Adept Cobra PLC600/PLC800 Robot

User's Guide

(includes the Adept PLC server)

adept®

Adept Cobra PLC600/PLC800 Robot

User's Guide

(includes the Adept PLC server)

P/N: 04866-000, Rev C

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

adept

3011 Triad Drive • Livermore, CA 94551 • USA • Phone 925.245.3400 • Fax 925.960.0452

Otto-Hahn-Strasse 23 • 44227 Dortmund • Germany • Phone +49.231.75.89.40 • Fax +49.231.75.89.450

151 Lorong Chuan #04-07 • New Tech Park, Lobby G • Singapore 556741 • Phone +65.6281.5731 • Fax +65.6280.5714

Printed in the United States of America

Table of Contents

List of Figures

List of Tables

Introduction 1

1.1 Product Description

The Adept Cobra PLC Robot system consists of a customer-supplied PLC, an Adept PLC Server, and an Adept Cobra PLC600 or PLC800 robot. This manual covers the installation, operation, and maintenance of the Adept Cobra PLC600/PLC800 robot system, and describes the PLC Server software.

Customer-Supplied PLC

The customer-supplied PLC is used to command and control the robot. (The PLC may also be used to control other devices and processes in the workcell.) All application programs and location data are stored on the PLC. When the PLC application runs, the PLC sends commands to the Adept PLC Server using DF1 Protocol.

DF1 Protocol

DF1 Protocol is an Allen-Bradley serial protocol that is available on every Allen-Bradley PLC. It supports full-duplex (peer-to-peer) and half-duplex (master-slave) communication, and is data transparent. With the protocol, data transmissions contain a 16-bit CRC field to ensure data integrity. The maximum baud rate is 38.4 kps on most Allen-Bradley PLCs. DF1 is an “open” specification that has no licensing requirements. It is fully documented in Allen-Bradley publication 1770-6.5.16.

Adept PLC Server

The Adept PLC Server receives commands from the PLC, interprets the information, and then commands the robot to move. As the robot is commanded to move, status information is returned to the PLC.

The Adept PLC Server also provides facilities to connect external E-Stop circuitry to the system. A front panel with an E-Stop is included with the Adept PLC Server.

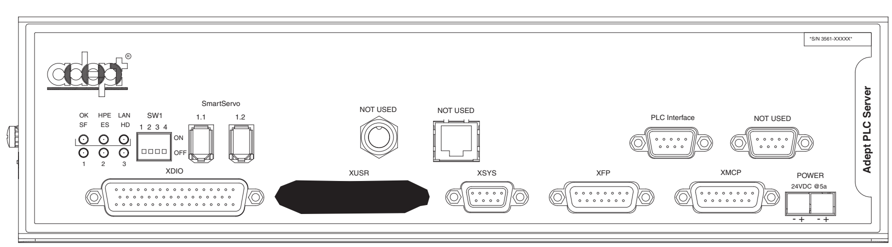


Figure 1-1. Adept PLC Server

NOTE: Programming of the PLC Server is not required. All application programming is done from the customer-supplied PLC.

Adept Cobra PLC Robot

The Adept Cobra PLC600 and PLC800 robots are four-axis SCARA robots (Selective Compliance Assembly Robot Arm). See **Figure 1-2**. Joints 1, 2, and 4 are rotational; Joint 3 is translational. See **Figure 1-3** for a description of the robot joint locations.

NOTE: The descriptions and instructions in this manual apply to both the Cobra PLC600 and the Cobra PLC800, except for instances where there is a difference, as in dimension and work envelope drawings. In those cases the information is presented for both robots.

Figure 1-2. Adept Cobra PLC800 Robot

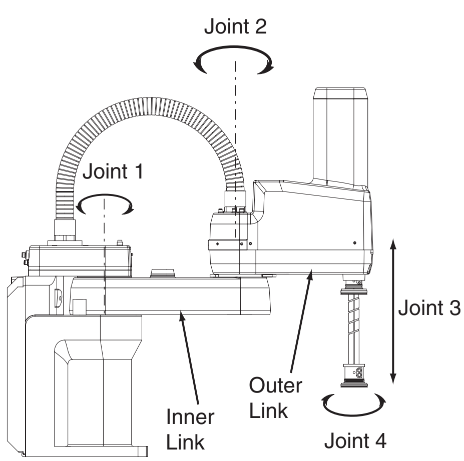


Figure 1-3. Robot Joint Motions

Software

The PLC Server software – used to provide seamless communication between the PLC and the robot – is supplied with the system. The Adept PLC Server requires operating system version 16.1D6 or later.

The application software and robot location data reside on the customer-supplied PLC. See **Chapter 6** for details.

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 47**.

Table 1-1. Installation Overview

Task to be Performed	Reference Location
1. Mount the robot on a flat, secure mounting surface.	See Section 3.5 on page 40.
2. Install the PLC Server, the Front Panel and any user-supplied equipment such as the PLC, PLC User Interface and PLC programming software.	See Section 3.6 on page 42.
3. Install the IEEE 1394 and XSYS cables between the robot and PLC Server.	See Section 4.4 on page 51.
4. Install the null-modem serial cable between the user-supplied PLC and the PLC Server.	See Section 4.5 on page 51.
5. Create a 24 VDC cable and connect it between the robot and the user-supplied 24 VDC power supply.	See Section 4.6 on page 52.
6. Create a 200-240 VAC cable and connect it between the robot and the facility AC power source.	See Section 4.7 on page 56.
7. Create a 24 VDC cable and connect it between the PLC Server and the user-supplied 24 VDC power supply.	See Section 4.8 on page 59.
8. Connect the workcell equipment to an earth grounding point.	See Section 4.9 on page 61.
9. Install user-supplied safety barriers in the workcell.	See Section 4.10 on page 63.
10. Read Chapter 5 to learn about commissioning the system, including system start-up and testing operation.	See Section 5.4 on page 78.
11. Read Chapter 7 if you need to install optional robot equipment, including end-effectors, user air and electrical lines, solenoids, etc.	See Section 7.1 on page 137.

1.3 Manufacturer's Declaration

The Manufacturer's Declaration of Incorporation and Conformity for Adept robot systems can be found on the Adept Website, in the Download Center of the Support section.

http://www.adept.com/support/downloads_disclaimer.asp

In the Download Types search box, select Regulatory Certificates to find the document, which you can then download.

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

Adept Document Library

In addition to the Adept Document Library on CD-ROM, you can find Adept product documentation on the Adept web site in the Document Library area. The Document Library search engine allows you to locate information on a specific topic. Additionally, the Document Menu provides a list of available product documentation.

To access the Adept Document Library, type the following URL into your browser:

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

or, select the Document Library link on the Home page of the Adept web site.

Safety 2

2.1 Dangers, 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

Figure 2-1 and Figure 2-2 show the warning labels on the Adept Cobra PLC robots.

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

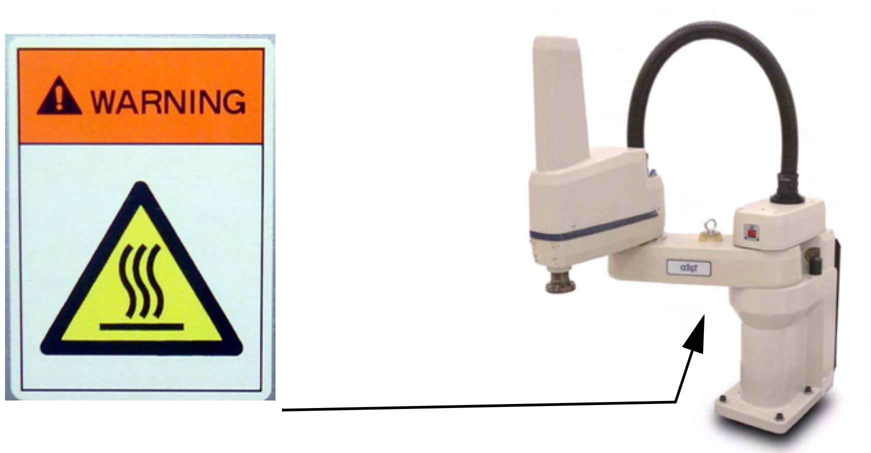


Figure 2-2. Thermal Warning Label on Underside of Inner Link

Figure 2-3. Warning Label on Encoder Cables

WARNING: When the Outer link cover is removed, you see the label shown above. Do not remove the J3-ENC or J4-ENC encoder cable connectors from their sockets. If they are removed, the calibration data will be lost and the robot must be run through a factory calibration process, which requires special software and tools.

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 according to 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.

The table below shows the standards that the robot system has been evaluated to meet.

Table 2-1. Standards Met by Robot

Standard
UL 1740
ANSI/RIA R15.06
NFPA 79
CSA/CAN Z434

Safety Barriers

Safety barriers must be an integral part of a 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., will be installed. The robot workcell must be designed according to the applicable local and national standards (see Section 2.8 on page 32).

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. See Chapter 5 for information on safe and effective use of the robot.

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 power is removed from the system, the arm can be moved manually. The Joint 3 Brake release button must be pressed to enable Joint 3 movement.

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 handbook contain additional guidelines for robot system installation, safeguarding, maintenance, testing, startup, and operator training. Table 2-2 lists some sources for the various standards.

Table 2-2. Sources for International Standards and Directives

SEMI International Standards 3081 Zanker Road San Jose, CA 95134 USA Phone: 1.408.943.6900 Fax: 1.408.428.9600 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: +1-847-272-8800 Fax: +1-847-272-8129 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

Table 2-2. Sources for International Standards and Directives (Continued)

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 robot could inflict serious injury on an operator working within its work envelope. Safety standards in several countries require appropriate safety equipment to be installed as part of the system. Table 2-3 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 2-3. 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

Adept has performed a Risk Assessment for this product, based on the intended applications of the robot. The conclusions are summarized below.

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 programmer (see **“Qualification of Personnel” on page 33**), who must wear safety equipment (see **“Safety Equipment for Operators” on page 34**) and carry the pendant (T1 or MCP). 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). The stop function is classified as NFPA Category 1.

See **Figure 8-9 on page 113** for an E-stop internal circuit diagram.

Slow Speed Control Function and Testing

Adept robots can also 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 (Manual Control Pendant (MCP) or T1). 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 32**).

The Adept Cobra PLC 600 and PLC800 robots are intended for use in parts assembly and material handling for payloads less than 5.5 kg (12.1 lb).

WARNING: For safety reasons, making certain modifications to Adept robots is prohibited (see **Section 2.6**).

The Adept Cobra PLC robots and the Adept PLC Server are component subassemblies of a complete industrial automation system. The PLC Server must be installed inside a suitable enclosure. The PLC Server must not come into contact with liquids. Additionally, a standard Adept Cobra PLC robot 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 39** for allowable temperature and humidity ranges.

WARNING: The instructions for installation, operation, and maintenance given in this User's Guide must be strictly observed.

Non-intended use of an Adept Cobra PLC 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 User's Guide

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.

Acceptable Modifications

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

- Attaching tooling, utility boxes, solenoid packs, vacuum pumps, screwdrivers, lighting, etc., to the inner link, outer link, or J1 harness support.
- Attaching hoses, pneumatic lines, or cables to the robot. These should be designed so they do not restrict joint motion or cause robot motion errors.

Unacceptable Modifications

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

CAUTION: Making any of the modifications outlined 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-PLC Server 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.
- Routing additional hoses, air lines, or wires through the robot.
- 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: Do not remain under the robot while it is transported.

2.8 Safety Requirements for Additional Equipment

Additional equipment used with the Adept Cobra PLC 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 obtained.

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 Cobra PLC robot depends on the speed and payload. The maximum value is 90dB(A), when running the robot at maximum AUTO-mode speed.

WARNING: Acoustic emission from this robot may be up to 90dB(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. Do not touch the robot base or outer link shortly after the robot has been running at high ambient temperatures (40-50°C) (104-122°F) or at fast cycle times (over 60 cycles per minute). The robot skin/surface temperature can exceed 85°C (185°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 34**) 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 working envelope of the robot, High Power (robot 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.

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. The user must provide the necessary additional training for all personnel who will be working with the system.

As noted in this user's guide, 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 sound 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.

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

1. Has received the user's guide.
2. Has read the user's guide.
3. Understands the user's guide and
4. Will work in the manner specified by the user's guide.

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 hats)
- 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 Manual Control 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 PLC Server.

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

2.16 Risks Due to Incorrect Installation or Operation

- Purposely defeating any aspect of the safety E-Stop system
- Improper installation or programming of the robot system
- Unauthorized use of cables other than those supplied or use of modified components in the system
- Defeating interlock so that operator can enter workcell with High Power ON

Take precautions to ensure that these situations do not occur.

2.17 What to Do in an Emergency Situation

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.

Equipment Installation 3

3.1 Transport and Storage

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

Use a forklift, pallet jack, or similar device to transport and store the packaged equipment (see **Figure 3-1**).

The robots 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 position: this could damage the robot.

The PLC600 robot weighs 41 kg (90 lb) and the PLC800 weighs 43 kg (95 lb) with no options installed.

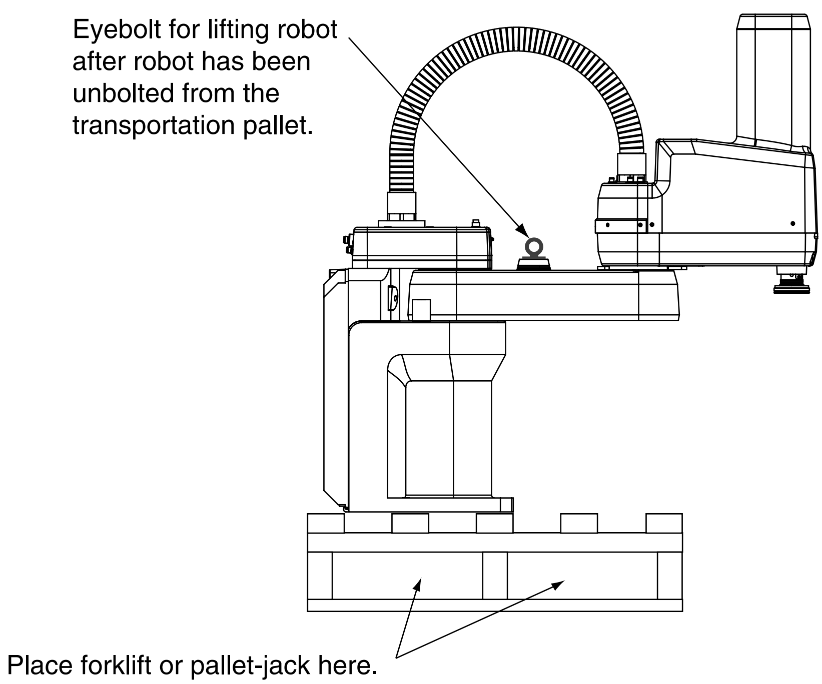


Figure 3-1. Cobra PLC600/PLC800 Robot on a Transportation Pallet

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.

Upon Unpacking

Before signing the carrier's delivery sheet, please compare the actual items received (not just the packing slip) with your equipment purchase order and 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.

If the items received do not match your order, please contact Adept immediately.

Inspect each item for external damage as it is removed from its container. If any damage is evident, contact Adept (see **Section 1.4 on page 19**).

Retain all containers and packaging materials. These items may be necessary to settle claims or, at a later date, to relocate 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 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. Specify this to the carrier if the robot is to be shipped.

CAUTION: Before unbolting the robot from the mounting surface, fold the outer arm against the Joint 2 hardstops to help centralize the center of gravity. The robot must always be shipped in an upright orientation.

3.4 Environmental and Facility Requirements

The Adept robot system installation must meet the operating environment requirements shown in **Table 3-1**.

Table 3-1. Robot System Operating Environment Requirements

Ambient temperature	5°C to 40°C (41°F to 104°F)
Humidity	5 to 90%, noncondensing
Altitude	up to 2000 m (6500 ft.)
Pollution degree	2 (IEC 1131-2/EN 61131-2)
Robot protection class	IP20 (NEMA Type 1)
Note: See **Section 9.1 on page 159** for robot dimensions.	

3.5 Mounting the Robot

Mounting Surface

The Adept Cobra PLC robot is designed to be mounted on a smooth, flat, level tabletop. The mounting structure must be rigid enough to prevent vibration and flexing during robot operation. Adept recommends a 25 mm (1 in.) thick steel plate mounted to a rigid tube frame. Excessive vibration or mounting flexure will degrade robot performance. Figure 3-2 shows the mounting hole pattern for the Adept Cobra PLC robots.

> **NOTE:** On the under side of the base there is a hole and a slot that can be used as locating points for user-installed dowel pins in the mounting surface; see Figure 3-2. Using locating pins could improve the ability to remove and reinstall the robot in the same position.

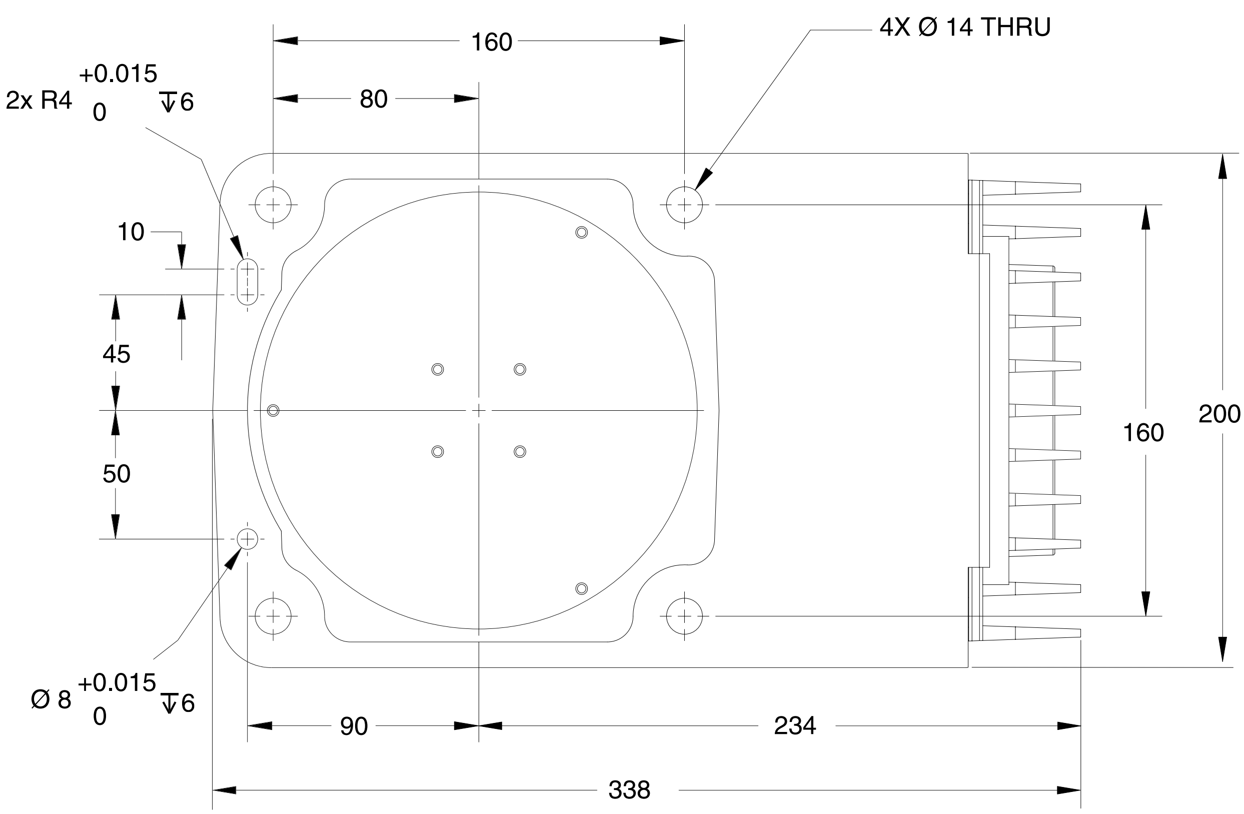


Figure 3-2. Mounting Hole Pattern for Robot

Robot Mounting Procedure

1. Using the dimensions shown in Figure 3-2, drill and tap the mounting surface for four M12 - 1.75 x 36 mm (or 7/16 - 14 UNC x 1.50 in.) machine bolts (bolts not provided). See Table 3-2 for bolt and torque specifications.

2. While the robot is still bolted to the transportation pallet, connect the hydraulic lift to the eyebolt at the top of the inner link (see **Figure 3-1 on page 37**). Take up any slack, but do not lift the robot at this time.

WARNING: Do not attempt to lift the robot at any points other than the eyebolt provided. Do not attempt to extend the inner or outer links of the robot until the robot has been secured in position. Failure to comply could result in the robot falling and causing either personnel injury or equipment damage.

3. Remove the four bolts securing the robot base to the pallet. Retain these bolts for possible later relocation of the equipment.
4. Lift the robot and position it directly over the mounting surface.
5. Slowly lower the robot while aligning the base and the tapped mounting holes in the mounting surface.

   NOTE: The base casting of the robot is aluminum and can easily be dented if bumped against a harder surface. Verify that the robot is mounted squarely (will not rock back and forth) before tightening the mounting bolts.

6. Install the customer-supplied mounting bolts and washers. Tighten bolts to torque specified in **Table 3-2**.

WARNING: The center of mass of the robot may cause the robot to fall over if the robot is not secured with the mounting bolts.

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	Specification	Torque
Metric	M12 x P1.75	ISO Property Class 8.8	85 N•m
SAE	7/16-14 UNC	SAE Grade 5	63 ft-lb

3.6 PLC Server Installation

This equipment must be shipped and stored in a temperature-controlled environment. See Table 3-3. It should be shipped and stored in the Adept-supplied packaging, which is designed to prevent damage from normal shock and vibration. You should protect the package from shock and vibration.

Table 3-3. Environmental Specifications

Ambient temperature	5°C to 40°C
Storage and shipment temperature	–25°C to +55°C
Humidity range	5 to 90%, nonconducting
Altitude	up to 2000 m (6500 feet)
Free space around PLC Server (for proper cooling)	10 mm at back, 13 mm on sides
Chassis protection class	IP20 (NEMA Type 1)
Recommendations for customer-supplied enclosure for Adept PLC Server. (Mandatory for installations in EU or EEA countries.)	Enclosure must meet EN 60204 (IEC 204) requirements and be rated at IP54.

Unpacking the PLC Server

Perform the steps below to unpack the PLC Server, optional Front Panel, and optional Manual Control Pendant (MCP). Then, see the later sections for information on mounting the equipment.

1. Remove the PLC Server from its shipping container and place it near the robot. If rack mounting is required, refer to the section "Mounting the PLC Server" on page 43 for details.
2. Remove the optional Front Panel from its shipping container and set it on a flat surface near the PLC Server.

Repacking for Relocation

If the PLC Server needs to be relocated, reverse the steps in the installation procedure. Reuse all original packing containers and materials and follow all safety notes used for installation. Improper packaging for shipment will void your warranty.

Space Around the Chassis

When the PLC Server is installed, you must allow 10 mm at the back of the unit and 13 mm on the sides of the unit for proper air cooling. To facilitate installation, make sure that the factory installed CompactFlash Memory Card is in place within the PLC Server prior to mounting it. This is crucial if you plan to mount it in a way that restricts access to the side of the unit, and thus to the CompactFlash Memory compartment (see the "CompactFlash Memory Card" on page 45 for information).

Mounting the PLC Server

The following mounting options are available for the PLC Server:

- Rack
- Panel
- Table

In addition, the PLC Server can be stack mounted (one unit placed on top of another). See the sections below for information on mounting the PLC Server; **page 93** for information on mounting the sDIO.

> **NOTE:** To maintain compliance with EN 60204 in European installations, the mounting of the PLC Server and all terminations at the PLC Server must be performed in accordance with this standard.

Rack Mounting the PLC Server

To rack mount the PLC Server in a standard 19-inch equipment rack, install the optional mounting brackets on the side of the PLC Server, as shown in **Figure 3-3**. These brackets must be ordered separately, they do not come with the PLC Server.

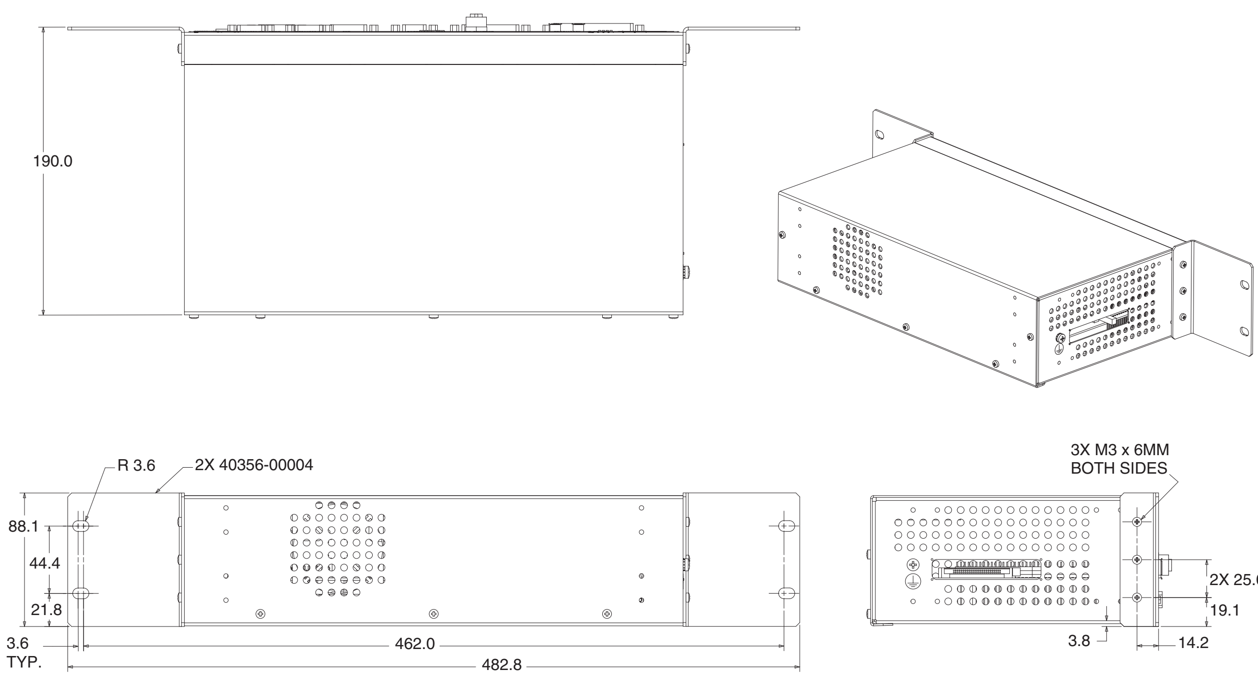


Figure 3-3. Rack Mounting the PLC Server

Panel Mounting the PLC Server

To panel mount the PLC Server, install two brackets on each side at the rear of the unit, as shown in **Figure 3-4**. Use the screws from the accessories kit.

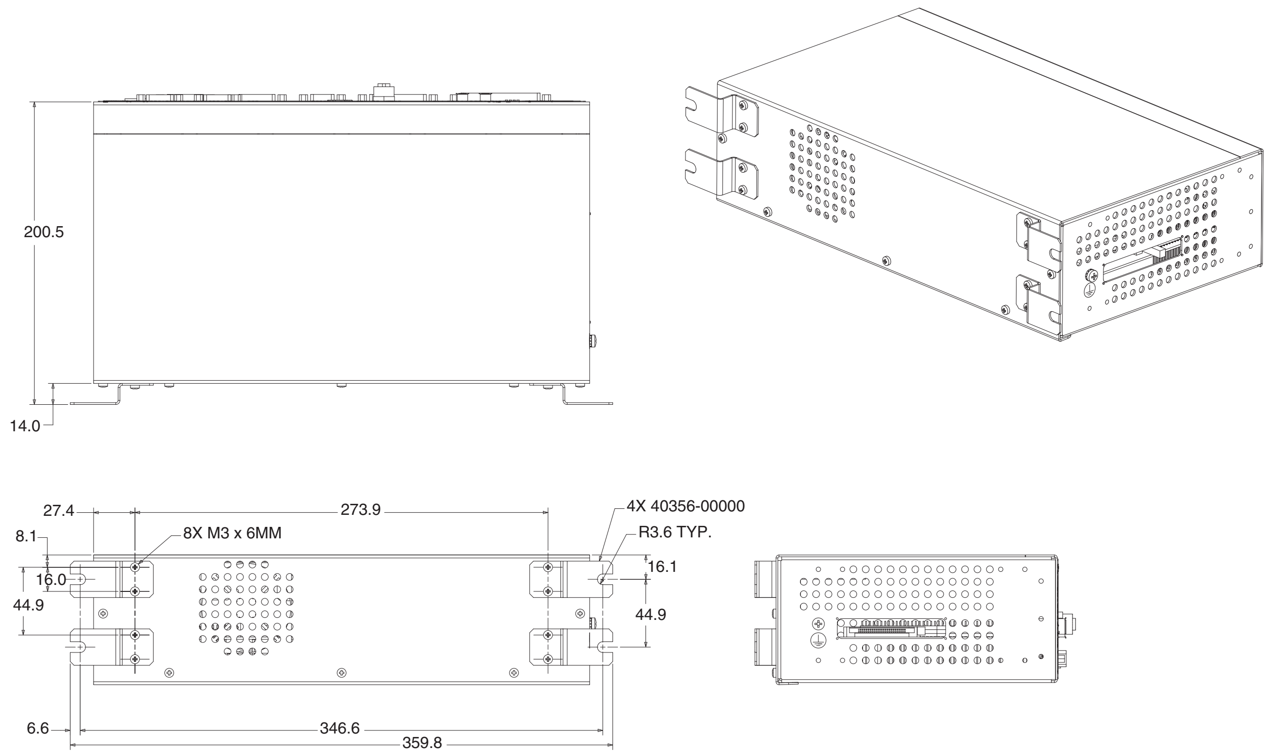


Figure 3-4. Panel Mounting the PLC Server

Table Mounting the PLC Server

To table mount the PLC Server, install two brackets on each side near the bottom of the unit, as shown in Figure 3-5. Use the screws from the accessories kit.

