power supply.	Section 4.6 on page 54.
6. Create a 200-240 VAC cable and connect it between the robot and the facility AC power source.	Section 4.7 on page 57.
7. Install user-supplied safety barriers in the workcell.	Section 4.9 on page 61.
8. Connect digital I/O through the XIO connector on the robot.	Section 5.5 on page 67.
9. Commission the system, including system start-up and testing operation.	Section 5.6 on page 73.
10. Install optional equipment, including end-effectors, user air and electrical lines, external equipment, solenoids, etc.	Section 6.1 on page 81.

1.3 Manufacturer's Declaration

The Manufacturer's Declaration of Incorporation and Conformity for Adept robot systems can be found at the Adept website, under the Support section. The URL for the folder is:

ftp://ftp1.adept.com/Download-Library/Manufacturer-Declarations/

Each Manufacturer's Declaration is supplied in PDF format and stored on the website in a ZIP archive. To access the PDF document:

1. Click on the appropriate .zip file. You are prompted to Open or Save the file.
2. Click Open to open the file and display the archive contents.
3. Double-click on a .pdf file to open it.

1.4 How Can I Get Help?

Refer to the ***How to Get Help Resource Guide*** (Adept P/N 00961-00700) for details on getting assistance with your Adept software and hardware. Additionally, you can access information sources on Adept's corporate web site:

http://www.adept.com

Related Manuals

This manual covers the installation, operation, and maintenance of an Adept Quattro s650H robot system. There are additional manuals that cover programming the system, reconfiguring installed components, and adding optional components. See the following table. These manuals are available on the Adept Document Library CD-ROM shipped with each system.

Table 1-2. Related Manuals

Manual Title	Description
Adept SmartController User's Guide	Contains complete information on the installation and operation of the Adept SmartController and the optional sDIO product.
AdeptWindows Installation Guide and AdeptWindows Online Help	Describes complex network installations, installation and use of NFS server software, the AdeptWindows Offline Editor, and the AdeptWindows DDE software.
Instructions for Adept Utility Programs	Describes the V+ utility programs used for advanced system configurations, system upgrades, file copying, and other operating system configuration procedures.
V+ Operating System User's Guide	Describes the V+ operating system, including disk file operations, monitor commands, and monitor command programs.
V+ Language User's Guide	Describes the V+ language and programming of an Adept control system.
Adept T1 Pendant User's Guide	Describes use of the optional T1 Manual Control Pendant, P/N 04962-000
Adept T2 Pendant User's Guide	Describes use of the optional T2 Manual Control Pendant, P/N 04962-200
Adept SmartMotion Developer's Guide	Describes the use of Adept Utilities, including SPEC. This is written for the Adept SmartMotion system, but is a good source for SPEC for the Quattro, too.

Adept Document Library

The Adept Document Library (ADL) contains documentation for Adept products. You can access the ADL from:

- the Adept Software CD shipped with your system
- the Adept web site. Select Document Library from the Adept home page. To go directly to the Adept Document Library, type the following URL into your browser:

  http://www.adept.com/Main/KE/DATA/adept_search.htm

To locate information on a specific topic, use the Document Library search engine on the ADL main page. To view a list of available product documentation, select the Document Titles option.

Safety 2

2.1 Warnings, Cautions, and Notes in Manual

There are six levels of special alert notation used in this manual. In descending order of importance, they are:

DANGER: This indicates an imminently hazardous electrical situation which, if not avoided, will result in death or serious injury.

DANGER: This indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING: This indicates a potentially hazardous electrical situation which, if not avoided, could result in injury or major damage to the equipment.

WARNING: This indicates a potentially hazardous situation which, if not avoided, could result in injury or major damage to the equipment.

CAUTION: This indicates a situation which, if not avoided, could result in damage to the equipment.

NOTE: This provides supplementary information, emphasizes a point or procedure, or gives a tip for easier operation.

2.2 Warning Labels on the Robot

The following figure shows the warning labels on the Adept Quattro s650H robot.

Figure 2-1. Electrical and Thermal Warning Labels on AIB Chassis

2.3 Precautions and Required Safeguards

This manual must be read by all personnel who install, operate, or maintain Adept systems, or who work within or near the workcell.

WARNING: Adept Technology strictly prohibits installation, commissioning, or operation of an Adept robot without adequate safeguards that comply with applicable local and national standards. Installations in EU and EEA countries must comply with EN 775/ISO 10218, especially sections 5,6; EN 292-2; and EN 60204-1, especially section 13.

Safety Barriers

Safety barriers must be an integral part of robot workcell design. Adept systems are computer-controlled and may activate remote devices under program control at times or along paths not anticipated by personnel. It is critical that safeguards be in place to prevent personnel from entering the workcell whenever equipment power is present.

The robot system integrator, or end user, must ensure that adequate safeguards, safety barriers, light curtains, safety gates, safety floor mats, etc., are installed. The robot workcell must be designed according to the applicable local and national standards (see Section 2.8 on page 31).

The safe distance to the robot depends on the height of the safety fence. The height and the distance of the safety fence from the robot must ensure that personnel cannot reach the danger zone of the robot.

The Adept control system has features that aid the user in constructing system safeguards, including customer emergency stop circuitry and digital input and output lines. The emergency power-off circuitry is capable of switching external power systems, and can be interfaced to the appropriate user-supplied safeguards.

Impact and Trapping Points

Adept robots are capable of moving at high speeds. If a person is struck by a robot (impacted) or trapped (pinched), death or serious injury could occur. Robot configuration, joint speed, joint orientation, and attached payload all contribute to the total amount of energy available to cause injury.

DANGER: The robot system must be installed to avoid interference with buildings, structures, utilities, other machines, and equipment that may create a trapping hazard or pinch points.

Instructions for Emergency Movement without Drive Power

In an emergency, when AC power is removed from the system but DC power is still present, the arm can be moved manually. The Brake Release button must be pressed to enable arm movement. Refer to **“Brake Release Button” on page 65**.

Emergency Recovery Procedures

In an emergency, follow your internal procedures for emergency recovery of systems.

Additional Safety Information

The standards and regulations listed in this manual contain additional guidelines for robot system installation, safeguarding, maintenance, testing, startup, and operator training. **Table 2-1** lists some sources for the various standards.

Table 2-1. Sources for International Standards and Directives

SEMI International Standards 3081 Zanker Road San Jose, CA 95134 USA Phone: 408-943-6900 Fax: 408-428-9600 http://www.semi.org	American National Standards Institute (ANSI) 11 West 42nd Street, 13th Floor New York, NY 10036 USA Phone 212-642-4900 Fax 212-398-0023 http://www.ansi.org
Underwriters Laboratories Inc. 333 Pfingsten Road Northbrook, IL 60062-2096 USA Phone: 847-272-8800 Fax: 847-272-8129 http://www.ul.com/info/standard.htm	BSI Group (British Standards) 389 Chiswick High Road London W4 4AL United Kingdom Phone +44 (0)20 8996 9000 Fax +44 (0)20 8996 7400 http://www.bsi-global.com
Global Engineering Documents 15 Inverness Way East Englewood, CO 80112 USA Phone 800-854-7179 Fax 303-397-2740 http://global.ihs.com	Document Center, Inc. 1504 Industrial Way, Unit 9 Belmont, CA 94002 USA Phone 415-591-7600 Fax 415-591-7617 http://www.document-center.com
IEC, International Electrotechnical Commission Rue de Varembe 3 PO Box 131 CH-1211 Geneva 20 Switzerland Phone +41 22 919-0211 Fax +41 22 919-0300 http://www.iec.ch	Robotic Industries Association (RIA) 900 Victors Way PO Box 3724 Ann Arbor, MI 48106 USA Phone 313-994-6088 Fax 313-994-3338 http://www.robotics.org
DIN, Deutsches Institut für Normung e.V. German Institute for Standardization Burggrafenstrasse 6 10787 Berlin Germany Phone.: +49 30 2601-0 Fax: +49 30 2601-1231 http://www.din.de http://www2.beuth.de/ (publishing)	

2.4 Risk Assessment

Without special safeguards in its control system, the Adept Quattro s650H robot could inflict serious injury on an operator working within its work envelope. Safety standards in some countries require appropriate safety equipment to be installed as part of the system. **Table 2-2** lists some of the safety standards that affect industrial robots. It is *not* a complete list. Safeguards must comply with *all* applicable local and national standards for the location where the robot is installed.

Table 2-2. Partial List of Robot and Machinery Safety Standards

International	USA	Canada	Europe	Title of Standard
ISO 10218			EN 775	Manipulating Industrial Robots - Safety
	ANSI/RIA R15.06	CAN/CSA-Z434-94		Industrial Robots and Robot Systems - Safety Requirements
			EN 292-2	Safety of Machinery - Basic Concepts, General Principles for Design
			EN 954-1	Safety Related Parts of Control Systems - General Principles for Design
			EN 1050	Safety of Machinery - Risk Assessment

Exposure

When Arm Power is ON, all personnel must be kept out of the robot work envelope by interlocked perimeter barriers. The only permitted exception is for teaching the robot in Manual Mode by a skilled person (see **“Qualification of Personnel” on page 32**), who must wear safety equipment (see **“Safety Equipment for Operators” on page 33**) and carry the Adept pendant. Therefore, exposure of personnel to hazards related to the robot is limited (seldom and/or short exposure time).

Severity of Injury

Provided that skilled personnel who enter the robot work envelope are wearing protective headgear, eyeglasses, and safety shoes, it is likely that any injuries caused by the robot would be slight (normally reversible).

Avoidance

A programmer must always carry the pendant when inside the work envelope, as the pendant provides both E-Stop and Enabling switch functions.

For *normal* operation (AUTO mode), user-supplied interlocked guarding must be installed to prevent any person entering the workcell while arm power is ON.

DANGER: The Adept-supplied system components provide a Category 3 E-Stop control system as defined by EN 954. The robot system must be installed with user-supplied interlock barriers. The interlocked barrier must open the E-Stop circuit in the event of personnel attempting to enter the workcell when Arm Power is enabled, except for teaching in Manual mode. Failure to install suitable guarding or interlocks could result in injury or death.

The E-Stop circuit is Dual Channel (redundant, diverse, and control reliable).

See **Figure 7-6 on page 87** for an E-Stop internal circuit diagram.

Slow Speed Control Function and Testing

Adept robots can be controlled manually when the operating mode key switch is in the MANUAL position and the High Power light on the front panel is illuminated. When Manual mode is selected, motion can only be initiated from the pendant. Per EN 775/ISO 10218, the maximum speed of the robot is limited to 250 mm per second (10 ips) in Manual mode. It is important to remember that the robot speed is *not* limited when the robot is in Automatic (AUTO) mode.

The Risk Assessment for *teaching* this product depends on the application. In many applications, the programmer will need to enter the robot workcell while Arm Power is enabled to teach the robot. Other applications can be designed so that the programmer does not have to enter the work envelope while Arm Power is ON. Examples of alternative methods of programming include:

1. Programming from outside the safety barrier.
2. Programming with Arm Power OFF.
3. Copying a program from another (master) robot.
4. Off-line or CAD programming.

Control System Behavior Category

The following paragraphs relate to the requirements of European (EU/EEA) directives for Machinery, Electric Safety, and Electromagnetic Compatibility (EMC).

In situations with low exposure consideration factors, European Standard EN 1050 specifies use of a Category 1 Control System per EN 954. EN 954 defines a Category 1 Control System as one that employs Category B components designed to withstand environmental influences, such as voltage, current, temperature, EMI, and well-tried safety principles. The standard control system described in this guide employs hardware components in its safety system that meet or exceed the requirements of the *EU Machinery Directive* and *Low Voltage Directive*.

The standard control system is fully hardened to all EMI influences per the EU EMC *Directive* and meets all functional requirements of ISO 10218 (EN 775) *Manipulating Robots Safety*. In addition, a software-based reduced speed mode has been incorporated to limit speed and impact forces on the operator and production tooling when the robot is operated in Manual Mode.

The standard control system meets or exceeds the requirements imposed by the EN 954 specified Category 1 level of safety.

2.5 Intended Use of the Robots

The installation and use of Adept products must comply with all safety instructions and warnings in this manual. Installation and use must also comply with all applicable local and national requirements and safety standards (see **Section 2.8 on page 31**).

The Adept Quattro s650H robot is intended for use in parts assembly and material handling for payloads of less than 6.0 kg (4.4 lb).

The Adept Quattro s650H robot and the Adept SmartController are component subassemblies of a complete industrial automation system. The controller must be installed inside a suitable enclosure. The controller must not come into contact with liquids.

The Adept equipment is not intended for use in any of the following situations:

- In hazardous (explosive) atmospheres
- In mobile, portable, marine, or aircraft systems
- In life-support systems
- In residential installations
- In situations where the Adept equipment will be subject to extremes of heat or humidity. See **Table 3-1 on page 37** for allowable temperature and humidity ranges.

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

Non-intended use of an Adept Quattro s650H robot can:

- Cause injury to personnel
- Damage the robot or other equipment
- Reduce system reliability and performance

All persons that install, commission, operate, or maintain the robot must:

- Have the necessary qualifications
- Read and follow exactly the instructions in this manual

If there is any doubt concerning the application, ask Adept to determine if it is an intended use or not.

2.6 Robot Modifications

It is sometimes necessary to modify the robot in order to successfully integrate it into a workcell. Unfortunately, many seemingly simple modifications can either cause a robot failure or reduce the robot's performance, reliability, or lifetime. The following information is provided as a guideline to modifications.

WARNING: For safety reasons, it is prohibited to make certain modifications to Adept robots.

Acceptable Modifications

In general, the following robot modifications will not cause problems, but may affect robot performance:

- Attaching utility boxes, solenoid packs, vacuum pumps, cameras, lighting, etc., to the robot base.
- Attaching hoses, pneumatic lines, or cables to the robot. These should be designed so they do not restrict arm motion or cause robot motion errors.
- Attaching user tooling to the platform.

NOTE: Due to the kinematics of parallel robots, user cabling and tooling can have a significant effect on robot performance, and must be considered as part of the 6 kg payload rating of the Adept Quattro s650H robot. Significant consideration should be placed on symmetrically loading the platform, and not overloading one arm with respect to the others.

Unacceptable Modifications

The following modifications may damage the robot, reduce system safety and reliability, or shorten the life of the robot.

CAUTION: Making any of the modifications listed below will void the warranty of any components that Adept determines were damaged due to the modification. You must contact Adept Customer Service if you are considering any of the following modifications.

- Modifying any of the robot harnesses or robot-to-controller cables.
- Modifying any robot access covers or drive system components.
- Modifying, including drilling or cutting, any robot casting.
- Modifying any robot electrical component or printed-circuit board.
- Modifications that compromise EMC performance, including shielding.

2.7 Transport

Always use adequate equipment to transport and lift Adept products. See **Chapter 3** for more information on transporting, lifting, and installing.

WARNING: Never get under the robot while it is being lifted or transported.

2.8 Safety Requirements for Additional Equipment

Additional equipment used with the Adept Quattro s650H robot (grippers, conveyor belts, etc.) must not reduce the workcell safeguards.

All emergency stop switches must always be accessible.

If the robot is to be used in an EU or EEA member country, all components in the robot workcell must comply with the safety requirements in the European Machine Directive 89/392/EEC (and subsequent amendments) and related harmonized European, international, and national standards. For robot systems, these include: EN 775/ISO 10218, sections 5,6; EN 292-2; and EN 60204. For safety fences, see EN 294.

In other countries, Adept strongly recommends, in addition to complying with the applicable local and national regulations, that a similar level of safety be attained.

In the USA, applicable standards include ANSI/RIA R15.06 and ANSI/UL 1740.

In Canada, applicable standards include CAN/CSA Z434.

2.9 Sound Emissions

The sound emission level of the Adept Quattro s650H robot depends on the speed and payload. The maximum value is under 90 dB. (This is at maximum AUTO-mode speed.)

WARNING: Acoustic emission from this robot may approach 90 dB (A) 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.

2.10 Thermal Hazard

WARNING: You can burn yourself on some surfaces of the robot. Do not touch the robot casting shortly after the robot has been running at high ambient temperatures (40° C/104° F) or at fast cycle times (over 60 cycles per minute). The robot skin/surface temperature can exceed 60° C (140° F).

2.11 Working Areas

Adept robots have a Manual and an Automatic (AUTO) operating mode. While in Automatic Mode, personnel are not allowed in the workcell.

In Manual Mode, operators with additional safety equipment (see **Section 2.13 on page 33**) are allowed to work in the robot workcell. For safety reasons the operator should, whenever possible, stay outside of the robot work envelope to prevent injury. The maximum speed and power of the robot is reduced, but it could still cause injury to the operator.

Before performing maintenance in the work envelope of the robot, high power must be switched OFF and the power supply of the robot must be disconnected. After these precautions, a skilled person is allowed to maintain the robot. See **Section 2.12** for the specifications of personnel qualifications.

WARNING: Never remove any safeguarding and never make changes in the system that will decommission a safeguard.

2.12 Qualification of Personnel

This manual assumes that all personnel have attended an Adept training course and have a working knowledge of the system. You must provide the necessary additional training for all personnel who will be working with the system.

As noted in this manual, certain procedures should be performed only by **skilled** or **instructed** persons. For a description of the level of qualification, Adept uses the standard terms:

- **Skilled persons** have technical knowledge or sufficient experience to enable them to avoid the dangers, electrical and/or mechanical.
- **Instructed persons** are adequately advised or supervised by skilled persons to enable them to avoid the dangers, electrical and/or mechanical.

All personnel must observe good safety practices during the installation, operation, and testing of all electrically powered equipment. To avoid injury or damage to equipment, always remove power by disconnecting the AC power from the source before attempting any repair or upgrade activity. Use appropriate lockout procedures to reduce the risk of power being restored by another person while you are working on the system.

DANGER: Any person who programs, teaches, operates, maintains or repairs the robot system must be trained and demonstrate the competence to safely perform the assigned task.

You must get confirmation from every entrusted person before they start working with the robot that the person:

1. Has received this manual
2. Has read this manual
3. Understands this manual
4. Will work in the manner specified by this manual

2.13 Safety Equipment for Operators

Adept advises operators to wear extra safety equipment in the workcell. For safety reasons operators must wear the following when they are in the robot workcell.

- Safety glasses
- Protective headgear (hard hat)
- Safety shoes

Install warning signs around the workcell to ensure that anyone working around the robot system knows they must wear safety equipment.

2.14 Protection Against Unauthorized Operation

The system must be protected against unauthorized use. Restrict access to the keyboard and the pendant by locking them in a cabinet or use another adequate method to prevent access to them.

2.15 Safety Aspects While Performing Maintenance

Only skilled persons with the necessary knowledge about the safety and operating equipment are allowed to maintain the robot and controller.

WARNING: During maintenance and repair, the power to the robot and controller must be turned off. Unauthorized third parties must be prevented, through the use of lockout measures, from turning on power.

2.16 Risks Due to Incorrect Installation or Operation

Take precautions to ensure that the following situations do not occur:

- Purposely defeating any aspect of the safety E-Stop system
- Improper installation or programming of the robot system
- Use of cables other than those supplied, or use of modified components in the system
- Defeating an interlock so that an operator can enter the workcell with high power On

2.17 What to Do in an Emergency

Press any E-Stop button (a red push-button on a yellow background/field) and then follow the internal procedures of your company or organization for an emergency situation. If a fire occurs, use CO_2 to extinguish the fire.

Robot Installation 3

3.1 Transport and Storage

This equipment must be shipped and stored in a temperature-controlled environment, within the range –25° to +55° C (-13° to 131° F). The recommended humidity range is 5 to 90 percent, non-condensing. It should be shipped and stored in the Adept-supplied crate, which is designed to prevent damage from normal shock and vibration. You should protect the crate from excessive shock and vibration.

Use a forklift, pallet jack, or similar device to transport and store the packaged equipment.

The robot must always be stored and shipped in an upright position in a clean, dry area that is free from condensation. Do not lay the crate on its side or any other non-upright position. This could damage the robot.

The Adept Quattro s650H robot weighs 111 kg (245 lb) with no options installed.

3.2 Unpacking and Inspecting the Adept Equipment

Before Unpacking

Carefully inspect all shipping crates for evidence of damage during transit. Pay special attention to tilt and shock indication labels on the exteriors of the containers. If any damage is indicated, request that the carrier's agent be present at the time the container is unpacked.

Unpacking

The Adept Quattro s650H robot is shipped in a crate that holds the robot base, outer arms, platform, controller, miscellaneous hardware, and any accessories ordered. The crate will be combined wood and cardboard.

The top of the crate should be removed first.

- Remove the bands holding the top to the rest of the crate.

Refer to **Figure 3-1**.

The outer arms will be above the robot base. These should be removed from the crate, followed by the cardboard and foam that support them.

Figure 3-1. Quattro Shipping Crate

The robot base is shipped with the inner arms attached. The outer arms are shipped assembled in pairs; the platform is shipped fully assembled, but separate from the robot base and outer arms.

The robot base is held by lag bolts to the crate sides. Under the robot base, the ancillary items will be attached to the crate bottom.

- Lift off the cardboard sides.

Refer to the following figure.

Figure 3-2. Crate with Front Panel/Sides Removed

Upon Unpacking

Before signing the carrier's delivery sheet, compare the actual items received (not just the packing slip) with your equipment purchase order. Verify that all items are present and that the shipment is correct and free of visible damage.

- If the items received do not match the packing slip, or are damaged, do **not** sign the receipt. Contact Adept as soon as possible (see **Section 1.4 on page 21**).
- If the items received do not match your order, please contact Adept immediately.

Retain all containers and packaging materials. These items may be necessary to settle claims or, at a later date, to relocate the equipment.

3.3 Repacking for Relocation

If the robot or other equipment needs to be relocated, reverse the steps in the installation procedures that follow in this chapter. Reuse all original packing containers and materials and follow all safety notes used for installation. Improper packaging for shipment will void your warranty.

CAUTION: The robot must always be shipped in an upright orientation.

3.4 Environmental and Facility Requirements

The Adept Quattro s650H robot system installation must meet the operating environment requirements shown in the following table.

Table 3-1. Robot System Operating Environment Requirements

Ambient temperature	1 to 40° C (34 to 104° F)
Humidity	34 to 90%, noncondensing
Altitude	up to 2000 m (6500 ft)
Pollution degree	2 (IEC 1131-2/EN 61131-2)
Protection class: robot base, arms	IP-66 (with optional cable sealing kit)
Protection class: platform	IP-67
Note: See **"Dimension Drawings" on page 83** for robot dimensions.	
Note: See **"Connecting 24 VDC Power to Robot" on page 54** and **"Connecting 200-240 VAC Power to Robot" on page 57** for power requirements.	
Note: The Adept SmartController must be installed inside a NEMA-1 rated enclosure. The controller must not come into contact with liquids.	

3.5 Mounting Frame

Overview

The Adept Quattro s650H robot is designed to be mounted above the work area suspended on a user-supplied frame. The frame must be adequately stiff to hold the robot rigidly in place while the robot platform moves around the workspace.

While Adept does not offer robot frames for purchase, and the frame design is the responsibility of the user, we provide here some general guidelines as a service to our users. Adept makes no representation or warranty with respect to these guidelines, or the rigidity and longevity of the structure designed and built by the user or for the user by a third party using these guidelines. In addition, when the robot is mounted on the structure based on these guidelines, Adept does not guarantee that the robot will perform to the specifications given in this product documentation, due to user's frame or user's production environmental factors.

As an example, a sample frame design is presented and discussed. For generalized application performance, frames built to the specifications of this sample should experience no degradation in robot performance due to frame motions. Applications requiring higher than 6 kg * 10 g forces across the belt and/or 6 kg * 3 g along the belt may require a stiffer frame design.

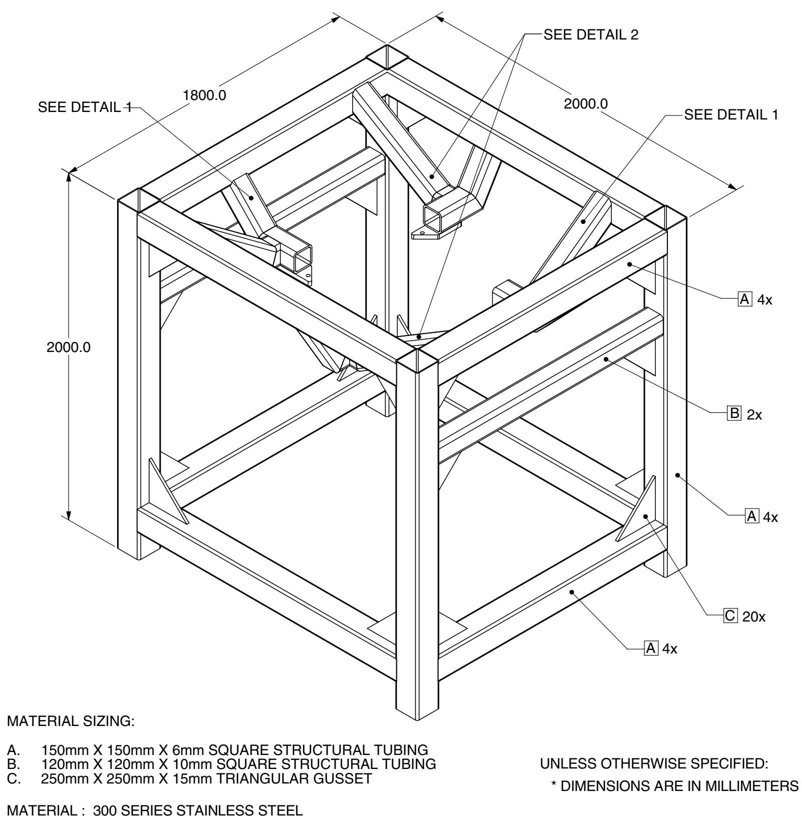


Figure 3-3. Sample Quattro Mounting Frame

NOTE: More specifications for the sample frame are provided in Section 7.6.

Any robot's ability to settle to a fixed point in space is governed by the forces, masses, and accelerations of the robot. Since "every action has an equal and opposite reaction", these forces are transmitted to the robot frame and cause the frame and base of the robot to move and possibly vibrate in space. As the robot system works to position the tool flange relative to the base of the robot, any frame or base motion will be "unobservable" to the robot system, and will be transmitted to the tool flange. This transmitted base motion will result in inertial movement of the tool flange mass, and will cause disturbance forces to be introduced into the robot control system. These disturbance forces cause "work" to be done by the robot servo control system which may result in longer settling times for robot operations.

It is important to note that, even after the system reports the robot to be fully settled, the tool flange will still be moving by any amount of motion that the suspended base of the robot may be experiencing.

Frame Orientation

The sample robot frame design is stiffer in one direction than the other. This is to accommodate conveyor belt applications where the robot is moving with much more acceleration across a conveyor belt than along it. The conveyor should generally be aligned so that the belt travel is along the robot World Y-axis, and the mid-height frame members cross the belt at a 90° angle. The across-the-belt dimension of the frame should be minimized to get the best performance of the robot in that direction. While this frame design assumes a 1.8 m across-the-belt frame dimension, a 1.5 m dimension would offer increased stiffness and possibly increased robot performance at high accelerations and payloads. The mid-height horizontal members are important to the frame stiffness, and should be located as close to the belt as possible.

For applications requiring high accelerations along the direction of belt travel, consideration should be given to strengthening the frame in that direction.

Frame Construction

Typically, the frame is constructed of welded steel members. Hygiene-sensitive applications may call for stainless steel fabrication, with care taken to seal up all possible voids and grind smooth all weld joints. For other applications, it may be suitable to manufacture the frame of carbon steel and paint the resulting assembly. The frame design presented here is based on a stainless steel construction using 10 mm thick members. It may be reasonable to use a reduced thickness for carbon steel assemblies. Some customers may choose to use tubular members, or turn horizontal members at 45° angles to facilitate water runoff from the flat frame surfaces.

Robot-to-Frame Considerations

The Quattro has a moderately-complex mounting requirement due to the nature of the parallel-arm kinematics and the need to minimize the robot size and mass. Figure 7-5 on page 86 shows the inner arm travel and how it may encroach on the robot mounting points. The design suggested here uses transition pieces to allow for butt welds and mating interfaces where there will be no protruding surfaces to collect contamination. This mounting design results in a natural frequency of about 90 Hz for just the robot mounting members, but not the entire frame assembly. Alternate designs should consider 90 Hz as a goal for this part of the frame. Note that this design allows for lengthening the frame in the direction along the belt travel without significantly changing the natural frequency.

The robot mounts in four locations, as detailed in the drawings. The holes are tapped for an M16x2.0 bolt. The Adept Quattro s650H robot may be mounted from the top or bottom of the frame. A crane or forklift should be used to position the robot. If lifted from above, the robot must be lifted by user-supplied eyebolts and slings.

Figure 7-1 on page 83 shows the mounting hole pattern for the Adept Quattro s650H robot. Note the hole location and mounting pad tolerances for position and flatness (**Figure 7-8 on page 92**).

Deviation from this flatness specification will, over time, cause a possible loss of robot calibration.

> **NOTE:** Adept suggests welding the robot mounting tabs as a last step in the frame fabrication, using a flat surface as a datum surface during the tack welding operation.

Gussets

The triangular gussets are an integral part of the frame stiffness. The vibrational strength of a structural assembly is strongly governed by controlling the shear forces between members. The 250 mm gussets, shown in **Figure 3-3 on page 38**, are nominally sufficient for transferring the load from the vertical members into the horizontal cross pieces. Preferably, gussets should be placed at the edges of the frame members to transfer the loading into the walls of the members, instead of the faces, and enable easier cleaning. Some frame designs may benefit from extending these gussets to 500 mm in the vertical direction, as the design intent of the gussets is mainly to secure the long vertical members from rotating out of position. For this reason, the gussets to the across-the-belt horizontal member should be at the bottom of the member, as shown in **Figure 3-3 on page 38**, and as close to the vertical midplane of the frame as feasible (15 mm thickness is adequate for most situations).

3.6 Mounting the Robot Base

> **NOTE:** All mounting hardware is user-supplied.

> **CAUTION:** Remove all ancillary components (controller, outer arms, platform, etc.) from the shipping crate before lifting the robot base.

Robot Orientation

Adept recommends mounting the Adept Quattro s650H robot so that the Status Display Panel faces away from the conveyor belt. Although the work envelope of the robot is symmetrical, this orientation gives better access to the status display, status LED, and Brake Release button. It also balances the arm loading for aggressive moves across the belt.

This orientation places the robot World Y-axis along the conveyor belt, and the X-axis across the belt.

Mounting Surfaces

Mounting surfaces for the robot flanges must be within 0.75 mm of a flat plane.

CAUTION: Failure to mount the Quattro robot within 0.75 mm of a flat plane will result in inconsistent robot motions.

Mounting Options

Using the mounting frame design provided by Adept, there are several options for mounting the Adept Quattro s650H robot:

- Lower the robot into the frame from above, or
  Lift the robot into the frame from below.
- Place the robot mounting pads on top of the frame mounting pads, or
  Place the robot mounting pads under the frame mounting pads.
- Mounting hardware can be bolts threaded directly into the robot base mounting pads, or bolts that go through the robot base mounting pads into nuts.

CAUTION: Do not attempt to lift the robot from any points other than with eyebolts or slings as described here, or with a padded board, as described here.

Mounting Procedure from Above the Frame

The Adept Quattro s650H robot has four mounting pads. Each pad has one M16x2.0 threaded hole. The robot can be mounted either on top of the frame pads, using the bottom surface of the robot base mounting pads, or to the bottom of the frame pads, using the top surface of the robot base mounting pads.

Mounting to Top of Frame Pads

This procedure uses two user-supplied M16x2.0 eyebolts and jam nuts.

1. Remove all lag bolts from the robot base mounting pads.

2. Screw the M16 eyebolts into opposing robot mounting pads, so that the robot will be balanced when lifted.
3. Lock each eyebolt with a jam nut.
4. Connect slings to the M16 eyebolts and take up any slack in the slings.

CAUTION: Do not attempt to lift the robot from any points other than the eyebolts. Failure to comply could result in the robot falling and causing either personnel injury or equipment damage.

5. Lift the robot and position it directly over the mounting frame.
6. Slowly lower the robot while aligning the M16 holes in the robot mounting pads with the holes in the frame mounting pads.
7. When the mounting pad surfaces are touching, start a bolt in each of the two unused mounting holes. Refer to **"Install Mounting Hardware" on page 44**.
8. Remove the slings and M16 eyebolts.
9. Follow the instructions in **"Install Mounting Hardware" on page 44**.

Mounting to Bottom of Frame Pads

NOTE: Since eyebolts would be in the way of this mounting method, you will have to use slings or other means to lift the robot base. Nylon slings can be wrapped across the center of the robot base, away from the inner arms. See **Figure 3-4**.

1. Remove all lag bolts from the mounting pads before lifting the robot base.
2. Wrap slings around the robot base. See **Figure 3-4** for two methods.

   NOTE: Make sure the slings do not touch the status panel or inner arms.

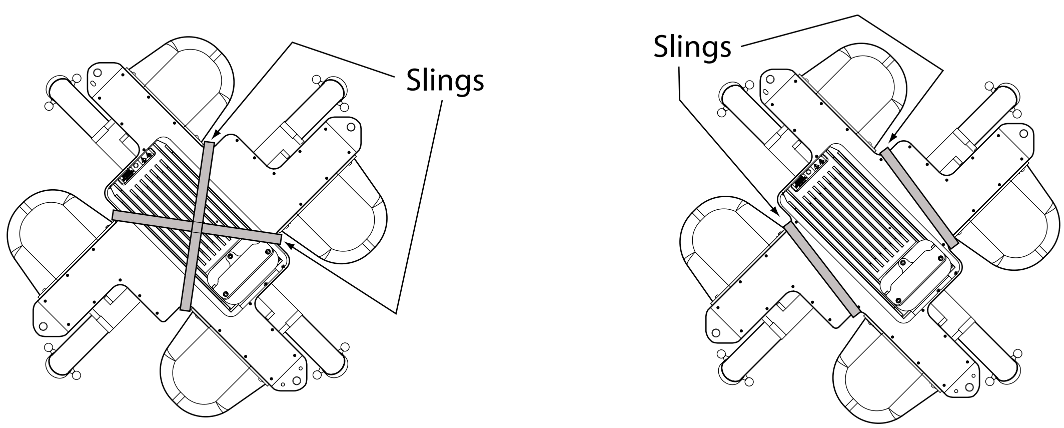


Figure 3-4. Location of Slings for Lifting Robot Base

3. Lift the robot and position it directly over the mounting frame.

4. Slowly lower the robot while rotating it slightly, so that the four mounting pads are lowered past the frame mounting pads without touching.
5. When the robot base mounting pads are below the lower surface of the frame mounting pads, rotate the robot base so that the M16 threaded holes in the robot base mounting pads align with the holes in the frame mounting pads.
6. Lift the robot base up, keeping the holes in the robot base pads and the frame pads aligned, until the top surfaces of the robot base pads are touching the bottom surface of the frame mounting pads.
7. Follow the instructions in **“Install Mounting Hardware” on page 44**.

Mounting Procedure from Below the Frame

The Adept Quattro s650H robot has four mounting pads. Each pad has one M16x2.0 threaded hole. The robot can be mounted either on top of the frame pads, using the bottom surface of the robot base pads, or to the bottom of the frame pads, using the top surface of the robot base pads.

The Adept Quattro s650H robot can be mounted from beneath the mounting frame using a forklift. Use a padded board as a support under the robot base. The robot base can be rotated by hand, once mounted on the lifting pad on a forklift, when needed for clearing obstacles.

Mounting to Bottom of Frame Pads

1. Remove all lag bolts from the mounting pads before lifting the robot base.
2. Lift the robot and position the robot directly under the mounting frame.
3. Slowly lift the robot and align the M16 holes in the robot mounting pads with the holes in the frame mounting pads.
4. Lift the robot until the top of the robot base mounting pads are touching the bottom of the frame mounting pads.
5. Follow the instructions in **Install Mounting Hardware**.

Mounting to Top of Frame Pads

1. Remove all lag bolts from the mounting pads before lifting the robot base.
2. Lift the robot so the mounting pads are directly under the mounting pads of the frame.
3. Slowly lift the robot while rotating it slightly, so that the four mounting pads are raised past the frame mounting pads without touching.
4. When the robot base mounting pads are above the top surface of the frame mounting pads, rotate the robot base back, so that the M16 threaded holes in the robot base mounting pads align with the holes in the frame mounting pads.
5. Slowly lower the robot base while aligning the M16 holes in the robot mounting pads with the holes in the frame mounting pads.
6. Continue lowering the robot base until the bottom surface of the robot base mounting pads are touching the top surface of the frame mounting pads.
7. Follow the instructions in **Install Mounting Hardware**.

Install Mounting Hardware

NOTE: When mounting the robot, note the following:

- The base casting of the robot is aluminum and can be dented if bumped against a harder surface.
- Verify that the robot is mounted squarely before tightening the mounting bolts.
- All mounting hardware is user-supplied.

1. Place split lock, then flat washers on the bolts.

   Bolts are M16x2.0 if threaded into the robot base mounting tabs.

   Bolts are M12 or ½ in. if going through the robot base mounting tabs into nuts.

2. Insert the bolts through the holes in the frame mounting pads and into the threaded holes in the robot base mounting pads. See **Table 3-2**.

   If using through-bolts, insert the bolts through the holes in both the mounting pads and through the threaded holes in the robot base mounting pads into nuts.

3. Tighten the mounting hardware to the specifications listed in **Table 3-2**.

   NOTE: Check the tightness of the mounting bolts one week after initial installation, and then recheck every 6 months. See **Chapter 8** for periodic maintenance.

Table 3-2. Mounting Bolt Torque Specifications

Standard	Size	Minimum Specification	Torque
Threaded into base (aluminum):			
Metric	M16x2.0	ISO Property Class 5.8	98 N•m (74 ft-lb)
Using base mounting tab hole as through-hole:			
Metric	M12	ISO Property Class 9.8	100 N•m (75 ft-lb)
SAE	½ in.	SAE Grade 7	100 N•m (75 ft-lb)

3.7 Attaching the Outer Arms and Platform

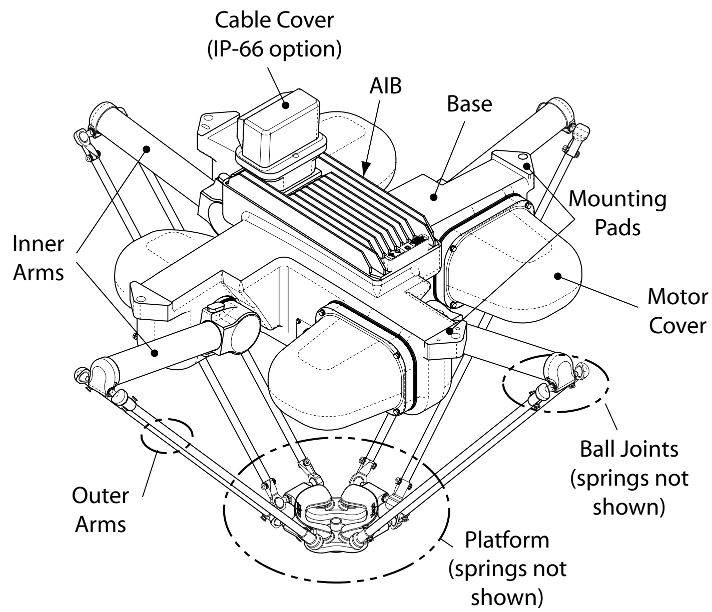


Figure 3-5. Major Robot Components, Top View

The Adept Quattro s650H robot platform is attached to the inner arms by the outer arms.

> **NOTE:** Except for attaching the outer arms and end-effector tooling, the platform is shipped fully assembled.

Clocking the Platform to the Base

The rotational alignment (clocking) of the platform to the base is critical to the correct operation of the Adept Quattro s650H robot.

CAUTION: Incorrect clocking of the platform will result in incorrect robot performance.

- The ends of the platform cross-pieces (between each pair of ball studs) are labeled with matching designators (1 - 4).
- In addition, +X and +Y World Coordinates are labeled on the platform near the flange. See **Figure 3-6**.
- When installing the platform, the numbers between the platform ball studs must match the numbers on the underside of the robot base.

Figure 3-6. Platform Orientation Labeling

NOTE: The labeling on both platforms is the same except for the part number.

Attaching the Outer Arms

One pair of outer arms attaches between each inner arm and the platform. No tools are needed.

- The outer arms have a ball joint socket at each end.

CAUTION: Ensure that the bearing insert is in place in the end of each outer arm. If an insert has fallen out of the arm, simply press it into the arm end.

- The inner arms and the platform have mating pairs of ball studs.
- Outer arm pairs are shipped assembled. Each pair has two springs at either end.
- The procedure for attaching outer arms is the same for all platforms.

Figure 3-7. Inner Arm Ball Studs

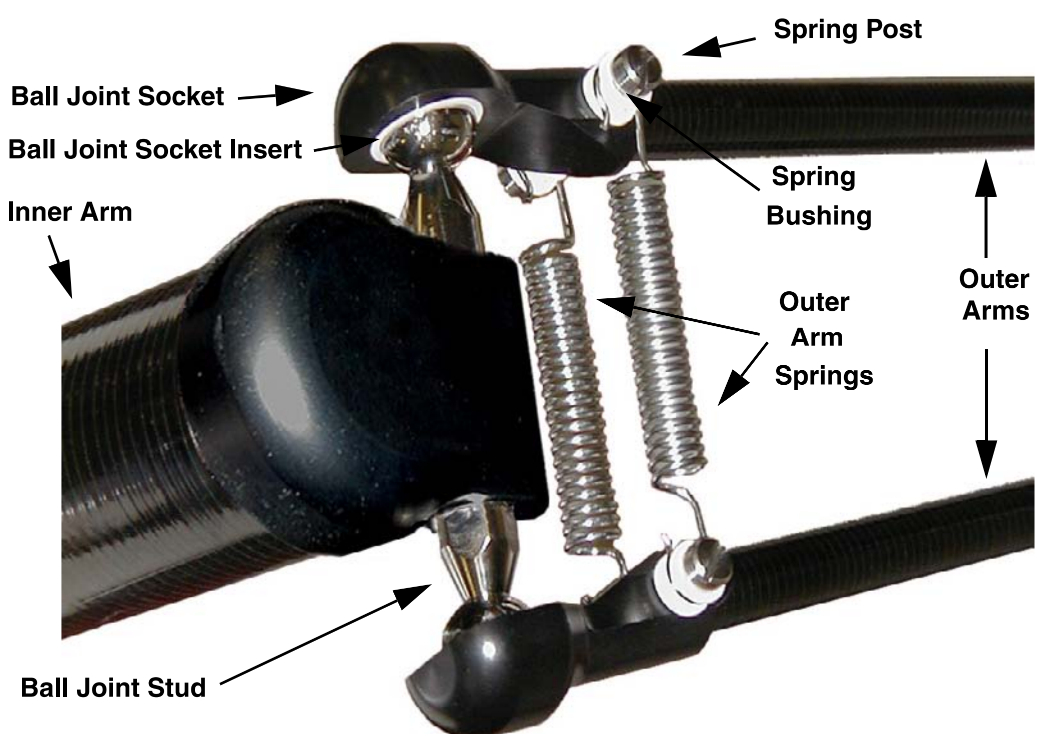


Figure 3-8. Ball Joint Assembly

WARNING: Pinch hazard. Ball joints are spring-loaded. Be careful not to pinch your fingers.

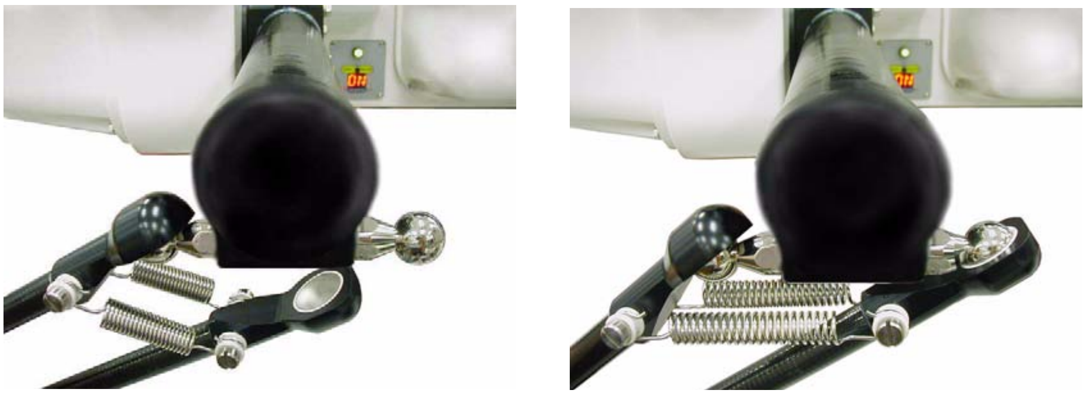


Figure 3-9. Installing Ball Joints

CAUTION: Do not overstretch the outer arm springs. Separate the ball joint sockets only enough to fit them over the ball studs.

NOTE: In the following steps, take care not to trap debris between the balls and their sockets.

1. Attach one pair of outer arms to each inner arm.
    a. As illustrated in **Figure 3-9**, the outer arm assembly is most easily achieved by pivoting the two arms away from each other lengthwise. This requires the least stretching of the spring to attach the ball joints.
    b. Slip one ball joint socket over the corresponding ball.
    c. Swing the bottom end of the outer arm pair sideways as you slip the other ball joint socket over the corresponding ball.
2. Attach one pair of outer arms to each of the four pairs of ball studs on the platform.