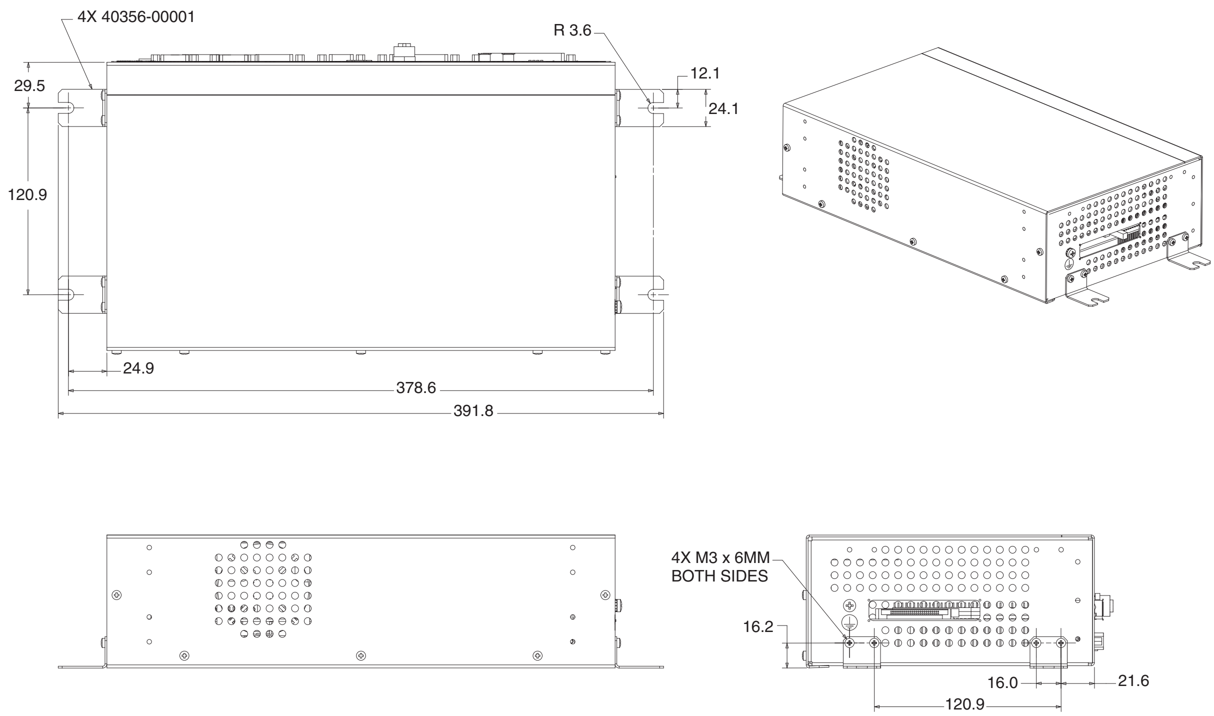


Figure 3-5. Table Mounting the PLC Server

CompactFlash Memory Card

The PLC Server is equipped with a CompactFlash™ (CF) memory card. The PLC Server system uses a CF in place of a traditional hard disk drive. In fact, it is often referred to as a "solid state hard drive". The CF is about half the size of a credit card and twice as thick. It has no moving parts and is therefore reliable and durable.

The CF shipped with all systems has a capacity of 30 MB and is factory configured by Adept. The CF stores the PLC Server software.

> **NOTE:** Adept reserves the right to increase the size of the standard CF without notice.

Not all types of CompactFlash are compatible with the PLC Server. Adept requires the use of the CF supplied by Adept at the time of the PLC Server purchase and that all replacement CF cards be obtained from Adept.

CAUTION: Use suitable measures for eliminating electrostatic discharge during handling of the CompactFlash. This includes, but is not limited to, the use of a grounded wrist strap while performing this operation.

CAUTION: Never install or remove the CompactFlash when power is connected to the PLC Server.

Installing CompactFlash

To install a CompactFlash (CF) into a PLC Server:

1. Make sure that the PLC Server is disconnected from its power source.
2. Locate the CF compartment (see **Figure 3-6**).

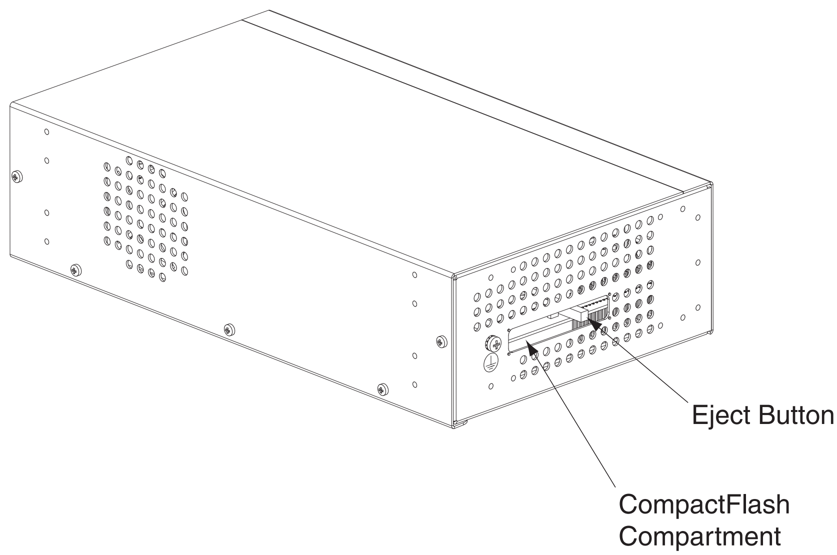


Figure 3-6. CompactFlash Memory Card Compartment

3. Carefully remove the CF from its shipping container. Locate the CF slot and position the card so its connector is facing towards the PLC Server and the label is facing up.
4. Insert the CF into the PLC Server.

Once installed, Adept recommends that you do not repeatedly remove and insert the CF.

Wiring the System 4

4.1 System Cable Diagram

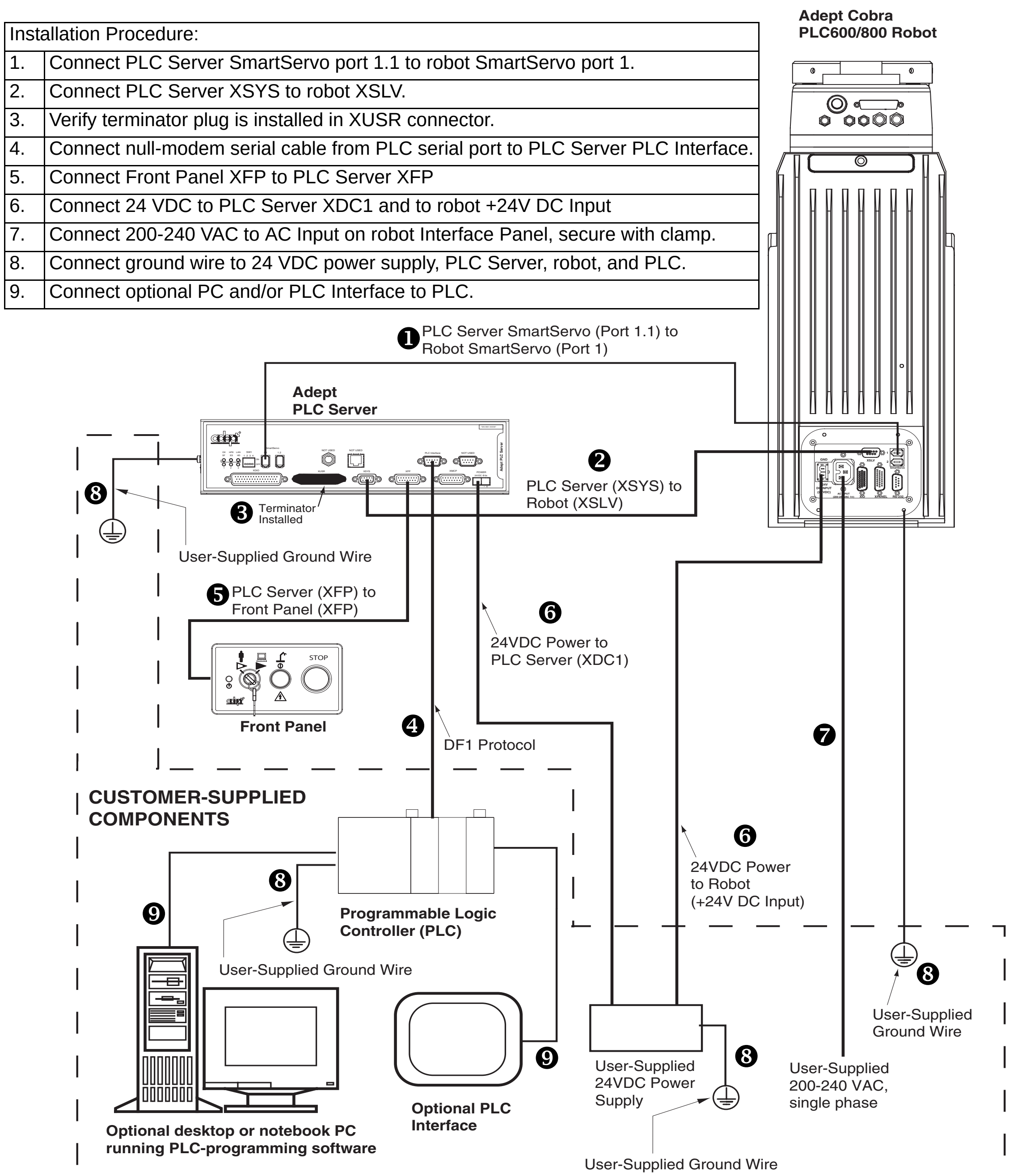


Figure 4-1. System Cable Diagram for Adept Cobra PLC Robots

4.2 Cobra PLC Robot Interface Panel Connectors

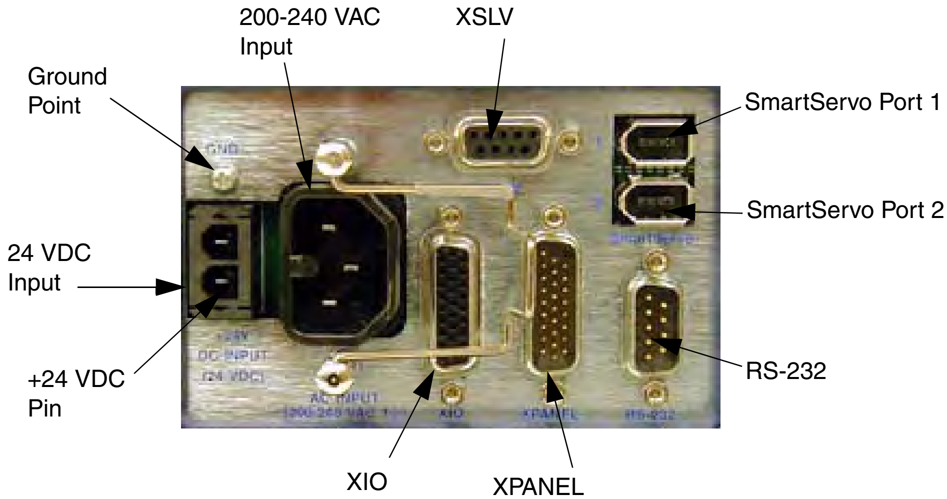


Figure 4-2. Robot Interface Panel

24 VDC - for connecting user-supplied 24 VDC power to the robot. The mating connector is provided.

Ground Point - for connecting cable shield from user-supplied 24 VDC cable.

200/240VAC - for connecting 200-240 VAC, single-phase, input power to the robot. The mating connector is provided.

XSLV - for connecting the supplied XSYS cable from the PLC Server XSYS connector. (DB-9, female)

SmartServo 1/2 - for connecting the IEEE 1394 cable from the PLC Server (SmartServo 1.1) to the robot upper connector (SmartServo 1).

> **NOTE:** The robot lower connector (SmartServo 2) is not used.

RS-232 - NOT USED.

XPANEL - NOT USED.

XIO - NOT USED.

4.3 PLC Server Connectors and Indicators

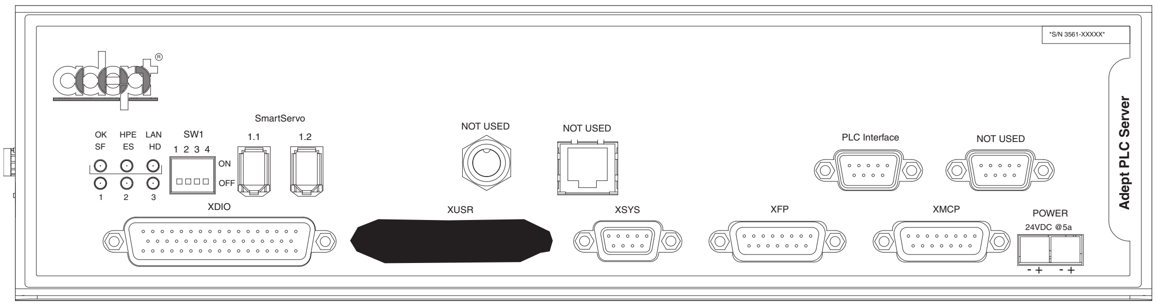


Figure 4-3. Adept PLC Server

All the connectors on the PLC Server use standard density spacing, D-subminiature connectors. For customization purposes, the user needs to provide connectors of the appropriate gender and pin count or use optional Adept cables.

1. **Top Three Status LEDs**
   The top three two-color LEDs indicate diagnostic test, power control, and communication status.

Table 4-1. PLC Server LEDs

LED	Green Indicates	Red Indicates
OK/SF	System OK	System Fault
HPE/ES	High Power Enabled	E-Stop Open
LAN/HD	Ethernet Access	Read/Write from CompactFlash

During system bootup, the red OK/SF and HPE/ES LEDs are lit and the red LAN/HD LED blinks. After system bootup, the OK/SF LED should show green. If the HPE/ES LED shows red, the E-Stop circuit is open. During CompactFlash reads and writes, the LAN/HD LED pulses red. When the PLC Server is active on an Ethernet network, the LAN/HD LED pulses green.

2. **Bottom Three Status LEDs**
   The bottom three LEDs on the front of the PLC Server give the following information about the status of the main PLC Server.

O = Off   G = Green   R = Red

Table 4-2. LED Status Indicators

LED Display 1 2 3	Error #	Description
O-O-O	0	No error.

Table 4-2. LED Status Indicators

LED Display 1 2 3	Error #	Description
R-O-O	1	System clock is dead or too fast. Clock interrupts are not being received.
O-R-O	2	Hardware configuration error.
O-O-R	4	Memory test failure. Free storage error.
O-R-R	6	Software serial I/O configuration error.
R-R-R	7	Initial display set by hardware before software has started.
G-O-O	9	Transient display set when PCI is configured.
O-O-G	C	Uninitialized trap.
G-O-G	D	Bus error detected.

If the PLC Server displays any of the above errors, cycle the power off, then on again. If the problem persists, then contact Adept Customer Service.

3. **SW1 DIP switches**
The DIP switches define certain configuration settings.

> **NOTE:** The DIP switches are set at the factory and must not be changed by the user.

4. **SmartServo 1.1 and 1.2**
These ports connect any approved products onto Adept's 1394-based servo network. For this product, these ports are used to connect to the Cobra PLC robot only.

> **WARNING:** Remove power from the PLC Server before plugging in or unplugging any IEEE-1394 cables to or from these connectors. Failure to remove power could result in unpredictable behavior by the system.

5. **DeviceNet connector**
Not used.

6. **Ethernet (Eth 10/100) connector**
Not used.

7. **PLC Interface connector**
Connects the user-supplied PLC to the Adept PLC server. This connection provides the communications link between the PLC Server/Cobra PLC robot and the user-supplied PLC using the DF1 Protocol.

8. **RS-422/RS-485 connector**
Not used.

9. **XDIO connector**
This connector includes 20 signal pairs; 8 digital outputs (100 mA max) and 12 digital inputs, including four fast inputs (the first four input signals on this connector are the only input signals that can be configured as fast inputs). The digital outputs are short-circuit protected. This connector also supplies 24 VDC power for customer equipment. See **Section 4.11 on page 70** for more information.

10. **XUSR connector**
Provides switch functions for emergency stop (E-Stop) and Manual/Automatic interfaces to external push buttons and other equipment. For example, an external E-Stop can be connected to the XUSR connector. A line E-Stop from other equipment can be connected. A muted safety gate that causes an E-Stop only in Automatic mode is included. Also included are contacts to report the status of E-Stop push buttons and the Manual/Automatic switch.

NOTE: The PLC Server ships with a terminator plug attached to the XUSR connector. The terminator plug must be installed in the absence of any customer supplied safety devices to close the E-Stop circuit. For more information about the XUSR connector, see **Section 4.10 on page 63**.

11. **XSYS connector**
Connects to AIB unit on the Cobra PLC. This connection is used for internal Adept signals for high power relays.

12. **XFP connector**
Connects to the Front Panel. See **Section 4.10 on page 63** for information.

13. **XMCP connector**
Not used. The PLC Server ships with a terminator plug attached to the XMCP connector.

14. **Power 24 VDC connectors**
Connect power from a customer-supplied 24 VDC power supply to the XDC1 connector (see the **"Connecting Power" on page 30** for information).

4.4 Cable Connections from Robot to PLC Server

1. Locate the IEEE 1394 cable (length 4.5M) and the XSYS cable (length 4.5M). They are typically shipped in the cable/accessories box.
2. Install one end of the IEEE 1394 cable into the SmartServo port 1.1 connector on the PLC Server, and install the other end into the SmartServo port 1 connector on the robot interface panel. See **Figure 4-1 on page 47**.
3. Install the XSYS cable between the robot interface panel XSLV safety interlock connector and XSYS connector on the PLC Server, and tighten the latching screws.

4.5 Cable Connections from the PLC to PLC Server

The user-supplied PLC is connected to the PLC Server through a null-modem serial cable. The cable connects to the PLC's RS-232 port (typically, channel 0) and to the PLC Server's PLC Interface port (9-pin, male, D-sub).

Table 4-3. PLC to PLC Server Cable Pin Description

Signal	Adept DB-9 Pin	AB PLC DB-9 Pin
TD (Transmit Data)	2	3
RD (Receive Data)	3	2
RTS (Request To Send)	8	7
CTS (Clear To Send)	7	8
SG (Signal Ground)	5	5
DSR (Data Set Ready)	4	6
CD (Carrier Detect)	4	1
DTR (Data Terminal Ready)	1	4
DTR (Data Terminal Ready)	6	4

The PLC's RS-232 communication port must be configured to use:

- DF1 Full Duplex driver
- no parity
- no handshaking
- CRC error checking.
- 38,400 bps (recommended), 19,200 bps may also be used.

4.6 Connecting 24 VDC Power to Robot

NOTE: This section provides information on the 24 VDC power supply and making the 24 VDC power cable. If you have ordered the optional Starter Kit, then you can skip to **"Installing 24 VDC Robot Cable" on page 54**.

Specifications for 24 VDC Power

Table 4-4. Specifications for 24 VDC User-Supplied Power Supply

User-Supplied Power Supply	24 VDC (+/- 10%), 150W (6A) (21.6 V< V_{in} < 26.4 V)
Circuit Protection[a]	output must be less than 300W peak **or** 8 Amp in-line fuse
Power Cabling	1.5 – 1.85mm² (16-14 AWG)
Shield Termination (recommended for compliance with EN Standards)	Braided shield connected to "-" terminal at both ends of cable. See Figure 4-4 on page 55.

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

NOTE: Fuse information is located on the AIB electronics.

The power requirements for the user-supplied power supply will vary depending on the configuration of the robot and connected devices. Adept recommends a 24V, 6A 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 V power supply, increase the supply capacity by 3A for each additional robot.

CAUTION: Make sure you select a 24 VDC power supply that meets the specifications in Table 4-4. Using an underrated supply can cause system problems and prevent your equipment from operating correctly. See Table 4-5 for recommended power supplies.

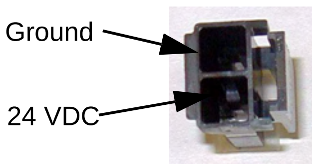
Table 4-5. Recommended 24VDC Power Supplies

Vendor Name	Model	Ratings
XPiQ	JMP160PS24	24VDC, 6.7 A, 160 W
AstroDyne	SP-150-24	24VDC, 6.3 A, 150 W
Mean Well	SP-150-24	24VDC, 6.3 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 4-6. 24 VDC Mating Connector Specs

Connector Details  	Connector receptacle, 2 position, type: Molex Saber, 18A, 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 tool, Molex Hand Crimper	Molex P/N 63811-0400
	Digi-Key P/N WM9907-ND

Procedure for Creating 24 VDC Cable

1. Locate the connector and pins from **Table 4-6 on page 54**.
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: You also must create a separate 24 VDC cable for the PLC Server. That cable uses a different style of connector. See **Section 4.8 on page 59** for details.

3. Crimp the pins onto the wires using the crimping tool recommended in **Table 4-6 on page 54**.
4. Insert the pins into the connector. Confirm that the 24V 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 24 VDC cable to your user-supplied 24 VDC power supply. 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 back of the robot. The cable shield should be connected to the ground point on the interface panel.

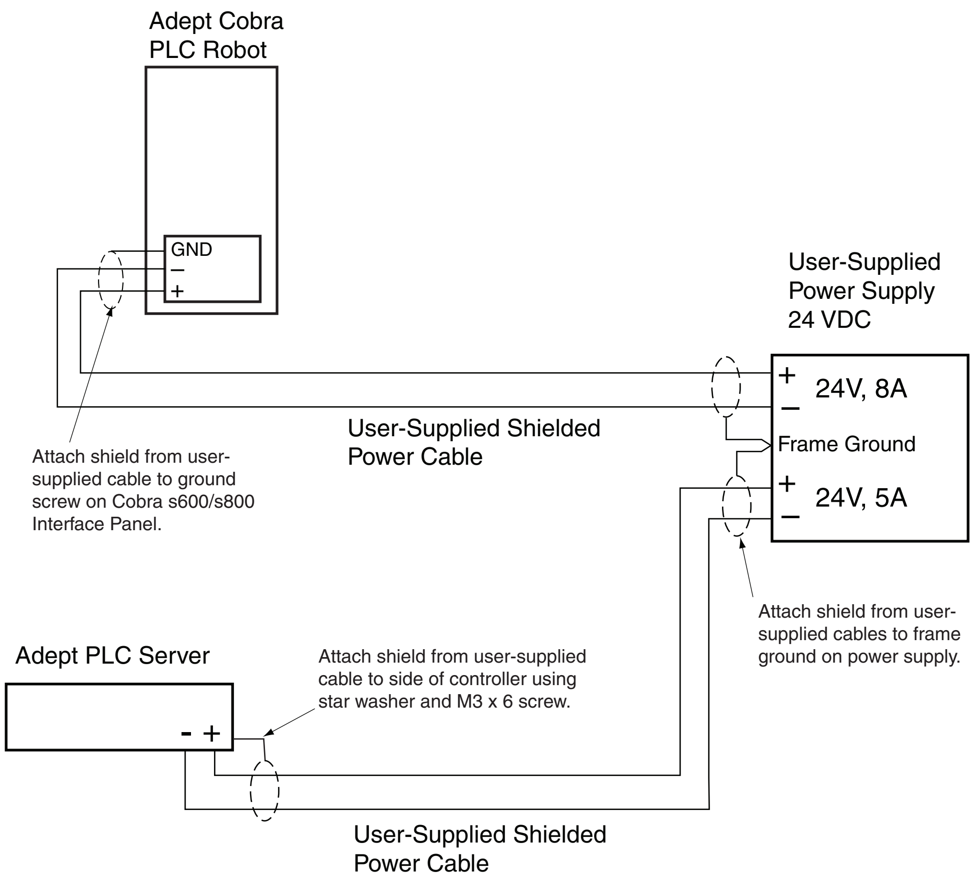


Figure 4-4. User-Supplied 24 VDC Cable

NOTE: In order to maintain compliance with EN standards, DC power must 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 4-7. Specifications for 200/240VAC User-Supplied Power Supply

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

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

Table 4-8. Typical Robot Power Consumption

Cobra Robot	Move	Average Power (W)	RMS Current (A)	Peak Power (W)[a]
PLC600	No load - Adept cycle	344	1.56	1559
	5.5 kg - Adept cycle	494	2.25	2061
	5.5 kg - all joints move	880	4.00	2667
PLC800	No load - Adept cycle	531	2.41	1955
	5.5 kg - Adept cycle	377	1.71	1406
	5.5 kg - all joints move	794	3.61	2110

[a] For short durations (100 ms)

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

DANGER: AC power installation must be performed by a skilled and instructed person - see Section 2.12 on page 33. During installation, fail-safe lockout measures must be used to prevent unauthorized third parties from turning on power.

Facility Overvoltage Protection

The user must protect the robot 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, nonperiodic 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. The user shall take the necessary steps to prevent damage to the robot system (such as by interposing a transformer). See IEC 1131-4 for additional information.

AC Power Diagrams

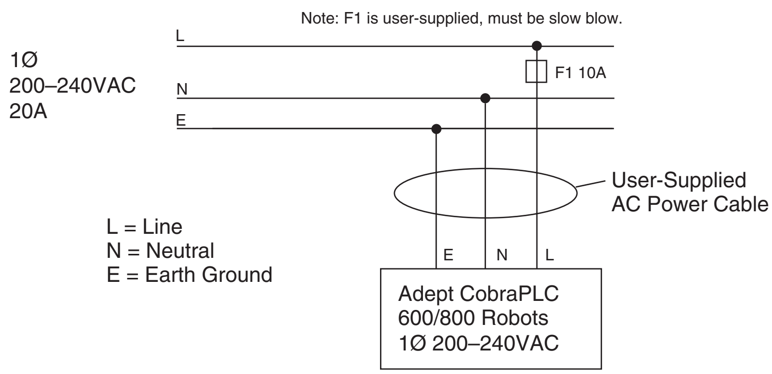


Figure 4-5. Typical AC Power Installation with Single-Phase Supply

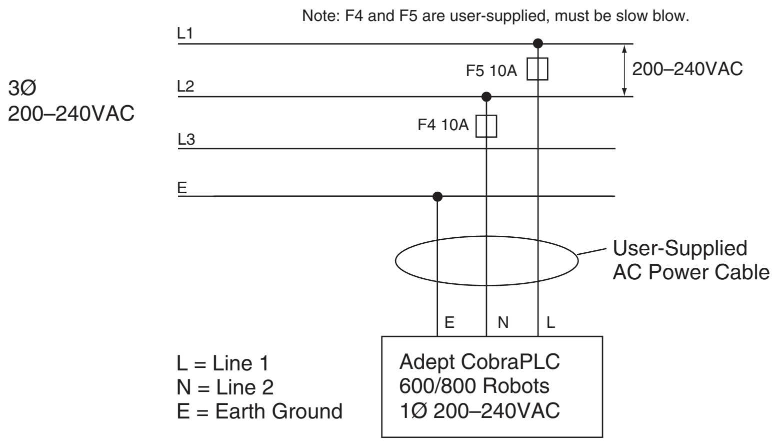
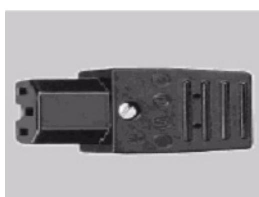


Figure 4-6. Single-Phase AC Power Installation from a Three-Phase AC Supply

Details for AC Mating Connector

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

Table 4-9. 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

Procedure for Creating 200-240 VAC Cable

1. Locate the AC mating connector shown in Table 4-9.
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 4-7 on page 59.
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 approximately 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. Replace the cover and tighten the screw to seal the connector.
10. Prepare the opposite end of the cable for connection to the facility AC power source.

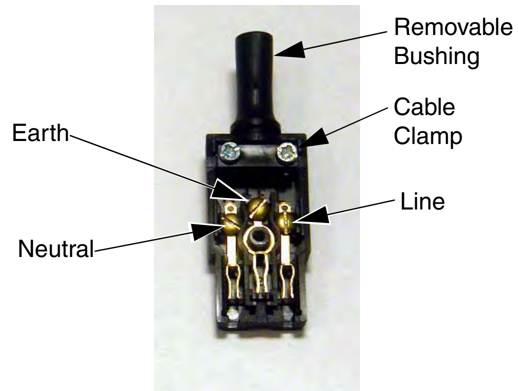


Figure 4-7. AC Power Mating Connector

Installing AC Power Cable to Robot

1. Connect the unterminated end of the AC power cable to your facility AC power source. See **Figure 4-6 on page 58**. 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 Connecting 24 VDC Power to the PLC Server

The PLC Server requires filtered 24 VDC power.

NOTE: *Users must provide their own power supply.* Make sure the power cables and power supply conform to the specifications below.

24 VDC Power Specifications

Table 4-10. Specifications for 24 VDC User-Supplied Power Supply

Customer-Supplied Power Supply	24 VDC, 120W (5A).

Table 4-10. Specifications for 24 VDC User-Supplied Power Supply

Circuit Protection	Not more than 8A (below the amperage rating of the cable used).
Power Cabling	1.5 - 1.85 mm2 (16-14 AWG), maximum length 10 meters
Shield Termination	Braided shield connected to "-" terminal at the appropriate XDC connector.

NOTE: The power requirements for the user-supplied power supply will vary depending on the configuration of the PLC Server and connected devices.

24 VDC Power Cabling

In order to maintain compliance with EN standards, DC power must be delivered over a shielded cable, with the shield connected to the return conductors at both ends of the cable as shown in **Figure 4-4**. Conductors should be 1.5 mm^2- 1.85 mm^2 (16 to 14 AWG) in size. The maximum length for the 24 VDC cable is 10 meters.

Daisy-Chaining Power

The PLC Server is equipped with two DC power connectors. These connectors allow the daisy-chaining of power from one PLC server to another. When daisy-chaining power, the power supply circuit must be limited to the lesser of 8 Amps or the amperage rating of the cabling. This can be done with a circuit breaker or a fuse. The DC power can be applied to either the XDC1 or XDC2 connector.

CAUTION: Use only one 24 VDC power supply per circuit. Failure to do this could result in damage to the equipment.

Installing 24 VDC Connectors

Use the Adept-supplied connectors to connect the customer-supplied 24 VDC power supply to the PLC Server. The connectors are Weidmuller #169042.

1. Locate two 24 VDC connectors that are shipped with the PLC Server. See **Figure 4-8 on page 61**.
2. Use 14 or 16 gauge wires to connect the 24 VDC power supply to the PLC Server.
3. Strip 7 mm of insulation from the end of the wire that connects to the positive output of the 24 VDC supply.
4. Insert a small flat-blade screwdriver (2.5 mm) into the top opening on the right-hand (positive) side of the connector. Push the blade in until the clamp in the lower opening folds back.

5. Insert the stripped end of the wire into the right-hand lower opening, then remove the screwdriver from the top opening. The clamp will close on the wire. Pull on the wire to confirm it is securely attached in the connector.
6. Visually inspect the connection to make sure that the clamp has closed on the wire, not the insulation.
7. Repeat this process for the wire from the negative side of the power supply to the left-hand side of the connector.

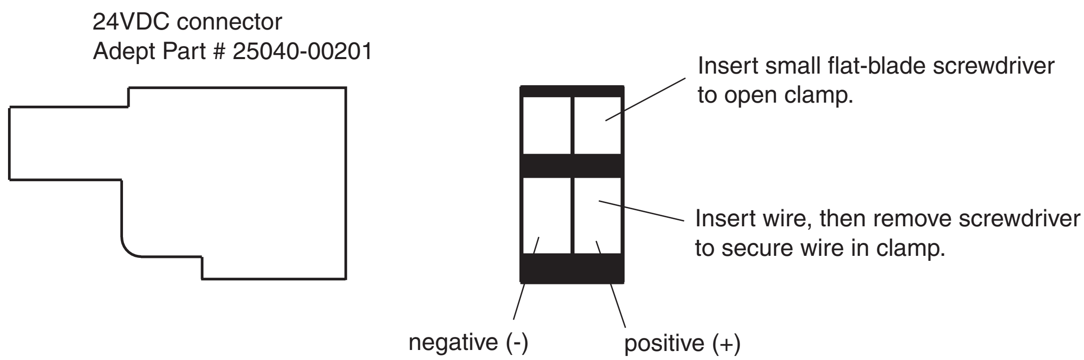


Figure 4-8. 24V Connectors

NOTE: Although no damage will occur, the PLC Server will not turn on if the DC polarities on the XDC connectors are reversed.

4.9 Grounding the Adept Robot System

Proper grounding is required for safe and reliable robot operation. Follow these recommendations to properly ground your robot system.