    NOTE: Ensure that the numbers on the platform match the numbers on the underside of the robot base. This will place the platform tool flange closest to the Status Display Panel. See **“Clocking the Platform to the Base” on page 45**. The platform is installed flange-down.

    a. Swing the bottom end of the outer arm pair to the right, as far as possible.
    b. Slip the left ball joint socket over the left ball stud. (Move the platform as needed to do this.)

c. Move the platform and outer arm pair to the left as you slip the right ball joint socket over the corresponding ball.

CAUTION: The ends of the outer arm springs must fit snugly around their bushings. Do not widen the gap between the spring hook and the opposing spring shaft. This gap should be 7.4 ± 0.5 mm (0.29 ± 0.02 in.) Refer to the following figure.

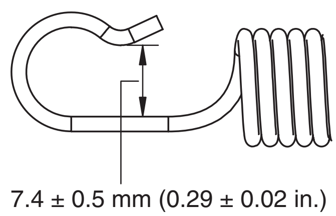


Figure 3-10. Spring Hook Gap Dimension

3. Ensure that all spring hooks are fully-seated in the groove of the bushing, as shown in the following illustration:

Figure 3-11. Spring Hook in Bushing

System Installation 4

4.1 System Cable Diagram

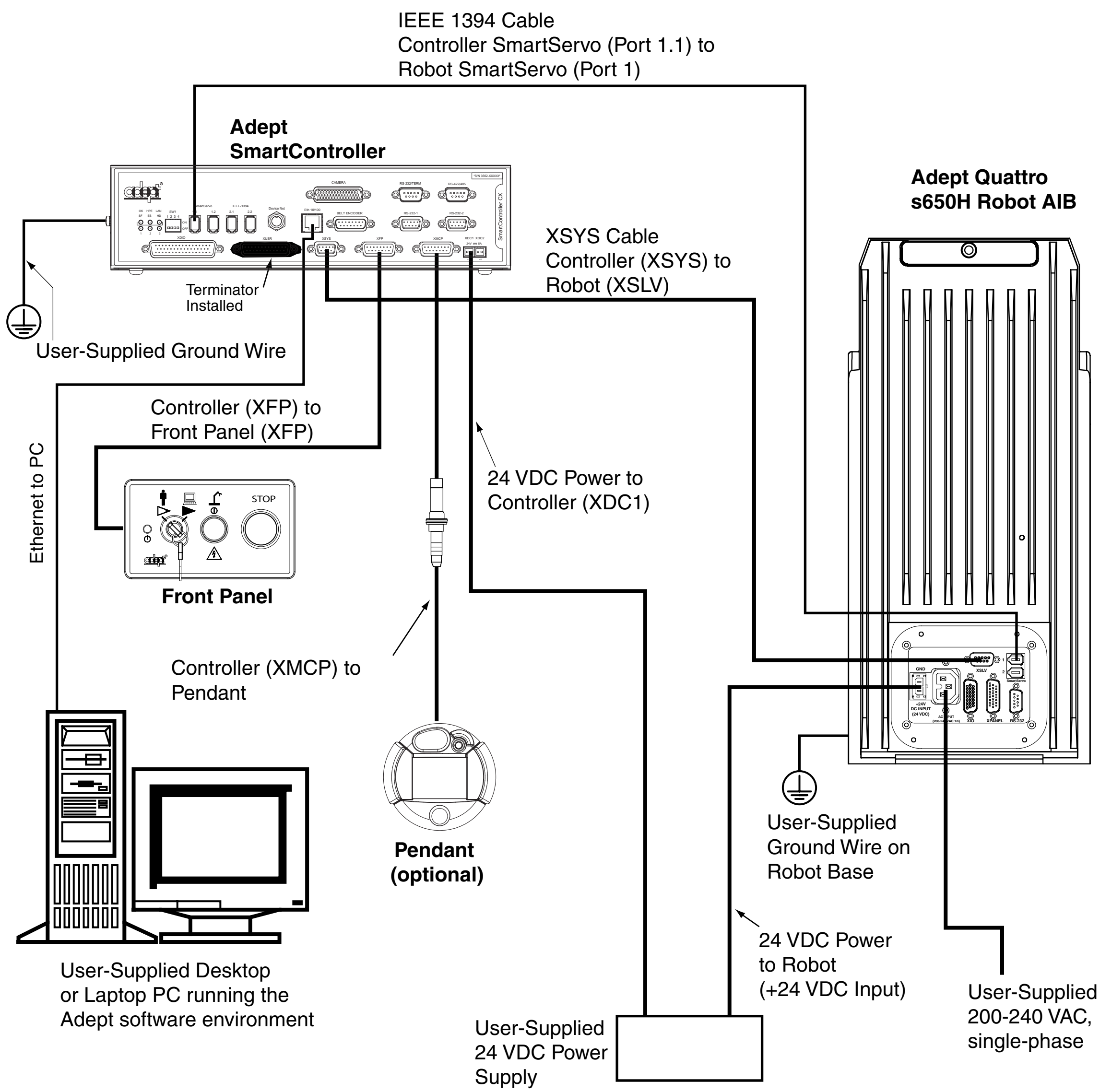


Figure 4-1. System Cable Diagram

NOTE: See **"Installing 24 VDC Robot Cable" on page 56** for additional information on system grounding.

4.2 Cable Parts List

Table 4-1. Cable Parts List

Part Description	Part Number	Notes
IEEE 1394 Cable, 4.5 M	10410-10545	Standard cable - supplied with system
XSYS Cable, 4.5 M	02928-000	Standard cable - supplied with system
Front Panel Cable	10356-10500	Supplied with front panel
T1/T2 Pendant Adapter Cable	05002-000	Supplied with optional T1/T2 pendants
Power Cable Kit - contains 24 VDC and AC power cables	04972-000	Available as option
XIO Breakout Cable, 12 inputs/ 8 outputs, 5 meter	04465-000	Available as option - see page 72.

4.3 Installing the SmartController

Refer to the ***Adept SmartController User's Guide*** for complete information on installing the Adept SmartController. This list summarizes the main steps.

1. Mount the SmartController and front panel.
2. Connect the front panel to the SmartController.
3. Connect the pendant (if purchased) to the SmartController.
4. Connect user-supplied 24 VDC power to the controller.
5. Install a user-supplied ground wire between the SmartController and ground.
6. Install the AdeptWindows PC user interface. Refer to the ***AdeptWindows Installation Guide***.

4.4 Description of Connectors on Robot Interface Panel

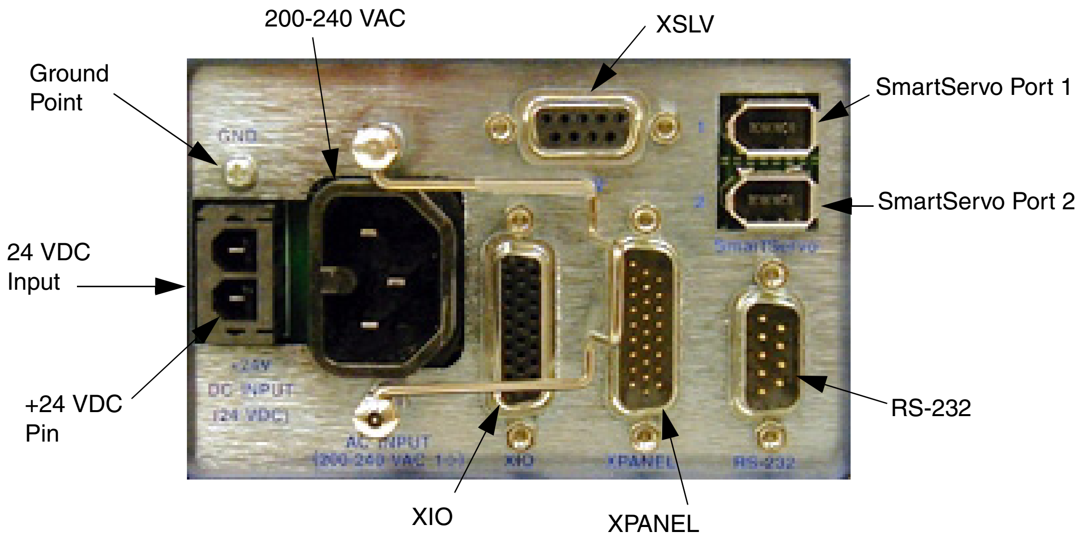


Figure 4-2. Robot Interface Panel

Connector	Connects to	Notes
24 VDC	24 VDC to the robot	User-supplied
Ground Point	Cable shield from 24 VDC cable	User-supplied
200/240 VAC	200-240 VAC, single-phase, input power to the robot	Mating connector is provided.
XSLV	XSYS cable from the controller XSYS connector	Supplied DB-9
SmartServo 1 & 2	IEEE 1394 cable from the controller (SmartServo 1.1 or 1.2) to the robot (SmartServo 1)	SmartServo 2 can be used to connect to a second robot or another 1394-based motion axis.
RS-232	Not used with Quattro robots	
XPANEL	Not used with Quattro robots	
XIO	User I/O signals for peripheral devices	This connector provides 8 outputs and 12 inputs. See 5.5 on page 67 for connector pin allocations for inputs and outputs. That section also contains details on how to access these I/O signals via V+. (DB26, high density, female)

4.5 Cable Connections from Robot to SmartController

1. Locate the IEEE 1394 cable (length 4.5 M) and the XSYS cable (length 4.5 M). They are typically shipped in the cable/accessories box.
2. Plug one end of the IEEE 1394 cable into the SmartServo port 1.1 or 1.2 connector on the SmartController, and plug the other end into the SmartServo port 1 connector on the robot interface panel. See **Figure 4-1 on page 51**.

   NOTE: The IEEE 1394 cable MUST be in either the 1.1 or 1.2 SmartServo port of the SmartController. Do NOT use the 2.1 or 2.2 ports.

3. Install the XSYS cable between the robot interface panel XSLV safety interlock connector and XSYS connector on the SmartController, and tighten the latching screws.

4.6 Connecting 24 VDC Power to Robot

Specifications for 24 VDC Robot and Controller Power

Table 4-2. 24 VDC User-Supplied Power Supply

Customer-Supplied Power Supply	24 VDC (± 10%), 150 W (6 A) (21.6 V< V_{in} < 26.4 V)
Circuit Protection[a]	Output must be < 300 W peak, or 8 Amp in-line fuse
Power Cabling	1.5 – 1.85 mm² (16-14 AWG)
Shield Termination	Braided shield connected to '-' terminal at both ends of cable. See Figure 4-3 on page 56.

[a] User-supplied 24 VDC power supply must incorporate overload protection to limit peak power to less than 300 W, **or** an 8 A in-line fuse protection must be added to the 24 VDC power source. (In case of multiple robots on a common 24 VDC supply, each robot must be fused individually.)

NOTE: Fuse information is located on the AIB electronics.

The requirements for the user-supplied power supply will vary depending on the configuration of the robot and connected devices. Adept recommends a 24 VDC, 6 A power supply to allow for startup current draw and load from connected user devices, such as solenoids and digital I/O loads. If multiple robots are to be sourced from a common 24 VDC power supply, increase the supply capacity by 3 A for each additional robot.

CAUTION: Make sure you select a 24 VDC power supply that meets the specifications in **Table 4-2**. Using an underrated supply can cause system problems and prevent your equipment from operating correctly. See **Table 4-3** for recommended power supplies.

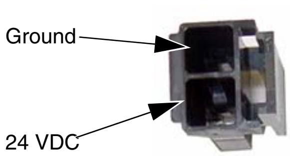
Table 4-3. Recommended 24 VDC Power Supplies

Vendor Name	Model	Ratings
XP Power	JPM160PS24	24 VDC, 6.7 A, 160 W
Mean Well	SP-150-24	24 VDC, 6.3 A, 150 W
Astrodyne	ASM150-24	24 VDC, 6.66 A, 150 W

Details for 24 VDC Mating Connector

The 24 VDC mating connector and two pins are supplied with each system. They are typically shipped in the cable/accessories box.

Table 4-4. 24 VDC Mating Connector Specs

Connector Details  	Connector receptacle, 2 position, type: Molex Saber, 18 A, 2-Pin
	Molex P/N 44441-2002
	Digi-Key P/N WM18463-ND
Pin Details 	Molex connector crimp terminal, female, 14-18 AWG
	Molex P/N 43375-0001
	Digi-Key P/N WM18493-ND
Recommended crimping tools:	Molex P/N 63811-0400
	Digi-Key P/N WM9907-ND

Procedure for Creating 24 VDC Cable

NOTE: The 24 VDC cable is not supplied with the system, but is available in the optional Power Cable kit. See **Table 4-1 on page 52**.

1. Locate the connector and pins shown in**Table 4-4**.
2. Use 14-16 AWG wire to create the 24 VDC cable. Select the wire length to safely reach from the user-supplied 24 VDC power supply to the robot base.

NOTE: A separate 24 VDC cable is required for the SmartController. That cable uses a different style of connector. See the ***Adept SmartController User's Guide***.

3. Crimp the pins onto the wires using the crimping tool.
4. Insert the pins into the connector. Confirm that the 24 VDC and ground wires are in the correct terminals in the plug.
5. Prepare the opposite end of the cable for connection to your user-supplied 24 VDC power supply.

Installing 24 VDC Robot Cable

1. Connect one end of the shielded 24 VDC cable to your user-supplied 24 VDC power supply. See **Figure 4-3**.
   - The cable shield should be connected to frame ground on the power supply.
   - Do not turn on the 24 VDC power until instructed to do so in **Chapter 5**.
2. Plug the mating connector end of the 24 VDC cable into the 24 VDC connector on the interface panel on the top of the robot.
3. Connect the cable shield to the ground point on the interface panel.

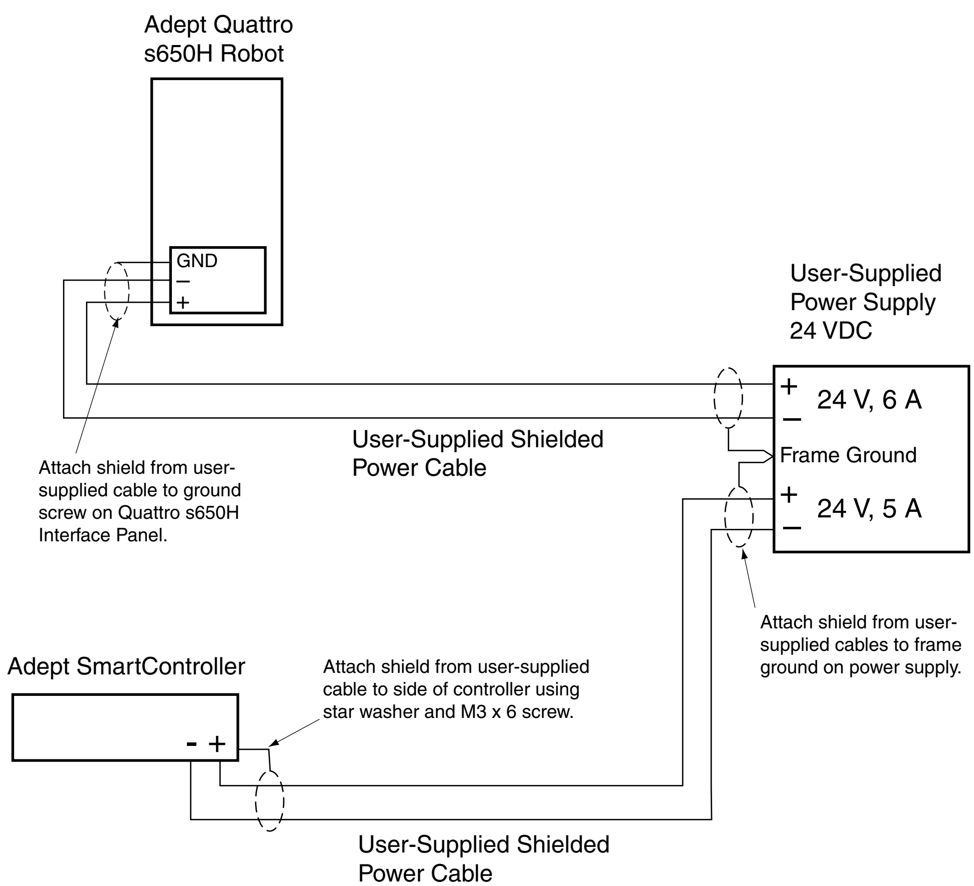


Figure 4-3. User-Supplied 24 VDC Cable

NOTE: To comply with EN standards, Adept recommends that DC power be delivered over a shielded cable, with the shield connected to the return conductors at both ends of the cable.

4.7 Connecting 200-240 VAC Power to Robot

WARNING: Appropriately-sized branch circuit protection and lockout/tagout capability must be provided in accordance with the National Electrical Code and any local codes.

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

Specifications for AC Power

Table 4-5. Specifications for 200/240 VAC User-Supplied Power Supply

Auto-Ranging Nominal Voltage Ranges	Minimum Operating Voltage[a]	Maximum Operating Voltage	Frequency/ Phasing	Recommended External Circuit Breaker, User-Supplied
200 to 240 V	180 V	264 V	50/60 Hz 1-phase	10 Amps

[a] Specifications are established at nominal line voltage. Low line voltage can affect robot performance.

NOTE: The Adept robot system is intended to be installed as a piece of equipment in a permanently-installed system.

NOTE: Adept products are designed for connection to symmetrically-earthed, three-phase AC mains systems (with grounded neutral). Connections called out as single-phase can be wired Line-to-Neutral or Line-to-Line.

WARNING: Adept systems require an isolating transformer for connection to mains systems that are asymmetrical or use an isolated (impedant) neutral. Many parts of Europe use an impedant neutral.

DANGER: AC power installation must be performed by a skilled and instructed person - see Section 2.12 on page 32. During installation, unauthorized third parties must be prevented, through the use of fail-safe lockout measures, from turning on power.

Facility Overvoltage Protection

The robot must be protected from excessive overvoltages and voltage spikes. If the country of installation requires a CE-certified installation or compliance with IEC 1131-2, the following information may be helpful. IEC 1131-2 requires that the installation must ensure that Category II overvoltages (i.e., line spikes not directly due to lightning strikes) are not exceeded. Transient overvoltages at the point of connection to the power source shall be controlled not to exceed overvoltage Category II, i.e., not higher than the impulse voltage corresponding to the rated voltage for the basic insulation. The user-supplied equipment or transient suppressor shall be capable of absorbing the energy in the transient.

In the industrial environment, non-periodic overvoltage peaks may appear on mains power supply lines as a result of power interruptions to high-energy equipment (such as a blown fuse on one branch in a 3-phase system). This will cause high current pulses at relatively low voltage levels. Take the necessary steps to prevent damage to the robot system (for example, by interposing a transformer). See IEC 1131-4 for additional information.

AC Power Diagrams

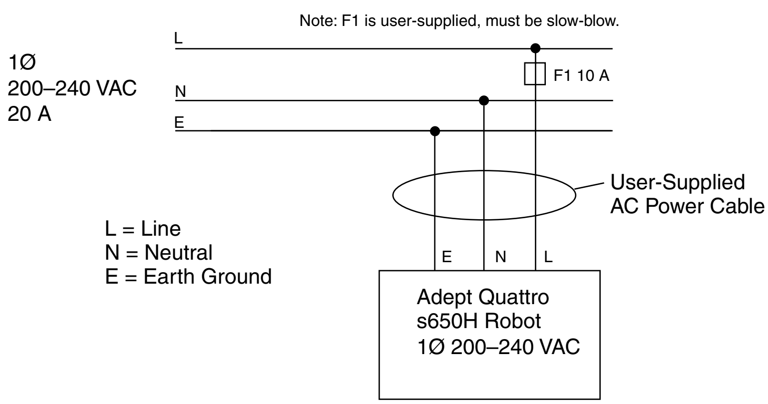


Figure 4-4. Typical AC Power Installation with Single-Phase Supply

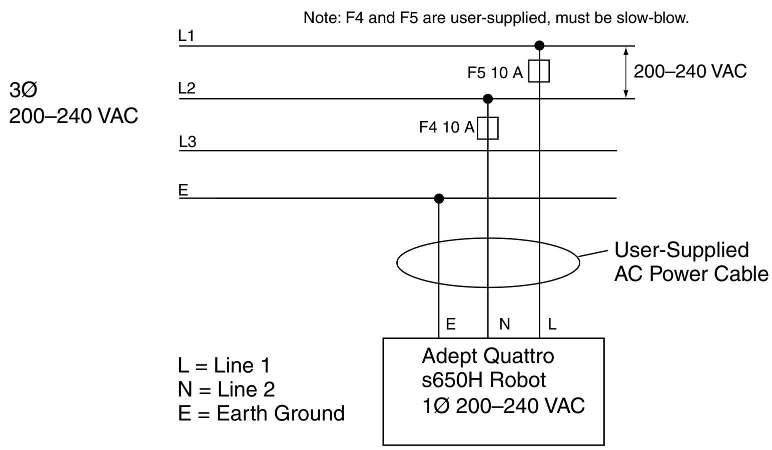


Figure 4-5. Single-Phase AC Power Installation from a Three-Phase AC Supply

Details for AC Mating Connector

The AC mating connector is supplied with each system. It is typically shipped in the cable/accessories box. The plug is internally labeled for the AC power connections (L, E, N).

Table 4-6. AC Mating Connector Details

AC Connector details 	AC in-line power plug, straight, female, screw terminal, 10 A, 250 VAC
	Qualtek P/N 709-00/00
	Digi-Key P/N Q217-ND

NOTE: The AC power cable is not supplied with the system. However, it is available in the optional Power Cable kit. See **Table 4-1 on page 52**.

Procedure for Creating 200-240 VAC Cable

1. Locate the AC mating connector shown in **Table 4-6**.
2. Open the connector by unscrewing the screw on the shell and removing the cover.
3. Loosen the two screws on the cable clamp. See **Figure 4-6**.
4. Use 18 AWG wire to create the AC power cable.
   Select the wire length to safely reach from the user-supplied AC power source to the robot base.
5. Strip 18 to 24 mm insulation from each of the three wires.
6. Insert the wires into the connector through the removable bushing.
7. Connect each wire to the correct terminal screw and tighten the screw firmly.

8. Tighten the screws on the cable clamp.
9. Reinstall the cover and tighten the screw to secure the connector.
10. Prepare the opposite end of the cable for connection to the facility AC power source.