Ground Point on Robot Base

The user can install a ground wire at the robot base to ground the robot. See **Figure 4-9**. The robot ships with an M8 x 12 stainless steel, hex-head screw, and M8 split and flat washers installed in the grounding hole. The user is responsible for supplying the ground wire to connect to earth ground.

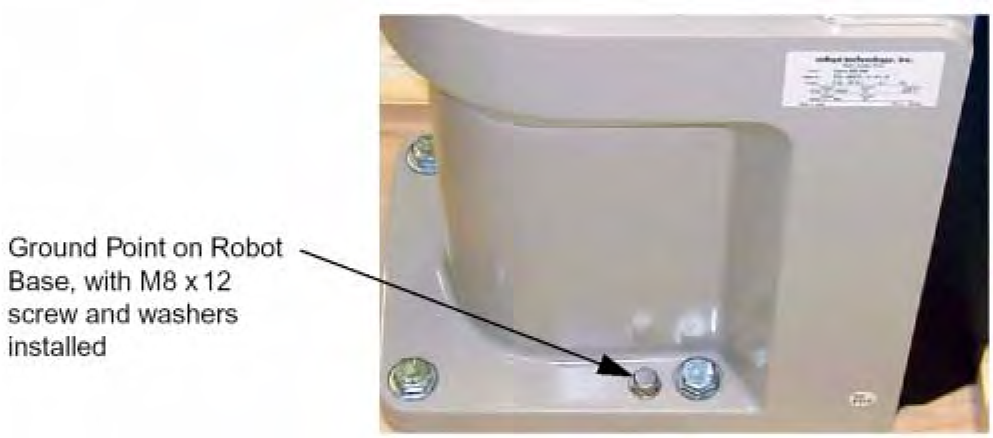


Figure 4-9. Ground Point on Robot Base

PLC Server Grounding

The PLC Server is equipped with a grounding point. See **Figure 4-10**. Adept recommends connecting a ground wire from the ground point on the PLC Server to earth ground and that all other interconnected Adept components share the same electrical ground potential. The ground wire must meet all local regulations. Additional grounding information for other Adept products are provided in the documentation for those products.

> **NOTE:** The maximum length for the ground wire for the PLC Server is 3 meters.

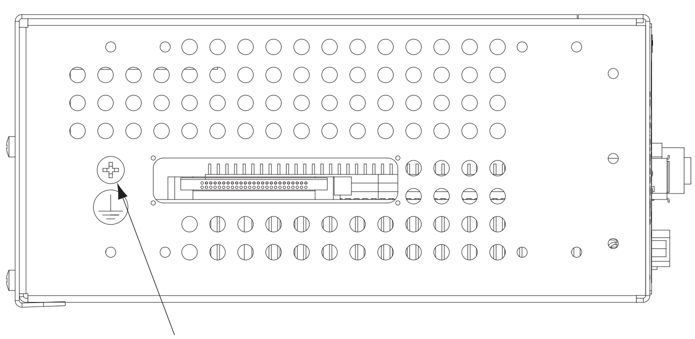


Figure 4-10. Chassis Grounding Point

The mounting of the PLC Server and all terminations in Europe must be performed in accordance with EN 60204 to maintain proper compliance.

Robot-Mounted Equipment Grounding

The following parts of an Adept Cobra PLC600/PLC800 robot are not grounded to protective earth: the Joint 3 quill and the tool flange. If hazardous voltages are present at any user-supplied robot-mounted equipment or tooling, you must install a ground connection from that equipment/tooling to the ground point on the robot base. Hazardous voltages can be considered anything in excess of 30 VAC (42.4 VAC peak) or 60 VDC.

See also **Figure 9-3 on page 161** for the grounding point on the tool flange.

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.

4.10 Connecting Customer-Supplied Safety and Power Control Equipment

The user is responsible for installing safety barriers to protect personnel from coming in contact with the robot unintentionally. Depending on the design of the workcell, safety gates, light curtains, and emergency stop devices can be used to create a safe environment. Read **Chapter 2** in this manual for a discussion of safety issues.

Connecting Equipment to the System

The connection of the customer-supplied safety and power control equipment to the system is done through the XUSR and XFP connectors on the PLC Server. The XUSR connector (25-pin) and XFP (15-pin) connector are both female D-sub connectors located on the front panel of the PLC Server. Refer to **Table 4-11** for the XUSR pin-out explanations. Refer to **Table 4-12 on page 64** for the XFP pin-out explanations. See **Figure 4-11 on page 66** for the XUSR wiring diagram.

Table 4-11. Contacts Provided by the XUSR Connector

Pin Pairs	Description	Comments	Shorted if NOT Used
Voltage-Free Contacts Provided by Customer			
1, 14	User E-Stop CH 1 (mushroom PB, safety gates, etc.).	N/C contacts	Yes
2,15	User E-Stop CH 2 (same as pins 1 and 14).	N/C contacts	Yes
3,16	Line E-Stop (used for other robot or assembly line E-Stop interconnection. Does not affect E-Stop indication (pins 7, 20.))	N/C contacts	Yes

Table 4-11. Contacts Provided by the XUSR Connector (Continued)

Pin Pairs	Description	Comments	Shorted if NOT Used
4,17	Line E-Stop (Same as pins 3 and 16. See above comment.)	N/C contacts	Yes
5,18	Muted safety gate CH 1 (causes E-stop in AUTOMATIC mode only).	N/C contacts	Yes
6,19	Muted Safety Gate CH 2 (same as pins 5 and 18).	N/C contacts	Yes
Voltage-Free Contacts provided by Adept			
7,20	E-Stop indication CH 1.	Contacts are closed when Front Panel, MCP, and customer E-Stops are *not* tripped	
8,21	E-stop indication CH 2 (same as pins 7 and 20.	Contacts are closed when Front Panel, MCP, and customer E-stops are *not* tripped	
9,22	MANUAL/AUTO indication CH 1	Contacts are closed in AUTOMATIC mode	
10,23	MANUAL/AUTO indication CH 2	Contacts are closed in AUTOMATIC mode	
11,12, 13,24,25	No connection		

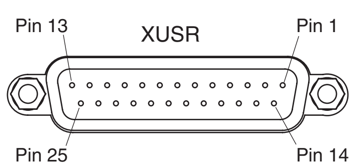
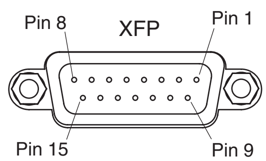


Table 4-12. Contacts Provided by the XFP Connector

Pin Pairs	Description	Comments
Voltage-Free Contacts Provided by Customer		
1,9	Front Panel E-Stop CH 1	N/C contacts
2,10	Front Panel E-Stop CH 2	N/C contacts
3,11	Remote MANUAL/AUTOMATIC switch CH 1. MANUAL = Open AUTOMATIC = Closed	

Table 4-12. Contacts Provided by the XFP Connector (Continued)

Pin Pairs	Description	Comments
4,12	Remote MANUAL/AUTOMATIC switch CH 2. MANUAL = Open AUTOMATIC = Closed	
6,14	Remote High Power on/off momentary PB	Used to enable High Power
Nonvoltage-Free Contacts		
5,13	Adept Supplied 5 VDC and GND for High Power On/Off Switch Lamp	Use with Remote High Power On/Off switch above.
7,15	PLC Server system 5V power on LED, 5V, 20mA	
8	No connection	



See Figure 4-12 on page 67 for a schematic diagram of the optional Adept Front Panel.

Figure 4-11 shows an E-Stop diagram for the CAT-3 version of the Adept PLC Server.

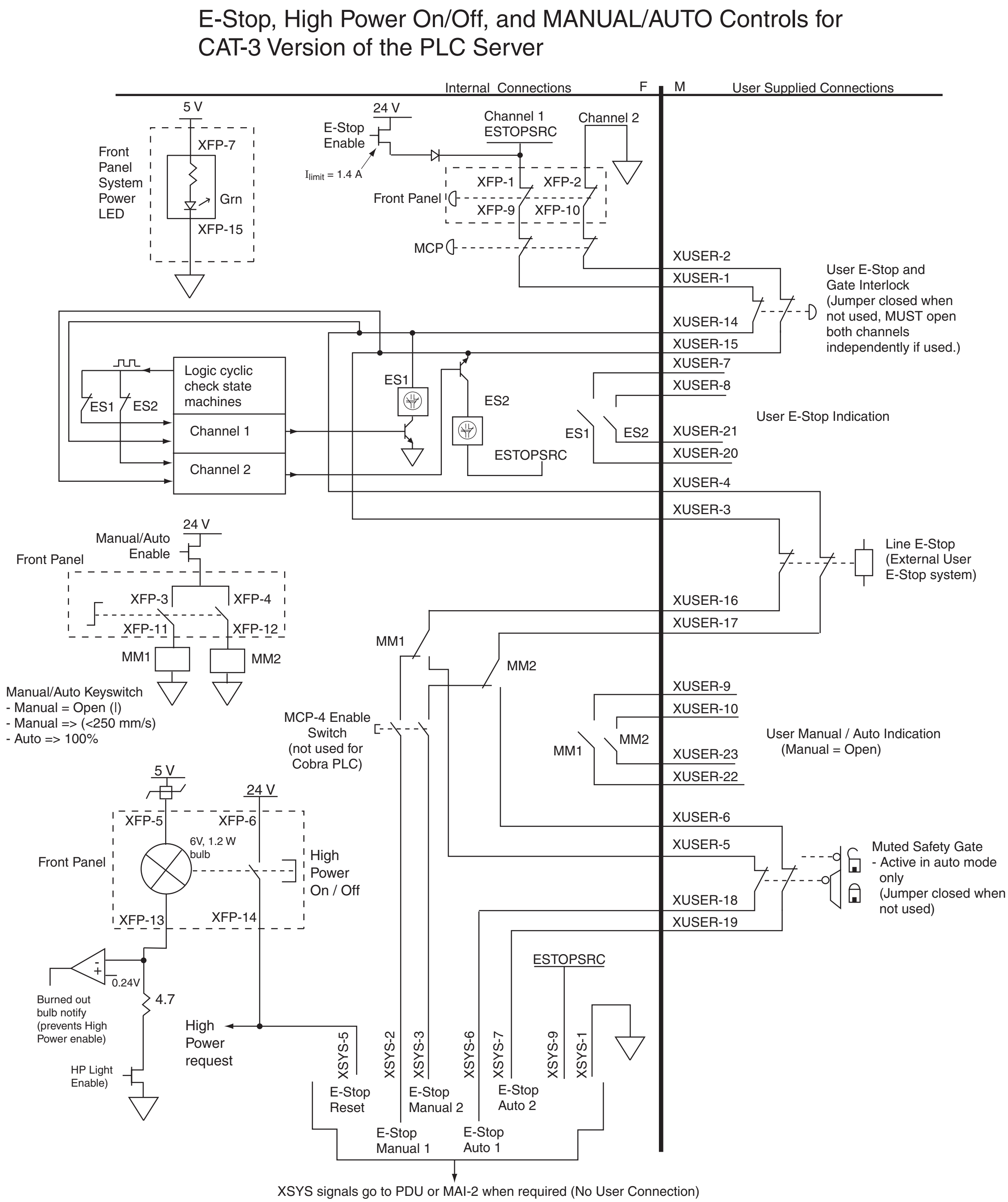


Figure 4-11. CAT-3 E-Stop Circuit on XUSR and XFP Connectors

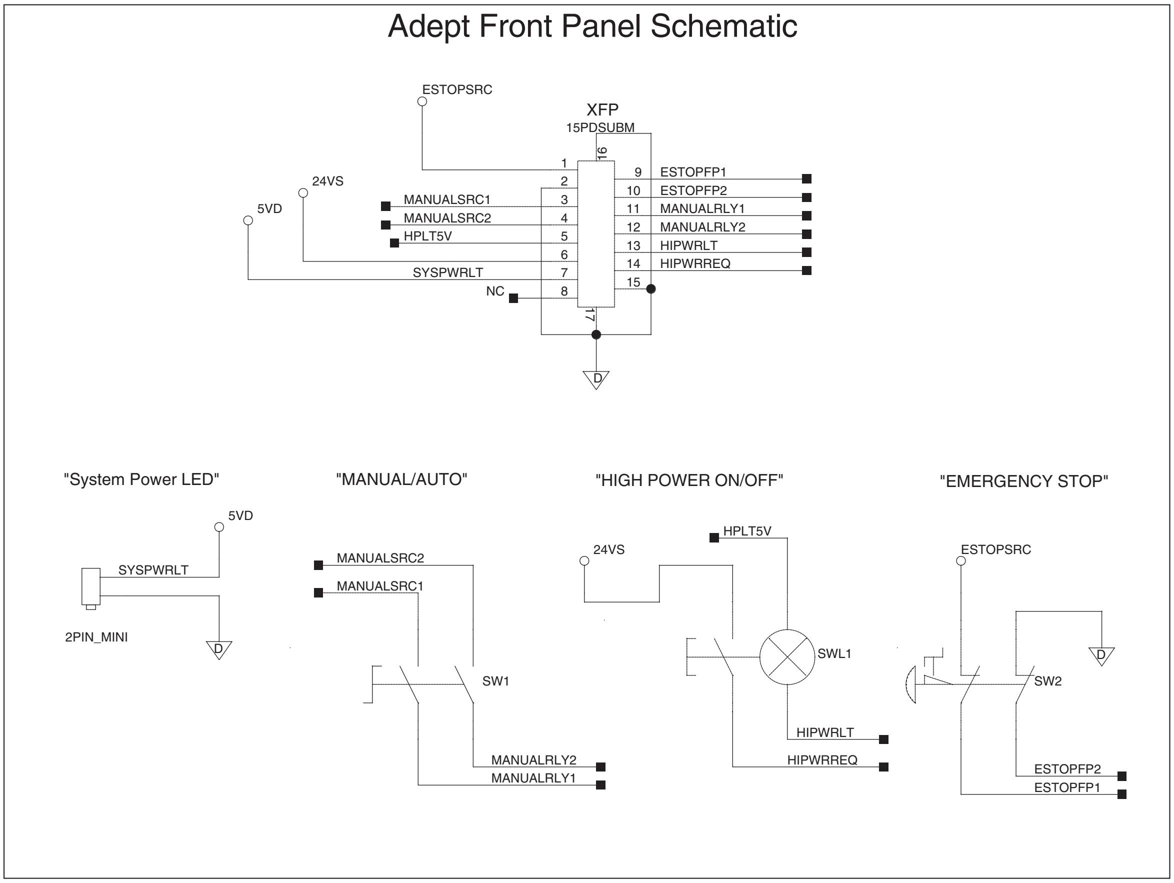


Figure 4-12. Optional Front Panel Schematic

Emergency Stop Circuits

The PLC Server provides connections for Emergency Stop (E-Stop) circuits on the XUSR and XFP connectors. This gives the PLC Server system the ability to duplicate E-Stop functionality from a remote location using voltage-free contacts. See **Figure 4-11**.

The XUSR connector provides external two-channel E-Stop input on pins 1 to 14 and 2 to 15. The XFP connector provides two-channel E-Stop input on pins 1 to 9 and 2 to 10.

> **NOTE:** These pins must be shorted if not used. Both channels must open independently if used. Although an Emergency Stop will occur, the PLC Server will malfunction if one channel is jumpered closed and the other channel is opened. It will also malfunction if the channels are shorted together.

User E-Stop Indication - Remote Sensing of E-Stop

Two pairs of pins on the XUSR connector (pins 7, 20 and 8, 21) provide voltage-free contacts, one for each channel, to indicate whether the E-Stop chain, as described above, on that channel is closed. Both switches are closed on each of the redundant circuits in normal condition (no E-Stop). The user may use these contacts to generate an E-Stop for other equipment in the workcell. This output does NOT report status of "line E-Stop" input (see the section below for more information). The load on the contacts must not exceed 40VDC or 30VAC at a maximum of 1A.

These voltage-free contacts are provided by a redundant, cyclically checked, positive-drive, safety relay circuit for EN-954-1 Category 3 operation (see **Figure 4-11 on page 66** and **Table 4-11 on page 63** for the customer E-Stop circuitry).

Line E-Stop Input

The XUSR connector on the PLC Server contains a two-channel Line E-Stop input for workcell or other equipment emergency stop inputs. Generally, the customer E-Stop Indication contact outputs are used to cause an emergency stop in such external equipment. Thus, if one were to wire the same equipment's outputs into the customer E-Stop input (that is, in series with the local robot's E-Stop push buttons), a lock up situation can occur.

The Line E-Stop input comes into the circuit at a point where it cannot affect the customer E-Stop indication relays and will not cause such a lock up situation. For any situation where two systems should be "cross-coupled", for example, the customer E-Stop indication of one PLC Server is to be connected to the input of another PLC Server, the Line E-Stop input is the point to bring in the other PLC Server's output contacts, see **Figure 4-11 on page 66** for more information.

Do not use the Line E-Stop for such devices as local E-Stop push buttons since their status should be reported to the outside on the local customer E-Stop indication output contact while the Line E-Stop inputs will not.

Muted Safety Gate E-Stop Circuitry

Two pairs of pins on the XUSR connector (pins 5, 18 and 6, 19) provide connections for a safety gate designed to yield an E-Stop allowing access to the workspace of the robot in Manual mode only, *not* in Automatic mode. The E-Stop is said to be "muted" in Manual mode (see **Figure 4-11 on page 66, Table 4-11 on page 63**, and **Table 4-12 on page 64** for the customer E-Stop circuitry).

The muted capability is useful for the situation where a shutdown must occur if the cell gate is opened in normal production mode, but you need to open the gate in manual mode. In muted mode, the gate can be left open for personnel to work in the robot cell. However, safety is maintained because of the speed restriction.

CAUTION: If the cell gate must always cause a robot shutdown, do not wire the gate switch into the muted safety gate inputs. Instead, wire the gate switch contacts in series with the user E-Stop inputs.

Remote Manual Mode

The Front Panel provides for a Manual Mode circuit (see **Figure 4-11 on page 66**, **Table 4-11 on page 63**, and **Table 4-12 on page 64**, and your robot manual for further details about the customer Remote Manual Mode circuitry).

The Adept Front Panel, or customer-supplied panel, must be incorporated into the robot workcell to provide a "Single Point of Control" (the operator) when the PLC Server is placed in Manual mode. Certain workcell devices, such as PLCs or conveyors, may need to be turned off when the operating mode switch is set to Manual mode. This is to ensure that the robot PLC Server does not receive commands from devices other than from the MCP, the single point of control.

If the user needs to control the Manual/Automatic mode selection from other control equipment, then a custom splitter cable or complete replacement of the Adept Front Panel may be required. See **Figure 4-12 on page 67** for the Front Panel schematic. In this situation, a pair of contacts should be wired *in series* with the Adept Front Panel Manual/Automatic mode contacts. Thus, both the Adept Front Panel and the customer contacts need to be closed to allow Automatic mode.

WARNING: Do not wire customer-supplied Manual/Automatic contacts in parallel with the Adept Front Panel switch contact. This would violate the "Single Point of Control" principle and might allow Automatic (high-speed) mode to be selected while an operator is in the cell.

User Manual/Auto Indication

Two pairs of pins on the XUSR connector (pins 9, 22 and 10, 23) provide a voltage-free contact to indicate whether the Front Panel and/or remote Manual/Automatic switches are closed. The user may use these contacts to control other mechanisms (for example, conveyor, linear modules, etc.) when Manual mode is selected. The load on the contacts should not exceed 40VDC or 30VAC at a maximum of 1A.

User High Power On Indication

In the PLC Server (see **page 21**), a normally open relay contact, on the XDIO connector (pins 45 and 46, see **Table 4-15 on page 74**), will close when High Power has been enabled. The user can use this feature to power an indicator lamp, or other device, that signals High Power is On. The limit on these contacts is 1 A at 30VDC or 30VAC.

High Power On/Off Lamp

The Front Panel High Power On/Off Lamp (P/N 27400-29006) will cause an error if the lamp burns out. This error prevents High Power from being turned on. This safety feature prevents a user from not realizing that High Power is enabled because the High Power indicator is burned out. See **Section 8.8 on page 156** for information on changing this lamp.

4.11 Connecting Customer-Supplied Digital I/O Equipment

The PLC Server provides capability for Inputs and Outputs (I/O) using a hard-wired interface to the XDIO connector.

The XDIO connector on the PLC Server provides 12 hard-wired inputs and 8 hard-wired outputs for Digital I/O connections. The signals are numbered 1001 through 1012 for the inputs and 1 through 8 for the outputs. All the signals have independent source and ground connections. These inputs contain the four high speed inputs that are used by the system for interrupts and latching.

XDIO Connector

The XDIO connector on the PLC Server is a 50-pin, standard density D-Sub female connector (see **Figure 4-3 on page 49** for location). There are 12 inputs and 8 outputs, each optically isolated from the circuitry of the PLC Server. The connector also provides 24V pins for powering customer equipment. There are four 24V pins and four ground pins, which are limited to a total of 1A of current. The source of the 24V is the XDC1 or XDC2 connector on the front of the PLC Server.

Input Signals

The XDIO connector handles input signals 1001 to 1012. Each channel has an input and a corresponding return line. See **Table 4-13** for input specifications. The connector pin-outs are shown in **Table 4-15 on page 74**.

Table 4-13. DIO Input Circuit Specifications (XDIO connector)

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 K Ω 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.

In the following figure, example 1 shows inputs (1001 to 1004) with a negative common, example 2 shows inputs (1005 to 1008) with a positive common, and example 3 shows inputs (1009 to 1012) with an independent power supply (no common).

NOTE: These are examples. Either method can be used on any channel.

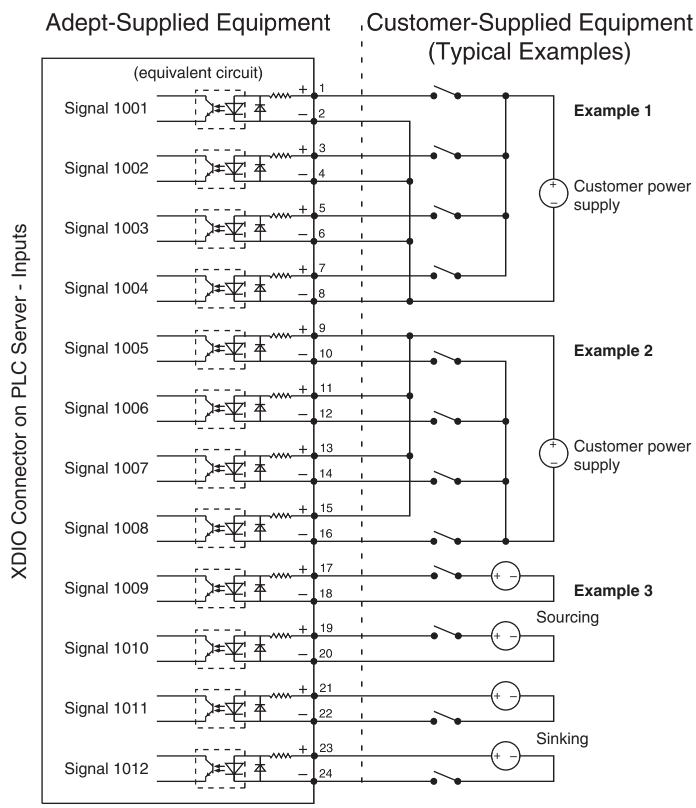


Figure 4-13. Digital Input Wiring Examples (XDIO Connector)

NOTE: Power from pins 41-44 and 47-50 can be substituted for the customer power supply. See Figure 4-14 on page 73 and Table 4-14 on page 72 for additional information.

Output Signals

The XDIO connector handles output signals 0001 to 0008. Refer to Table 4-14 for output specifications. The locations of the signals on the connector are shown in Table 4-15 on page 74. The XDIO connector provides separate positive and negative connections for each channel (no internal common connections). This allows the choice of wiring for current-sourcing or current-sinking modes.

Table 4-14. DIO Output Specifications (XDIO connector)

Operating voltage range	0 to 24 VDC
Operational current range, per channel	$I_{out} \leq$ 100 mA, short-circuit Protected
V_{drop} across output in "on" condition	$V_{drop} \leq$ 2.7 V at 100 mA $V_{drop} \leq$ 2.0 V at 10 mA
Output off leakage current	$I_{out} \leq$ 600 µA
Turn on response time (hardware) Software scan rate/response time	3 µsec maximum 16 ms scan cycle/ 32 ms max. response time
Turn off response time (hardware) Software scan rate/response time	200 µsec maximum 16 ms scan cycle/ 32 ms max. response time

Figure 4-14 shows two examples of different connections to the digital outputs on the XDIO connector. The examples are negative common and positive common using the internal 24V and ground connections.

Example 1: outputs 0001 to 0004 are shown with positive common.

Example 2: outputs 0005 to 0008 are shown with negative common.

NOTE: These are examples. Either method can be used, in any combination, on any channel. Also, an external customer-provided power supply could have been provided instead of the power provided on the XDIO connector.

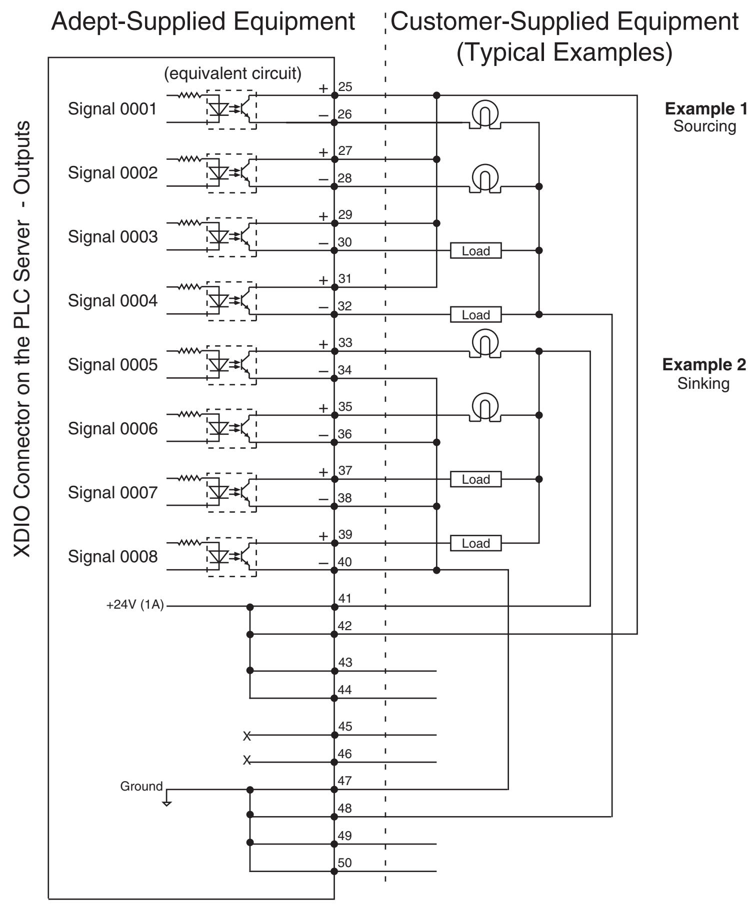
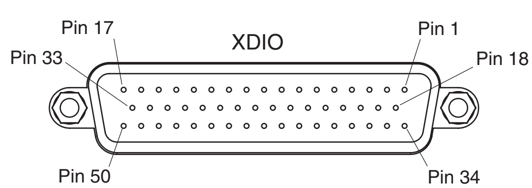


Figure 4-14. Digital Output Wiring for XDIO Connector

Table 4-15. XDIO Digital I/O Connector Pin Assignments

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	Input 1001	2	1001 return	27	Output 0002+	28	Output 0002–
3	Input 1002	4	1002 return	29	Output 0003+	30	Output 0003–
5	Input 1003	6	1003 return	31	Output 0004+	32	Output 0004–
7	Input 1004	8	1004 return	33	Output 0005+	34	Output 0005–
9	Input 1005	10	1005 return	35	Output 0006+	36	Output 0006–
11	Input 1006	12	1006 return	37	Output 0007+	38	Output 0007–
13	Input 1007	14	1007 return	39	Output 0008+	40	Output 0008–
15	Input 1008	16	1008 return	41	24V Output[a]	42	24V Output[a]
17	Input 1009	18	1009 return	43	24V Output[a]	44	24V Output[a]
19	Input 1010	20	1010 return	45	High Power On Indicator +	46	High Power On Indicator –
21	Input 1011	22	1011 return	47	24V return	48	24V return
23	Input 1012	24	1012 return	49	24V return	50	24V return
25	Output 0001+	26	Output 0001–				



[a] Limited to combined total of 1A of current.

System Operation 5

5.1 Robot Status LED Description

The robot Status LED Indicator is located on the top of the robot. The color and blinking pattern indicates the status of the robot.

The current robot models support the UL standard. The LED on these robots has an amber LED. See **Figure 5-1** for the status information displayed by this LED.

Legacy models have a bi-color, red and green LED. See Table 5-2 for the status information displayed by this LED.

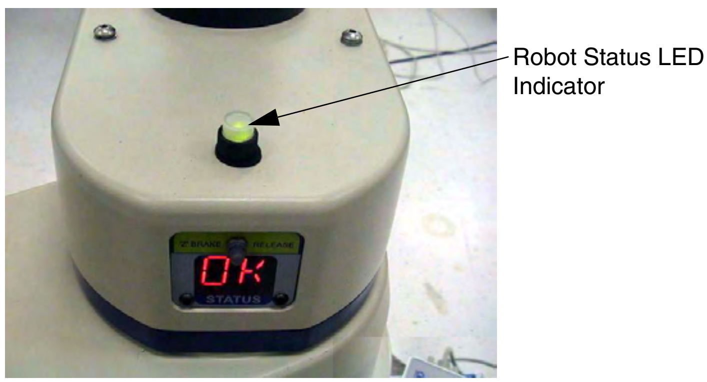


Figure 5-1. Robot Status LED Indicator Location

Table 5-1. Robot Status LED Definition on UL-Certified Robots

LED Status	2-Digit Status Panel Display	Description
Off	Off	24 VDC not present
Off	OK	High Power Disabled
Amber, Solid	ON	High Power Enabled
Amber, Slow Blink	N/A	Selected Configuration Node
Amber, Fast Blink	Fault Code(s)	Fault, see Diagnostics Display
Amber, Solid	Fault Code(s)	Fault, see Diagnostics Display

Table 5-2. Legacy Robot Status LED Definition

LED Status	Description
Off	24 VDC not present
Green, Slow Blink	High Power Disabled
Green, Fast Blink	High Power Enabled
Green/Red Blink	Selected Configuration Node
Red, Fast Blink	Fault, see Diagnostics Display
Solid Green or Red	Initialization or Robot Fault

5.2 Status Panel Fault Codes

The Status panel, shown in **Figure 5-2**, displays alpha-numeric codes that indicate the operating status of the robot, including detailed status codes. **Table 5-3** gives definitions of the status codes. These codes provide details for quickly isolating problems during troubleshooting.

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

Figure 5-2. Status Panel

Table 5-3. Status Panel Codes

LED	Status Code	LED	Status Code
OK	No Fault	h#	High Temp Amp (Joint #)
ON	High Power ON Status	H#	High Temp Encoder (Joint #)
MA	Manual Mode	hV	High Voltage Bus Fault
24	24V Supply Fault	I#	Initialization Stage (Step #)
A#	Amp Fault (Joint #)	M#	Motor Stalled (Joint #)
B#	IO Blox Fault (Address #)	NV	Non-Volatile Memory

Table 5-3. Status Panel Codes

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	V#	Hard Envelope Error (Joint #)

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. Instructions on configuring the Programmable E-Stop delay can be found within the SPEC section of the ***Instructions for Adept Utility Programs*** manual. The default setting is correct for most applications.