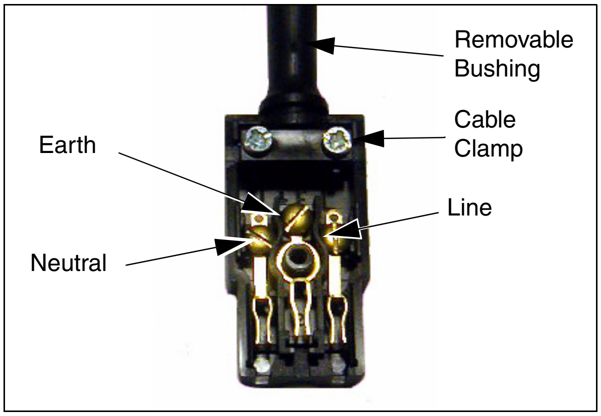


Figure 4-6. AC Power Mating Connector

Installing AC Power Cable to Robot

1. Connect the AC power cable to your facility AC power source. See **Figure 4-4** and **Figure 4-5 on page 59**. Do not turn on AC power at this time.
2. Plug the AC connector into the AC power connector on the interface panel on the robot.
3. Secure the AC connector with the locking latch.

4.8 Grounding the Adept Quattro s650H Robot System

Proper grounding is essential for safe and reliable robot operation.

NOTE: You must ground the robot base to the frame for all installations.

- One of the base mounting pads has two small holes (in addition to the M16 mounting hole). One of these is an M8 hole, provided as a ground.
- For identification: The mounting pad opposite this mounting pad has a single slot (in addition to the M16 mounting hole).

Robot-Mounted Equipment Grounding

DANGER: Failing to ground robot-mounted equipment or tooling that uses hazardous voltages could lead to injury or death of a person touching the end-effector when an electrical fault condition exists.

If hazardous voltages are present at any user-supplied robot-mounted equipment or tooling, you must install a ground connection for that equipment or tooling. Hazardous voltages can be considered anything in excess of 30 VAC (42.4 VAC peak) or 60 VDC.

If there will be hazardous voltages present at the tool flange or end-effector, you must:

- Connect the robot base ground.
- Ground the end-effector to the robot base.

NOTE: A ground strap from the end-effector to the base mounting tab must include a service loop that allows full rotation and movement of the tool flange.

4.9 Installing User-Supplied Safety Equipment

You must install safety barriers to protect personnel from unintentional contact with the robot. Depending on the design of the workcell, you can use safety gates, light curtains, and emergency stop devices to create a safe environment. Read **Chapter 2** in this manual for a discussion of safety issues.

Refer to the ***Adept SmartController User's Guide*** for information on connecting safety equipment into the system through the XUSR connector on the SmartController. There is a detailed section on Emergency Stop Circuits and diagrams on recommended E-Stop configurations.

System Operation 5

5.1 Robot Status Display Panel

The robot Status Display panel is located on the robot base. The Status Display and LED blinking pattern indicate the status of the robot.

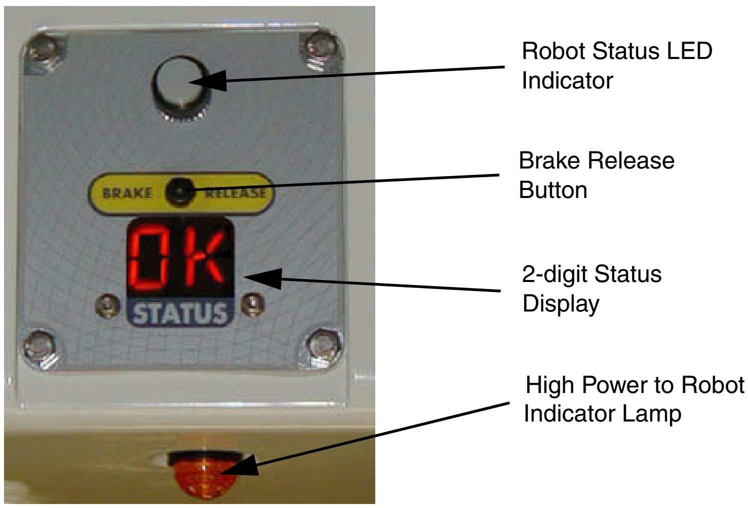


Figure 5-1. Robot Status Display Panel

Table 5-1. Robot Status LED Definition

LED Status	2-Digit Status Panel Display	Description
Off	No display	24 VDC not present
Off	**OK**	High Power Disabled
Amber, Solid	**ON**	High Power Enabled
Amber, Solid	Fault Code(s)	Fault, see Status Display[1]
Amber, Slow Blink	**OK** or Fault Code(s)	Selected Configuration Node[1]
Amber, Fast Blink	Fault Code(s)	Fault, see Status Display[1]

[1]See Section 5.2

5.2 Status Panel Fault Codes

The Status Display, shown in **Figure 5-1**, displays alpha-numeric codes that indicate the operating status of the robot, including fault codes. **Table 5-2** gives definitions of the fault codes. These codes provide details for quickly isolating problems during troubleshooting.

The displayed fault code will continue to be displayed even after the fault is corrected or additional faults are recorded. All displayed faults are cleared from the display, and reset to a no-fault condition, upon successfully enabling high power to the robot, or power cycling the 24 V supply to the robot.

Table 5-2. Status Panel Codes

Code	Meaning	Code	Meaning
OK	No Fault	H#	High Temp Encoder (Joint #)
ON	High Power ON Status	hV	High Voltage Bus Fault
MA	Manual Mode	I#	Initialization Stage (Step #)
24	24 V Supply Fault	M#	Motor Stalled (Joint #)
A#	Amp Fault (Joint #)	NV	Non-Volatile Memory
AC	AC Power Fault	P#	Power System Fault (Code #)
D#	Duty Cycle Exceeded (Joint #)	PR	Processor Overloaded
E#	Encoder Fault (Joint #)	RC	RSC Fault
ES	E-Stop	SW	Watchdog Timeout
F#	External Sensor Stop	S#	Safety System Fault (Code #)
FM	Firmware Mismatch	T#	Safety System Fault (Code 10 + #)
FW	1394 Fault		
h#	High Temp Amp (Joint #)	V#	Hard Envelope Error (Joint #)

NOTE: All joint numbers correspond to the number on the under-side of the base.

For more information on status codes, go to the Adept Document Library on the Adept website, and in the Procedures, FAQs, and Troubleshooting section, look for the *Adept Status Code Summary* document.

5.3 Using the Brake Release Button

Brakes

The robot has a braking system which decelerates the robot in an emergency condition, such as when the emergency stop circuit is open or a robot joint passes its softstop.

The standard braking system does not prevent you from moving the robot manually, once the robot has stopped (and high power has been disabled).

In addition, the motors have electromechanical brakes. The brakes are released when high power is enabled. When high power is disabled, the brakes engage and hold the position of the robot fixed.

Brake Release Button

Under some circumstances, you may want to manually position the platform without enabling high power. For such instances, a Brake Release button is located on the Status Panel (see **Figure 5-1 on page 63**). When system power is ON, pressing this button releases the brakes, which allows movement of the arms and platform.

If this button is pressed while high power is ON, high power automatically shuts down.

NOTE: 24 Volt robot power must be ON to release the brakes.

CAUTION: When the Brake Release button is pressed, the end-effector platform may drop to the bottom of its travel. To prevent possible damage to the equipment, make sure that the platform is supported when releasing the brake and verify that the end-effector or other installed tooling is clear of all obstructions.

5.4 Connecting Digital I/O to the System

You can connect digital I/O to the system in several different ways. See **Table 5-3** and **Figure 5-2**.

Table 5-3. Digital I/O Connection Options

Product	I/O Capacity	For more details
XIO Connector on Robot	12 inputs 8 outputs	see **Section 5.5 on page 67**
XDIO Connector on SmartController	12 inputs 8 outputs	see ***Adept SmartController User's Guide***
Optional sDIO Module, connects to controller	32 inputs, 32 outputs per module; up to four sDIO per system	see ***Adept SmartController User's Guide***

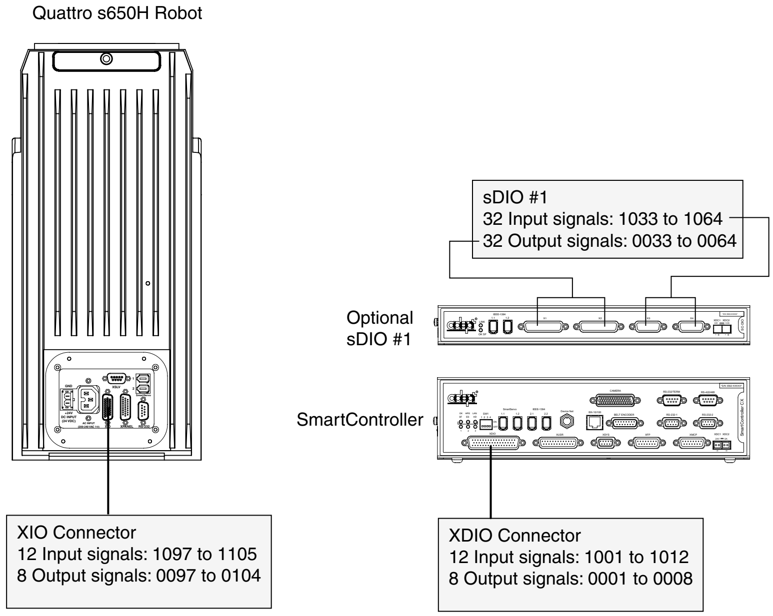


Figure 5-2. Connecting Digital I/O to the System

Table 5-4. Default Digital I/O Signal Configuration, Single Robot System

Location	Type	Signal Range
Controller XDIO connector	Inputs	1001 - 1012
	Outputs	0001 - 0008
sDIO Module	Inputs	1033 - 1064
	Outputs	0033 - 0064
sDIO Module 2	Inputs	1065 - 1096
	Outputs	0065 - 0096
sDIO Module 3 (recommended [a])	Inputs	1201 - 1232
	Outputs	0201 - 0232
sDIO Module 4 (recommended [a])	Inputs	1233 - 1264
	Outputs	0233 - 0264
Robot 1 XIO connector	Inputs	1097 - 1108
	Outputs	0097 - 0104

[a] For sDIO modules 3 and 4, you must configure the signals using CONFIG_C to have the system support those modules. See the ***Adept SmartController User's Guide*** for additional information on that process.

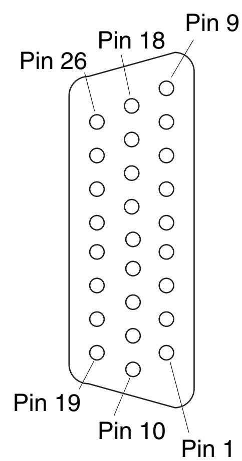
5.5 Using Digital I/O on Robot XIO Connector

The XIO connector on the robot interface panel offers access to digital I/O, 12 inputs and 8 outputs. These signals can be used by V+ to perform various functions in the workcell. See **Table 5-5** for the XIO signal designations.

- 12 Inputs, signals 1097 to 1108
- 8 Outputs, signals 0097 to 0104

Table 5-5. XIO Signal Designations

Pin No.	Designation	Signal Bank	V+ Signal Number	Pin Locations
1	GND			
2	24 VDC			
3	Common 1	1		
4	Input 1.1	1	1097	
5	Input 2.1	1	1098	
6	Input 3.1	1	1099	
7	Input 4.1	1	1100	
8	Input 5.1	1	1101	
9	Input 6.1	1	1102	
10	GND			
11	24 VDC			
12	Common 2	2		
13	Input 1.2	2	1103	
14	Input 2.2	2	1104	
15	Input 3.2	2	1105	
16	Input 4.2	2	1106	
17	Input 5.2	2	1107	
18	Input 6.2	2	1108	
19	Output 1		0097	
20	Output 2		0098	
21	Output 3		0099	
22	Output 4		0100	
23	Output 5		0101	
24	Output 6		0102	
25	Output 7		0103	
26	Output 8		0104	



XIO 26-pin female connector on Robot Interface Panel

Optional I/O Products

These optional products are also available for use with digital I/O:

- **XIO Breakout Cable**, 5 meters long, with flying leads on user's end. See **page 72** for information. This cable is not compatible with the XIO Termination Block.
- **XIO Termination Block**, with terminals for user wiring, plus input and output status LEDs. Connects to the XIO connector with 6-foot cable. See the ***Adept XIO Termination Block Installation Guide*** for details.

XIO Input Signals

The 12 input channels are arranged in two banks of six. Each bank is electrically isolated from the other bank and is optically isolated from the robot's ground. The six inputs within each bank share a common source/sink line.

The inputs are accessed through direct connection to the XIO connector (see **Table 5-5 on page 68**), or through the optional XIO Termination Block. See the documentation supplied with the Termination Block for details.

The XIO inputs cannot be used for REACTI programming, high-speed interrupts, or vision triggers. See the ***V+ Language User's Guide*** for information on digital I/O programming.

XIO Input Specifications

Table 5-6. XIO Input Specifications

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	V_{in} = 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 7.5 mA
Typical threshold current	2.0 mA
Impedance (V_{in}/I_{in})	3.9 KΩ minimum
Current at V_{in} = +24 VDC	$I_{in} \leq$ 6 mA
Turn-on response time (hardware) Software scan rate/response time	5 µsec maximum 16 ms scan cycle/ 32 ms max response time
Turn-off response time (hardware) Software scan rate/response time	5 µsec maximum 16 ms scan cycle/ 32 ms max response time

NOTE: The input current specifications are provided for reference. Voltage sources are typically used to drive the inputs.

Typical Input Wiring Example

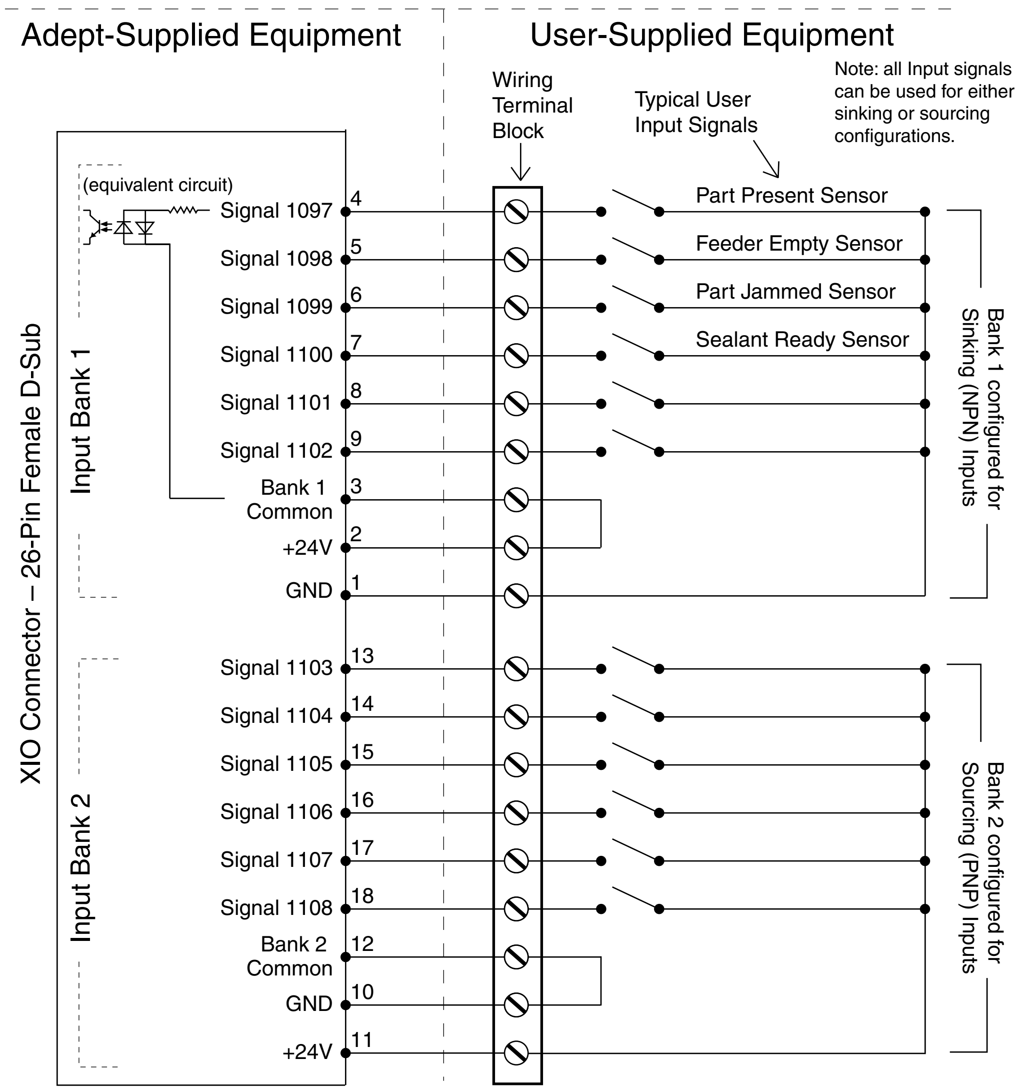


Figure 5-3. Typical User Wiring for XIO Input Signals

NOTE: The OFF state current range exceeds the leakage current of XIO outputs. This guarantees that the inputs will not be turned on by the leakage current from the outputs. This is useful in situations where the outputs are looped-back to the inputs for monitoring purposes.

XIO Output Signals

The eight digital outputs share a common, high side (sourcing) driver IC. The driver is designed to supply any kind of load with one side connected to ground. It is designed for a range of user-provided voltages, from 10 to 24 VDC, and each channel is capable of up to 0.7 A of current. This driver has overtemperature protection, current limiting, and shorted-load protection. In the event of an output short or other overcurrent situation, the affected output of the driver IC turns off and back on automatically to reduce the temperature of the IC. The driver draws power from the primary 24 VDC input to the robot through a self-resetting polyfuse.

The outputs are accessed through a direct connection to the XIO connector (see **Table 5-5 on page 68**), or through the optional XIO Termination Block. See the documentation supplied with the Termination Block for details.

XIO Output Specifications

Table 5-7. XIO Output Circuit Specifications

Parameter	Value
Power supply voltage range	See **Table 4-2 on page 54**.
Operational current range, per channel	$I_{out} \leq$ 700 mA
Total Current Limitation, all channels on	$I_{total} \leq$ 1.0 A @ 40° C ambient $I_{total} \leq$ 1.5 A @ 25° C ambient
ON-state resistance (I_{out} = 0.5 A)	$R_{on} \leq$ 0.32 Ω @ 85° C
Output leakage current	$I_{out} \leq$ 25 µA
Turn-on response time	125 µsec max., 80 µsec typical (hardware only)
Turn-off response time	60 µsec. max., 28 µsec typical (hardware only)
Output voltage at inductive load turnoff (I_{out} = 0.5 A, Load = 1 mH)	(+V - 65) $\leq V_{demag} \leq$ (+V - 45)
DC short circuit current limit	0.7 A $\leq I_{LIM} \leq$ 2.5 A
Peak short circuit current	$I_{ovpk} \leq$ 4 A

Typical Output Wiring Example

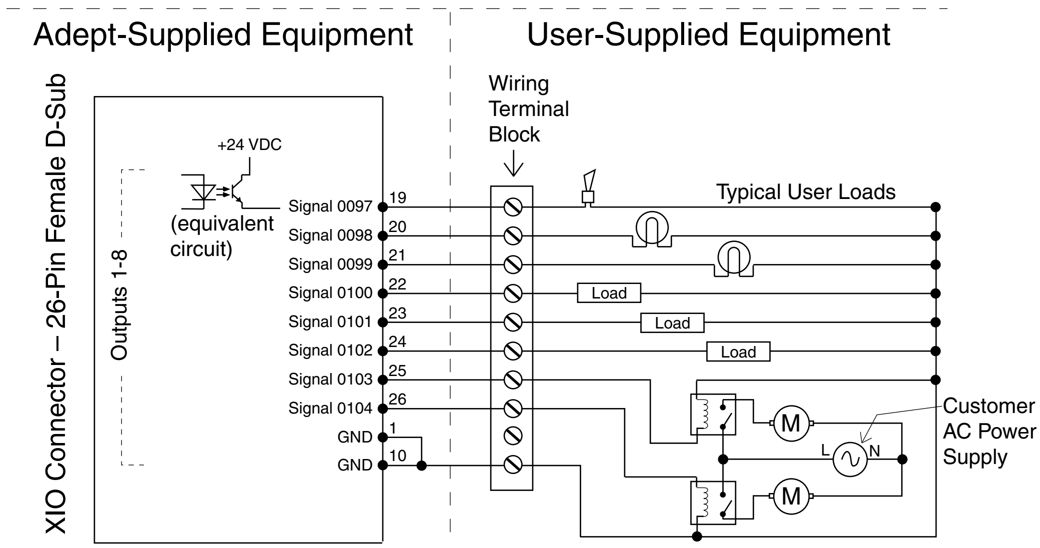


Figure 5-4. Typical User Wiring for XIO Output Signals

XIO Breakout Cable

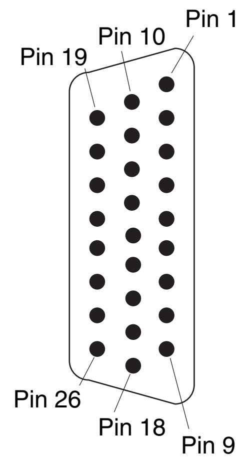
The XIO Breakout cable is available as an option (see **Figure 5-5**). This cable connects to the XIO connector on the robot, and provides flying leads for connecting input and output signals in the workcell. The 5 M (16.4 ft) cable is Adept P/N 04465-000.

See **Table 5-8 on page 73** for the wire chart on the cable.

NOTE: This cable is not compatible with the XIO Termination Block.

Figure 5-5. Optional XIO Breakout Cable

Table 5-8. XIO Breakout Cable Wire Chart

Pin No.	Signal Designation	Wire Color	Pin Locations
1	GND	White	 **26-pin male connector on XIO Breakout Cable**
2	24 VDC	White/Black	
3	Common 1	Red	
4	Input 1.1	Red/Black	
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	Grey	
16	Input 4.2	Grey/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	

5.6 Commissioning the System

Turning on the robot system for the first time is known as "commissioning the system." Follow the steps in this section to safely bring up your robot system. The tasks include:

- Verifying installation, to confirm that all tasks have been performed correctly.
- Starting up the system by turning on power for the first time.
- Verifying that all E-Stops in the system function correctly.
- Moving the robot with the pendant (if purchased), to confirm that each joint moves correctly.

Verifying Installation

Verifying that the system is correctly installed and that all safety equipment is working correctly is an important process. Before using the robot, perform the following checks to ensure that the robot and controller have been properly installed.

DANGER: 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.

Mechanical Checks

- Verify that the robot is mounted level and that all fasteners are properly installed and tightened.
- Verify that any platform tooling is properly installed.
- Verify that the platform is clocked.
- Verify that all peripheral equipment is properly installed such that it is safe to turn on power to the robot system.