The braking system will not prevent you from moving the robot manually once the robot has stopped (and High Power has been removed).

In addition, Joint 3 has an electromechanical brake. The brake is released when High Power is enabled. When High Power is turned off, the brake engages and holds the position of Joint 3.

Brake Release Button

Under some circumstances you may want to manually position Joint 3 on the Z-Axis without turning on High Power. For such instances, a “Z” Brake Release button is located above the robot diagnostic panel (see **Figure 5-2 on page 76**). When system power is on, pressing this button releases the brake, which allows movement of Joint 3.

If this button is pressed while High Power is on, High Power will automatically shut down.

WARNING: Due to the effect of gravity, pressing the Brake Release button may cause the arm to fall.

When the Brake Release button is pressed, Joint 3 may drop to the bottom of its travel. To prevent possible damage to the equipment, make sure that Joint 3 is supported while releasing the brake and verify that the end-effector or other installed tooling is clear of all obstructions.

5.4 Commissioning the System

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

- Verifying installation, to confirm all tasks have been performed correctly.
- Starting up the system by turning on power for the first time.
- Verifying all E-Stops in the system function correctly.
- Move each axis of the robot with the customer-supplied PLC interface to confirm it moves in the proper directions.

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, make the following checks to ensure that the robot and PLC Server 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 or 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 end-of-arm tooling is properly installed.
- Verify that all other peripheral equipment is properly installed and in a state where it is safe to turn on power to the robot system.

System Cable Checks

Verify the following connections (see **Section 4.4 on page 51** for details):

- Front Panel to the PLC Server.
- PLC to PLC Server.
- User-supplied 24 VDC power to the PLC Server.
- User-supplied 24 VDC power to the Cobra PLC robot.
- User-supplied ground wire between the PLC Server and ground.
- User-supplied ground wire between the Cobra PLC robot and ground.
- User-supplied ground wire between the PLC and ground.
- IEEE 1394 cable into the SmartServo port 1.1 connector on the PLC Server, and the other end into the SmartServo port 1 connector on the robot interface panel.
- XSYS cable between the robot interface panel XSLV safety interlock connector and XSYS connector on the PLC Server.
- User-supplied 200/240 VAC power to the robot 200/240VAC connector.
- (Optional) User-supplied PLC Interface to PLC.
- (Optional) User-supplied desktop or notebook PC to PLC.

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 200/240VAC power.
2. Switch on the 24 VDC power to the robot.
3. Switch on the 24 VDC power to the PLC Server. The PLC server software will start automatically when the PLC Server is done booting.
4. Switch on the user-supplied PLC and any optional user-supplied equipment.
5. Wait for the system to complete the boot cycle.
6. The system is ready for operation.

Verifying E-Stop Functions

Verify that all E-Stop devices are functional (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.

Programming the Robot 6

6.1 PLC Server Software Overview

The Adept PLC Server communicates with the user-supplied PLC to retrieve the predefined data registers for executing robot motions. The programmer will use the familiar PLC software environment to sequence the robot by loading the PLC registers. Programs can be created using Ladder Diagram, Structured Text, Sequential Function Chart, or Function Block Diagram format.

The Adept PLC Server reads the command registers, executes the command, and returns the current state of the robot. No PLC MSG commands are required as the PLC Server will initiate all communication with the PLC to read/write the data.

This product is compatible with the Allen-Bradley SLC, MicroLogix and ControlLogix product lines.

NOTE: The Allen-Bradley PLC5 family is not currently supported.

6.2 Initializing a System

The user-supplied PLC communicates with the PLC Server through the DF1 protocol. See **"DF1 Protocol" on page 15** for details. See **Section 4.5 on page 51** for cable connection and PLC configuration details. During start-up, the PLC Server automatically determines the type of PLC being used (SLC/Micrologix or ControlLogix), and matches the PLC's baud rate.

The PLC's RS-232 communication port must be configured to use the DF1 Full Duplex driver, no parity, no handshaking, and CRC error checking. See **Figure 6-1**, **Figure 6-2** and **Figure 6-3** (below) for example screen shots of the channel configuration.

NOTE: The baud rate should be set at 38,400 (recommended) or 19,200.

RSLogix 500

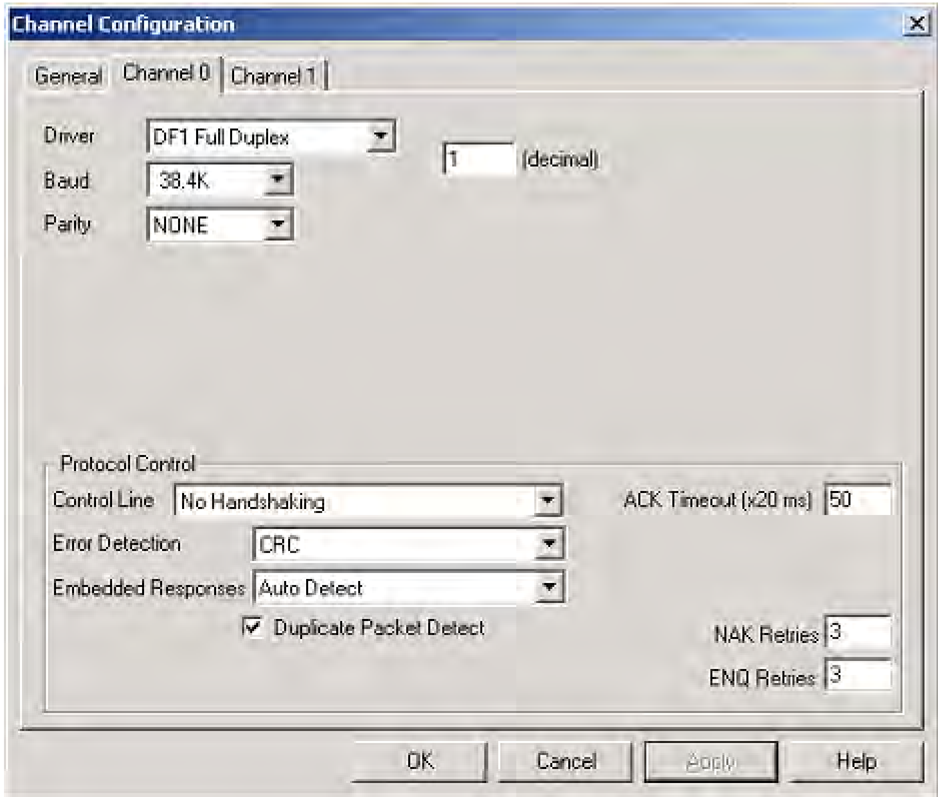


Figure 6-1. RSLogix 500 Channel configuration

RSLogix 5000

Figure 6-2. RSLogix 5000 Channel configuration (Protocol)

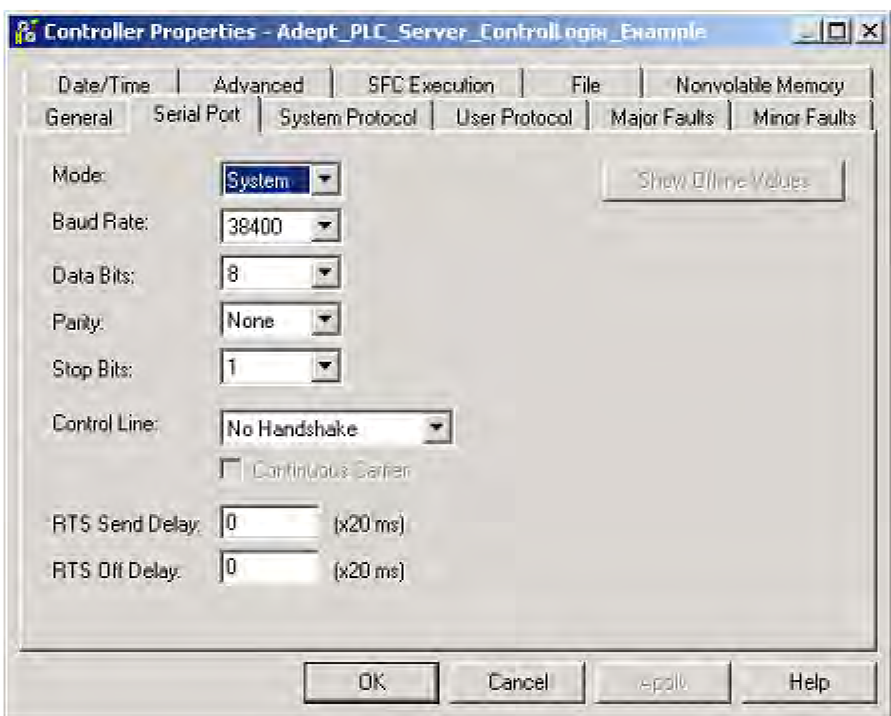


Figure 6-3. RSLogix 5000 Channel configuration (Serial Port)

6.3 PLC Software Overview

NOTE: Throughout this section, you will see references to RSLogix 500 registers. To find the corresponding RSLogix 5000 tag name, simply go to the table containing the referenced RSLogix 500 register and locate the corresponding RSLogix 5000 tag name in the adjacent column.

There Adept PLC Server uses five PLC registers: Command, Error, Position, Location & Pallet Definition, and Status. These are described in detail in the following sections.

The Command registers determine the functions performed by the Adept PLC robot. For example, if N30:0=1 (meaning bit 1 is on) then the PLC Server will attempt to enable robot high power. The Status registers reflect the current state of the PLC Server and robot. For example, if N31:0=6 (^B110) then the PLC Server is in a fault state and robot is calibrated. The real-value format registers contain floating point data that define location, pallet and motion parameters.

NOTE: With RSLogix 500, the PLC Server uses file 30 and above, as indicated in Table 6-2 through Table 6-12.

The table below lists the data types and format. Note that the PLC Server is responsible for requesting all data from the PLC.

Table 6-1. PLC Registers: Data Type, Format and Access

Data Type	Format	Access by PLC
Command Register	Integer	Write
Status Register	Integer	Read Only
Location & Pallet Definition Registers	Real	Write
Current Position Register	Real	Read Only
Error Message	String	Read Only

Command Registers

The following tables and sections describe the Command registers.

Table 6-2. PLC Command Registers

RSLogix 500	RSLogix 5000	Function
N30:0	Adept_Command_Bits	Instruction command register (see Table 6-3 on page 87)

RSLogix 500	RSLogix 5000	Function
N30:1	Adept_Output	Output Signals command register (see **Table 6-4 on page 88**)
N30:2	Adept_Jog_Mode	Jog Mode command register (see **Table 6-5 on page 88**)
N30:3	Adept_Motion_Qualifier	Motion Qualifier command register (see **Table 6-6 on page 89**)
N30:4	Adept_Speed	Motion/Jog speed
N30:5	Adept_Acceleration	Motion acceleration
N30:6	Adept_Location_Number	Location number
N30:7	Adept_Approach_Height	Approach height
N30:8	Adept_Pallet_Number	Pallet number
N30:9	Adept_Row_Count	Pallet row count
N30:10	Adept_Column_Count	Pallet column count
N30:11	Adept_Layer_Count	Pallet layer count

Moving the Robot

This section describes the "basic" steps for moving the robot. The method described here is useful when the robot must be stopped at the end of each motion, in order to perform some operation. Note that it does not use the Motion Counter, which means that the robot stops (i.e., the path is broken) at the end of each movement. Therefore, this method cannot be used to sequence motions together for continuous-path movement. If you require a continuous-path motion, please see "**Moving the Robot Using Continuous Path**" (below) for more details.

> **NOTE:** If you are not moving relative to a pallet (not a pallet motion) the value for N30:8 must be 0.

1. Load N30:4 with the motion speed.[1]
2. Load N30:5 with the motion acceleration.[1]

---

[1] There are no default values for the motion speed and acceleration. If moving to a taught location, an error will occur if a value that is less than or equal to 0 is entered. Additionally, if you specify a very low motion speed, it may take a long time for the robot to get to the requested position. Refer to **page 171** for more information on speed and acceleration.

3. Load N30:6 with the number of the location to be moved to (see **page 95** for details).
4. Set the motion qualifier bits in N30:3 (see **page 89** for details).
5. Enable N30:0/8 (Move robot bit) to start the motion (see **page 87** for details).
6. Wait for N31:0/5 (Command Executing) to go high, indicating the motion has started.
7. Wait for N31:0/6, which is enabled when the robot is in position.
8. Disable N30:0/8 (Move robot bit).
9. Wait for N31:0/5 (Command Executing) to go low, indicating the Move robot bit has been turned off.

Moving the Robot Using Continuous Path

This method uses the Motion Counter to track the robot motion. For a ladder-logic example, see **"Move Robot Routine" on page 112**. The advantage of this method is that it allows you to sequence motions together for continuous-path movement. See **"Continuous-Path Motion" on page 173** for information on continuous paths.

1. Load N30:4 with the motion speed.[1]
2. Load N30:5 with the motion acceleration.[1]
3. Load N30:6 with the number of the location to be moved to (see **page 95** for details).
4. Enable/disable the motion qualifier bits in N30:3 (see **page 89** for details).
5. Record the value in N31:2, the Current Motion Counter
6. Enable N30:0/8 (Move-robot bit) to start the motion (see **page 87** for details).
7. Wait for the Current Motion Counter (N31:2) to change.
8. Start the next motion at Step 1.

   NOTE: If you are going to delay issuing the next motion (wait for a signal on timer) then you must turn off the Move command bit. Otherwise, the PLC Server may read the command register while the PLC is writing to it, which could result in an unexpected command being executed.

[1] There are no default values for the motion speed and acceleration. If moving to a taught location, an error will occur if a value that is less than or equal to 0 is entered. Additionally, if you specify a very low motion speed, it may take a long time for the robot to get to the requested position. Refer to **page 171** for more information on speed and acceleration.

Instruction Command Register

The table below describes the Instruction command register definitions.

Table 6-3. Instruction command register definitions

Bit	RSLogix 500	RSLogix 5000	Description
0	N30:0/0	Adept_Command_Bits.0	Enable high power
1	N30:0/1	Adept_Command_Bits.1	Update current position
2	N30:0/2	Adept_Command_Bits.2	RESERVED
3	N30:0/3	Adept_Command_Bits.3	RESERVED
4	N30:0/4	Adept_Command_Bits.4	RESERVED
5	N30:0/5	Adept_Command_Bits.5	Reset fault condition
6	N30:0/6	Adept_Command_Bits.6	Calibrate robot
7	N30:0/7	Adept_Command_Bits.7	Enable jog mode
8	N30:0/8	Adept_Command_Bits.8	Move robot
9	N30:0/9	Adept_Command_Bits.9	Define location
10	N30:0/10	Adept_Command_Bits.10	Define pallet
11	N30:0/11	Adept_Command_Bits.11	RESERVED
12	N30:0/12	Adept_Command_Bits.12	RESERVED
13	N30:0/13	Adept_Command_Bits.13	RESERVED
14	N30:0/14	Adept_Command_Bits.14	RESERVED
15	N30:0/15	Adept_Command_Bits.15	RESERVED

Bits 0 through 5 can be on or off regardless of the settings of the other command-word bits. However, only one of the 5 through 15 bits can be on at any time. Otherwise, a -3007 error will occur (see Section 6.5 on page 133).

Bit 0 attempts to enable robot high-power, if the system is not in a fault state. If faulted, this bit will have no effect. This bit must be latched on for high-power to be maintained.

Bit 1 commands the PLC Server to update the current robot position registers (F34 or Adept_Here). The data in these registers might or might not be valid if the robot has not been calibrated. Due the amount of data being transmitted, this bit should be off as much as possible to improve DF1 communication performance.

Bit 5 resets the PLC Server if it is in a fault state. The current error message (ST35 or Adept_Error) is cleared with the reset command.

Bit 6 requests calibration of the robot if the system is not faulted and if robot high power is on (N31:0/0 or Adept_Status_Bits.0).

Output Signals Command Register

The table below describes the Output Signals command register

Table 6-4. Output Signals Command Register

Bit	RSLogix 500	RSLogix 5000	Function
0	N30:1/0	Adept_Output.0	XDIO Output 1
1	N30:1/1	Adept_Output.1	XDIO Output 2
2	N30:1/2	Adept_Output.2	XDIO Output 3
3	N30:1/3	Adept_Output.3	XDIO Output 4
4	N30:1/4	Adept_Output.4	XDIO Output 5
5	N30:1/5	Adept_Output.5	XDIO Output 6
6	N30:1/6	Adept_Output.6	XDIO Output 7
7	N30:1/7	Adept_Output.7	XDIO Output 8
8	N30:1/8	Adept_Output.8	Gripper Output 3001
9	N30:1/9	Adept_Output.9	Gripper Output 3002
10	N30:1/10	Adept_Output.10	RESERVED
11	N30:1/11	Adept_Output.11	RESERVED
12	N30:1/12	Adept_Output.12	RESERVED
13	N30:1/13	Adept_Output.13	RESERVED
14	N30:1/14	Adept_Output.14	RESERVED
15	N30:1/15	Adept_Output.15	RESERVED

The XDIO connector is located on the front of the PLC Server. See Section 4.11 on page 70 for detailed wiring information. The gripper signals (3001 and 3002) are part of an optional solenoid kit that can be purchased from Adept (see Section 7.5 on page 141).

Jog Mode Command Register

The table below describes the Jog Mode command register.

Table 6-5. Jog Mode Command Register

Bit	RSLogix 500	RSLogix 5000	Function	Description
0	N30:2/0	Adept_Jog_Mode.0	Enable World mode	Bit on: Jog axis in World mode
1	N30:2/1	Adept_Jog_Mode.1	Enable Tool mode	Bit on: Jog axis in Tool mode

Bit	RSLogix 500	RSLogix 5000	Function	Description
2	N30:2/2	Adept_Jog_Mode.2	Enable Joint mode	Bit on: Jog axis in Joint mode
3	N30:2/3	Adept_Jog_Mode.3	Enable Free mode	Bit on: Put axis in Free mode
4	N30:2/4	Adept_Jog_Mode.4		RESERVED
5	N30:2/5	Adept_Jog_Mode.5	Joint 1/X-axis	Bit on: Select joint 1 or X-axis for jogging
6	N30:2/6	Adept_Jog_Mode.6	Joint 2/Y-axis	Bit on: Select joint 2 or Y-axis for jogging
7	N30:2/7	Adept_Jog_Mode.7	Joint 3/Z-axis	Bit on: Select joint 3 or Z-axis for jogging
8	N30:2/8	Adept_Jog_Mode.8	Joint 4/Yaw-angle	Bit on: Select joint 4/Yaw-angle for jogging
9	N30:2/9	Adept_Jog_Mode.9	Joint 5/Pitch-angle	Bit on: Select joint 5/Pitch-angle for jogging
10	N30:2/10	Adept_Jog_Mode.10	Joint 6/Roll-angle	Bit on: Select joint 6/Roll-angle for jogging
11	N30:2/11	Adept_Jog_Mode.11		RESERVED
12	N30:2/12	Adept_Jog_Mode.12		RESERVED
13	N30:2/13	Adept_Jog_Mode.13		RESERVED
14	N30:2/14	Adept_Jog_Mode.14		RESERVED
15	N30:2/15	Adept_Jog_Mode.15		RESERVED

Only one of the jog-mode bits (bits 0-3) can be on at a time. When World, Tool, or Joint mode is selected, only one joint or axis bit (bits 5-10) can be selected. In Free mode, multiple joints or axes can be selected.

In jog mode, the motion speed parameter may have a value from -127 to 127 (the sign determines the direction of motion). The value 0 stops the motion. A value outside of -127 to 127 generates a fault. See **“Speed, Acceleration, and Deceleration” on page 171** for more information.

Motion Qualifier Command Register

The table below describes the Motion Qualifier command register.

Table 6-6. Motion Qualifier Command Register

Bit	RSLogix 500	RSLogix 5000	Bit Off	Bit On
0	N30:3/0	Adept_Motion_Qualifier.0	Absolute motion	Relative motion

Bit	RSLogix 500	RSLogix 5000	Bit Off	Bit On
1	N30:3/1	Adept_Motion_Qualifier.1	Cartesian coordinates	Joint coordinates
2	N30:3/2	Adept_Motion_Qualifier.2		RESERVED
3	N30:3/3	Adept_Motion_Qualifier.3		RESERVED
4	N30:3/4	Adept_Motion_Qualifier.4		RESERVED
5	N30:3/5	Adept_Motion_Qualifier.5		RESERVED
6	N30:3/6	Adept_Motion_Qualifier.6		RESERVED
7	N30:3/7	Adept_Motion_Qualifier.7	Trapezoidal acceleration	S-curve acceleration
8	N30:3/8	Adept_Motion_Qualifier.8	Relative approach height	Absolute approach height
9	N30:3/9	Adept_Motion_Qualifier.9	Joint motion	Straight-line motion
10	N30:3/10	Adept_Motion_Qualifier.10	Null after motion	No-null after motion
11	N30:3/11	Adept_Motion_Qualifier.11	Fine nulling tolerances	Coarse nulling tolerances
12	N30:3/12	Adept_Motion_Qualifier.12	Multiple-turn wrist	Single-turn wrist
13	N30:3/13	Adept_Motion_Qualifier.13	Lefty arm configuration	Righty arm configuration
14	N30:3/14	Adept_Motion_Qualifier.14	Above arm configuration	Below arm configuration
15	N30:3/15	Adept_Motion_Qualifier.15	Flip arm configuration	No-flip arm configuration

The motion qualifier bits are used to define the characteristics of the next motion whenever a move command is given (N30:0/8 or Adept_Commands_Bits.8). Any combination of the bits can be set.

Bit 0 determines if the motion is to absolute coordinates or relative to the robot's current position. For relative motion, the coordinates of the specified destination location are added to the current position. Thus, this type of motion is relative to absolute Cartesian coordinates, not relative to the tool.

Bit 1 determines whether the component values of the location that is referenced by the Location Number register (N30:6 or Adept_Location_Number) are Cartesian or joint coordinates.

Bit 7 selects the acceleration profile that will be used to start and end the motion. The trapezoidal profile (bit 7 off) consists of a constant acceleration to the steady-state transit speed, followed by a constant deceleration to the motion endpoint. The S-curve profile (bit 7 on) consists of a soft transition between: stopped to acceleration ramp; acceleration ramp to steady-state transit speed; steady-state transit speed to deceleration ramp; and deceleration to motion end point (see **Figure 6-4**).

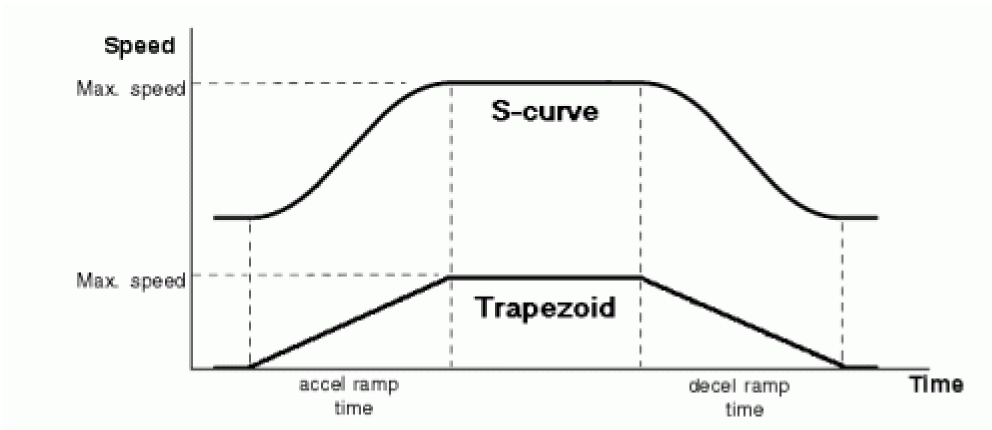


Figure 6-4. S-Curve versus Trapezoid Acceleration Profile

Bit 8 determines the effect of the approach-height value (N30:7 or Adept_Approach_Height).

- If this bit is off, the next motion will approach the location with this Z offset.
- If this bit is on, the next motion moves to the specified destination location using this absolute Z value, based on the World Coordinate System.

NOTE: This overrides the setting of bit 0.

See **page 172** for more details on approach and depart; see **page 175** for more details on the World Coordinate System.

Bit 9 determines if the motion will be joint-interpolated or straight-line. If straight-line motion is chosen, it is not possible to change the arm configuration during the motion (see bits 13 to 15).

When bit 10 is off, continuous-path motion is disabled, and the robot will null at the destination before the next motion is planned. This could increase cycle time. Setting this bit will allow the PLC Server to blend motions (i.e., round corners between motion segments), assuming that the next motion is commanded in sufficient time.

Bit 11, which is used only when bit 10 is off, determines the nulling tolerances that will apply at the end of the motion. Fine (bit 11 off) specifies tighter settling than coarse (bit 11 on).

Bit 12 off allows full rotations of the robot wrist joints (joint 4 on an Adept Cobra robot). Turning bit 12 on limits rotations of the wrist joints to the range ±180 degrees.

Bits 13-15 determine the arm configuration that is to be achieved during the motion. For the Cobra PLC robot, only bit 12 (Lefty/Righty) has any effect. The arm configuration cannot be changed during a straight-line motion (see bit 9).

When a motion is commanded, the speed and acceleration parameters must be greater than 0 (except that a negative speed is okay for a jog-mode motion). Otherwise, an error will be returned. There are no default values. If moving to taught location and a value that is less than or equal to 0 is entered, an error will occur. Additionally, if you specify a very low motion speed, it may take a long time for the robot to get to the requested position. Refer to page 171 for more information on speed and acceleration.

If the motion destination is defined relative to a pallet, the pallet-number parameter (N30:8 or Adept_Pallet_Number) determines to which pallet the location will be relative. The row (N30:9 or Adept_Row_Count), column (N30:10 or Adept_Column_Count), and layer (N30:11 or Adept_Layer_Count) values are multiplied by their respective spacing parameters (which are defined with the pallet) to determine the pallet reference frame. The specified destination location is applied to that reference frame to determine the motion endpoint.

Status Registers

The tables and sections below describe the Status registers.

Table 6-7. Status Registers

RSLogix 500	RSLogix 5000	Function	Form
N31:0	Adept_Status_Bits	Main status bits (see Table 6-8 on page 92)	Bit-encoded integer
N31:1	Adept_Inputs	Inputs (see Table 6-9 on page 93)	Bit-encoded integer
N31:2	Adept_Current_Motion _Counter	Current motion number (see "Current Motion Counter" on page 94)	Integer
F34	Adept_Here	Current position (see Table 6-10 on page 94)	Real array
ST35	Adept_Error	Error message (see "Error Register" on page 95)	String

Status Word Bit Definitions

The following table describes the Status word bit definitions.

Table 6-8. Status Word Bit Definitions

Bit	RSLogix 500	RSLogix 5000	State Description
0	N31:0/0	Adept_Status_Bits.0	Robot power is on
1	N31:0/1	Adept_Status_Bits.1	System is faulted

Bit	RSLogix 500	RSLogix 5000	State Description
2	N31:0/2	Adept_Status_Bits.2	Robot is calibrated?
3	N31:0/3	Adept_Status_Bits.3	System is initialized
4	N31:0/4	Adept_Status_Bits.4	E-stop is pressed
5	N31:0/5	Adept_Status_Bits.5	Command is executing
6	N31:0/6	Adept_Status_Bits.6	Robot is in position
7	N31:0/7	Adept_Status_Bits.7	RESERVED
8	N31:0/8	Adept_Status_Bits.8	RESERVED
9	N31:0/9	Adept_Status_Bits.9	RESERVED
10	N31:0/10	Adept_Status_Bits.10	RESERVED
11	N31:0/11	Adept_Status_Bits.11	RESERVED
12	N31:0/12	Adept_Status_Bits.12	RESERVED
13	N31:0/13	Adept_Status_Bits.13	Robot has RIGHTY configuration
14	N31:0/14	Adept_Status_Bits.14	Robot has LEFTY configuration
15	N31:0/15	Adept_Status_Bits.15	Robot has FLIP configuration

Input Word Bit Definitions

The following table describes the Input Word bit definitions.

Table 6-9. Input Word Bit Definitions

Bit	RSLogix 500	RSLogix 5000	Description
0	N31:1/0	Adept_Input.0	XDIO Input 1001
1	N31:1/1	Adept_ Input.1	XDIO Input 1002
2	N31:1/2	Adept_ Input.2	XDIO Input 1003
3	N31:1/3	Adept_ Input.3	XDIO Input 1004
4	N31:1/4	Adept_ Input.4	XDIO Input 1005
5	N31:1/5	Adept_ Input.5	XDIO Input 1006
6	N31:1/6	Adept_ Input.6	XDIO Input 1007
7	N31:1/7	Adept_ Input.7	XDIO Input 1008
8	N31:1/8	Adept_ Input.8	XDIO Input 1009

Bit	RSLogix 500	RSLogix 5000	Description
9	N31:1/9	Adept_ Input.9	XDIO Input 1010
10	N31:1/10	Adept_ Input.10	XDIO Input 1011
11	N31:1/11	Adept_ Input.11	XDIO Input 1012
12	N31:1/12	Adept_ Input.12	RESERVED
13	N31:1/13	Adept_ Input.13	RESERVED
14	N31:1/14	Adept_ Input.14	RESERVED
15	N31:1/15	Adept_ Input.15	RESERVED

Current Motion Counter

The current motion counter (N31:2 or Adept_Current_Motion_Counter) is incremented each time a motion begins. It can be used to indicate that the previous motion command has started and the next motion parameters can be loaded into the command registers. This gives the optimum continuous-path performance. Without this counter, the programmer would need to handshake with the command-executing bit to determine when a motion has started, which would introduce delay into trajectory planning.

> **NOTE:** If your program is using this in conjunction with a timer or other event, you must turn off the latch bit. Otherwise, the program could read position registers during an update, which could result in corrupted data.

Current Position Array

The following table describes the Current Position array.

Table 6-10. Current Position Array

RSLogix 500	RSLogix 5000	Function
F34:0	Adept_Here.0	Current X-axis coordinate
F34:1	Adept_Here.1	Current Y-axis coordinate
F34:2	Adept_Here.2	Current Z-axis coordinate
F34:3	Adept_Here.3	Current Yaw-angle coordinate
F34:4	Adept_Here.4	Current Pitch-angle coordinate
F34:5	Adept_Here.5	Current Roll-angle coordinate
F34:6	Adept_Here.6	Current Joint-1 position
F34:7	Adept_Here.7	Current Joint-2 position
F34:8	Adept_Here.8	Current Joint-3 position
F34:9	Adept_Here.9	Current Joint-4 position
F34:10	Adept_Here.10	Current Joint-5 position

RSLogix 500	RSLogix 5000	Function
F34:11	Adept_Here.11	Current Joint-6 position

When teaching locations, it is up to the programmer or system developer to create a method for storing that data, for example, in a data table. (The data structure for storing the taught locations in the PLC is up to you.) Then, when moving the robot to one of those locations, the data must be moved from the data table into the Adept Location registers (F32:0-5 or Adept_Location.0-5) or, if using a pallet, a combination of the Adept Location registers (F32:0-5 or Adept_Location.0-5) and the Adept Pallet registers (F33:0-5 Adept_Pallet.0-5).

To teach (record) a location:

1. Enable N30:0/1 (Update position registers) bit (see **Table 6-3 on page 87**).
2. Move F34:0-5 (current robot coordinates) to appropriate data array.

Error Register

The current error register (ST35 or Adept_Error) is a string containing the current system error message. The maximum message length is 82 characters. The current error is cleared when a fault reset command is issued.

Location & Pallet Register Definitions

This section describes the Location registers and the steps used for defining a location in the PLC Server. All location data are stored in the PLC, and need to be sent to the PLC Server for use.

Table 6-11. Location & Pallet Register Definitions

RSLogix 500	RSLogix 5000	Function
F32:0	Adept_Location.0	Joint-1 or X-axis coordinate
F32:1	Adept_Location.1	Joint-2 or Y-axis coordinate
F32:2	Adept_Location.2	Joint-3 or Z-axis coordinate
F32:3	Adept_Location.3	Joint-4 or Yaw-angle coordinate
F32:4	Adept_Location.4	Joint-5 or Pitch-angle coordinate
F32:5	Adept_Location.5	Joint-6 or Roll-angle coordinate

To define a location in the PLC Server:

1. Enter the appropriate coordinates into the registers listed in **Table 6-11**. See **"Defining a Location" on page 176** for more details on defining locations.
2. Put the number of the location to be defined into N30:6 or Adept_Location_Number.

3. Turn on the “define location” command bit (N30:0/9 or Adept_Command_Bits.9)
4. Wait for the “command executing” bit to be set (N31:0/5 or Adept_Status_Bits.5).
5. Turn off the “define location” command bit.

Pallet Registers

This section describes the Pallet registers and the steps used for defining a pallet.

Table 6-12. Pallet Register Definitions

RSLogix 500	RSLogix 5000	Function
F33:0	Adept_Pallet.0	Pallet row spacing (mm)
F33:1	Adept_Pallet.1	Pallet column spacing (mm)
F33:2	Adept_Pallet.2	Pallet layer spacing (mm)
F33:3	Adept_Pallet.3	Location number for pallet origin
F33:4	Adept_Pallet.4	Location number for pallet X-axis
F33:5	Adept_Pallet.5	Location number for pallet Y-axis

To define a pallet in the PLC Server:

1. Enter the pallet spacing and pallet frame parameters into the registers listed in **Table 6-12**. See **“Defining a Reference Frame” on page 180** for details on defining a pallet frame.
2. Enter the number of the pallet to be defined into N30:8 or Adept_Pallet_Number.
3. Turn on the “define pallet” command bit (N30:0/10 or Adept_Command_Bits.10)
4. Wait for the “command executing” bit to be set (N31:0/5 or Adept_Status_Bits.5).
5. Turn off the “define pallet” command bit.

6.4 Programming an Application from the PLC

This section contains ladder-logic examples that can be used as an aid in developing your application. These examples are also available for download from the Adept website Download Center. To access the Download Center, go to:

http://www.adept.com/main/support/index.asp

and select Adept Download Center. In the Download ID field, enter 5092 and click SEARCH to locate the file.

> **NOTE:** The examples are designed for the RSLogix 5000 PLC. If you are using the RSLogix 500 PLC, please note that the addressing will be different.

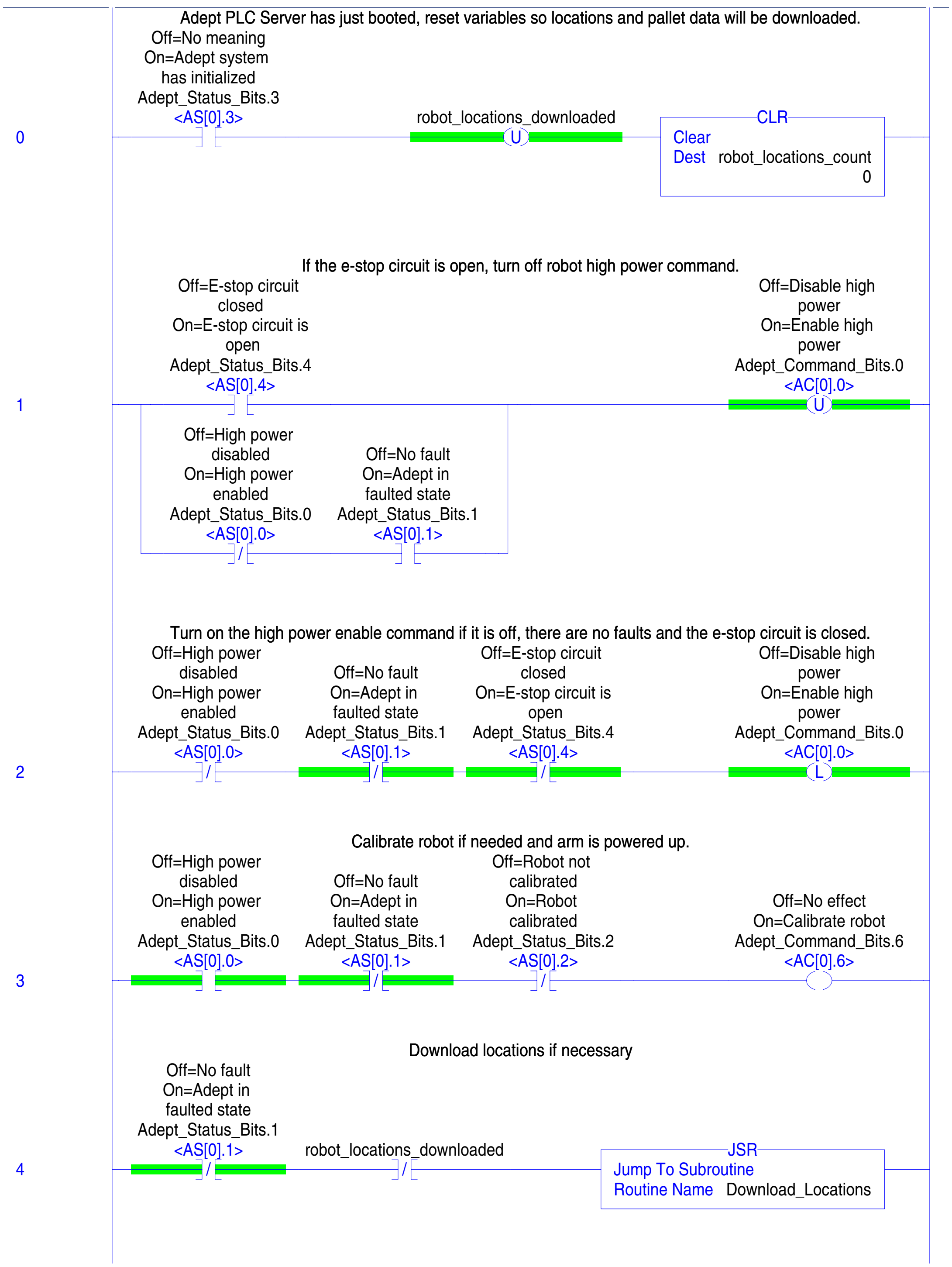
Main Routine

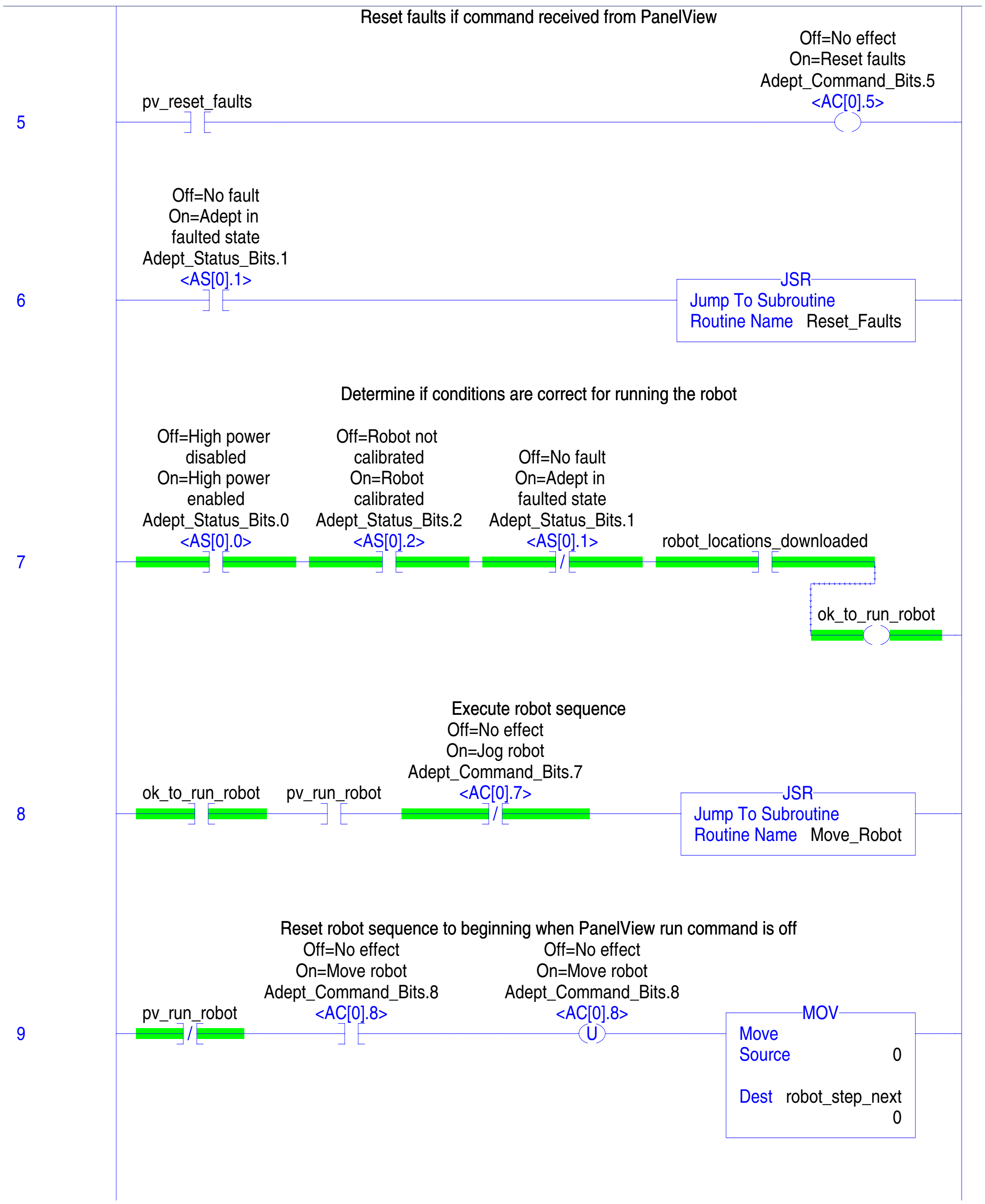
This section shows the ladder logic and tag files for a main routine of a pick-and-place program. The subroutines called by the main routine are shown in later sections.

MainRoutine - Ladder Diagram **Page 1**

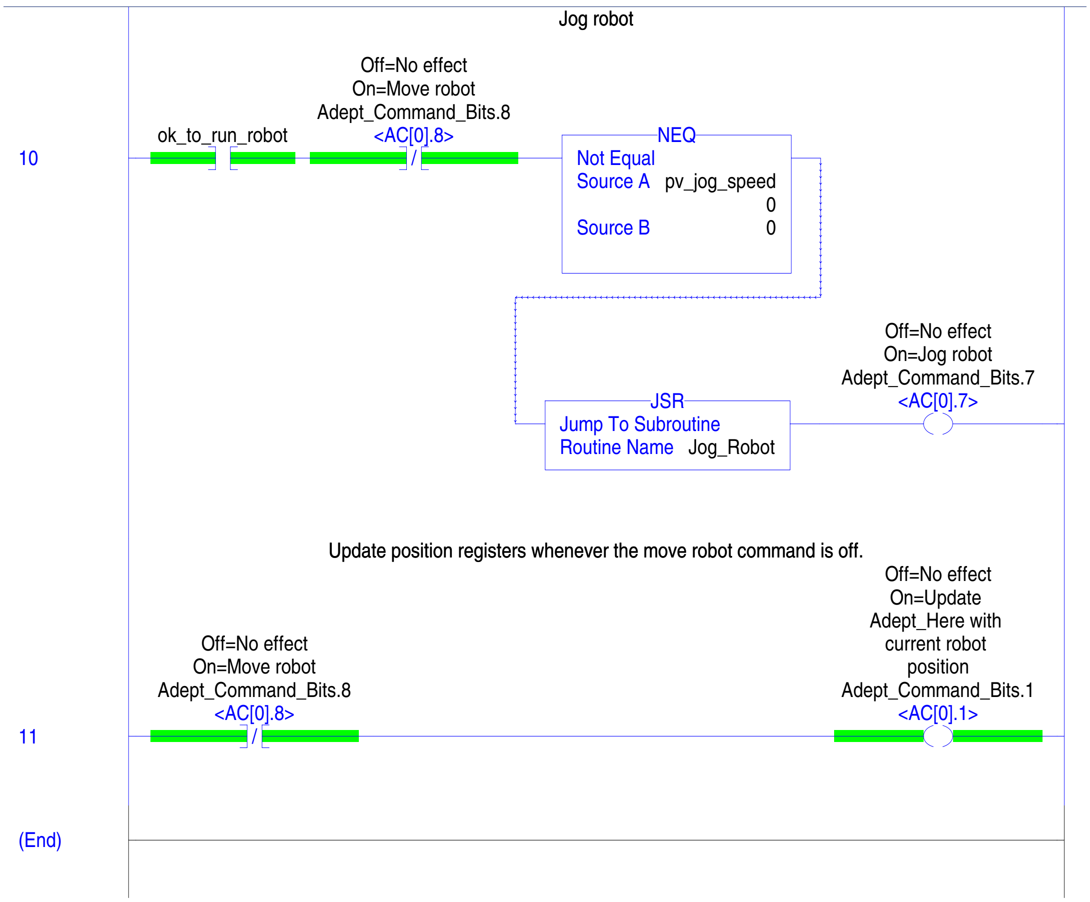
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/4/2004 9:34:48 AM

Total number of rungs: 12 ControlLogix_Example.ACD




Reset faults if command received from PanelView
5
pv_reset_faults
Off=No effect
On=Reset faults
Adept_Command_Bits.5
<AC[0].5>
6
Off=No fault
On=Adept in
faulted state
Adept_Status_Bits.1
<AS[0].1>
JSR
Jump To Subroutine
Routine Name Reset_Faults
Determine if conditions are correct for running the robot
7
Off=High power
disabled
On=High power
enabled
Adept_Status_Bits.0
<AS[0].0>
Off=Robot not
calibrated
On=Robot
calibrated
Adept_Status_Bits.2
<AS[0].2>
Off=No fault
On=Adept in
faulted state
Adept_Status_Bits.1
<AS[0].1>
robot_locations_downloaded
ok_to_run_robot
Execute robot sequence
8
ok_to_run_robot
pv_run_robot
Off=No effect
On=Jog robot
Adept_Command_Bits.7
<AC[0].7>
JSR
Jump To Subroutine
Routine Name Move_Robot
Reset robot sequence to beginning when PanelView run command is off
9
pv_run_robot
Off=No effect
On=Move robot
Adept_Command_Bits.8
<AC[0].8>
Off=No effect
On=Move robot
Adept_Command_Bits.8
<AC[0].8>
U
MOV
Move
Source 0
Dest robot_step_next
0

MainRoutine - Ladder Diagram **Page 3**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/4/2004 9:34:48 AM
Total number of rungs: 12 ControlLogix_Example.ACD



Tag Name	Type	Description
⊟-Adept_Command_Bits	INT	Robot command bits
├Adept_Command_Bits.0	BOOL	Off=Disable high power On=Enable
├Adept_Command_Bits.1	BOOL	Off=No effect On=Update Adept_He
├Adept_Command_Bits.5	BOOL	Off=No effect On=Reset faults
├Adept_Command_Bits.6	BOOL	Off=No effect On=Calibrate robot
├Adept_Command_Bits.7	BOOL	Off=No effect On=Jog robot
├Adept_Command_Bits.8	BOOL	Off=No effect On=Move robot
├Adept_Command_Bits.9	BOOL	Off=No effect On=Download Adept_
└Adept_Command_Bits.10	BOOL	Off=No effect On=Download Adept_
⊟-Adept_Status_Bits	INT	Adept Status Bits
├Adept_Status_Bits.0	BOOL	Off=High power disabled On=High p
├Adept_Status_Bits.1	BOOL	Off=No fault On=Adept in faulted sta
├Adept_Status_Bits.2	BOOL	Off=Robot not calibrated On=Robot
├Adept_Status_Bits.3	BOOL	Off=No meaning On=Adept system h
├Adept_Status_Bits.4	BOOL	Off=E-stop circuit closed On=E-stop
├Adept_Status_Bits.5	BOOL	Off=Command is not executing On=
├Adept_Status_Bits.6	BOOL	Off=Robot in motion On=Robot finis
├Adept_Status_Bits.13	BOOL	Off=Robot has lefty configuration On
├Adept_Status_Bits.14	BOOL	Off=Robot has above configuration O
└Adept_Status_Bits.15	BOOL	Off=Robot has flip configuration On
ok_to_run_robot	BOOL	
⊞-pv_jog_speed	INT	
pv_reset_faults	BOOL	
pv_run_robot	BOOL	
⊞-robot_locations_count	INT	
robot_locations_downloaded	BOOL	
⊞-robot_step_next	INT	

Reference	Scope	Program	Routine	BaseTag	Referenced At [*=Destructive, ?=Not Verified]
Adept_Command_Bits.0	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].0	*1(OTU) *2(OTL)
Adept_Command_Bits.1	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].1	*11(OTE)
Adept_Command_Bits.10	Adept_PLC_Server_ControlLogix_Example	MainProgram	Reset_Faults	AC[0].10	*0(OTU)
Adept_Command_Bits.5	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].5	*5(OTE)
Adept_Command_Bits.6	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].6	*3(OTE)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.7	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].7	8(XIO) *10(OTE)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.8	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].8	9(XIC) *9(OTU) 10(XIO) 11(XIO)
			Move_Robot		0(XIO) *7(OTL) *16(OTL) *25(OTL) *34(OTL) *43(OTL) *52(OTL) *61(OTL)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.9	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations	AC[0].9	0(XIO) *9(OTL) 11(XIC) *11(OTU) 12(XIO)
			Reset_Faults		*0(OTU)
Adept_Status_Bits.0	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].0	1(XIO) 2(XIO) 3(XIC) 7(XIC)
Adept_Status_Bits.1	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].1	1(XIC) 2(XIO) 3(XIO) 4(XIO) 6(XIC) 7(XIO)
Adept_Status_Bits.2	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].2	3(XIO) 7(XIC)
Adept_Status_Bits.3	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].3	0(XIC)
Adept_Status_Bits.4	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].4	1(XIC) 2(XIO)
Adept_Status_Bits.5	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations	AS[0].5	0(XIO) 11(XIC) 12(XIC)
			Move_Robot		0(XIO)

Reference	Scope	Program	Routine	BaseTag	Referenced At [*=Destructive, ?=Not Verified]
Adept_Status_Bits.6	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AS[0].6	27(XIC) 54(XIC)
ok_to_run_robot	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine		*7(OTE) 8(XIC) 10(XIC)
pv_jog_speed	Adept_PLC_Server_ControlLogix_Example	MainProgram	Jog_Robot		1(MOV)
			MainRoutine		10(NEQ)
pv_reset_faults	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine		5(XIC)
pv_run_robot	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine		8(XIC) 9(XIO)
			Reset_Faults		*2(OTU)
robot_locations_count	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		*1(ADD) 1(ADD) 2(MOV) 3(MOV) 4(MOV) 5(MOV) 6(MOV) 7(MOV) 8(MOV) 12(EQU) *12(CLR)
			MainRoutine		*0(CLR)
robot_locations_downloaded	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		*12(OTL)
			MainRoutine		*0(OTU) 4(XIO) 7(XIC)
robot_step_next	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine		*9(MOV)
			Move_Robot		0(EQU) *6(MOV) 9(EQU) *15(MOV) 18(EQU) *24(MOV) 27(EQU) *33(MOV) 36(EQU) *42(MOV) 45(EQU) *51(MOV) 54(EQU) *60(MOV)
			Reset_Faults		*1(CLR)

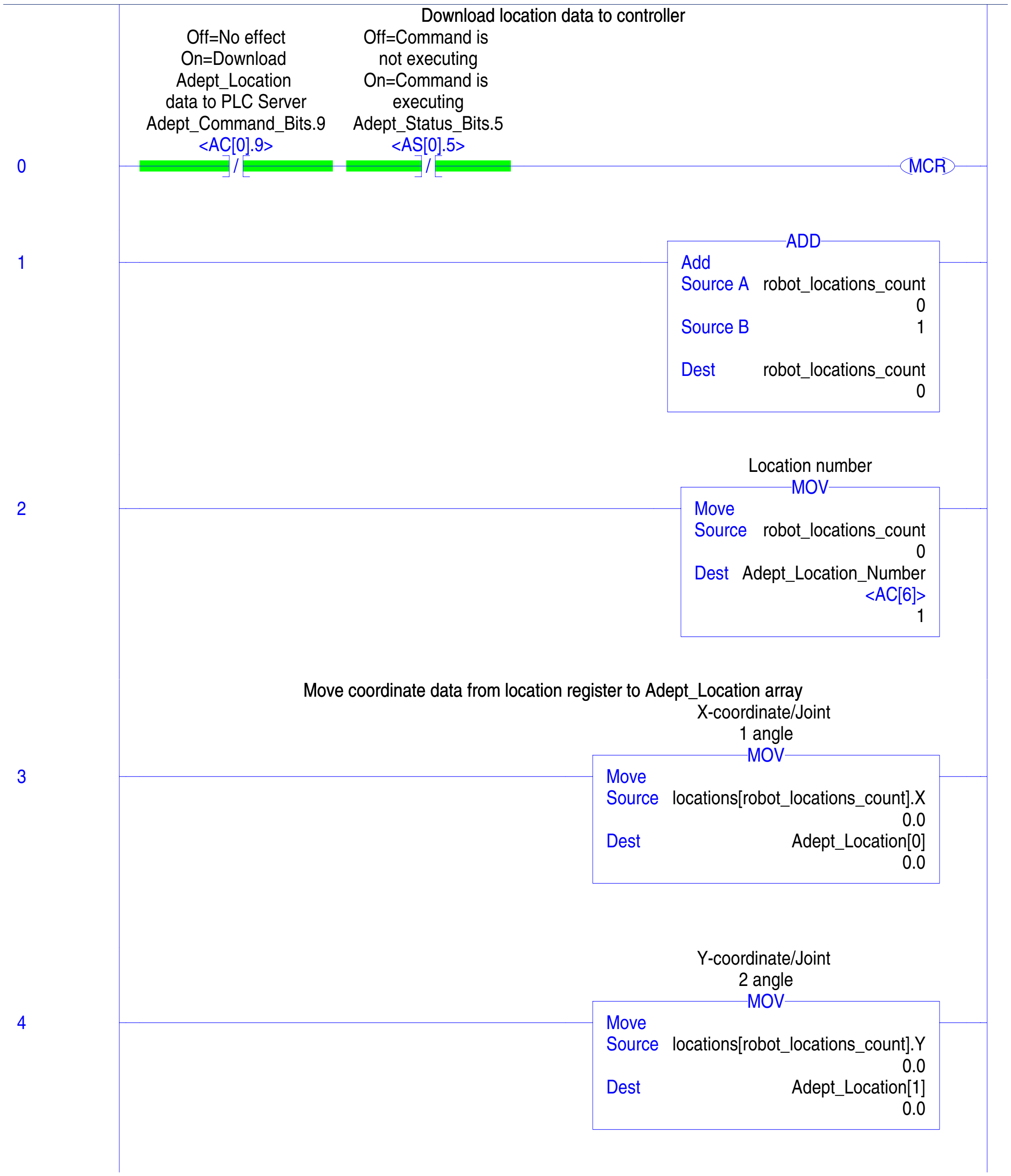
Download Locations Routine

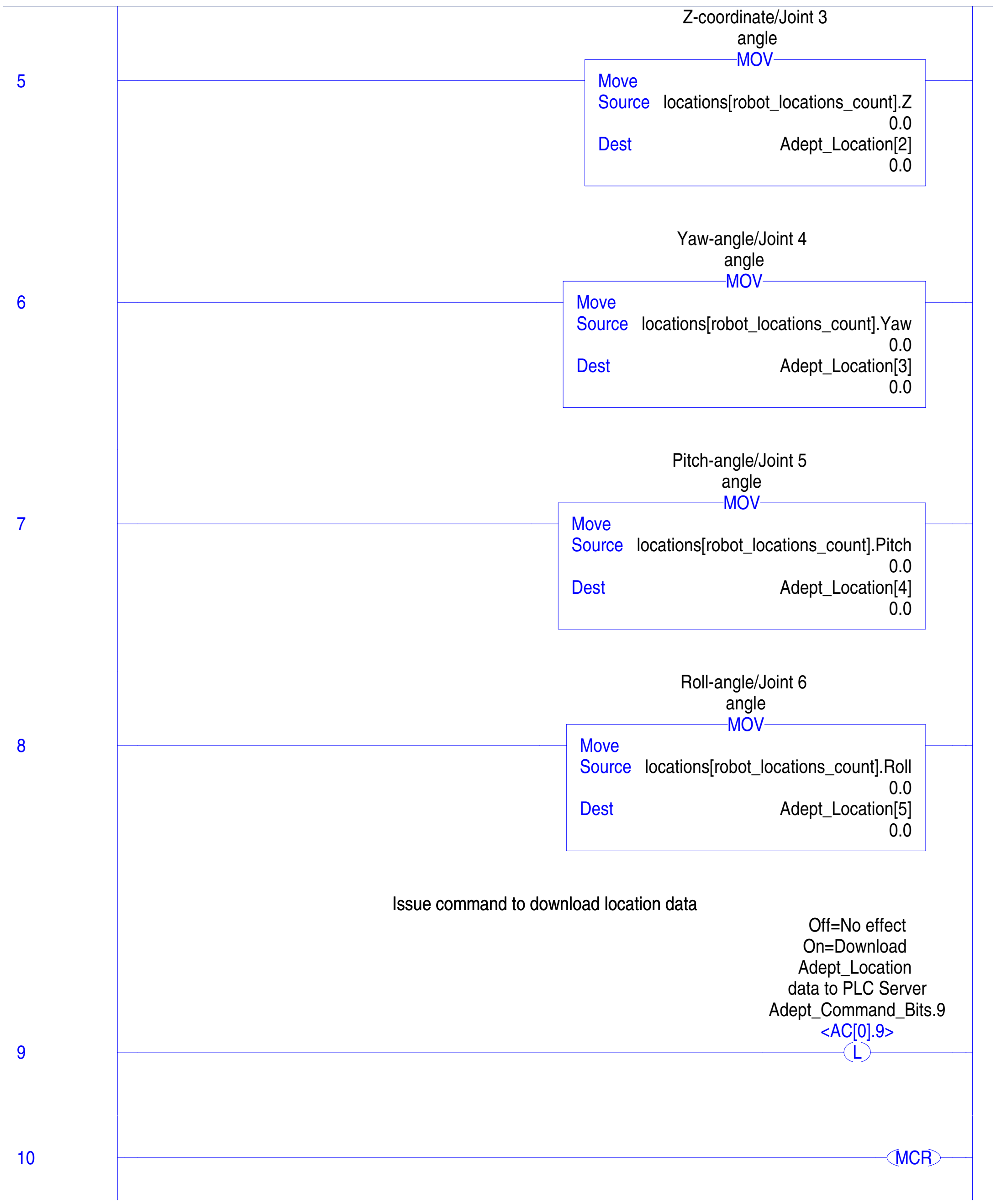
This section shows the ladder logic and tag listings for a routine to download locations to the PLC Server.