System Cable Checks

Verify the following connections:

- Front panel connected to the SmartController
- Optional pendant connected to the SmartController, via the adapter cable, or a loop-back dongle installed
- User-supplied 24 VDC power connected to the controller
- User-supplied ground wire installed between the SmartController and ground.
- One end of the IEEE 1394 cable installed into SmartServo port 1.1 or 1.2 on the SmartController, and the other end installed into SmartServo port 1 on the robot interface panel
- XSYS cable installed between the robot interface panel XSLV safety interlock connector and XSYS connector on the SmartController, and latching screws tightened
- User-supplied 24 VDC power connected to the robot 24 VDC connector
- User-supplied 200/240 VAC power connected to the robot 200/240 VAC connector

User-Supplied Safety Equipment Checks

Verify that all user-supplied safety equipment and E-Stop circuits are installed correctly.

System Start-up Procedure

Once the system installation has been verified, you are ready to start up the system.

1. Switch ON the 200/240 VAC power.
2. Switch ON the 24 VDC power to the robot.
3. Switch ON the 24 VDC power to the controller.
4. Connect to the controller using AdeptWindows, and boot the system from the ‘D’ default drive.
5. Wait for the system to complete the boot cycle.

   Once completed, the system returns a “dot” prompt, and the following window is displayed:

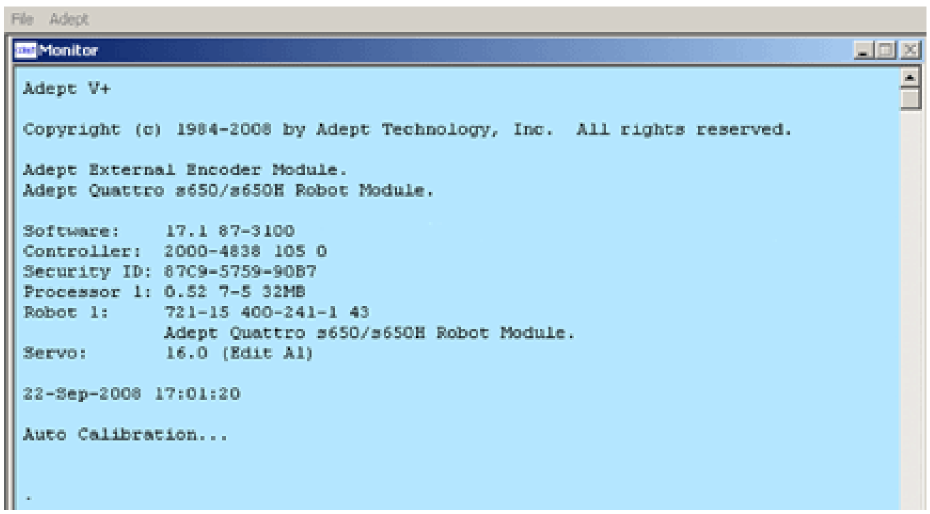


Figure 5-6. Typical Startup Screen

   There should be no listed errors if the boot sequence completes successfully.

6. Disengage any E-Stops.
   This can be verified by toggling the mushroom E-Stop and listening for the sound of the relay clicking on and off.
7. Verify correct outer arm installation by holding the platform and moving it around the work volume while pressing the Brake Release button.

   NOTE: Make sure that you hold the platform prior to pressing the Brake Release button.

   The platform motion should be smooth and free from any binding.

8. Enable high power.

   ENA POW <ENTER>

   Press the High Power button, on the front panel, while it is blinking.

   NOTE: Listen for an audible click from the brakes releasing, indicating that the robot is servoing all motors to remain in position at all times.

9. If you do not hear a click in the previous step, you must explicitly calibrate the robot:

   CAL <ENTER>

10. The system returns a “dot” (.) prompt if everything is successful, then high power is enabled, and the status panel displays “OK.”

    The system is ready for operation.

    NOTE: You may receive an “exception overrun” or “obstacle detected” error if the platform is not in the robot work envelope or is disconnected from the robot base. If so, disable power (by typing “DIS POW” at the V+ dot prompt), release the brakes, and move the platform into the work envelope.

Verifying E-Stop Functions

Verify that all E-Stop devices are functional (pendant, front panel, and user-supplied). Test each mushroom button, safety gate, light curtain, etc., by enabling high power, and then opening the safety device. The High Power push button/light on the front panel should go out.

Verifying Robot Motions

Use the pendant (if purchased) to verify that the robot moves correctly. Refer to the *Adept T1 (or T2) Pendant User's Guide* for complete instructions on using the pendant.

The Adept Quattro s650H robot is a parallel-arm robot and, as such, individual joint motions are not allowed. If you attempt to move a joint in Joint mode, you will get an error message:

JOINT <n> OUT OF RANGE

where <n> is the joint that you attempted to move.

NOTE: All joint numbers correspond to the number embossed on the bottom of the base.

If one joint must be moved separately, release the brakes (while supporting the platform) and move the joint manually.

5.7 Quattro Motions

Straight-line Motion

Joint-interpolated motion is not possible with the Adept Quattro s650H robot, because the positions of all the joints must always be coordinated in order to maintain the connections to the moving platform. Therefore, for the Adept Quattro s650H robot, the V+ system automatically performs a straight-line motion when a joint-interpolated motion instruction is encountered.

Containment Obstacles

The work space of the robot is defined by an inclusion obstacle. This is done because, unlike other robots, joint limits are not meaningful in defining the work space. The V+ version that supports the Adept Quattro s650H robot defines a cone-like shape as a containment obstacle. This is actually the work envelope. See **Figure 7-2 on page 84**. Other obstacles can be defined within this obstacle.

Tool Flange Rotation Extremes

This section addresses an ambiguity that can occur at extremes of the tool flange rotation. Note the following exceptions:

- Quattro robots with tool flange rotation of less than 360° (e.g., 60° platforms) are not affected.
- Manual control is not affected.
- Program-controlled motions with destinations not near the extremes of tool flange rotation, or that start and stop on the same side (either + or -) of the center angle of rotation of the tool flange are not affected. This means that most of the range of tool rotation is not affected.

Since there is no robot axis directly associated with the tool flange rotation, that rotation is specified by the roll component of the destination transformation.

The V+ system considers the center angle of rotation of the tool flange to have a roll component of 180°. The roll component approaches 0° as the tool-rotation angle approaches ±180°.

> **NOTE:** The roll is -180° on one side of the center of rotation, and +180° on the other side. See **Figure 5-7 on page 78**.

An ambiguity, however, exists from just beyond the extreme of tool rotation to 0.2° past that extreme, in both rotation directions. These are considered to be the “ambiguity zones” for tool rotation. Note that, for a tool that can rotate exactly 360°, the two ambiguity zones touch.

If the total tool rotation is greater than 360°, the ambiguity zones shift by the amount that the total tool rotation exceeds 360°. This means that the 185° platform has ambiguity zones as follows:

$$-5° > Zone1 \geq -5.2°$$

$$+5° < Zone2 \leq +5.2°$$

In order to address this ambiguity, the following rule has been implemented in the motion-planning software:

> When a motion destination has a tool rotation ending within an “ambiguity zone”, the tool is permitted to rotate only in the direction of the shortest distance from the starting position to the destination position. But if that rotation would exceed the range of motion in that direction, the error “*Location out of range*” is reported and the motion is not performed.

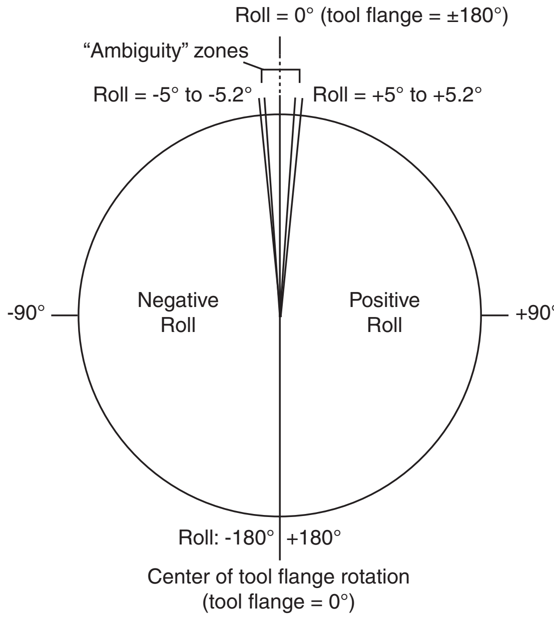


Figure 5-7. 185° Platform Ambiguity Zones

As examples:

- With the roll starting at +170°, an attempt to move to roll value -5.1 causes the system to try to rotate 175.1° (the shorter distance), through roll values 160, 150, 140, ..., 10, 0, to -5.1. However, the maximum possible rotation in that direction is 175°, so the error "*Location out of range*" results, and no motion occurs. An initial motion to any negative roll value outside the "ambiguity zones" (and not between the zones) will permit you to command a second, valid motion to the desired destination. See the following figure.

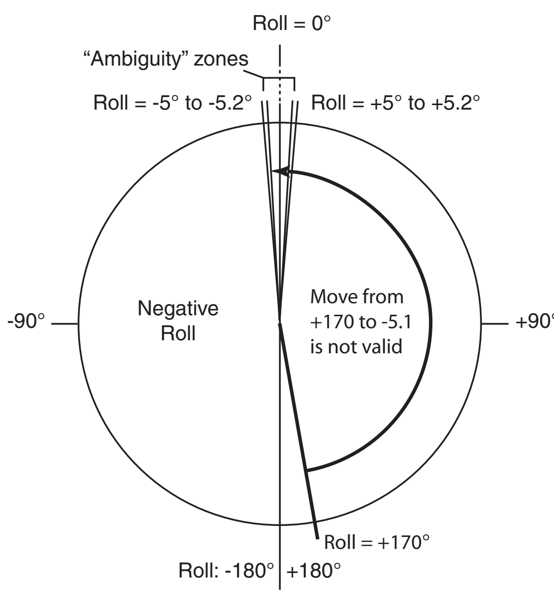


Figure 5-8. Invalid Move

- With the roll initially at +170°, a motion to roll value +5.1 causes the system to rotate 164.9° (the shorter distance), through roll values 160, 150, 140, ..., 10 to +5.1. See the following figure.

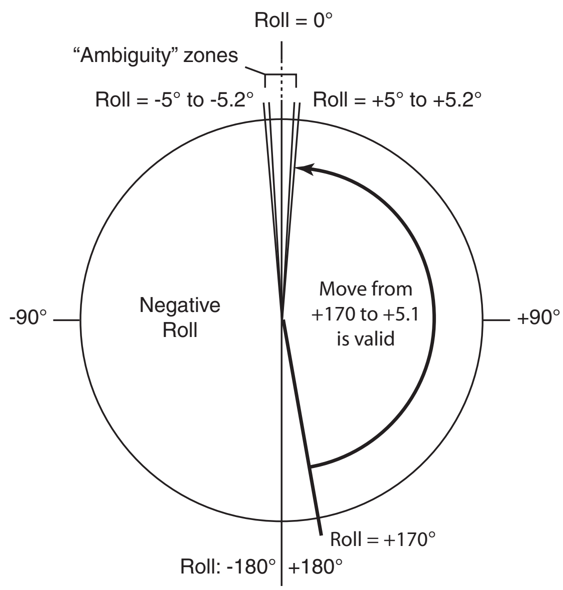


Figure 5-9. Valid Move

As these examples demonstrate, it might or might not be possible to perform a tool rotation to an "ambiguity zone" with a single motion instruction. In order to avoid that uncertainty, the following approach should be used:

- If necessary, the tool must first be rotated to a position on the destination side of the center angle of rotation of the tool flange.
- A motion to the destination can then be performed.

The two motions can be performed as one continuous-path motion, i.e., no break or stop motion is required.

In summary, any move that attempts to end beyond the extreme of rotation possible, or up to 0.2° past that extreme, will generate a "Location out of range" error.

5.8 Learning to Program the Adept Quattro Robot

To learn how to use and program the robot, go to the ***V+ Operating System User's Guide*** to find information on basic operation of the V+ Operating System. Also refer to the ***Instructions for Adept Utility Programs*** for information on using the Adept utility programs.

For programming information, refer to the following manuals:

- ***V+ Language User's Guide***
- ***V+ Language Reference Guide***
- ***V+ Operating System Reference Guide***

Optional Equipment Installation 6

6.1 End-Effectors

You are responsible for providing and installing any end-effector or other tooling, as well as vacuum lines and wiring to the end-effector.

Attaching

You can attach end-effectors to the tool flange using either four M6x1.0 screws, or a ring clamp. Hardware for both methods is supplied in the accessories kit. See **Figure 7-4 on page 85** for a dimension drawing of the tool flange.

NOTE: The combined weight of the end-effector and the payload must not exceed 6 kg.

The screws used to attach end-effectors to the tool flange must not extend more than 2 mm [0.079 in.] past the top of the tool flange.

Aligning

A 6 mm diameter x 12 mm dowel pin (user-supplied) fits in a hole in the tool flange and can be used as a keying or anti-rotation device in a user-designed end-effector. See **Figure 7-4 on page 85**.

NOTE: The dowel pin must not extend more than 2 mm [0.079 in.] past the top of the tool flange.

Grounding

If hazardous voltages are present at the end-effector, you must install a ground connection to the end-effector. See **"Robot-Mounted Equipment Grounding" on page 60**.

Accessing Vacuum

The tool flange is threaded at both ends with 1/8 G threads. This allows you to attach a vacuum line at the top, and attach a tool to the bottom of the flange to access the vacuum. See the bottom drawing in **Figure 7-4 on page 85**.

6.2 Routing End-effector Lines

End-effector lines (either vacuum/air lines or electrical wires) can be routed to the platform by:

- Attaching them to the inner and outer arms, and then to the platform.
- Routing them from the robot support frame to the outer arms.
- Routing them from the robot base directly to the platform.

If end-effector lines are attached to the outer arms to reach the end-effector, either directly from the frame, or along the inner arms:

- Make every attempt to keep the load on the outer arms as evenly-balanced as possible.
  The added weight should be attached symmetrically about the platform center.
- Verify that the arms can be fully-extended without interference from the lines. Ensure that there is enough line to reach the end-effector or vacuum fitting of the flange at all platform locations.
- Verify that the platform can be fully-rotated at all positions without affecting or being affected by the lines.
- Verify that any service loop or excess line does not hang down below the end-effector at any platform position.
- Verify that excess line cannot become tangled in the outer arms or platform.

If end-effector lines are attached directly to the bottom of the robot base to reach the end-effector:

- Lines attached to the robot base need some form of retraction mechanism or service loop to take up the slack when the platform is near the robot base.
- Ensure that the lines (and retraction mechanism) do not apply significant force, in any direction, to the platform.
- Ensure that lines going to the robot base do not block your view of the status LED.
- Ensure that lines going to the robot base do not interfere with the inner arm movement.

User-added end-effector lines:

- Should be checked for the entire work envelope being utilized.
  They must reach without being pulled, and without impeding arm or platform movement.
- Cannot pull against the platform with significant force. Robot performance will be affected.
- Must be considered as part of the payload, if they add weight to the platform or outer arms.
- Are the user's responsibility for maintenance.
  They are not covered in the Maintenance section of this manual.
- Are not considered in the robot's IP rating.

Technical Specifications 7

7.1 Dimension Drawings

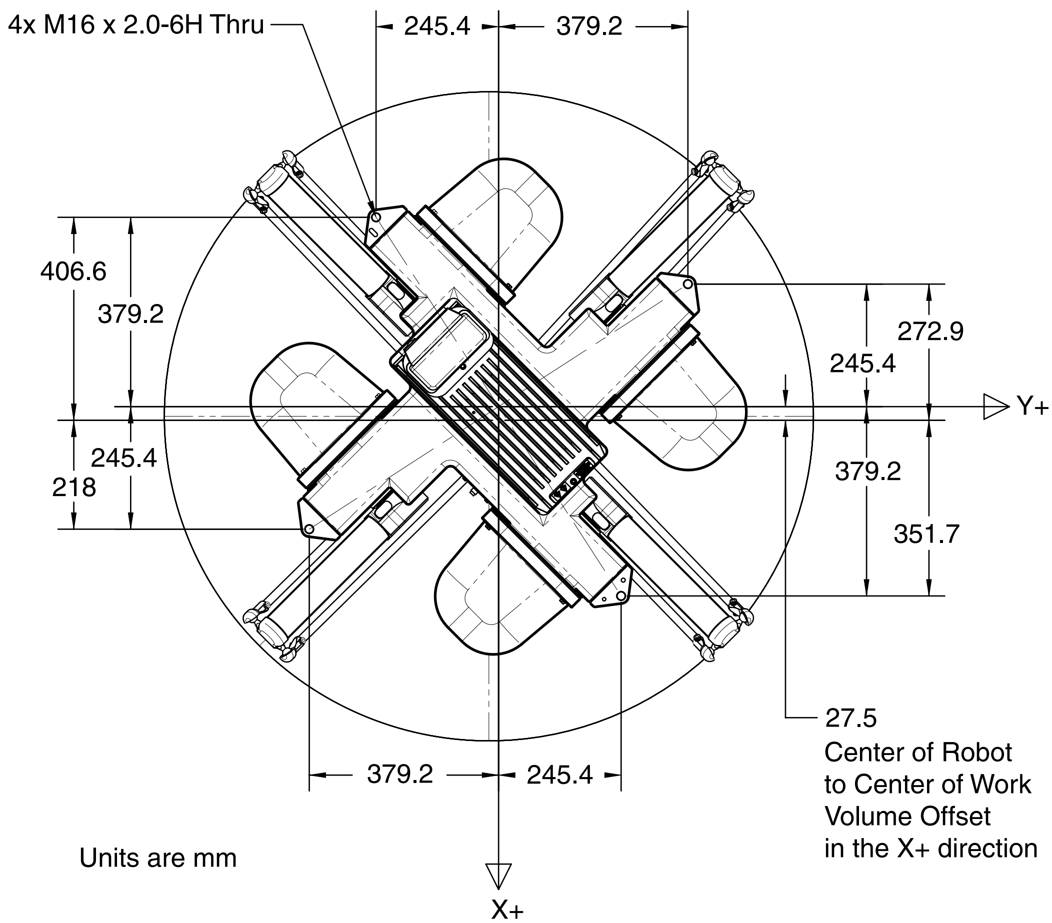


Figure 7-1. Top Dimensions, Work Envelope, and Mounting Hole Pattern

NOTE: The 60° platform flange is 27.1 mm higher, in Z, than the previous 1:1 and 4:1 platform flanges. An optional spacer of this thickness is available, from Adept, as P/N 02906-000.
The 185° platform is 9.78 mm higher, in Z. The optional spacer for it is P/N 09266-000.