Download_Locations - Ladder Diagram **Page 1**

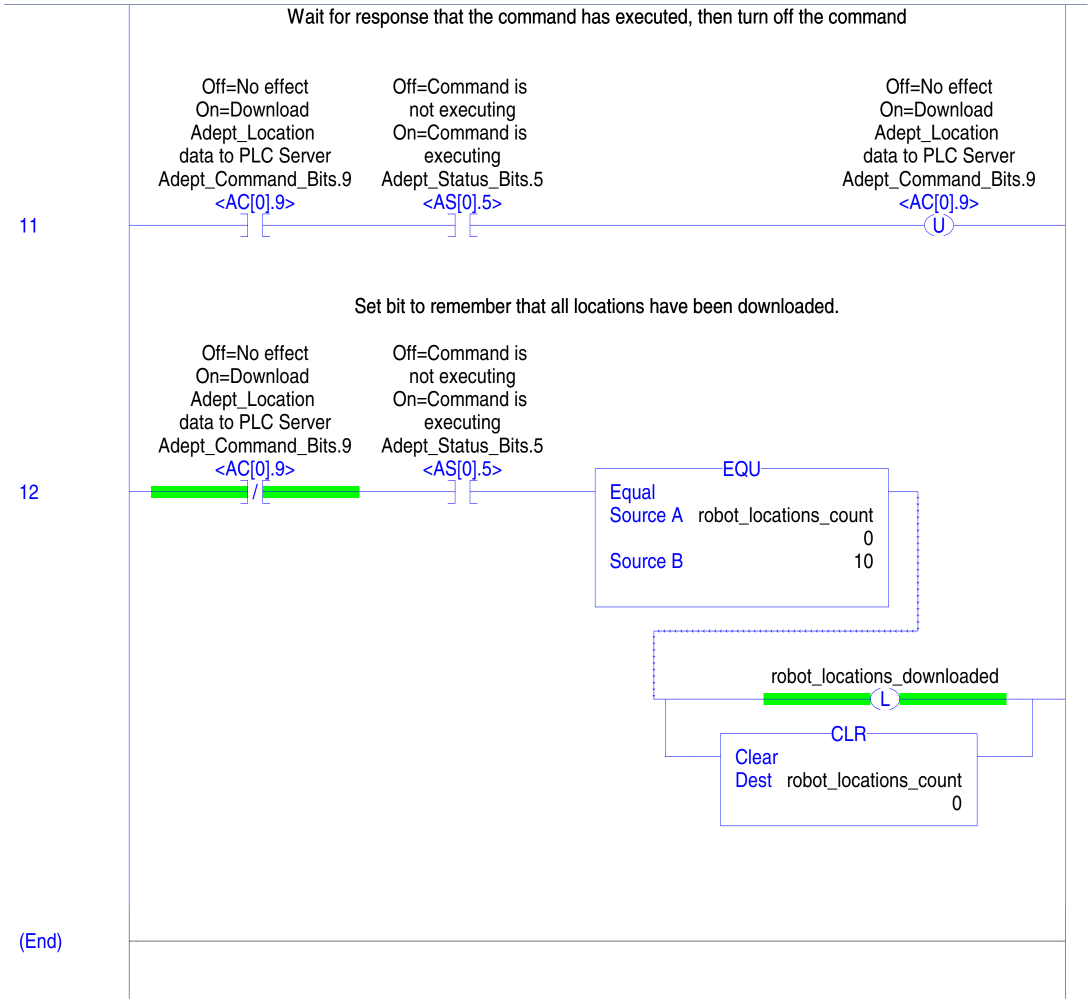
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:48:06 PM

Total number of rungs: 13 ControlLogix_Example.ACD




5
Z-coordinate/Joint 3
angle
MOV
Move
Source locations[robot_locations_count].Z
0.0
Dest Adept_Location[2]
0.0
6
Yaw-angle/Joint 4
angle
MOV
Move
Source locations[robot_locations_count].Yaw
0.0
Dest Adept_Location[3]
0.0
7
Pitch-angle/Joint 5
angle
MOV
Move
Source locations[robot_locations_count].Pitch
0.0
Dest Adept_Location[4]
0.0
8
Roll-angle/Joint 6
angle
MOV
Move
Source locations[robot_locations_count].Roll
0.0
Dest Adept_Location[5]
0.0
9
Issue command to download location data
Off=No effect
On=Download
Adept_Location
data to PLC Server
Adept_Command_Bits.9
<AC[0].9>
L
10
MCR

Download_Locations - Ladder Diagram **Page 3**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:48:07 PM
Total number of rungs: 13 ControlLogix_Example.ACD



Tag Name	Type	Description
⊟-Adept_Command_Bits	INT	Robot command bits
—Adept_Command_Bits.0	BOOL	Off=Disable high power On=Enable
—Adept_Command_Bits.1	BOOL	Off=No effect On=Update Adept_He
—Adept_Command_Bits.5	BOOL	Off=No effect On=Reset faults
—Adept_Command_Bits.6	BOOL	Off=No effect On=Calibrate robot
—Adept_Command_Bits.7	BOOL	Off=No effect On=Jog robot
—Adept_Command_Bits.8	BOOL	Off=No effect On=Move robot
—Adept_Command_Bits.9	BOOL	Off=No effect On=Download Adept_
└Adept_Command_Bits.10	BOOL	Off=No effect On=Download Adept_
⊞-Adept_Location	REAL[6]	Location definition data
⊞-Adept_Location_Number	INT	Location number
⊟-Adept_Status_Bits	INT	Adept Status Bits
—Adept_Status_Bits.0	BOOL	Off=High power disabled On=High p
—Adept_Status_Bits.1	BOOL	Off=No fault On=Adept in faulted sta
—Adept_Status_Bits.2	BOOL	Off=Robot not calibrated On=Robot
—Adept_Status_Bits.3	BOOL	Off=No meaning On=Adept system h
—Adept_Status_Bits.4	BOOL	Off=E-stop circuit closed On=E-stop
—Adept_Status_Bits.5	BOOL	Off=Command is not executing On=
—Adept_Status_Bits.6	BOOL	Off=Robot in motion On=Robot finis
—Adept_Status_Bits.13	BOOL	Off=Robot has lefty configuration On
—Adept_Status_Bits.14	BOOL	Off=Robot has above configuration O
└Adept_Status_Bits.15	BOOL	Off=Robot has flip configuration On
⊞-locations	Transformation[11]	
⊞-robot_locations_count	INT	
robot_locations_downloaded	BOOL	

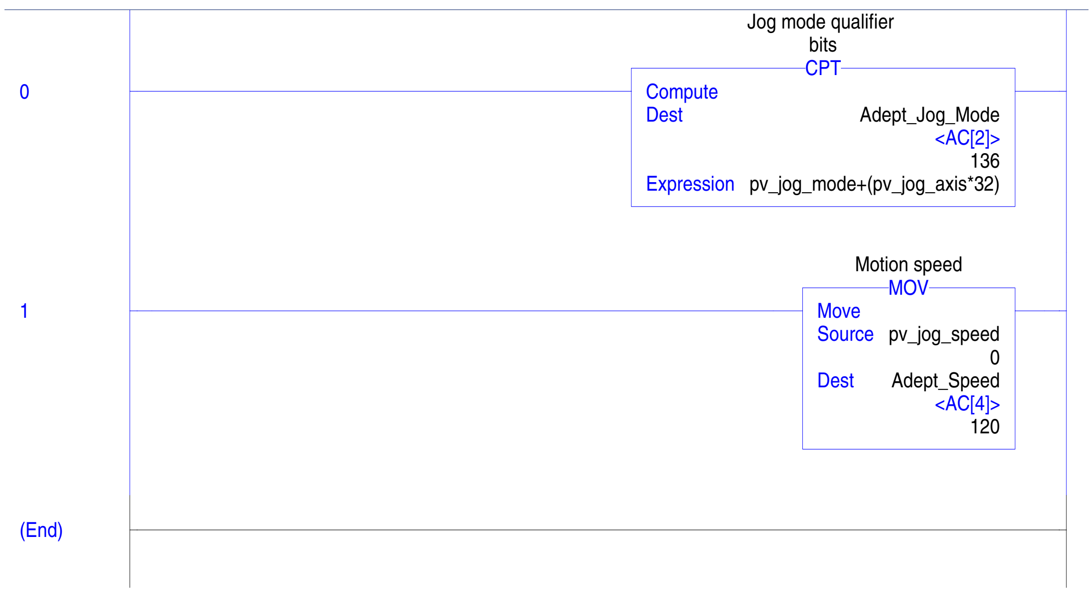
Reference	Scope	Program	Routine	BaseTag	Referenced At [*=Destructive, ?=Not Verified]
Adept_Command_Bits.0	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].0	*1(OTU) *2(OTL)
Adept_Command_Bits.1	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].1	*11(OTE)
Adept_Command_Bits.10	Adept_PLC_Server_ControlLogix_Example	MainProgram	Reset_Faults	AC[0].10	*0(OTU)
Adept_Command_Bits.5	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].5	*5(OTE)
Adept_Command_Bits.6	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].6	*3(OTE)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.7	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].7	8(XIO) *10(OTE)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.8	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].8	9(XIC) *9(OTU) 10(XIO) 11(XIO)
			Move_Robot		0(XIO) *7(OTL) *16(OTL) *25(OTL) *34(OTL) *43(OTL) *52(OTL) *61(OTL)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.9	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations	AC[0].9	0(XIO) *9(OTL) *11(OTU) 11(XIC) 12(XIO)
			Reset_Faults		*0(OTU)
Adept_Location[0]	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		*3(MOV)
Adept_Location[1]	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		*4(MOV)
Adept_Location[2]	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		*5(MOV)
Adept_Location[3]	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		*6(MOV)
Adept_Location[4]	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		*7(MOV)
Adept_Location[5]	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		*8(MOV)
Adept_Location_Number	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations	AC[6]	*2(MOV)

Reference	Scope	Program	Routine	BaseTag	Referenced At [*=Destructive, ?=Not Verified]
			Move_Robot		*1(MOV) *10(MOV) *19(MOV) *28(MOV) *37(MOV) *46(MOV) *55(MOV)
Adept_Status_Bits.0	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].0	1(XIO) 2(XIO) 3(XIC) 7(XIC)
Adept_Status_Bits.1	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].1	1(XIC) 2(XIO) 3(XIO) 4(XIO) 6(XIC) 7(XIO)
Adept_Status_Bits.2	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].2	3(XIO) 7(XIC)
Adept_Status_Bits.3	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].3	0(XIC)
Adept_Status_Bits.4	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].4	1(XIC) 2(XIO)
Adept_Status_Bits.5	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations	AS[0].5	0(XIO) 11(XIC) 12(XIC)
			Move_Robot		0(XIO)
Adept_Status_Bits.6	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AS[0].6	27(XIC) 54(XIC)
locations	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		3(MOV) 4(MOV) 5(MOV) 6(MOV) 7(MOV) 8(MOV)
robot_locations_count	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		*1(ADD) 1(ADD) 2(MOV) 3(MOV) 4(MOV) 5(MOV) 6(MOV) 7(MOV) 8(MOV) 12(EQU) *12(CLR)
			MainRoutine		*0(CLR)
robot_locations_downloaded	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations		*12(OTL)
			MainRoutine		*0(OTU) 4(XIO) 7(XIC)

Jog Robot Routine

This section shows the ladder logic and tag listings for a routine to jog (move) the robot.

Jog_Robot - Ladder Diagram **Page 1**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:49:46 PM
Total number of rungs: 2 ControlLogix_Example.ACD



Jog_Robot - Controller Tag Listing **Page 2**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:49:47 PM
ControlLogix_Example.ACD

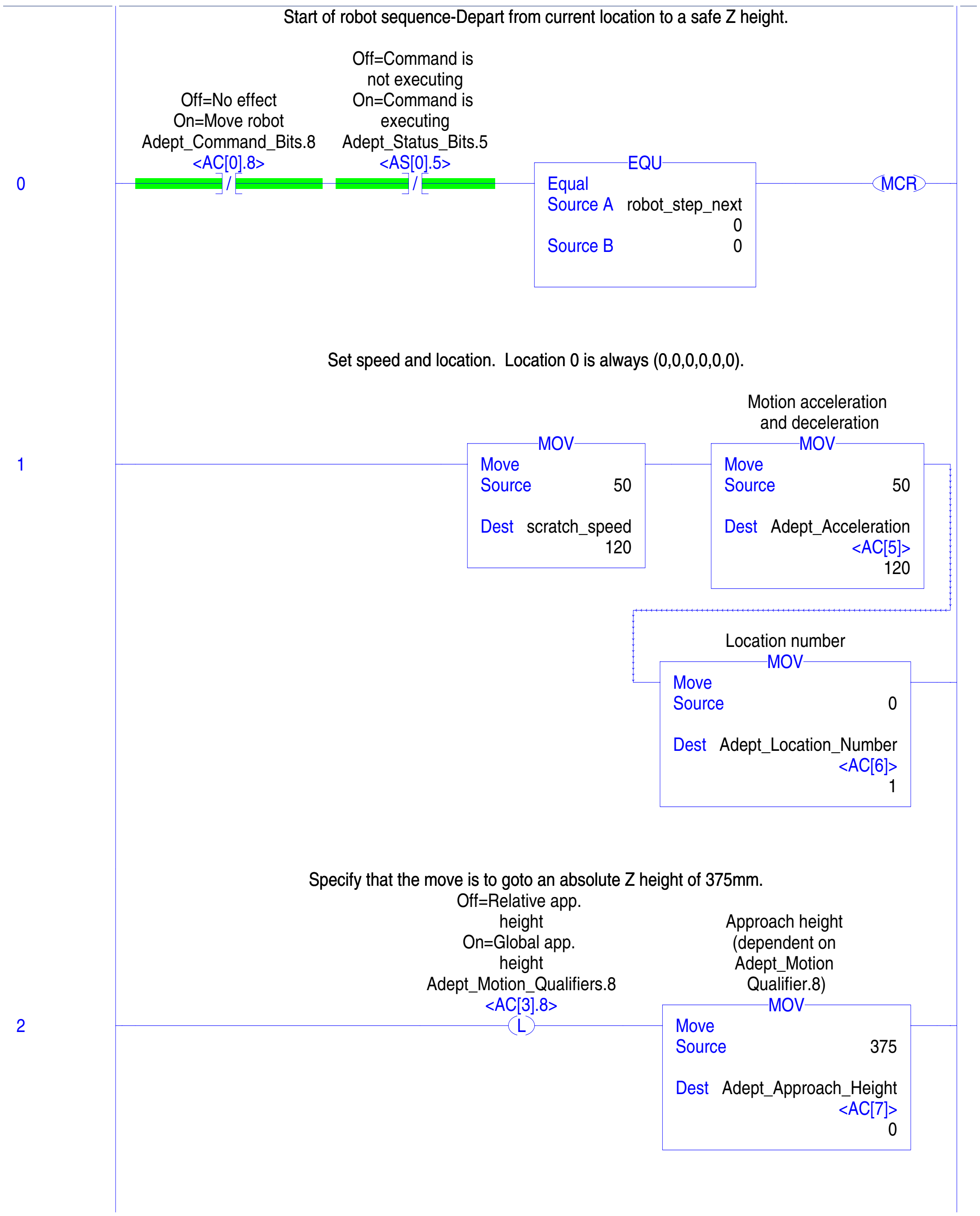
Tag Name	Type	Description
⊟-Adept_Jog_Mode	INT	Jog mode qualifier bits
Adept_Jog_Mode.0	BOOL	World mode
Adept_Jog_Mode.1	BOOL	Tool mode
Adept_Jog_Mode.2	BOOL	Joint mode
Adept_Jog_Mode.3	BOOL	Free mode
Adept_Jog_Mode.4	BOOL	Not used
Adept_Jog_Mode.5	BOOL	Joint 1/X-axis
Adept_Jog_Mode.6	BOOL	Joint 2/Y-axis
Adept_Jog_Mode.7	BOOL	Joint 3/Z-axis
Adept_Jog_Mode.8	BOOL	Joint 4/Yaw-angle
Adept_Jog_Mode.9	BOOL	Joint 5/Pitch-angle
Adept_Jog_Mode.10	BOOL	Joint 6/Roll-angle
Adept_Jog_Mode.11	BOOL	Not used
Adept_Jog_Mode.12	BOOL	Not used
Adept_Jog_Mode.13	BOOL	Not used
Adept_Jog_Mode.14	BOOL	Not used
Adept_Jog_Mode.15	BOOL	Not used
⊞-Adept_Speed	INT	Motion speed
⊞-pv_jog_axis	INT	
⊞-pv_jog_mode	INT	
⊞-pv_jog_speed	INT	

Reference	Scope	Program	Routine	BaseTag	Referenced At [*=Destructive, ?=Not Verified]
Adept_Jog_Mode	Adept_PLC_Server_ControlLogix_Example	MainProgram	Jog_Robot	AC[2]	*0(CPT)
Adept_Speed	Adept_PLC_Server_ControlLogix_Example	MainProgram	Jog_Robot	AC[4]	*1(MOV)
			Move_Robot		*63(CPT)
pv_jog_axis	Adept_PLC_Server_ControlLogix_Example	MainProgram	Jog_Robot		0(CPT)
pv_jog_mode	Adept_PLC_Server_ControlLogix_Example	MainProgram	Jog_Robot		0(CPT)
pv_jog_speed	Adept_PLC_Server_ControlLogix_Example	MainProgram	Jog_Robot		1(MOV)
			MainRoutine		10(NEQ)

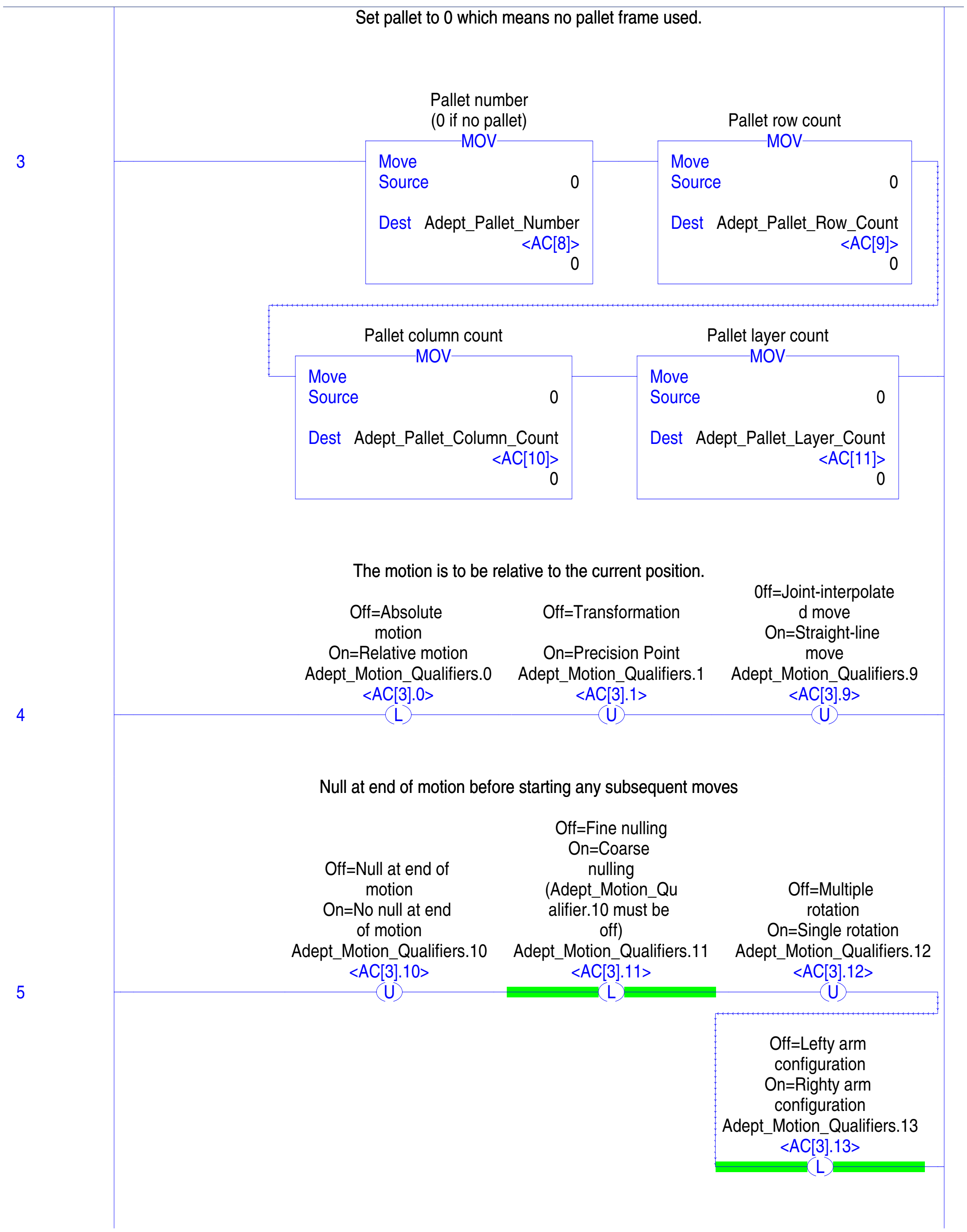
Move Robot Routine

This section shows the ladder logic and tag listings for a routine to move the robot.

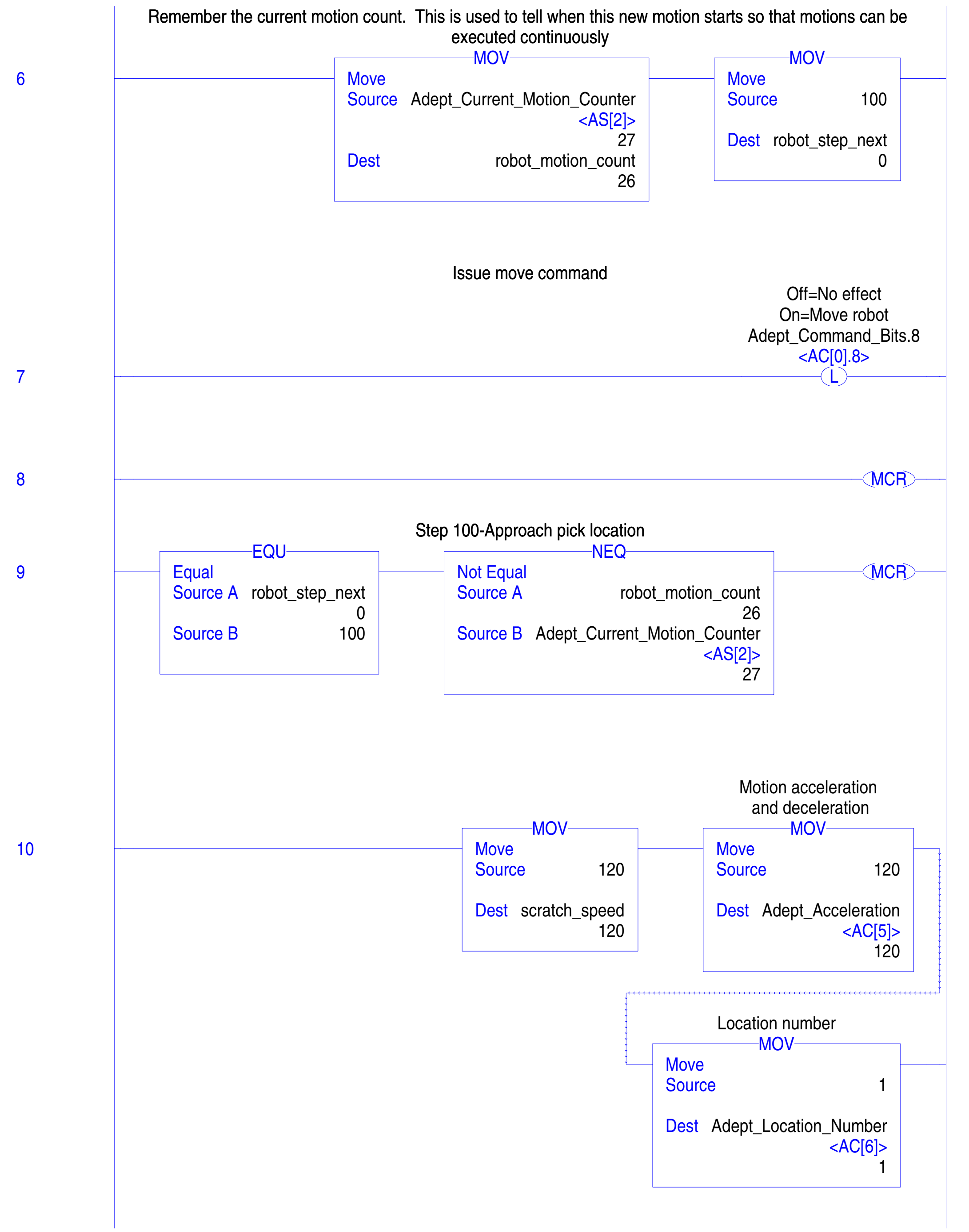
Move_Robot - Ladder Diagram **Page 1**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:02 PM
Total number of rungs: 64 ControlLogix_Example.ACD

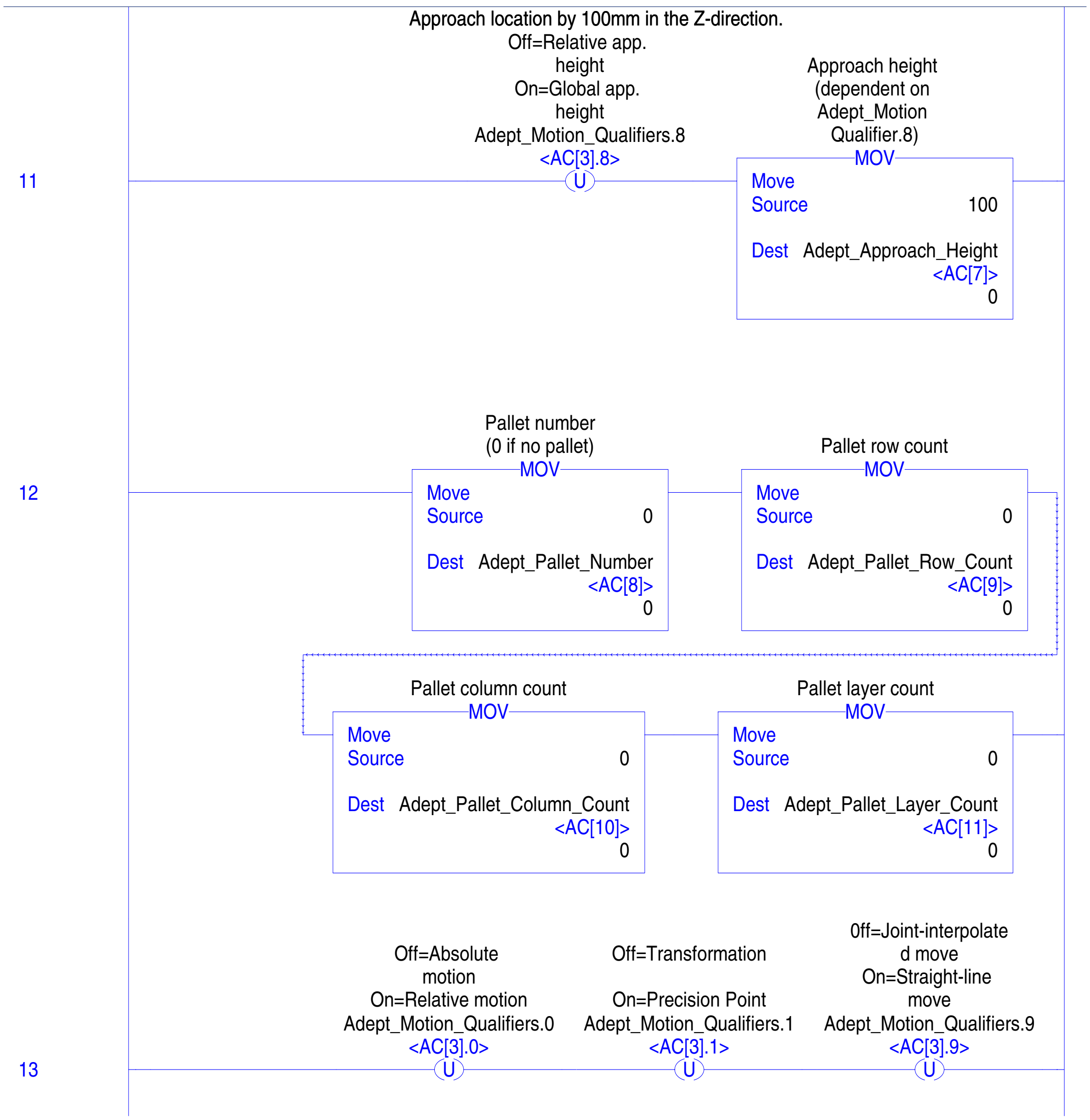


Move_Robot - Ladder Diagram **Page 2**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:02 PM
Total number of rungs: 64 ControlLogix_Example.ACD

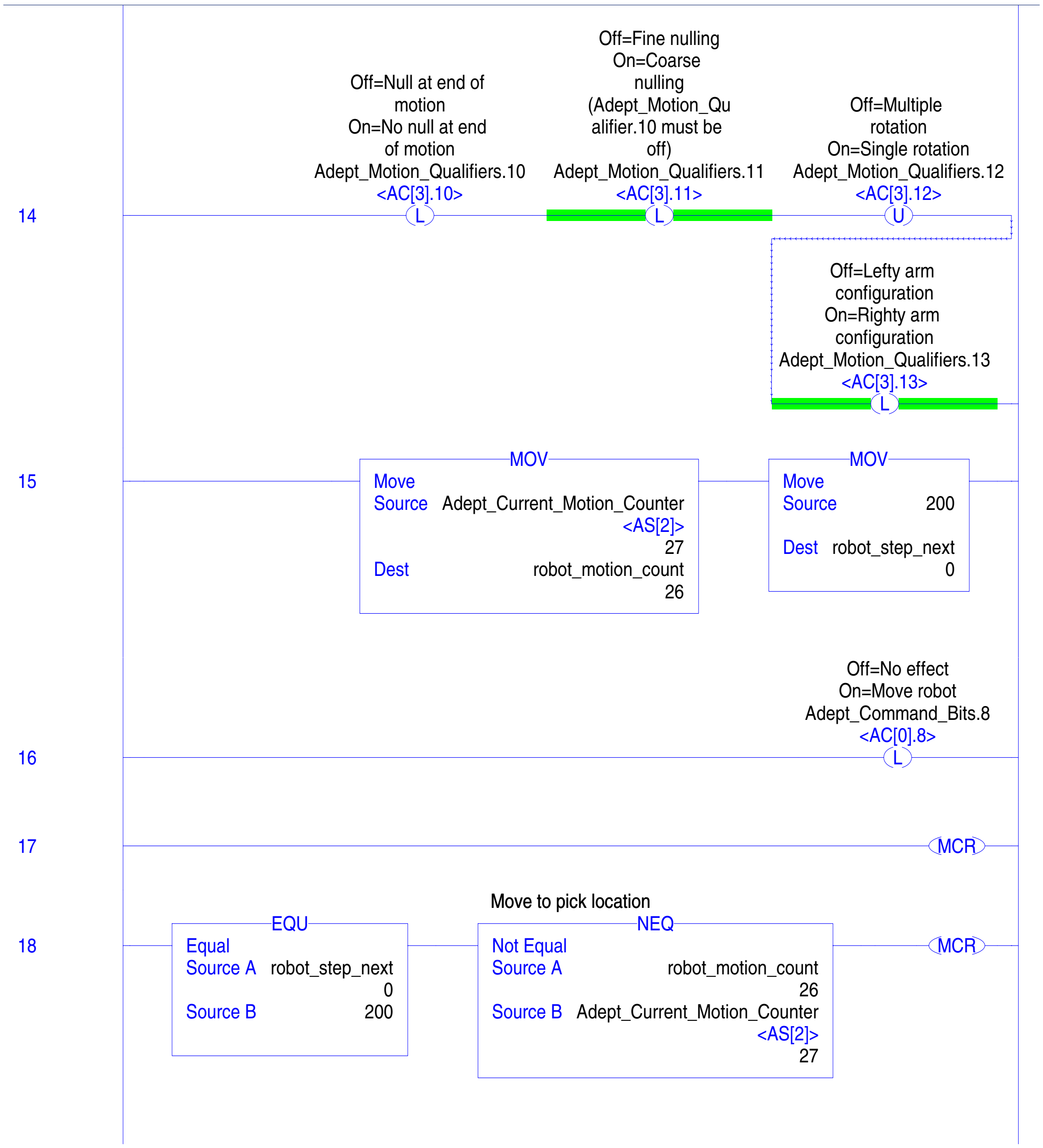


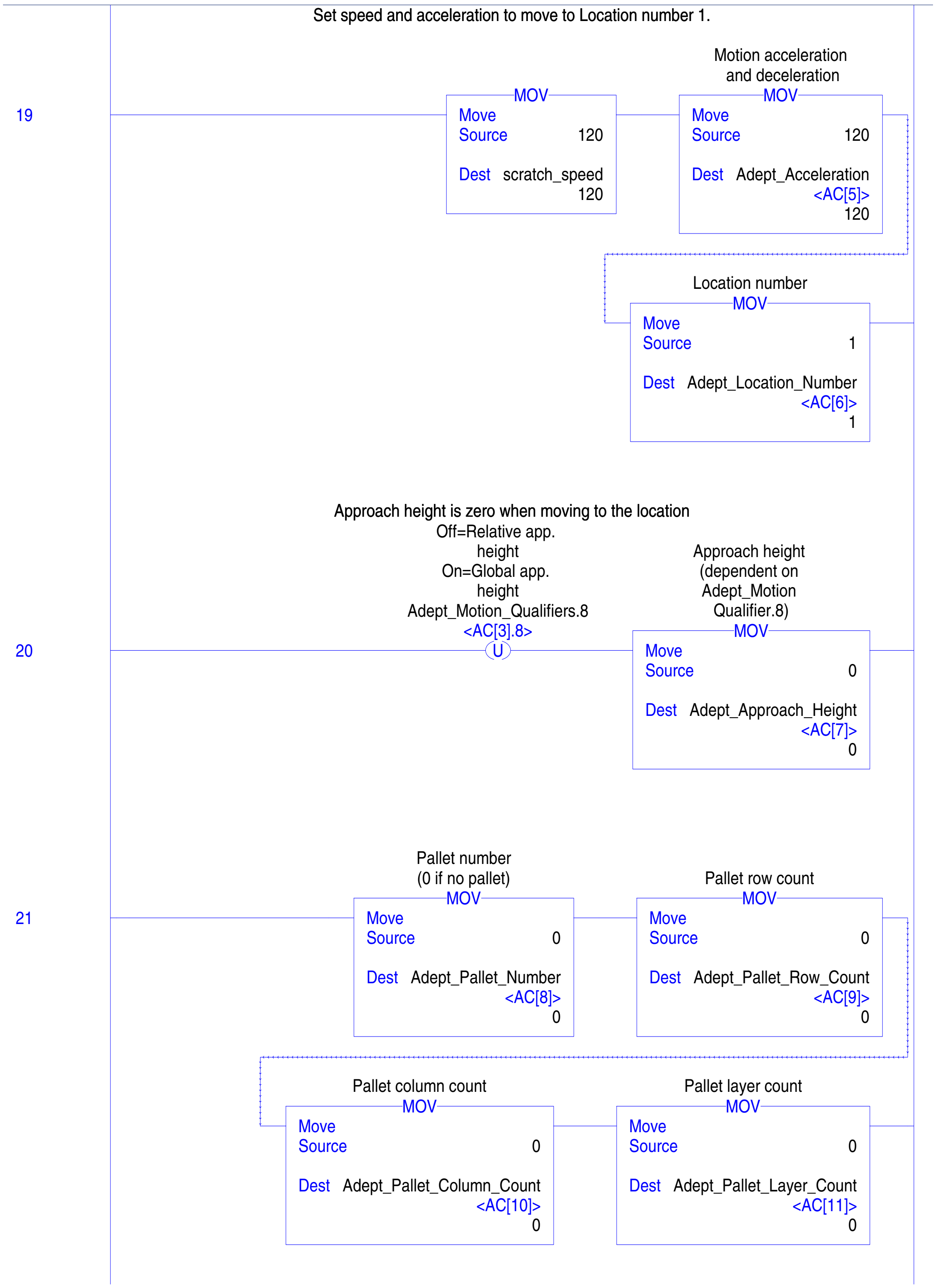
Move_Robot - Ladder Diagram **Page 3**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:02 PM
Total number of rungs: 64 ControlLogix_Example.ACD




11
Approach location by 100mm in the Z-direction.
Off=Relative app. height
On=Global app. height
Adept_Motion_Qualifiers.8
<AC[3].8>
U
Approach height (dependent on Adept_Motion Qualifier.8)
MOV
Move
Source 100
Dest Adept_Approach_Height
<AC[7]>
0
12
Pallet number (0 if no pallet)
MOV
Move
Source 0
Dest Adept_Pallet_Number
<AC[8]>
0
Pallet row count
MOV
Move
Source 0
Dest Adept_Pallet_Row_Count
<AC[9]>
0
Pallet column count
MOV
Move
Source 0
Dest Adept_Pallet_Column_Count
<AC[10]>
0
Pallet layer count
MOV
Move
Source 0
Dest Adept_Pallet_Layer_Count
<AC[11]>
0
13
Off=Absolute motion
On=Relative motion
Adept_Motion_Qualifiers.0
<AC[3].0>
U
Off=Transformation
On=Precision Point
Adept_Motion_Qualifiers.1
<AC[3].1>
U
Off=Joint-interpolated move
On=Straight-line move
Adept_Motion_Qualifiers.9
<AC[3].9>
U

Move_Robot - Ladder Diagram **Page 5**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:03 PM
Total number of rungs: 64 ControlLogix_Example.ACD

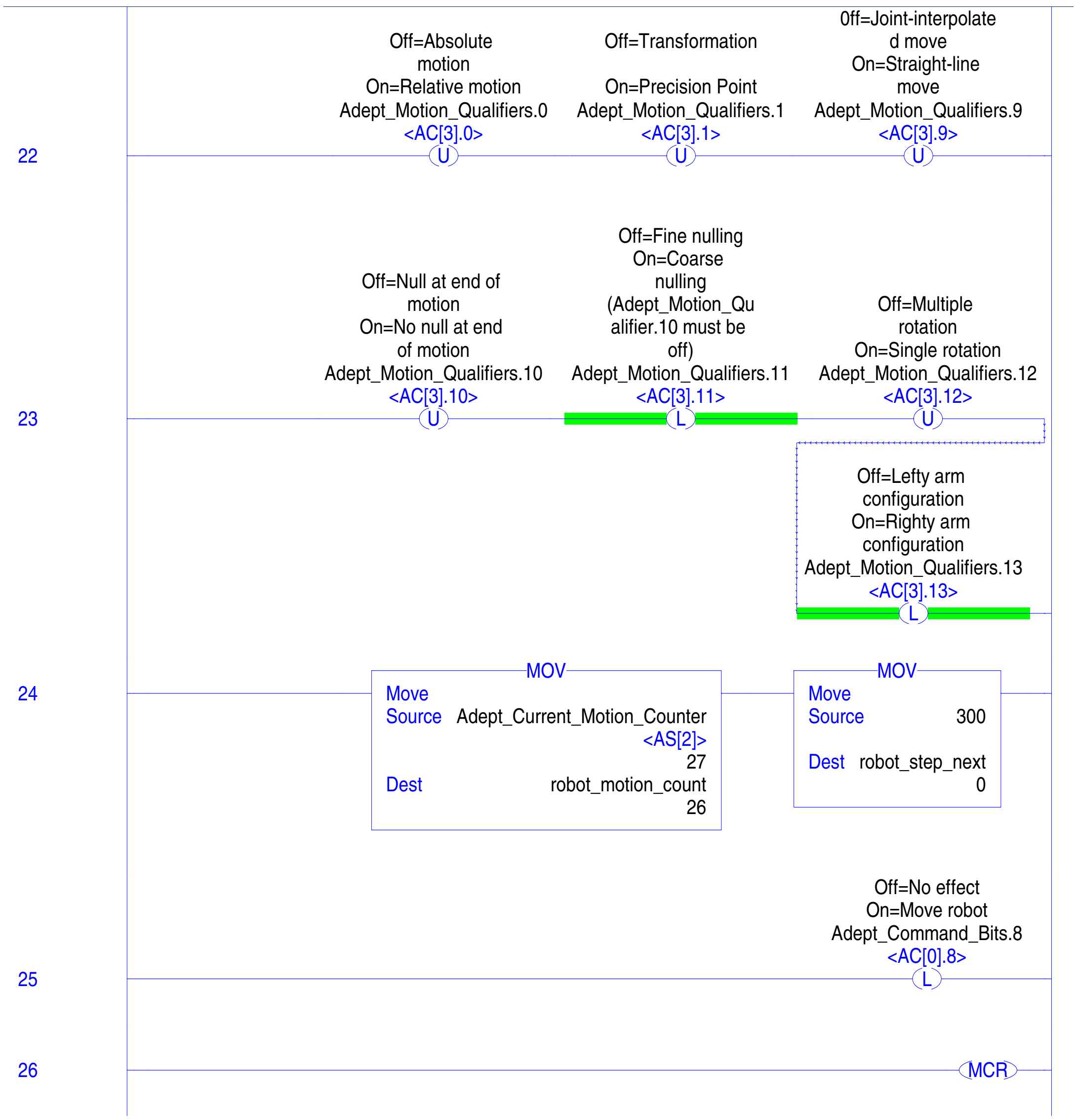


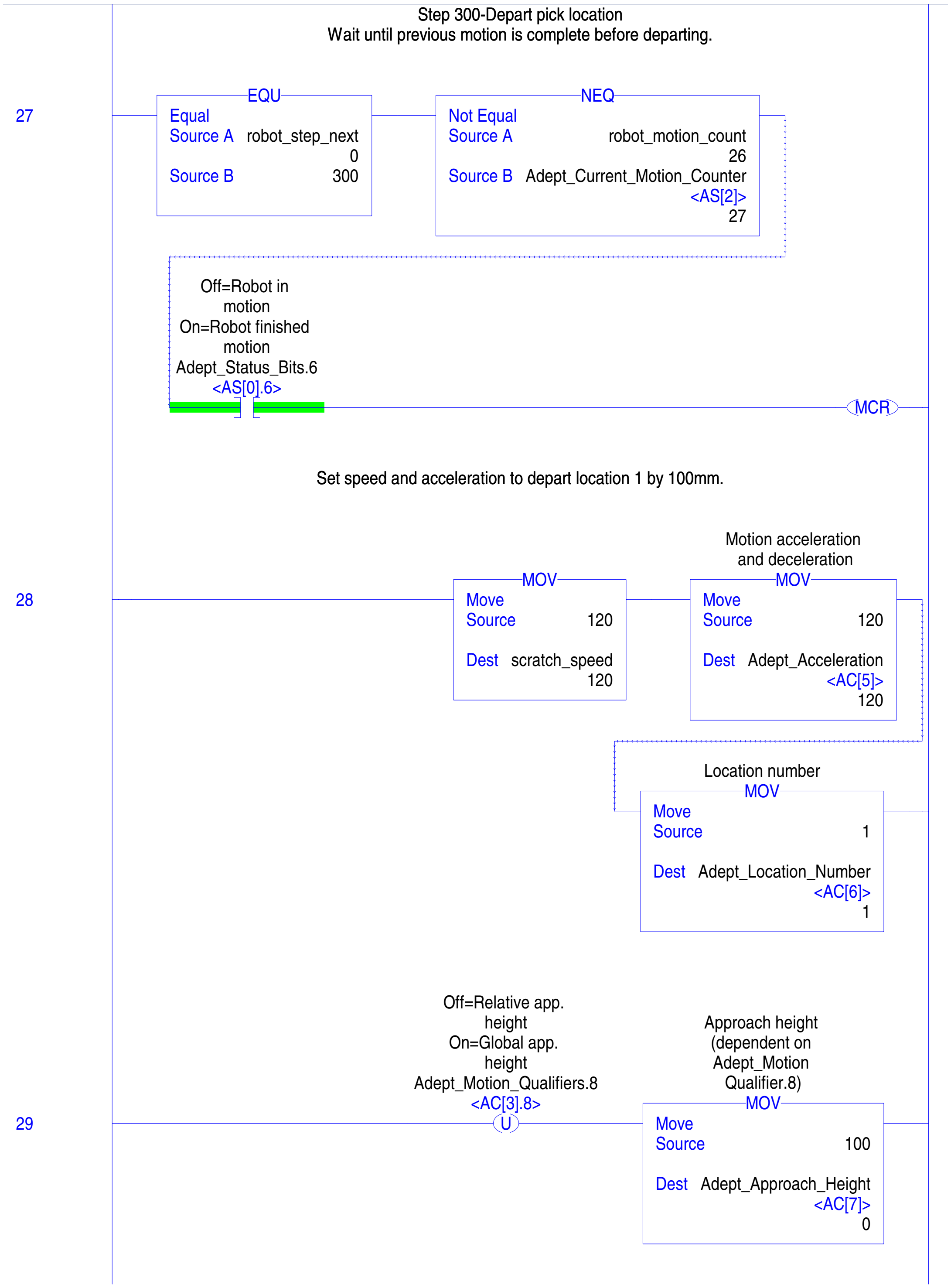

Set speed and acceleration to move to Location number 1.
19
MOV
Move
Source 120
Dest scratch_speed
120
Motion acceleration and deceleration
MOV
Move
Source 120
Dest Adept_Acceleration
<AC[5]>
120
Location number
MOV
Move
Source 1
Dest Adept_Location_Number
<AC[6]>
1
Approach height is zero when moving to the location
20
Off=Relative app. height
On=Global app. height
Adept_Motion_Qualifiers.8
<AC[3].8>
U
Approach height (dependent on Adept_Motion Qualifier.8)
MOV
Move
Source 0
Dest Adept_Approach_Height
<AC[7]>
0
21
Pallet number (0 if no pallet)
MOV
Move
Source 0
Dest Adept_Pallet_Number
<AC[8]>
0
Pallet row count
MOV
Move
Source 0
Dest Adept_Pallet_Row_Count
<AC[9]>
0
Pallet column count
MOV
Move
Source 0
Dest Adept_Pallet_Column_Count
<AC[10]>
0
Pallet layer count
MOV
Move
Source 0
Dest Adept_Pallet_Layer_Count
<AC[11]>
0

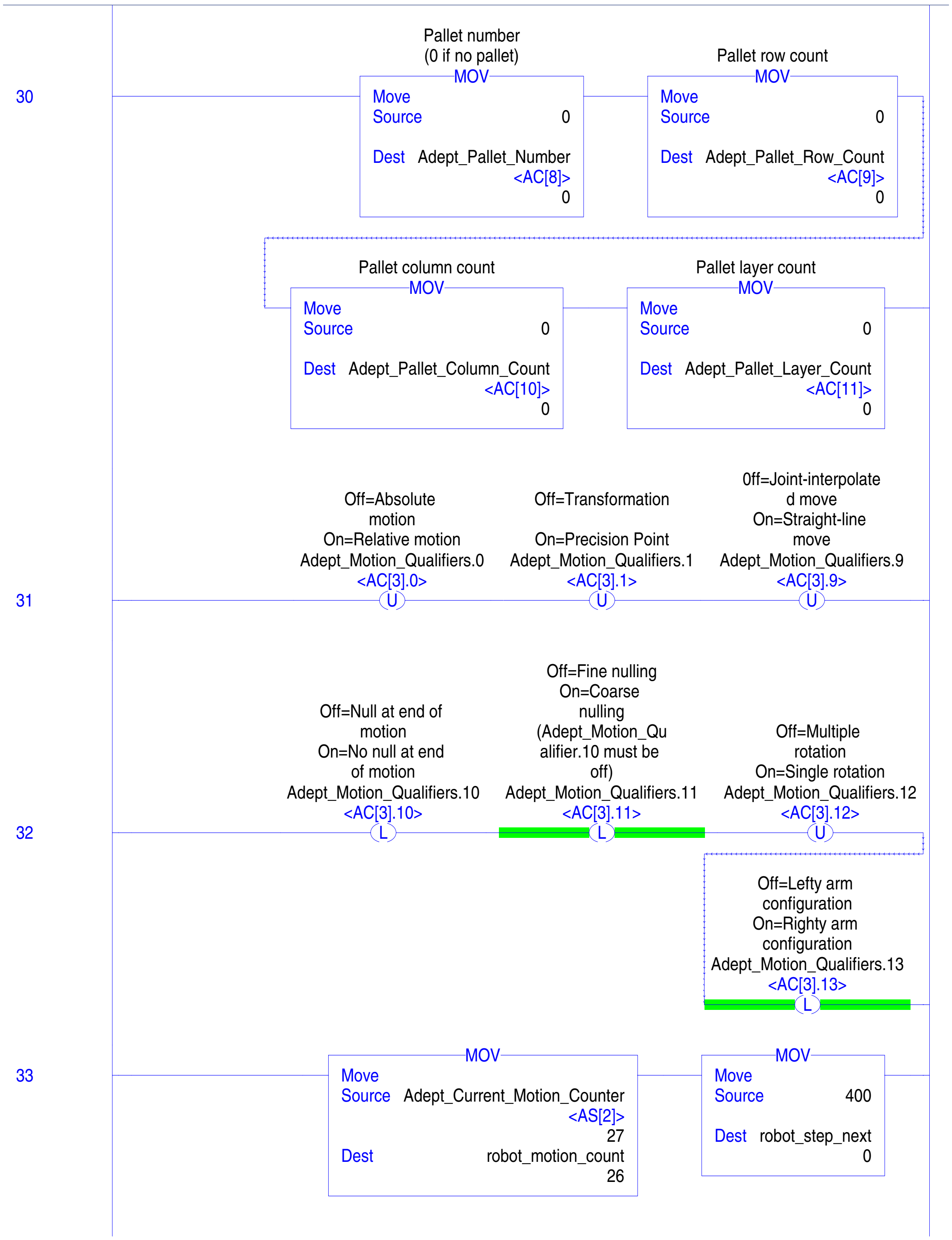
Move_Robot - Ladder Diagram **Page 7**

Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:04 PM

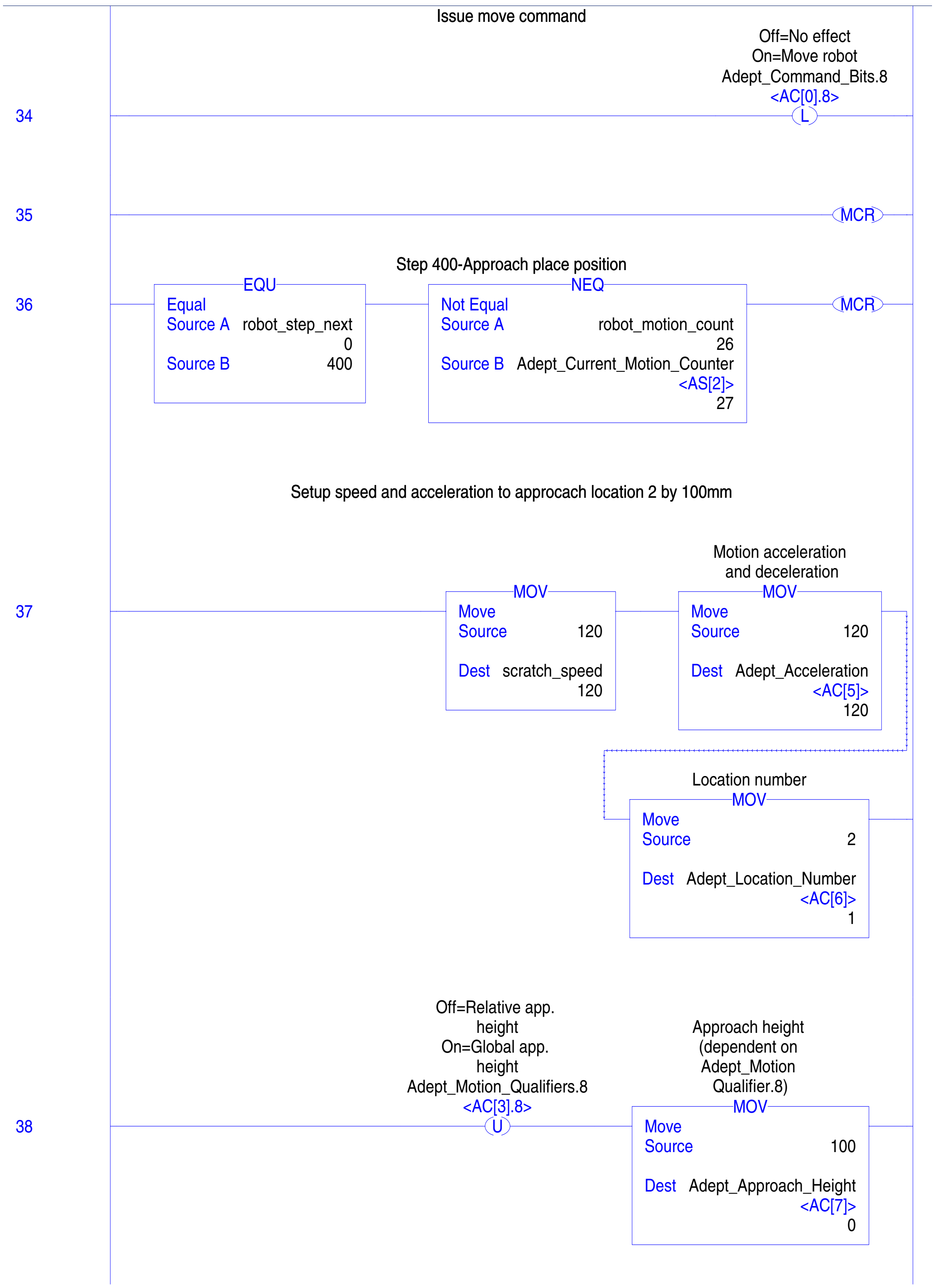
Total number of rungs: 64 ControlLogix_Example.ACD



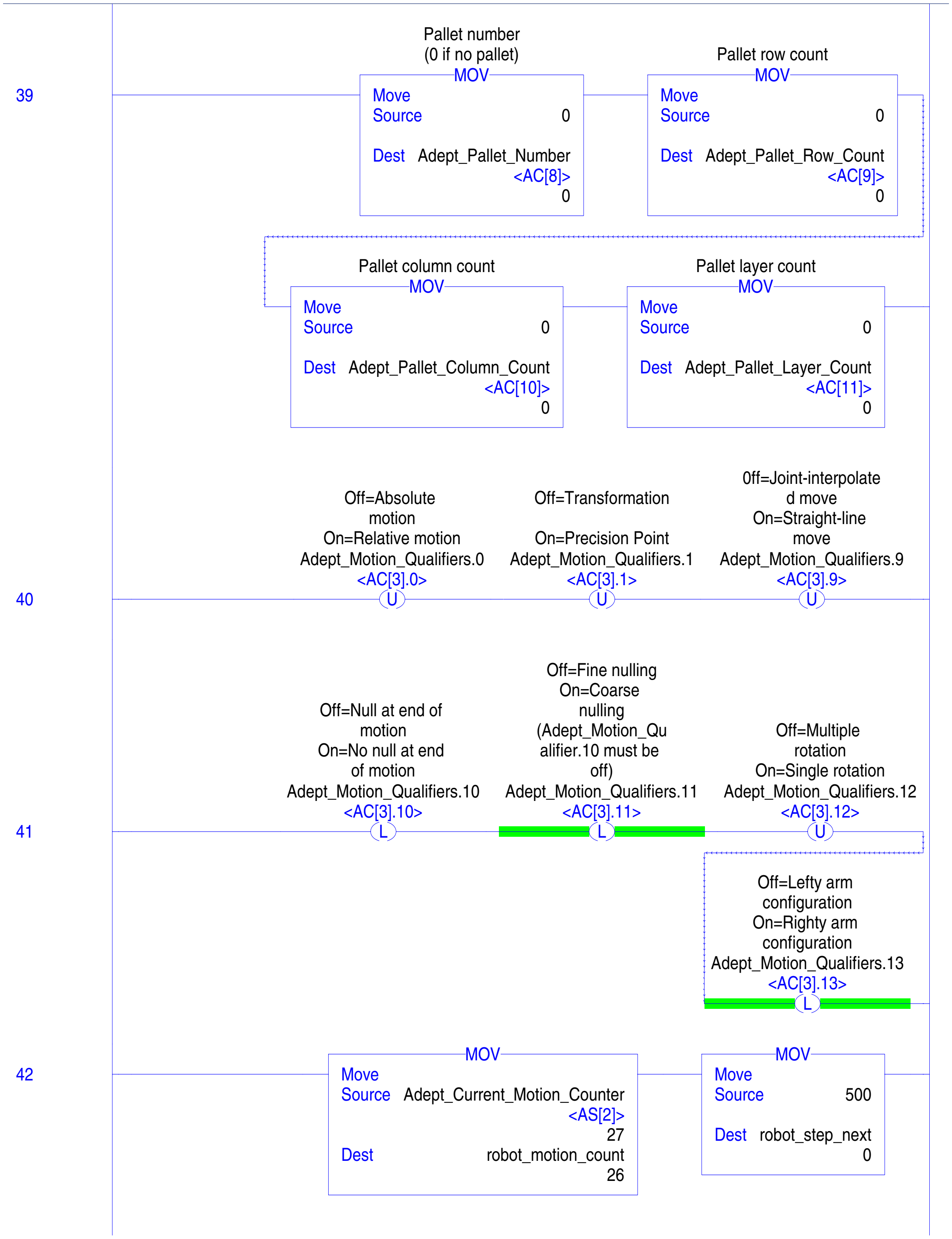

Step 300-Depart pick location
Wait until previous motion is complete before departing.
27
EQU
Equal
Source A robot_step_next
0
Source B 300
NEQ
Not Equal
Source A robot_motion_count
26
Source B Adept_Current_Motion_Counter
<AS[2]>
27
Off=Robot in motion
On=Robot finished motion
Adept_Status_Bits.6
<AS[0].6>
MCR
Set speed and acceleration to depart location 1 by 100mm.
28
MOV
Move
Source 120
Dest scratch_speed
120
Motion acceleration and deceleration
MOV
Move
Source 120
Dest Adept_Acceleration
<AC[5]>
120
Location number
MOV
Move
Source 1
Dest Adept_Location_Number
<AC[6]>
1
29
Off=Relative app. height
On=Global app. height
Adept_Motion_Qualifiers.8
<AC[3].8>
U
Approach height (dependent on Adept_Motion Qualifier.8)
MOV
Move
Source 100
Dest Adept_Approach_Height
<AC[7]>
0


30
Pallet number
(0 if no pallet)
MOV
Move
Source 0
Dest Adept_Pallet_Number
<AC[8]>
0
Pallet row count
MOV
Move
Source 0
Dest Adept_Pallet_Row_Count
<AC[9]>
0
Pallet column count
MOV
Move
Source 0
Dest Adept_Pallet_Column_Count
<AC[10]>
0
Pallet layer count
MOV
Move
Source 0
Dest Adept_Pallet_Layer_Count
<AC[11]>
0
31
Off=Absolute motion
On=Relative motion
Adept_Motion_Qualifiers.0
<AC[3].0>
U
Off=Transformation
On=Precision Point
Adept_Motion_Qualifiers.1
<AC[3].1>
U
0ff=Joint-interpolated move
On=Straight-line move
Adept_Motion_Qualifiers.9
<AC[3].9>
U
32
Off=Null at end of motion
On=No null at end of motion
Adept_Motion_Qualifiers.10
<AC[3].10>
L
Off=Fine nulling
On=Coarse nulling
(Adept_Motion_Qualifier.10 must be off)
Adept_Motion_Qualifiers.11
<AC[3].11>
L
Off=Multiple rotation
On=Single rotation
Adept_Motion_Qualifiers.12
<AC[3].12>
U
Off=Lefty arm configuration
On=Righty arm configuration
Adept_Motion_Qualifiers.13
<AC[3].13>
L
33
MOV
Move
Source Adept_Current_Motion_Counter
<AS[2]>
27
Dest robot_motion_count
26
MOV
Move
Source 400
Dest robot_step_next
0

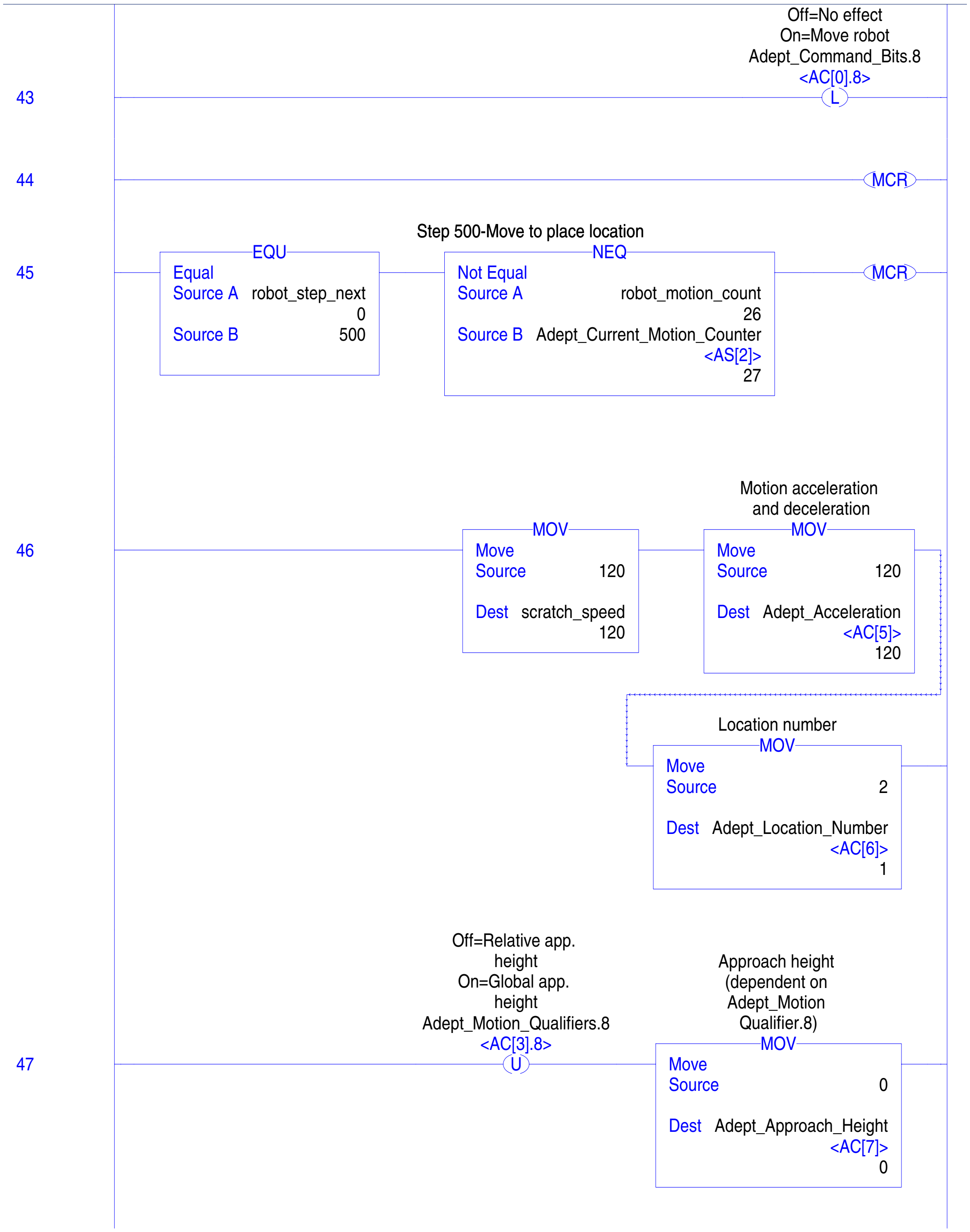
Move_Robot - Ladder Diagram **Page 10**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:06 PM
Total number of rungs: 64 ControlLogix_Example.ACD