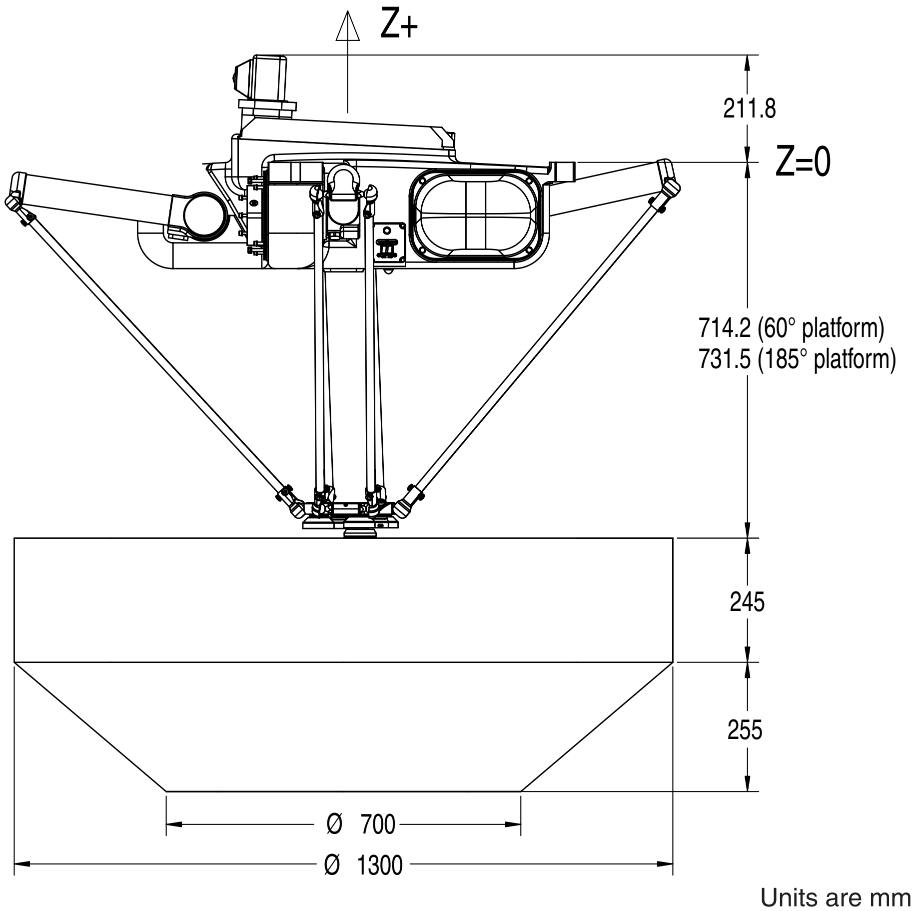


Figure 7-2. Work Envelope, Side View

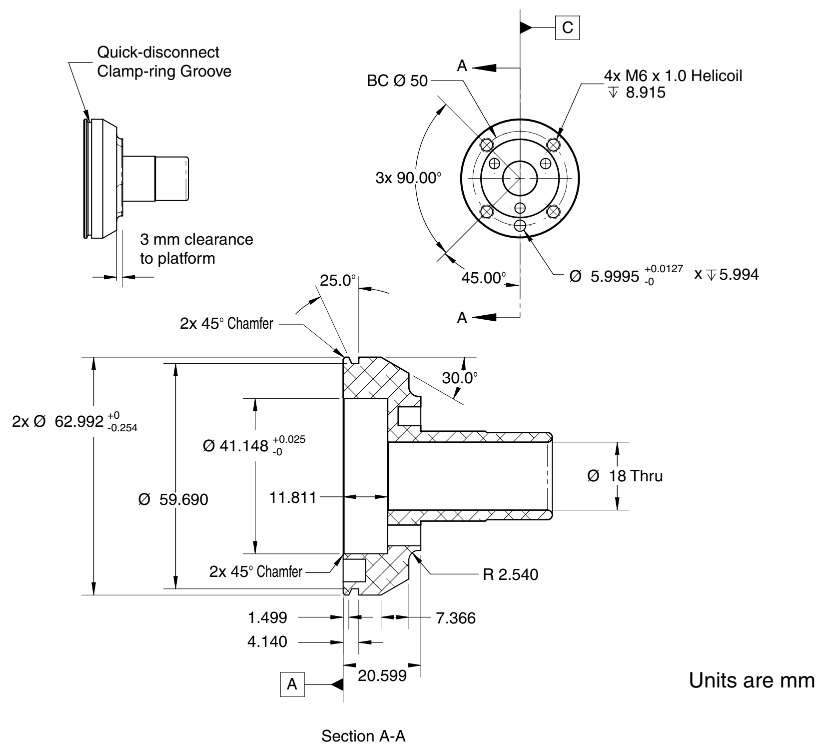


Figure 7-3. Tool Flange Dimensions, 60° Platform

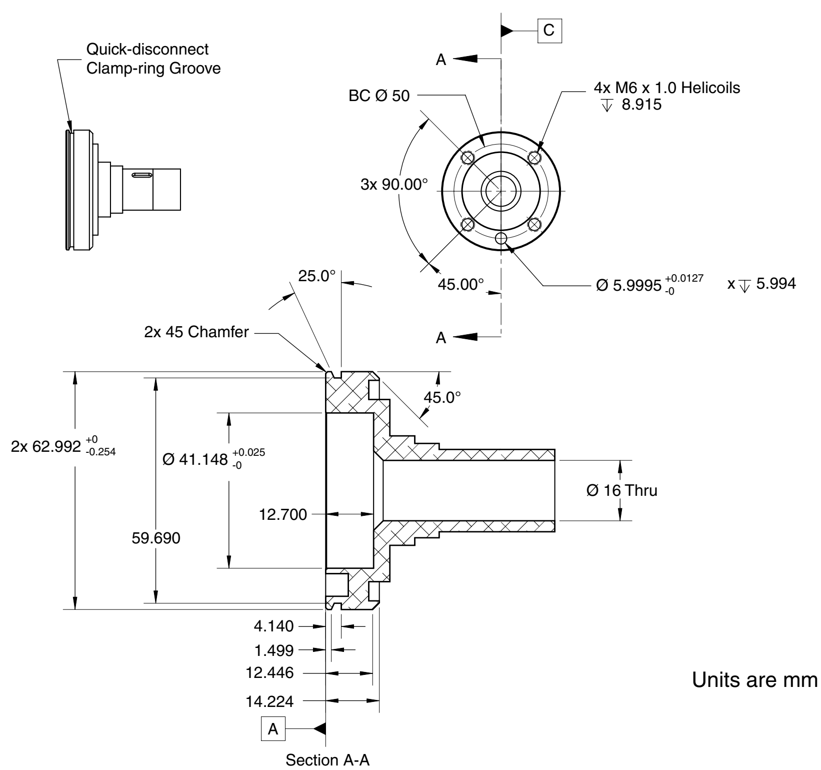


Figure 7-4. Tool Flange Dimensions, 185° Platform

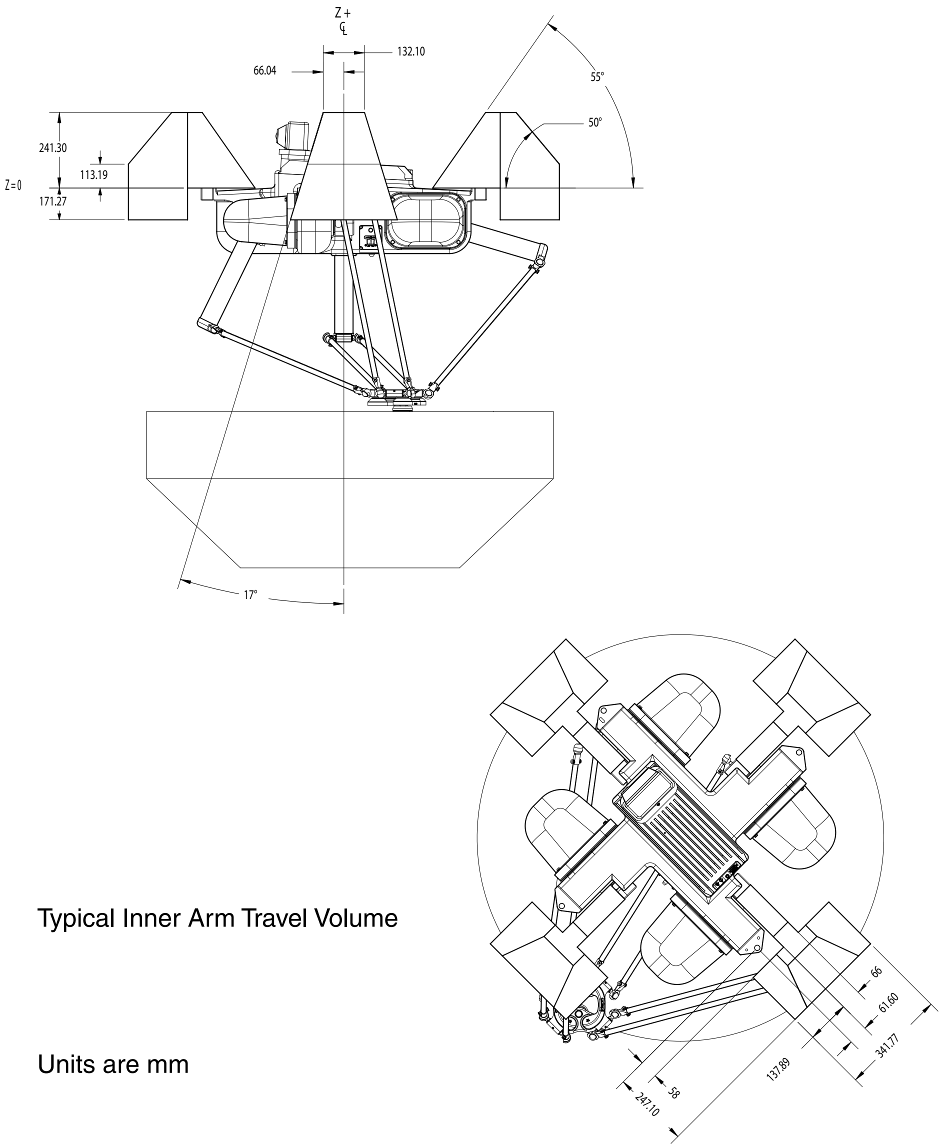


Figure 7-5. Arm Travel Volume

7.2 Adept Quattro s650H Robot Internal Connections

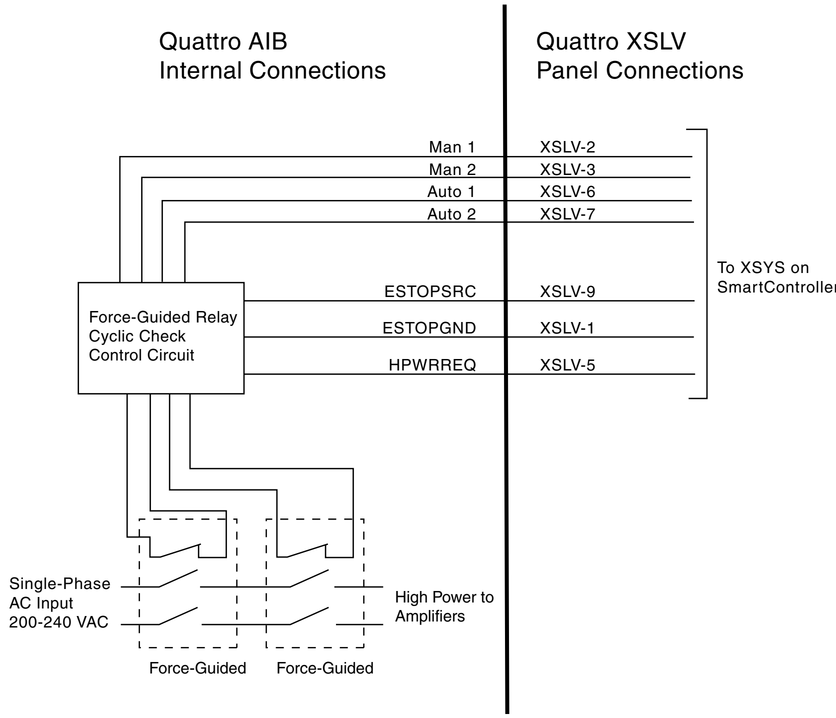
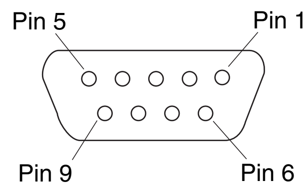


Figure 7-6. Robot Internal Connections Diagram

7.3 XSLV Connector

Table 7-1. XSLV Connector Pinout

Pin #	Description	Comment	Pin Location
1	ESTOPGND	ESTOP System Ground	
2	MAN1	ESTOP Manual Input Ch 1	
3	MAN2	ESTOP Manual Input Ch 2	
4	HIPWRDIS	High Power Disable	
5	ESTOP_RESET	Normally Closed Check Contacts	
6	AUTO1	ESTOP Auto Input Ch 1	XSLV1/2 Connector as viewed on Cobra
7	AUTO2	ESTOP Auto Input Ch 2	
8	N/C		
9	ESTOP_SRC	ESTOP System +24 V	
Mating Connector: AMP/Tyco #747904-2, 9-pin D-Sub AMP/Tyco #748676-1, D-Sub Cable Clamp			

7.4 Robot Specifications

Specifications subject to change without notice.

Table 7-2. Adept Quattro s650H Robot Specifications

Description	Specification
Reach (cylinder radius)	650 mm (25.6 in)
Payload - rated	2.0 kg (4.4 lb)
Payload - maximum	6.0 kg (13.2 lb)
Adept Cycle[a]	
0 kg	0.3 sec
1 kg	0.36 sec
2 kg	0.37 sec
4 kg	0.41 sec
6 kg	0.43 sec
Joint Range	+124° to -52°
Soft stops	+120° to -48°
Encoder type	Absolute
Robot Brakes	24 VDC
Digital I/O Channels	12 inputs, 8 outputs
Weight (without options)	111 kg (245 lb)
Weight (in crate)	148 kg (326 lb)
Footprint	883 x 883 mm (34.8 x 34.8 in.)

[a] The robot tool performs continuous path, straight-line motions 25 mm (1 in.) up, 305 mm (12 in.) over, 25 mm (1 in.) down, and back along the same path, at 20° C ambient. Not achievable over all paths.

Table 7-3. Adept Quattro s650H Robot Power Consumption

	Averaged Sustained Power (W)	Sustained RMS Current (A)	Peak Momentary Power (W)
25-700-25 mm cycle	830	4.0	5080
25-305-25 mm cycle	490	2.5	4640
Long Vertical Strokes	910 max.	4.5	5390

7.5 Platform Specifications

Torque and Rotation Limits

Table 7-4. Tool Torque and Rotation Limits of Platforms

Platform	60°	185°
Maximum Torque (N·m)	8	2.7
Maximum Rotation	± 60°	± 185°
Hard Stop Limit	± 65°	± 195°

Payload Inertia vs. Acceleration

To avoid excited vibrations, the following accel values are recommended for given tool inertias.

Table 7-5. Platform Accel Values

	Platform		**Degrees of Rotation (185°)**		
	60°	185°	90	180	360
Accel Value	**Allowable Tool Inertia ($Kg\text{-}cm^2$)**		**Time for Complete Rotation (ms)**		
100	672	75	316	>447	>632
250	269	30	200	283	>400
500	134	15	141	200	283
750	90	10	115	163	231

7.6 Robot Mounting Frame

The Adept Quattro s650H robot is designed to be mounted above the work area, suspended on a user-supplied frame. The frame must be adequately stiff to hold the robot rigidly in place while the robot platform moves around the workspace. You can either use the design provided or design a custom support frame. See **"Mounting Frame" on page 38**. The drawings for the sample frame are provided here, starting with **Figure 7-7 on page 91**.

If you choose to design a custom frame, it must meet the following specifications:

Frame natural frequencies for stable robot operations:

- Wn (X direction) > 45 Hz.
- Wn (Y direction) > 31 Hz.

- Wn (Twist) > 45 Hz.
- Mounting surfaces for the robot flanges must be within 0.75 mm of a flat plane.

CAUTION: Failure to mount the robot within 0.75 mm of a flat plane will result in inconsistent robot motions.

The AIB must be removable from the top of the frame, and the inner and outer arm travel envelopes must be considered. See **Figure 7-5 on page 86**.

The following are drawings of a frame suitable for supporting the Adept Quattro s650H robot. This frame allows the robot to be either lowered from above or lifted up from underneath the frame for installation.

> **NOTE:** This frame is designed to have the robot mounted to the underside of the frame mounting tabs.

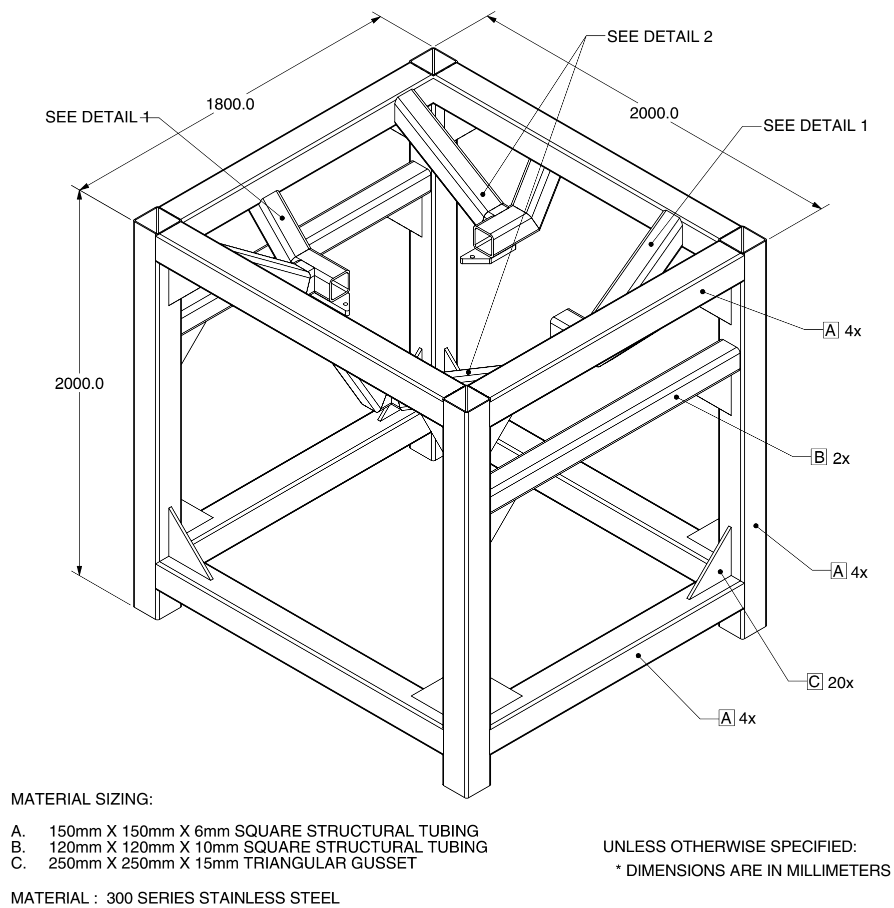


Figure 7-7. Mounting Frame, Orthogonal View

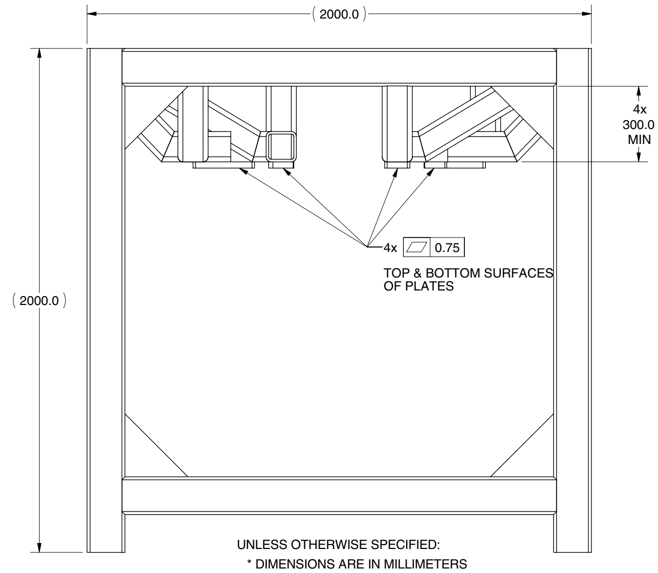


Figure 7-8. Mounting Frame, Side View 1

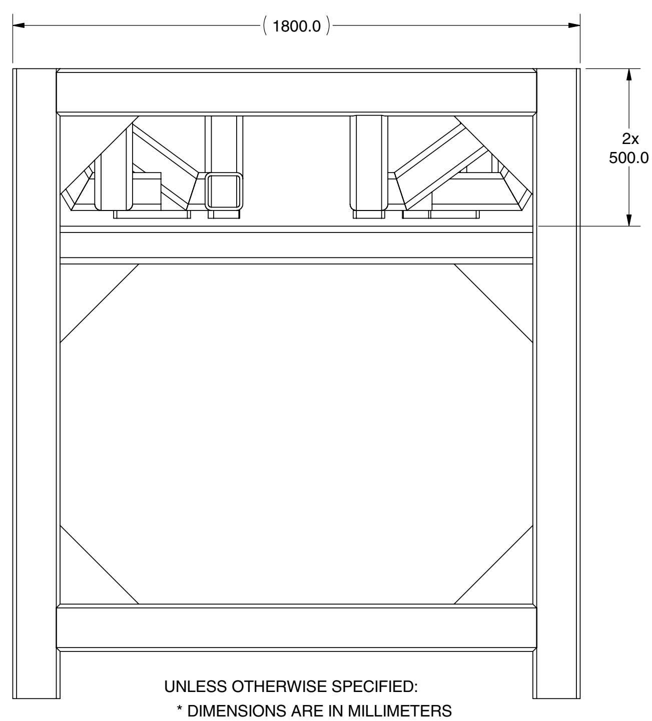


Figure 7-9. Mounting Frame, Side View 2

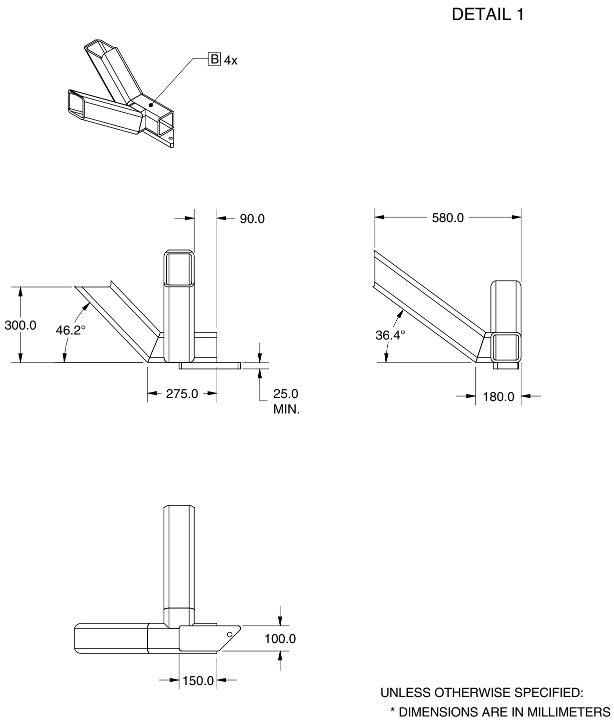


Figure 7-10. Mounting Frame, Detail 1

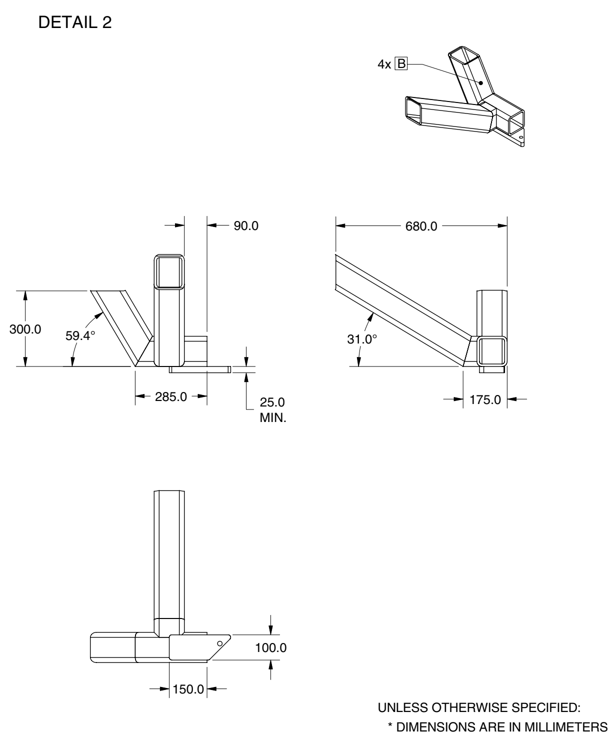


Figure 7-11. Mounting Frame, Detail 2

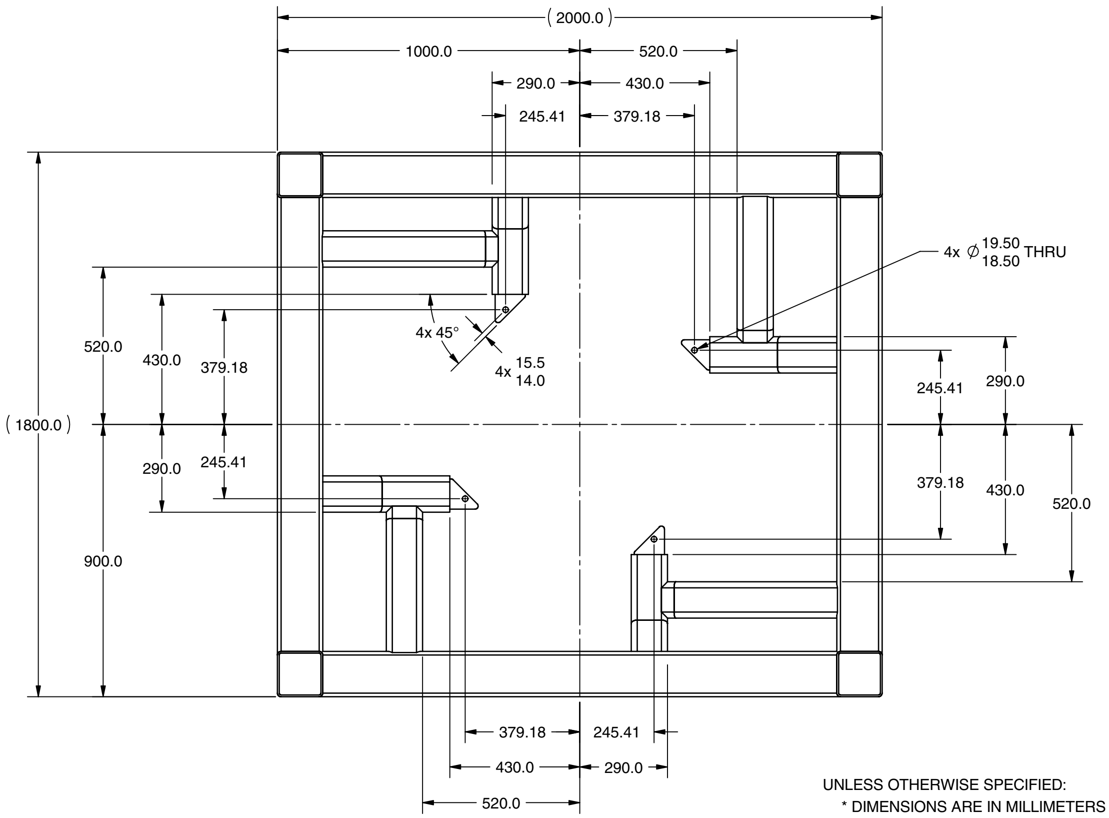


Figure 7-12. Mounting Frame, Top View

Maintenance 8

Maintenance of user-added optional equipment is the user's responsibility. It is not covered in this manual.

8.1 Periodic Maintenance Schedule

Table 8-1 and Table 8-2 give a summary of the preventive maintenance procedures and guidelines on frequency.

NOTE: The frequency of these procedures depends on the particular system, its operating environment, and amount of usage. Use the times in the tables as guidelines and modify the schedule as needed.

WARNING: The procedures and replacement of parts mentioned in this section should be performed only by skilled or instructed persons, as defined in Chapter 2.

The motor covers and the AIB on the robot are not interlocked – turn off and disconnect power if these have to be removed. Lockout and tagout power before servicing.

Table 8-1. Suggested Inspection and Cleaning Schedule

Item	Suggested Interval	Estimated Time of Maintenance	Description
Clean Outer Arms & Balls	1 Week	15 Min	Inspect balls and inserts for excessive wear. Clean with wipes or water.
Clean Platform	1 Week	15 Min	Clean with wipes, air, or water.
Inspect User Cabling	1 Week	15 Min	Inspect user cabling for wear around robot joints and possible binding on robot.
Inspect Outer Arms	3 Months	30 Min	Inspect outer arms for cracking or damage caused by possible accidental impact of robot. Inspect springs and bushings to look for excessive wear.
Inspect Platform	3 Months	30 Min	Inspect platform for damage caused by possible accidental impact of robot.

Inspect Robot Fans & Geardrives	3 Months	60 Min	Remove motor covers and inspect cooling fans for operation. Look for lubrication leaking from geardrives. See Section 8.4 and Section 8.5
Inspect Moving & Water Seals	3 Months	10 Min	Inspect moving seals on inner arms as well as static seals for water wash down environments.
Inspect Inner Arms	6 Months	30 Min	Inspect Inner arms for cracking or damage caused by possible accidental impact of robot.
Check E-Stop, enable and key switches, and barrier interlocks	6 months	30 Min	See Section 8.2
Check robot mounting bolts	6 months	15 Min	See Section 8.3

Table 8-2. Suggested Part Replacement

Item	**Suggested Interval**	**Estimated Time of Maintenance**	**Description**
Motor & Gear Assembly	5 Years	1 Hour + Factory Calibration for each joint	Motor and geardrives are sold as a unit because damage to one often results in damage to the other. Replacement interval is rated 5-10 years for most applications.
AIB	5 Years	1 Hour	Accumulated wear on electronics by excessive operations or poor line voltage.
Inner Arms	5 Years	1 Hour + Factory Calibration	Broken by accidental impact.
Outer Arms	5 Years	15 Minutes	Broken by accidental impact. Price is per pair with springs & inserts - or singly without springs & inserts.
Platform	3 Years	30 Minutes	Excessive wear, gritty environment, damage from accidental impact.
Motor & AIB Seal Kit	2 Years	3 Hours	Foam and rubberized seals may selectively be replaced as needed due to cleaning causing brittle seal failures. Replacement time controlled by seal condition at time of replacement.

Motor Fan	2 Years	30 Minutes	Fan lifetime is strongly affected by robot temperatures. Aggressive moves at high ambient temps will shorten fan lifetimes.
IP-66 Cable Seal Kit	2 Years	30 Minutes	AIB cables have IP-66 sealing kit available as an option.
Motor Cover	Indefinite	15 Minutes	Motor covers may become damaged by accidental impact.
Backup Encoder Battery	5 years to 10 years	15 Minutes	Replacement battery is inserted from the side of the robot through the Status Display opening. See **Section 8.7**
Factory Calibration	Indefinite	1 Hour	Needed for full accuracy after any motor change, inner arm breakage, or accidental battery disconnection. Usually performed by Adept or a trained service representative with a tooling fixture.
Springs & Bushings	Indefinite	15 Minutes	Springs and bushings can be replaced in case of excessive wear or unexpected breakage. Preferred solution is to stock and swap outer arms.
Outer Arm Inserts	Indefinite	15 Minutes	Plastic inserts can be replaced in case of excessive wear. Preferred solution is to stock and swap extra outer arms.

8.2 Checking Safety Systems

These tests should be done every six months.

NOTE: Operating **any** of the following switches or buttons must disable high power. If any of the tests fail, repairs must be made before the robot is put back into operation.

1. Test operation of:
   - E-Stop button on front panel
   - E-Stop button on pendant
   - Enabling switch on pendant
   - Auto/Manual switch on front panel
2. Test operation of any external (user-supplied) E-Stop buttons.
3. Test operation of barrier interlocks, etc.

8.3 Checking Robot Mounting Bolts

Check the tightness of the base mounting bolts every 6 months. Refer to **Table 3-2 on page 44** for torque specifications.

8.4 Checking Robot Gear Drives

Adept Quattro s650H robots use gear drives, which use oil in their components for lubrication. It is recommended that you periodically inspect the robot for signs of oil on and around the gear drives.

NOTE: Check the operation of the fans while the motor covers are off. See **Section 8.5**.

1. Remove all power to the robot before starting this check.
2. Wait for the motors to cool before performing this check.

WARNING: Do not remove the encoder cable connectors from their sockets on the motors. If they are removed, the calibration data will be lost and the robot must be recalibrated, which requires special software and tools

3. Check for oil inside the base of the robot after removing the motor covers.
   - Look through the venting slots under each motor for oil leakage.
   - Feel the bottom of the motors with your finger through the venting slots.
4. Check the outside of the motors and gear drives for any signs of oil.
5. Contact Adept if you find any signs of oil in these areas.

8.5 Checking Fan Operation

The motor fans are PWM controlled. This needs to be done with 24 VDC to the robot ON

Verify that all four motor fans operate:

1. Remove all motor covers.
2. Toggle power to the AIB.

   Motor fans run for about 1 minute before shutting off. (If the robot is hot, they will continue to run.)
3. Verify that each motor fan is running.
4. Verify that the AIB fan is running.

   NOTE: The AIB fan runs continuously, but its speed will vary.
5. Reinstall all motor covers.

8.6 Replacing the AIB Chassis

This section gives instructions on how to replace the AIB chassis on an Adept Quattro s650H robot.

CAUTION: Follow appropriate ESD procedures during the removal/replacement steps.

Removing the AIB Chassis

1. Switch OFF the SmartController.
2. Switch OFF the 24 VDC input supply to the AIB chassis.
3. Switch OFF the 200/240 VAC input supply to the AIB chassis.
4. Disconnect the 24 VDC supply cable from the chassis +24 VDC input connector. See **Figure 5-2 on page 66** for locations of connectors.
5. Disconnect the 200/240 VAC supply cable from the chassis AC input connector.
6. Disconnect the XSLV cable from the chassis XSLV connector.
7. Disconnect the 1394 cable from the chassis SmartServo connector.
8. Disconnect any other cables, which may be connected to the chassis, such as XIO or RS-232.

9. Using a 5 mm Allen key, carefully unscrew the chassis securing screw. See the following figure.

   NOTE: The screw does not need to be completely removed in order to remove the chassis, as this screw is captured on the chassis heat sink.

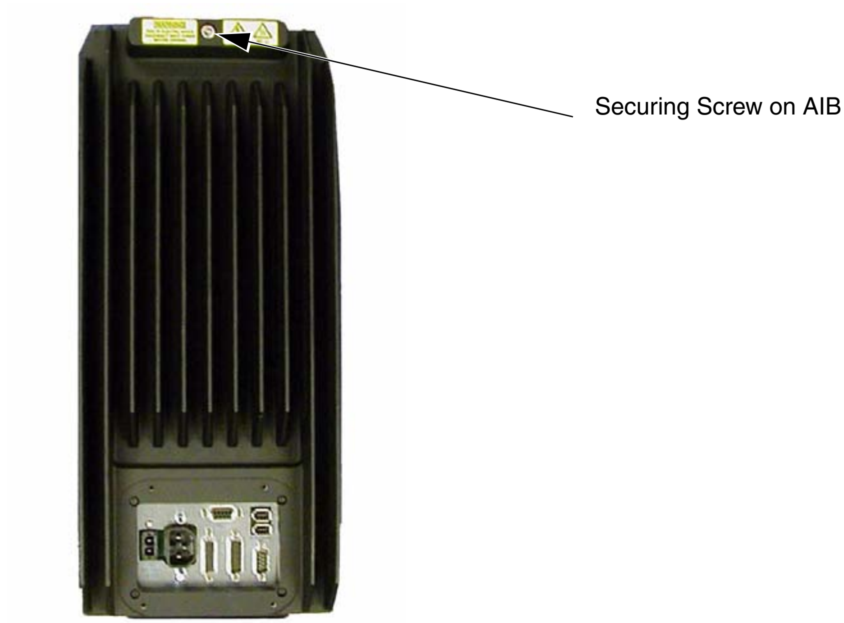


Figure 8-1. Securing Screw on AIB Chassis

10. While holding the chassis heat sink, slowly and carefully lift the chassis up (see the following figure), so that enough clearance is available to remove the chassis from the base.
11. Lay the chassis flat (on its heat sink fins) next to the base opening.

Figure 8-2. Opening the AIB Chassis

12. Disconnect the white amplifier cable (motor power) from the amplifier connector located on the chassis bracket. See the following figure.

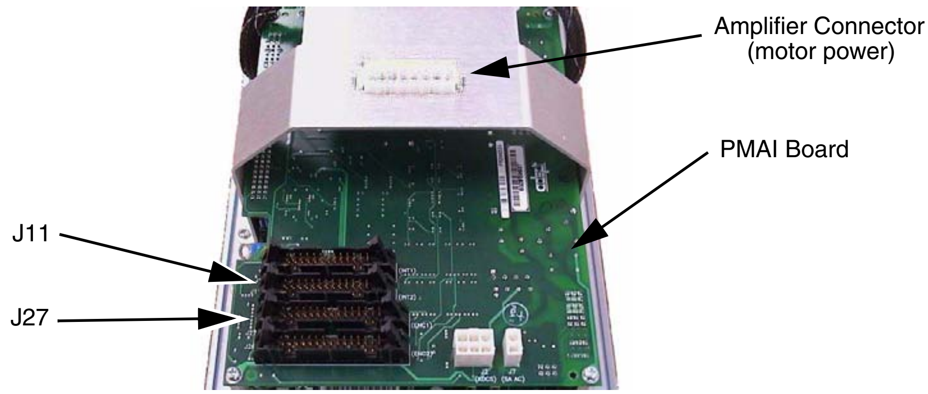


Figure 8-3. Connectors on AIB Chassis

13. Disconnect the J11 cable from the J11 connector on the PMAI by disengaging the securing latches.
14. Disconnect the J27 cable from the J27 connector on the PMAI by disengaging the securing latches.
15. Using a 5 mm Allen key, disconnect and remove the ground wire from the chassis. Keep the screw for reassembly later. See the following figure.

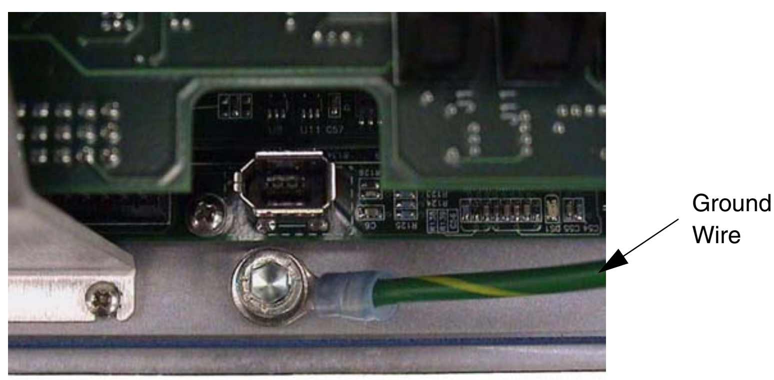


Figure 8-4. Ground Screw on AIB Chassis

16. Remove the chassis from the robot, and set it aside.
    Tag it with the appropriate fault/error diagnosis and robot serial number information.

Installing a New AIB Chassis

Harness Connections

1. Carefully remove the new chassis from its packaging, check it for any signs of damage, and remove any packing materials or debris from inside the chassis. Verify that the AIB is Adept P/N 08500-000.
2. Carefully place the chassis, on its heat-sink fins, next to the robot.
3. Using a 5 mm Allen key, connect the ground wire to the chassis. See **Figure 8-4**. The chassis is grounded to the robot base through the bare aluminum where they meet.
4. Connect the J27 cable to the J27 connector on the PMAI and engage the securing latches.
5. Connect the J11 cable to the J11 connector on the PMAI and engage the securing latches.
6. Connect the white amplifier cable (motor power) to the amplifier connector located on the chassis bracket. See **Figure 8-3**.
7. Insert the chassis into its mount, at the top of the base.
8. Lower the chassis into place against the mount, making sure that none of the cables get trapped or pinched and that the chassis O-ring is not damaged during installation.
9. Once the chassis is in place, use a 5 mm Allen key to tighten the chassis securing screw. See **Figure 8-1 on page 100**.
10. If the robot will be used in the presence of chemicals that are caustic to aluminum, follow the instructions at **“Caustic Compatibility” on page 110**.

External Connections

1. Connect the 200/240 VAC supply cable to the chassis AC input connector.
2. Connect the XSLV cable to the chassis XSLV connector.
3. Connect the 1394 cable to the chassis SmartServo connector.
4. Connect any other cables which may be connected to the chassis, such as XIO or RS-232.
5. Connect the 24 VDC supply cable to the chassis +24 VDC input connector.
6. Switch ON the 200/240 VAC input supply to the chassis.
7. Switch ON the 24 VDC input supply to the chassis.
8. Switch ON the SmartController.
9. Once the system has completed booting, test the robot for proper operation.

If you have problems bringing up the robot after AIB replacement

- Verify that all system cables are fully seated and installed correctly. See **Figure 4-1 on page 51**.
- Remove power from the AIB, then verify that all AIB electrical connectors are fully seated.

  After checking AIB cables, restore power to the robot and reboot the controller.

- Check the Status Display fault code. This should be either OK or ON. See **Table 5-1** and **Table 5-2 on page 64**.

8.7 Replacing the Encoder Battery

The data stored by the encoders is protected by a 3.6 V lithium backup battery located in the base of the robot.

CAUTION: Replace the battery only with a 3.6 V, 8.5 Ah lithium battery, Adept P/N 02704-000.

Battery Replacement Interval

If the robot is kept in storage and not in use, or if the robot is turned off (no 24 VDC supply) most of the time, then the battery should be replaced every 5 years.

If the robot is turned on, with 24 VDC supplied to the robot more than half the time, then you can increase the replacement interval to 10 years. If, for example, a robot is typically turned off only on weekends, the battery would need to be replaced every 10 years.

Battery Replacement Procedure

1. Obtain the replacement battery.
2. Switch OFF the SmartController.
3. Switch OFF the 24 VDC input supply to the robot.
4. Switch OFF the 200/240 VAC input supply to the robot.
5. Disconnect the 24 VDC supply cable from the robot +24 VDC input connector. See **Figure 4-2 on page 53** for locations of connectors.
6. Disconnect the 200/240 VAC supply cable from the robot AC input connector.
7. Switch OFF and disconnect any other power supplies connected to the robot.

8. Remove the four hex-head screws holding the Status Display panel.
   See the following figure:

Figure 8-5. Status Display Panel, Showing 4 hex-head Screws

9. Remove the Status Display panel.
   The battery is supported in a bracket that is attached to the back side of the Status Display panel with stand-offs. The battery is exposed when the Status Display panel is removed.
10. The battery bracket assembly has two connectors. Locate the unused battery connector on the battery bracket. See the following figure:

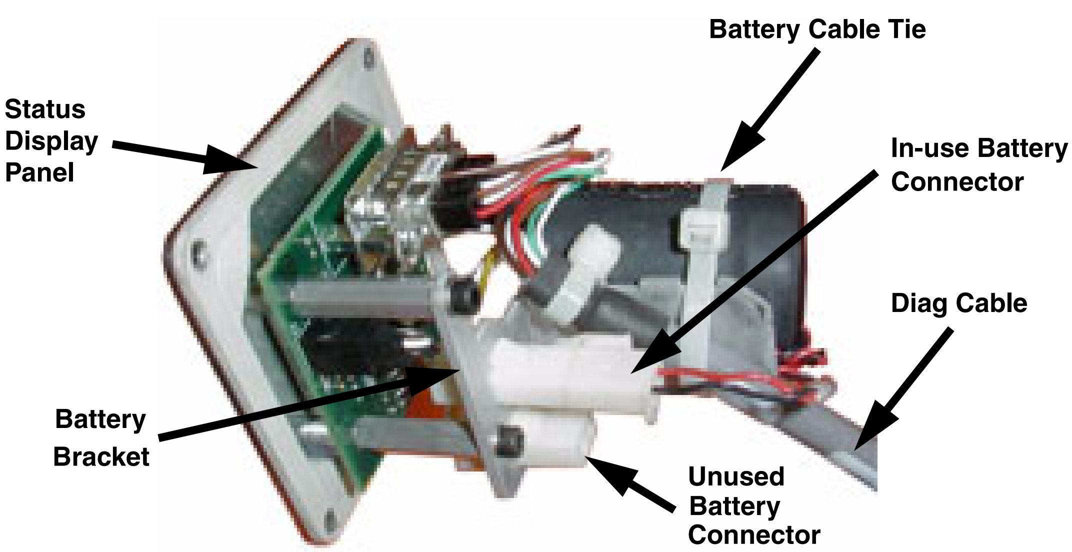


Figure 8-6. Battery Bracket on Status Display Panel

CAUTION: If battery power is removed from the robot, factory calibration data may be lost, requiring robot recalibration by Adept personnel.

11. Connect the new battery to the unused connector on the battery bracket, but do not disconnect the old battery.

    There is only one way to plug in the connector. See **Figure 8-6**.

12. Once the new battery is connected, you can disconnect and remove the old battery.
    You will need to cut the cable tie holding the battery in the bracket.

    NOTE: Dispose of the battery in accordance with all local and national environmental regulations regarding electronic components.

13. Place the new battery in the battery bracket, and secure it and the "diag" cable, using a cable tie.
    - The battery has shrink-wrap around the battery itself, its wires, and several components. It is important that these components (which can be seen as bumps in the shrink-wrap) face towards the 'V' in the battery bracket.
    - Fold any excess wiring (red and black) under the battery, so that it lies between the battery and the 'V' in the battery bracket.
    - The "diag" cable must be cable-tied to the bracket (and battery) to relieve strain on the Status Display connector. See **Figure 8-6**.

14. Reinstall the Status Display panel with four screws.
    - Take care that the "diag" cable is routed away from the AIB fan inside the robot base.
    - Be careful not to hit the top of the amber lamp with the back of the battery assembly.

8.8 Replacing a Platform

CAUTION: Do not overstretch the outer-arm springs. Separate the ball-joint sockets only enough to fit them over the ball studs.

Replacement

NOTE: Refer to **"Attaching the Outer Arms and Platform" on page 45** for details on installing the outer arms. Removal is the reverse of installation.

1. Remove the four pairs of outer arms from the four pairs of ball studs on the installed platform.
2. Attach one pair of outer arms to each of the four pairs of ball studs on the new platform.
    - The platform is installed flange-down.
    - Ensure that the numbers on the platform match the joint numbers on the underside of the robot base. This places the platform tool flange closest to the Status Display. See **"Clocking the Platform to the Base" on page 45**.

- Take care not to trap debris between the balls and their sockets.

Configuration

If the replacement platform has the same part number as the old platform, the robot does not need to be reconfigured.

If the replacement platform has a different part number, for instance, replacing a 185° platform with a 60° platform, the new configuration needs to be loaded using the SPEC utility.

Two binary SPEC files are available in the SPECDATA directory on the CompactFlash card of the Adept controller. These two files contain configuration data for the available Adept Quattro s650H robot platforms. The robot will not operate correctly if the wrong SPEC file is loaded. (If these files are not on your CompactFlash card, you can copy them from your V+ system CD-ROM.)

Platform Data Files:

Platform	Tool Rotation	Assembly P/N	SPEC File
185°	±185°	09068-000	QP09068.SPC
60°	±60°	09023-000	QP09023.SPC

Load the SPEC Program

Refer to the ***Adept SmartMotion Developer's Guide*** for a more thorough coverage of the SPEC utility.

1. Load the utility program into system memory and start execution of the program with the commands:

```
load d:\util\spec
execute 1 a.spec
```

2. Follow the prompts provided by the program (see the following sections).

   NOTE: If you want to exit the program, you can press Ctrl+Z at any prompt.

Load Robot Specifications from a Disk File

This function reads a specification data file that contains the specification information for a single robot, and writes over the data in memory for the currently selected robot. After loading the file, be sure to save the specification data to your V+ system disk.

To load a specification file:

1. To update the specification data for a robot, select the robot, if it is not already selected. (To change the selection, use the *Change robot number* option on the SPEC main menu.)
2. From the SPEC main menu, select *Load robot specifications from a disk file*. The following screen is displayed (the details of NFS mounts may be different for your system):

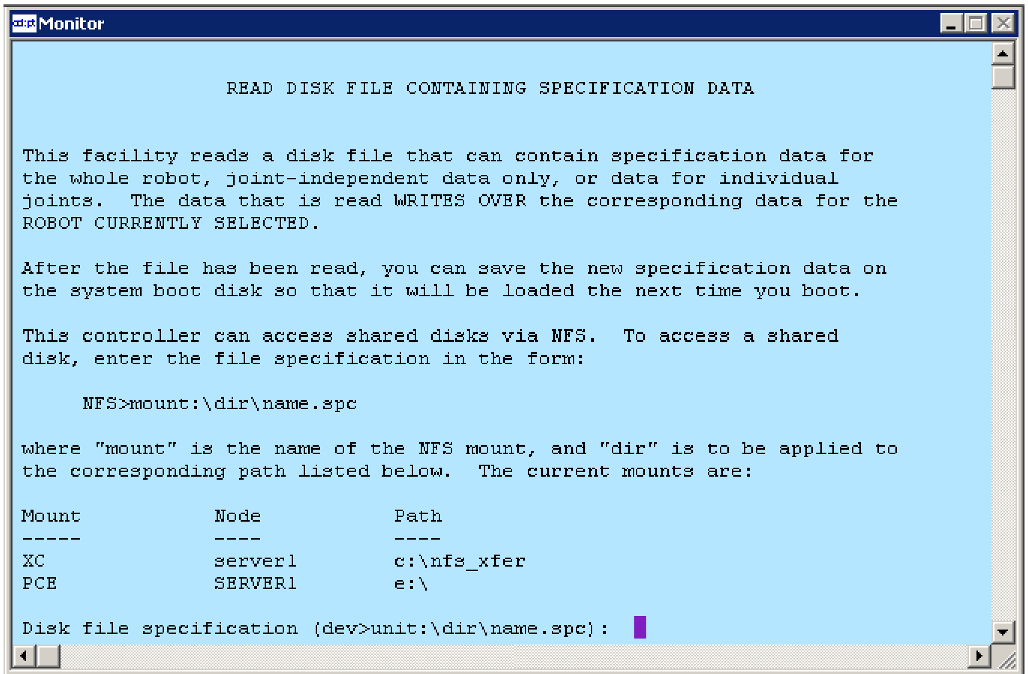


Figure 8-7. SPEC Utility Load Function

3. Enter the disk file specification for the data file you want to load (e.g., "\SPECDATA\QP08360.SPC").

   Components that match the current default file path can be omitted.

Save ALL specifications to system disk

After you have loaded the configuration data, you must store the new data on the V+ system disk. This menu item causes all the current configuration data to be written to the V+ system disk.

> **NOTE:** If the changed data is not stored on the system disk, the previous configuration data is used the next time the robot system is booted.

CAUTION: Before you modify a V+ system disk, you should make a backup copy of the system (with the DISKCOPY utility program).

If your Adept system controls more than one robot, this menu selection saves the data for ALL the robots (and any external encoders).

To use the *Save ALL specifications to system disk* option:

1. Select the *Save ALL specifications to system disk* option from the menu and then press Enter. The following screen is displayed:

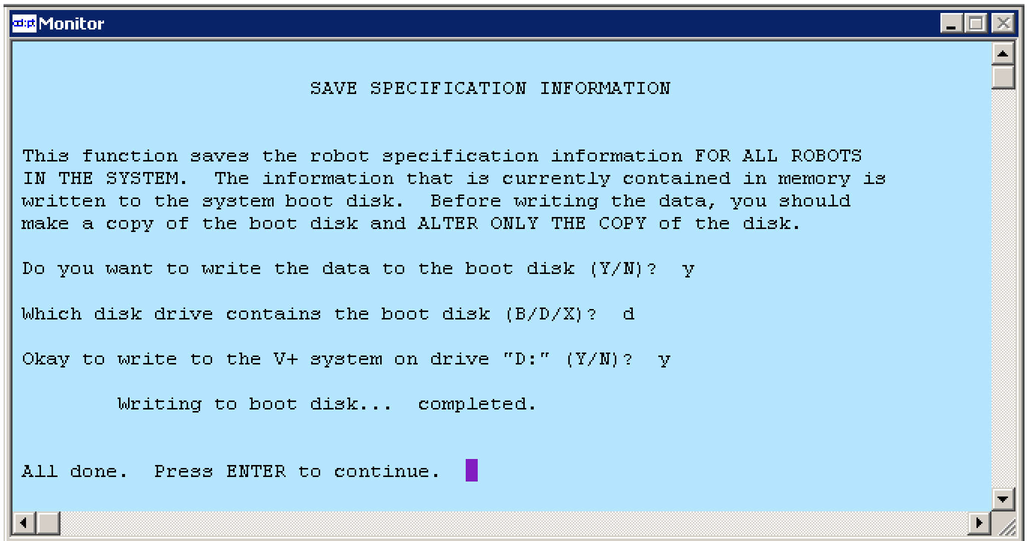


Figure 8-8. SPEC Save Specification Menu

2. At the prompt, press Y followed by the Enter key to initiate the process for writing the data to the boot disk (the data will not actually be written until later in the process).

   Otherwise, press N followed by the Enter key to cancel and return to the menu.

3. Enter the drive letter at the prompt, followed by the Enter key.

   You are prompted for permission to write the data to the V+ system on the selected drive.

4. At the prompt, press Y followed by the Enter key to write the data. To cancel, press N followed by the Enter key.

   If Y is selected, the data is written to the system disk.

When complete, you can clear the SPEC program from memory with the following commands:

```
kill 1
deletem a.spec
```

Robot Cleaning/ Environmental Concerns 9

This chapter applies to the Adept Quattro s650H robot, not to the Adept SmartController.

> **NOTE:** The Adept SmartController CX must be installed inside a NEMA-1 rated enclosure.

The Adept Quattro s650H robot is designed to be compatible with standard cleaning and operational needs for the handling of raw, unpackaged meat and dairy products, as well as less stringent requirements. These design criteria impact how the environment can affect the robot operations, as well as how the robot can affect the cleanliness of its operating environment.

The Adept Quattro s650H robot is designed for the following operating conditions:

- IP-67 rating for the robot platform.
- IP-66 rating for the rest of the robot (with optional cable sealing kit).
- Removal and submersion of the platform and outer arms (designed for COP tank).
- 1° to 40° C (34° to 104° F) ambient temperature.
- Humidity of 5% to 90%, non-condensing.
- Mild alcohol, alkali, and chlorinated caustic agents commonly used in cleaning operations.

The Adept Quattro s650H robot protects the operating environment in the following ways:

- High level of surface coating adhesion prevents erosion of coating during cleaning.
- Lubricants are contained within multiple seals.
- Ball joints and springs/bushings are designed for minimal particulate generation.
- All moving parts are designed so that small parts are encased within larger assemblies, and are unable to contaminate the work environment.

9.1 Ambient Environment

Humidity

The Adept Quattro s650H robot is designed to operate in environments with a relative humidity of 5% to 90%, non-condensing.

Temperature

The Adept Quattro s650H robot is designed to operate from 1° to 40° C (34° to 104° F) ambient temperature.

At near-freezing temperatures, moderate robot motions should be used until the robot mechanical joints warm up. Adept recommends a monitor speed of 10 or less for 10 minutes.

The robot system can sustain higher average throughput at lower ambient temperatures, and will exhibit reduced average throughput at higher ambient temperatures.

9.2 Cleaning

Caustic Compatibility

The Adept Quattro s650H robot is designed to be compatible with moderate cleaning agents commonly used in the cleaning of food-processing equipment. All robot components are designed to handle daily exposure to cleaning agents. Exposure may result in some discoloration of the materials, but no significant material removal. For acidic environments, refer to **"Acidic Operating Conditions" on page 112**.

If highly caustic cleaning agents are to be used, the perimeter of the AIB should be caulked where it meets the robot base to prevent corrosion of the aluminum at that point. (This is not anodized, in order to maintain electrical conductivity.) See the following two figures.

Figure 9-1. AIB and Base, Showing Non-anodized Aluminum

Figure 9-2. Joint, Between AIB and Base, to be Caulked

Water Shedding

Surfaces of the Adept Quattro s650H robot have been designed to shed water. This increases the likelihood that contaminants or cleaning agents will drain with a hose-down procedure.

> **NOTE:** The top of the robot base and the amplifiers have flat areas where it is possible for small amounts of water to pool.

Wipe-Down

Wipe-down cleaning with alcohol-impregnated disposable wipes is appropriate for cleaning the Adept Quattro s650H robot. Most surfaces and joints have been designed with smooth internal radii for easy cleaning.

9.3 Cleanroom Classification

The Adept Quattro s650H robot is rated for cleanroom FED STD 209E class 1000.

Please contact your Adept representative for more information.

9.4 Design Factors

Environmental and cleaning aspects are addressed by the following features in the Adept Quattro s650H robot.

Robot Base and Components

The aluminum robot base and the removable motor covers are coated with a Nylon-based coating, which will not flake off with repeated high-pressure washings. This coating is resistant to caustic and chlorinated agents, has strong adherence to the metal base to resist impact, and has a smooth finish that is easy to clean.

The gearboxes are sealed internally, and sealed externally by a lip seal that is designed to meet IP-66 rating.

All base seal materials are designed to be compatible with caustic agents and common industrial cleaning procedures.

CAUTION: Like most seals, it is possible to prematurely destroy these seals by deliberate, direct, excessive spraying of water-based agents into the sealing materials.

The motor cover seals (P/N 09016-000) allow for periodic motor and fan inspections.

Inner Arms

The inner arms are an epoxied assembly of carbon fiber tube and hard-anodized aluminum. The assemblies are resistant to caustic cleaning agents, as well as to chipping.

The inner arms are sealed at the robot base with a rotary V-ring seal (P/N 07043-000). The inner arms are designed to meet IP-66 rating.

Ball Joints

The ball studs are coated to resist chipping, as well as caustic agents. This coating also provides hardness and lubricity to minimize joint wear to the plastic bushings. The spherical plastic bushing is resistant to caustic agents. The bushings may experience some initial wear, but generally produce few wear particulates. The material used in the bushings is FDA-compliant. There is a pocket in the back of the bushing sphere where optional lubrication can be applied. However, lubrication is not needed for most applications.

Acidic Operating Conditions

The standard ball stud coating is not designed for use in highly-acidic conditions. Under such circumstances, stainless steel ball studs are available as an option. These require the use of an FDA-approved grease between the ball and the plastic bushing.

Contact Adept for more information.

Outer Arms

The outer arms are a composite assembly of anodized aluminum and carbon fiber. The interior volume of the carbon fiber tube is designed to be sealed with an internal and external continuous epoxy bond. The bushings are press-fit into the aluminum outer-arm ends with a slight interference, which seals the plastic to the aluminum.

The outer arms may be cleaned either with caustic wash-down in place on the robot, or removal and tank cleaning in hot soapy water.

Springs

The outer arms are attached through the positive pressure of springs that are made of electro-polished stainless steel. This open spring design allows inspection for contamination, as well as wash-down or soapy bath.

Platforms

The Adept Quattro s650H robot currently supports two types of platforms, depending on the amount of Theta rotation and inertia needed.

Both platforms are designed to meet the basic criteria of wipe down compatibility and long life. Please contact your Adept representative for more information.

9.5 Installing Cable Seal Kit

Overview

The cable seal assembly (P/N 08765-000) must be mounted on the top of the robot during the robot installation process. The cable seal assembly is shipped separately from the robot.

Components

- Cable harness
- AIB Cable Seal Housing, 2 gaskets, 4 screws (**Figure 9-3**)
- Cable Entry Top Cover assembly, screw (**Figure 9-4**)

  This includes the Roxtec CF 8 frame
- 4 x 2-hole Roxtec modules

  These are dense foam blocks surrounding pre-cut half-sleeves that can be peeled away to match the diameter of the cable to be sealed. See **Figure 9-6**.
- Roxtec grease, used to assemble and seal the modules (**Figure 9-7**).

NOTE: The Roxtec CF 8 consists of a frame and integrated compression unit (a wedge and bolt that compress the modules once they are assembled inside the CF frame). See **Figure 9-4**.

Tasks

1. Measure and mark cables to establish service length
2. Install AIB cable seal housing
3. Adapt Roxtec modules to fit cables
4. Install cables through cable entry top cover assembly
5. Attach cables to AIB
6. Attach cable entry top cover to AIB cable seal housing

Installation Procedure

1. Measure and mark all AIB cables at 10 - 12 in. from the cable ends.
   This amount of slack is needed to install the seal assembly after the connections are made to the AIB. See **Figure 9-10**.
2. Install the cable seal housing on the top of the AIB using four M4 x 50 screws, four M4 lock washers, and four M4 flat washers. Note that the centered M6-threaded hole must be toward the center of the robot base. See the following figure, right photograph. Ensure that the gasket is seated between the AIB surface and the cable seal housing.

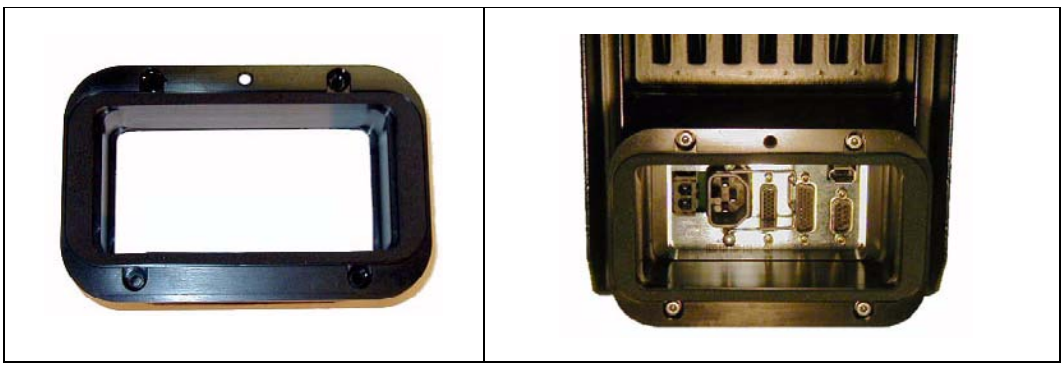


Figure 9-3. AIB Cable Seal Housing (left), Installed (right)

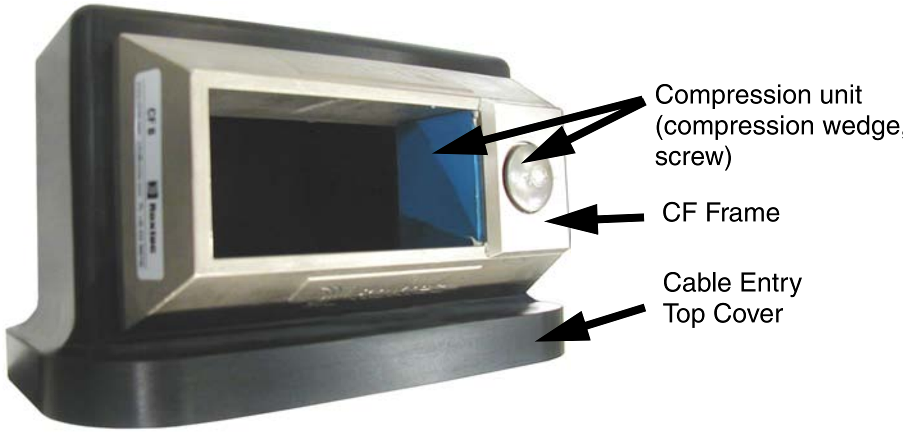


Figure 9-4. Cable Entry Top Cover Assembly

Figure 9-5. Bottom of Cable Entry Top Cover, CF Frame

3. Adapt Roxtec modules to fit the cables that will be used. There should be a 0.1 to 1.0 mm gap between the halves of the modules for a proper seal. See the following figure.

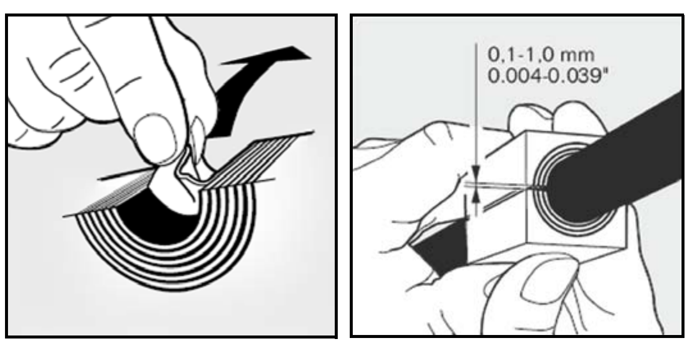


Figure 9-6. Adapting a Module to the Cable Size, Checking the Gap

4. Grease the Roxtec modules, using Roxtec grease. See the following figure.

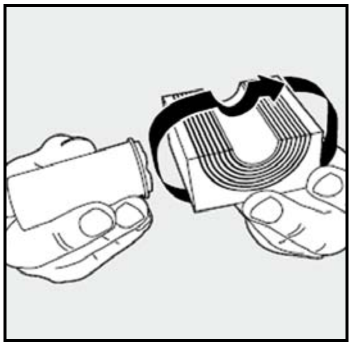


Figure 9-7. Greasing a Roxtec Module

5. Grease the inside of the CF frame, where the modules will touch, using Roxtec grease.
6. Install each AIB cable through its corresponding module, and insert the modules into the frame. See the following figure.
   Ensure that the terminated cable ends have 10 - 12 in. of slack. See **Figure 9-10**.

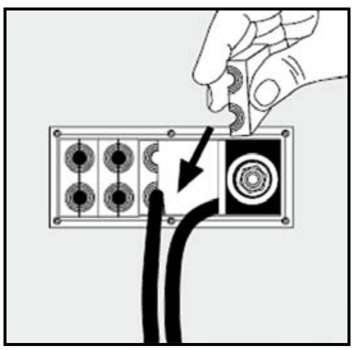


Figure 9-8. Installing Roxtec Modules into the Frame

7. When all of the modules are in place, tighten the compression unit to 8 - 12 N·m (6 - 9 ft·lb). See the following two figures.
   There should be no visible gaps between the modules or around the cables.

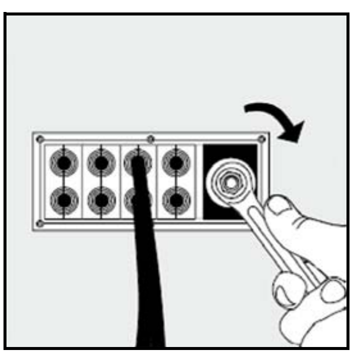


Figure 9-9. Tightening the Compression Unit

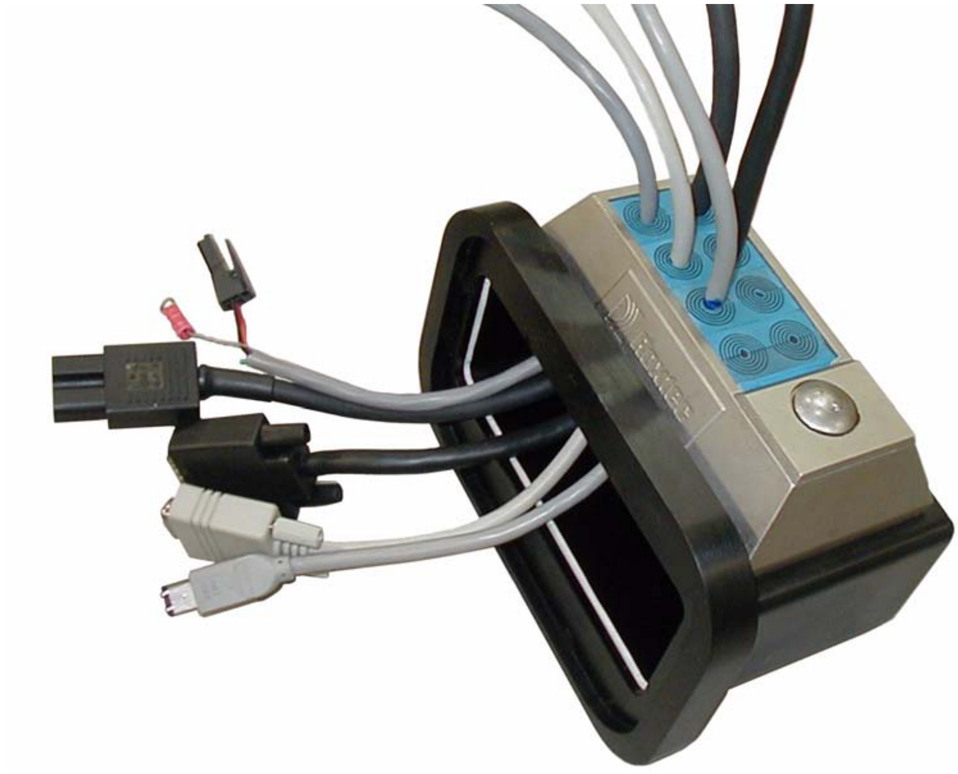


Figure 9-10. Cable Entry Assembly with Cables

8. Attach the ground lug to the AIB. The ground lug is for the cable shield of the user-supplied 24 VDC cable. See the following figure.

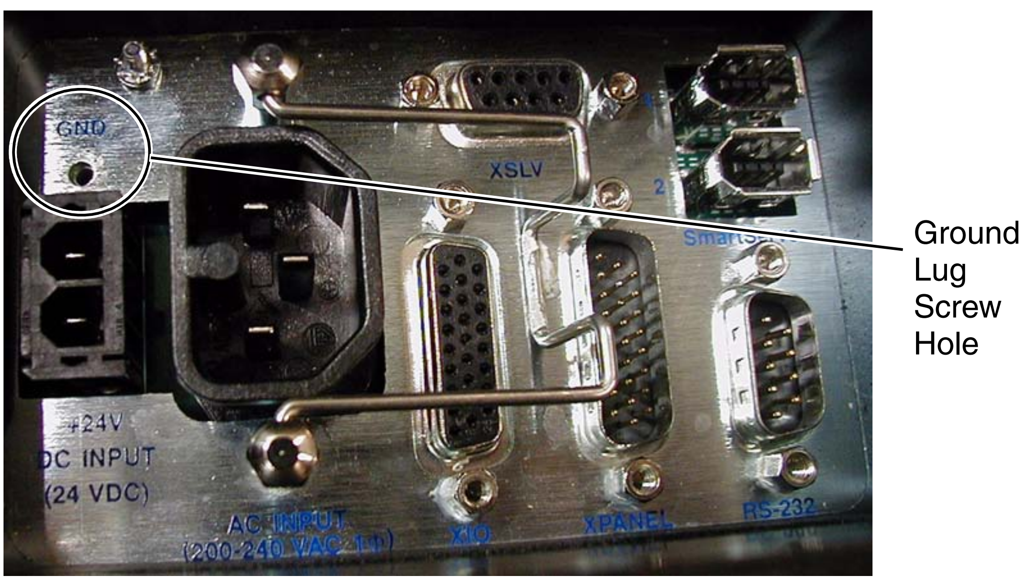


Figure 9-11. Ground Lug Attachment on the AIB

9. Hand-tighten all AIB cables to the AIB.

NOTE: All cables must be screwed into the AIB.

10. Attach the cable entry top cover, with Roxtec frame and modules, to the AIB cable seal housing.
    - Slide the top cover over the seal housing lip, as shown in the following figure.
    - Ensure that the gasket between the top cover and the cable seal housing is seated, and that all cables are contained within the top cover.
    - Lower the top cover onto the seal housing, and secure with one screw.

Figure 9-12. Installing Cable Entry Top Cover Assembly

Index

Numerics

A

B

U

V

W

X

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P/N: 09313-000, Rev A