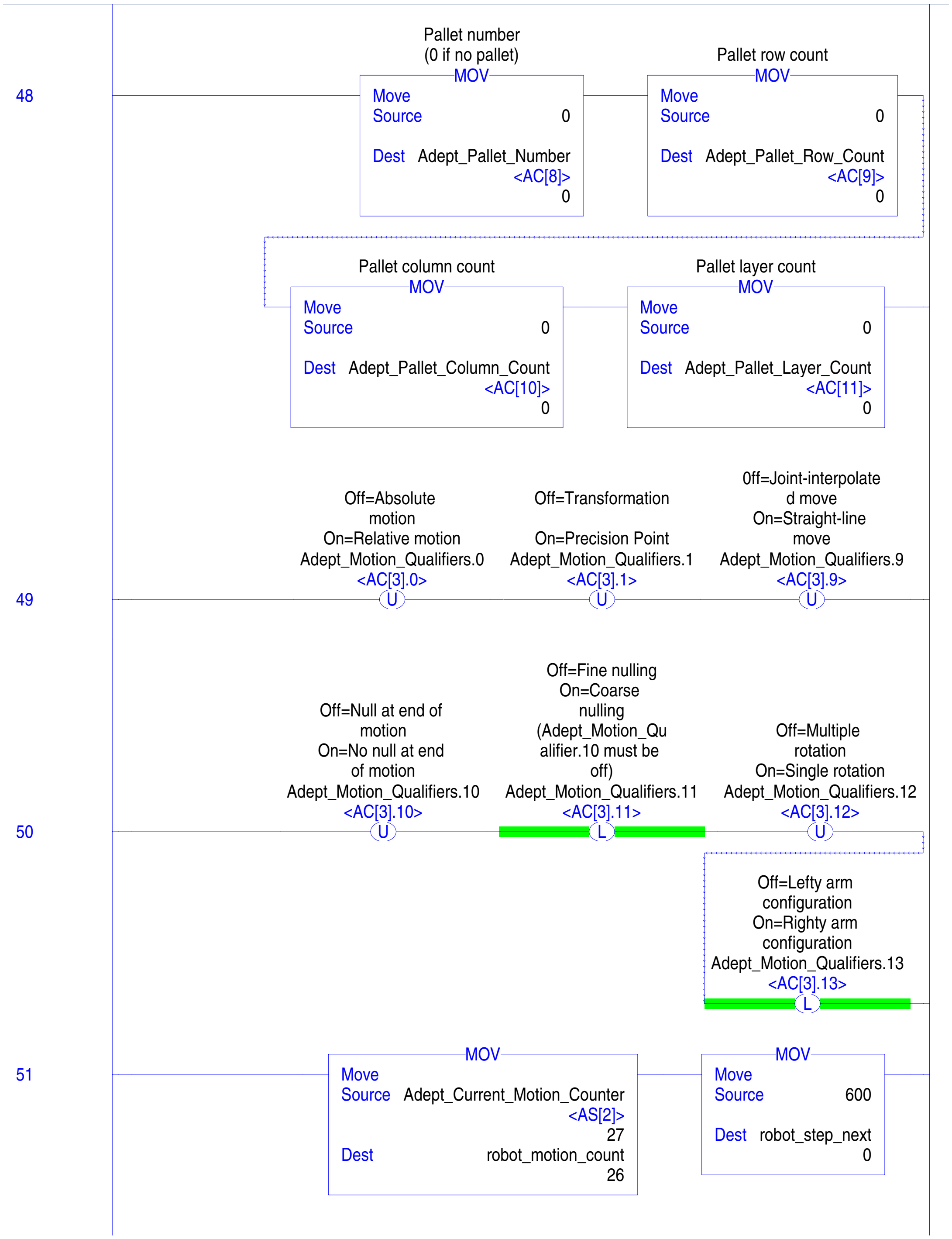


Move_Robot - Ladder Diagram **Page 11**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:07 PM
Total number of rungs: 64 ControlLogix_Example.ACD

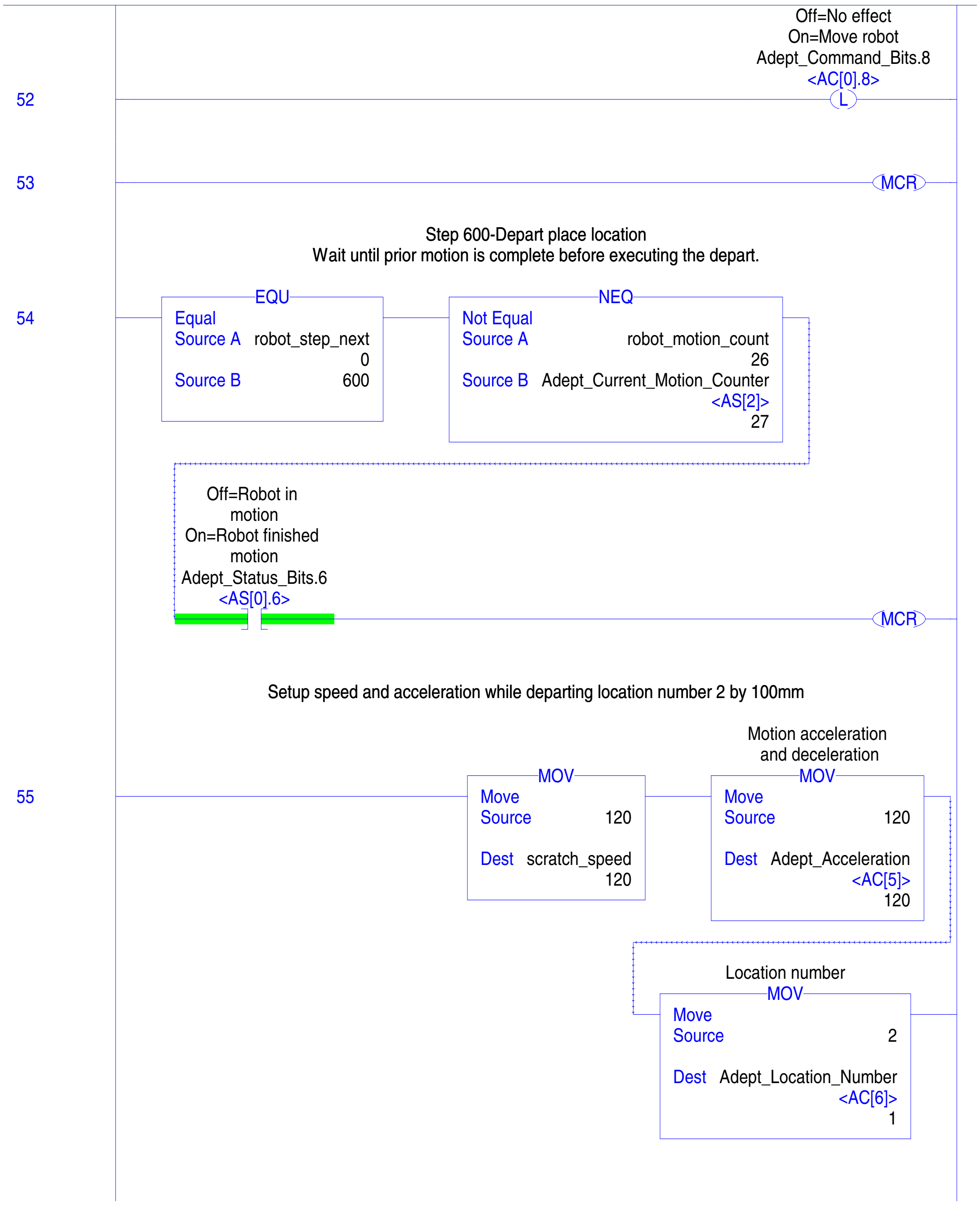


Move_Robot - Ladder Diagram **Page 12**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:07 PM
Total number of rungs: 64 ControlLogix_Example.ACD

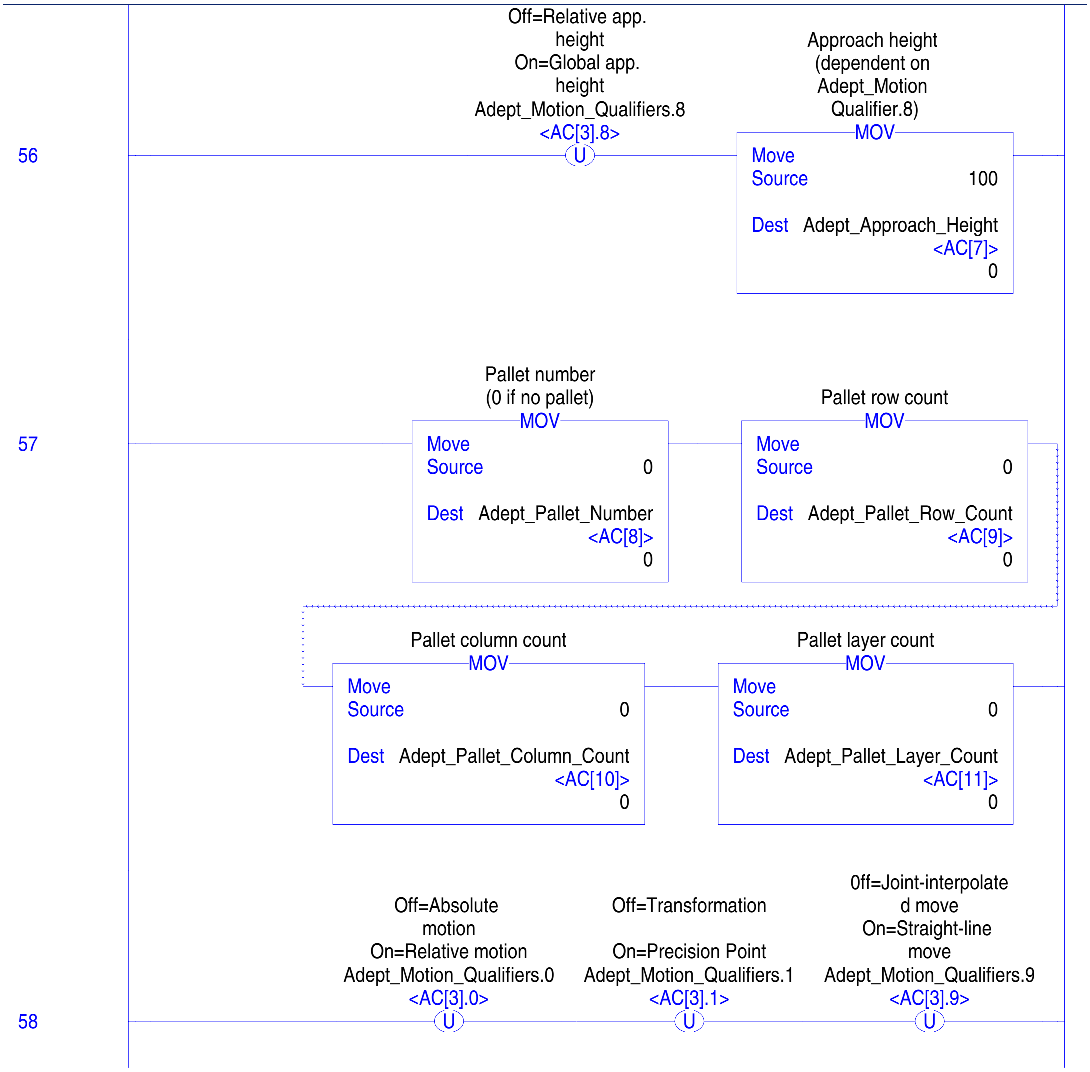



48
Pallet number
(0 if no pallet)
MOV
Move
Source 0
Dest Adept_Pallet_Number
<AC[8]>
0
Pallet row count
MOV
Move
Source 0
Dest Adept_Pallet_Row_Count
<AC[9]>
0
Pallet column count
MOV
Move
Source 0
Dest Adept_Pallet_Column_Count
<AC[10]>
0
Pallet layer count
MOV
Move
Source 0
Dest Adept_Pallet_Layer_Count
<AC[11]>
0
49
Off=Absolute
motion
On=Relative motion
Adept_Motion_Qualifiers.0
<AC[3].0>
U
Off=Transformation
On=Precision Point
Adept_Motion_Qualifiers.1
<AC[3].1>
U
Off=Joint-interpolate
d move
On=Straight-line
move
Adept_Motion_Qualifiers.9
<AC[3].9>
U
50
Off=Null at end of
motion
On=No null at end
of motion
Adept_Motion_Qualifiers.10
<AC[3].10>
U
Off=Fine nulling
On=Coarse
nulling
(Adept_Motion_Qu
alifier.10 must be
off)
Adept_Motion_Qualifiers.11
<AC[3].11>
L
Off=Multiple
rotation
On=Single rotation
Adept_Motion_Qualifiers.12
<AC[3].12>
U
Off=Lefty arm
configuration
On=Righty arm
configuration
Adept_Motion_Qualifiers.13
<AC[3].13>
L
51
MOV
Move
Source Adept_Current_Motion_Counter
<AS[2]>
27
Dest robot_motion_count
26
MOV
Move
Source 600
Dest robot_step_next
0

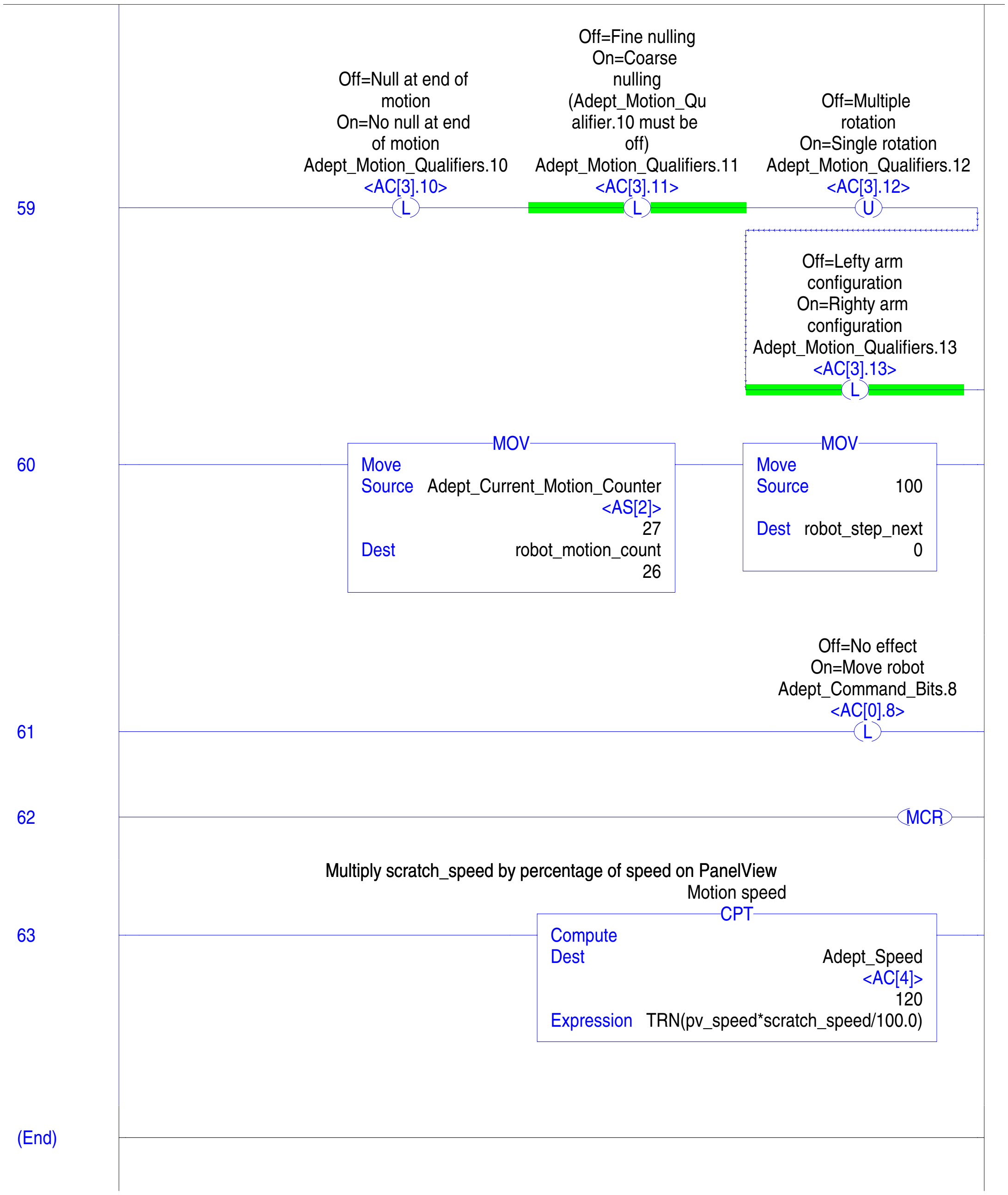
Move_Robot - Ladder Diagram **Page 14**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:08 PM
Total number of rungs: 64 ControlLogix_Example.ACD



Move_Robot - Ladder Diagram **Page 15**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:09 PM
Total number of rungs: 64 ControlLogix_Example.ACD



Move_Robot - Ladder Diagram **Page 16**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:51:09 PM
Total number of rungs: 64 ControlLogix_Example.ACD



Tag Name	Type	Description
⊞-Adept_Acceleration	INT	Motion acceleration and deceleration
⊞-Adept_Approach_Height	INT	Approach height (dependent on Adept_Motion Qualifier.8)
⊟-Adept_Command_Bits	INT	Robot command bits
—Adept_Command_Bits.0	BOOL	Off=Disable high power On=Enable
—Adept_Command_Bits.1	BOOL	Off=No effect On=Update Adept_He
—Adept_Command_Bits.5	BOOL	Off=No effect On=Reset faults
—Adept_Command_Bits.6	BOOL	Off=No effect On=Calibrate robot
—Adept_Command_Bits.7	BOOL	Off=No effect On=Jog robot
—Adept_Command_Bits.8	BOOL	Off=No effect On=Move robot
—Adept_Command_Bits.9	BOOL	Off=No effect On=Download Adept_
—Adept_Command_Bits.10	BOOL	Off=No effect On=Download Adept_
⊞-Adept_Current_Motion_Counter	INT	
⊞-Adept_Location_Number	INT	Location number
⊟-Adept_Motion_Qualifiers	INT	Motion qualifier bits
—Adept_Motion_Qualifiers.0	BOOL	Off=Absolute motion On=Relative m
—Adept_Motion_Qualifiers.1	BOOL	Off=Transformation On=Precision P
—Adept_Motion_Qualifiers.8	BOOL	Off=Relative app. height On=Global
—Adept_Motion_Qualifiers.9	BOOL	0ff=Joint-interpolated move On=Strai
—Adept_Motion_Qualifiers.10	BOOL	Off=Null at end of motion On=No nu
—Adept_Motion_Qualifiers.11	BOOL	Off=Fine nulling On=Coarse nulling
—Adept_Motion_Qualifiers.12	BOOL	Off=Multiple rotation On=Single rota
—Adept_Motion_Qualifiers.13	BOOL	Off=Lefty arm configuration On=Rig
—Adept_Motion_Qualifiers.14	BOOL	Off=Above arm configuration On=Be
—Adept_Motion_Qualifiers.15	BOOL	Off=Flip arm configuration On=No-fl
⊞-Adept_Pallet_Column_Count	INT	Pallet column count
⊞-Adept_Pallet_Layer_Count	INT	Pallet layer count
⊞-Adept_Pallet_Number	INT	Pallet number (0 if no pallet)
⊞-Adept_Pallet_Row_Count	INT	Pallet row count
⊞-Adept_Speed	INT	Motion speed
⊟-Adept_Status_Bits	INT	Adept Status Bits
—Adept_Status_Bits.0	BOOL	Off=High power disabled On=High p
—Adept_Status_Bits.1	BOOL	Off=No fault On=Adept in faulted sta
—Adept_Status_Bits.2	BOOL	Off=Robot not calibrated On=Robot
—Adept_Status_Bits.3	BOOL	Off=No meaning On=Adept system h
—Adept_Status_Bits.4	BOOL	Off=E-stop circuit closed On=E-stop
—Adept_Status_Bits.5	BOOL	Off=Command is not executing On=
—Adept_Status_Bits.6	BOOL	Off=Robot in motion On=Robot finis
—Adept_Status_Bits.13	BOOL	Off=Robot has lefty configuration On
—Adept_Status_Bits.14	BOOL	Off=Robot has above configuration O
—Adept_Status_Bits.15	BOOL	Off=Robot has flip configuration On
⊞-pv_speed	INT	
⊞-robot_motion_count	INT	
⊞-robot_step_next	INT	
⊞-scratch_speed	INT	

Reference	Scope	Program	Routine	BaseTag	Referenced At [*=Destructive, ?=Not Verified]
Adept_Acceleration	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[5]	*1(MOV) *10(MOV) *19(MOV) *28(MOV) *37(MOV) *46(MOV) *55(MOV)
Adept_Approach_Height	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[7]	*2(MOV) *11(MOV) *20(MOV) *29(MOV) *38(MOV) *47(MOV) *56(MOV)
Adept_Command_Bits.0	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].0	*1(OTU) *2(OTL)
Adept_Command_Bits.1	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].1	*11(OTE)
Adept_Command_Bits.10	Adept_PLC_Server_ControlLogix_Example	MainProgram	Reset_Faults	AC[0].10	*0(OTU)
Adept_Command_Bits.5	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].5	*5(OTE)
Adept_Command_Bits.6	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].6	*3(OTE)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.7	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].7	8(XIO) *10(OTE)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.8	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].8	9(XIC) *9(OTU) 10(XIO) 11(XIO)
			Move_Robot		0(XIO) *7(OTL) *16(OTL) *25(OTL) *34(OTL) *43(OTL) *52(OTL) *61(OTL)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.9	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations	AC[0].9	0(XIO) *9(OTL) *11(OTU) 11(XIC) 12(XIO)
			Reset_Faults		*0(OTU)
Adept_Current_Motion_Counter	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AS[2]	6(MOV) 9(NEQ) 15(MOV) 18(NEQ) 24(MOV) 27(NEQ) 33(MOV) 36(NEQ) 42(MOV) 45(NEQ) 51(MOV) 54(NEQ) 60(MOV)
Adept_Location_Number	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations	AC[6]	*2(MOV)
			Move_Robot		*1(MOV) *10(MOV) *19(MOV) *28(MOV) *37(MOV) *46(MOV) *55(MOV)
Adept_Motion_Qualifiers.0	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[3].0	*4(OTL) *13(OTU) *22(OTU) *31(OTU) *40(OTU) *49(OTU) *58(OTU)
Adept_Motion_Qualifiers.1	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[3].1	*4(OTU) *13(OTU) *22(OTU) *31(OTU) *40(OTU) *49(OTU) *58(OTU)

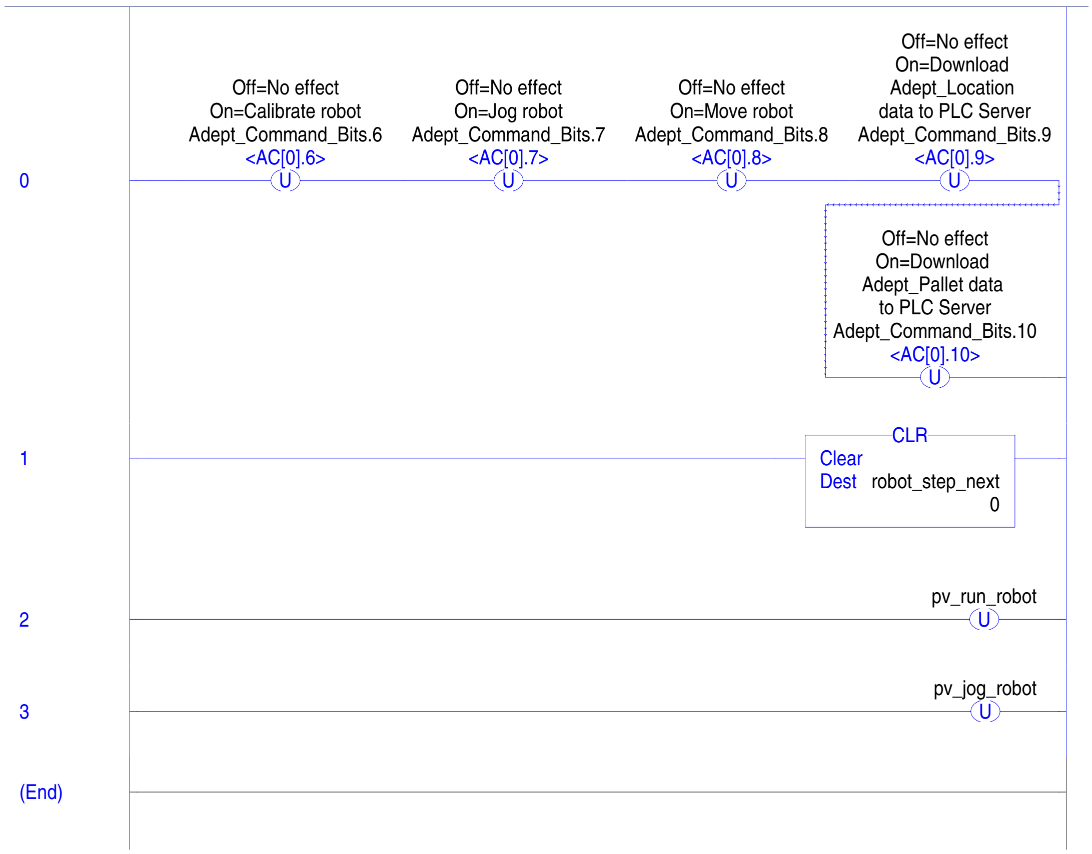
Reference	Scope	Program	Routine	BaseTag	Referenced At [*=Destructive, ?=Not Verified]
Adept_Motion_Qualifiers.10	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[3].10	*5(OTU) *14(OTL) *23(OTU) *32(OTL) *41(OTL) *50(OTU) *59(OTL)
Adept_Motion_Qualifiers.11	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[3].11	*5(OTL) *14(OTL) *23(OTL) *32(OTL) *41(OTL) *50(OTL) *59(OTL)
Adept_Motion_Qualifiers.12	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[3].12	*5(OTU) *14(OTU) *23(OTU) *32(OTU) *41(OTU) *50(OTU) *59(OTU)
Adept_Motion_Qualifiers.13	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[3].13	*5(OTL) *14(OTL) *23(OTL) *32(OTL) *41(OTL) *50(OTL) *59(OTL)
Adept_Motion_Qualifiers.8	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[3].8	*2(OTL) *11(OTU) *20(OTU) *29(OTU) *38(OTU) *47(OTU) *56(OTU)
Adept_Motion_Qualifiers.9	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[3].9	*4(OTU) *13(OTU) *22(OTU) *31(OTU) *40(OTU) *49(OTU) *58(OTU)
Adept_Pallet_Column_Count	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[10]	*3(MOV) *12(MOV) *21(MOV) *30(MOV) *39(MOV) *48(MOV) *57(MOV)
Adept_Pallet_Layer_Count	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[11]	*3(MOV) *12(MOV) *21(MOV) *30(MOV) *39(MOV) *48(MOV) *57(MOV)
Adept_Pallet_Number	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[8]	*3(MOV) *12(MOV) *21(MOV) *30(MOV) *39(MOV) *48(MOV) *57(MOV)
Adept_Pallet_Row_Count	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AC[9]	*3(MOV) *12(MOV) *21(MOV) *30(MOV) *39(MOV) *48(MOV) *57(MOV)
Adept_Speed	Adept_PLC_Server_ControlLogix_Example	MainProgram	Jog_Robot	AC[4]	*1(MOV)
			Move_Robot		*63(CPT)
Adept_Status_Bits.0	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].0	1(XIO) 2(XIO) 3(XIC) 7(XIC)
Adept_Status_Bits.1	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].1	1(XIC) 2(XIO) 3(XIO) 4(XIO) 6(XIC) 7(XIO)
Adept_Status_Bits.2	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].2	3(XIO) 7(XIC)
Adept_Status_Bits.3	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].3	0(XIC)
Adept_Status_Bits.4	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AS[0].4	1(XIC) 2(XIO)

Reference	Scope	Program	Routine	BaseTag	Referenced At [*=Destructive, ?=Not Verified]
Adept_Status_Bits.5	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations	AS[0].5	0(XIO) 11(XIC) 12(XIC)
			Move_Robot		0(XIO)
Adept_Status_Bits.6	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot	AS[0].6	27(XIC) 54(XIC)
pv_speed	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot		63(CPT)
robot_motion_count	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot		*6(MOV) 9(NEQ) *15(MOV) 18(NEQ) *24(MOV) 27(NEQ) *33(MOV) 36(NEQ) *42(MOV) 45(NEQ) *51(MOV) 54(NEQ) *60(MOV)
robot_step_next	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine		*9(MOV)
			Move_Robot		0(EQU) *6(MOV) 9(EQU) *15(MOV) 18(EQU) *24(MOV) 27(EQU) *33(MOV) 36(EQU) *42(MOV) 45(EQU) *51(MOV) 54(EQU) *60(MOV)
			Reset_Faults		*1(CLR)
scratch_speed	Adept_PLC_Server_ControlLogix_Example	MainProgram	Move_Robot		*1(MOV) *10(MOV) *19(MOV) *28(MOV) *37(MOV) *46(MOV) *55(MOV) 63(CPT)

Reset Faults Routine

This section shows the ladder logic and tag listings for a routine to reset error conditions.

Reset_Faults - Ladder Diagram **Page 1**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:45:48 PM
Total number of rungs: 4 ControlLogix_Example.ACD



Reset_Faults - Controller Tag Listing **Page 2**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:45:48 PM
ControlLogix_Example.ACD

Tag Name	Type	Description
⊟-Adept_Command_Bits	INT	Robot command bits
Adept_Command_Bits.0	BOOL	Off=Disable high power On=Enable
Adept_Command_Bits.1	BOOL	Off=No effect On=Update Adept_He
Adept_Command_Bits.5	BOOL	Off=No effect On=Reset faults
Adept_Command_Bits.6	BOOL	Off=No effect On=Calibrate robot
Adept_Command_Bits.7	BOOL	Off=No effect On=Jog robot
Adept_Command_Bits.8	BOOL	Off=No effect On=Move robot
Adept_Command_Bits.9	BOOL	Off=No effect On=Download Adept_
Adept_Command_Bits.10	BOOL	Off=No effect On=Download Adept_
pv_jog_robot	BOOL	
pv_run_robot	BOOL	
⊞-robot_step_next	INT	

Reset_Faults - Tag Cross Reference **Page 3**
Adept_PLC_Server_ControlLogix_Example:MainTask:MainProgram 6/3/2004 5:45:49 PM
ControlLogix_Example.ACD

Reference	Scope	Program	Routine	BaseTag	Referenced At [*=Destructive, ?=Not Verified]
Adept_Command_Bits.0	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].0	*1(OTU) *2(OTL)
Adept_Command_Bits.1	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].1	*11(OTE)
Adept_Command_Bits.10	Adept_PLC_Server_ControlLogix_Example	MainProgram	Reset_Faults	AC[0].10	*0(OTU)
Adept_Command_Bits.5	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].5	*5(OTE)
Adept_Command_Bits.6	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].6	*3(OTE)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.7	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].7	8(XIO) *10(OTE)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.8	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine	AC[0].8	*9(OTU) 9(XIC) 10(XIO) 11(XIO)
			Move_Robot		0(XIO) *7(OTL) *16(OTL) *25(OTL) *34(OTL) *43(OTL) *52(OTL) *61(OTL)
			Reset_Faults		*0(OTU)
Adept_Command_Bits.9	Adept_PLC_Server_ControlLogix_Example	MainProgram	Download_Locations	AC[0].9	0(XIO) *9(OTL) *11(OTU) 11(XIC) 12(XIO)
			Reset_Faults		*0(OTU)
pv_jog_robot	Adept_PLC_Server_ControlLogix_Example	MainProgram	Reset_Faults		*3(OTU)
pv_run_robot	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine		8(XIC) 9(XIO)
			Reset_Faults		*2(OTU)
robot_step_next	Adept_PLC_Server_ControlLogix_Example	MainProgram	MainRoutine		*9(MOV)
			Move_Robot		0(EQU) *6(MOV) 9(EQU) *15(MOV) 18(EQU) *24(MOV) 27(EQU) *33(MOV) 36(EQU) *42(MOV) 45(EQU) *51(MOV) 54(EQU) *60(MOV)
			Reset_Faults		*1(CLR)

6.5 PLC Server Error Messages

The following sections describe the error messages that are specific to the PLC Server.

PLC Server Error Messages (Numerical Listing)

Error	Description
-3001	*System initialized and ready to run*
-3002	*E-stop due to lost serial communication*
-3003	*DF1 communication error: Illegal data string length*
-3004	*DF1 communication error: NAK count exceeded*
-3005	*DF1 communication error: ENQ count exceeded*
-3006	*DF1 extended status error* Code n hex
-3007	*Illegal command: More than one command bit enabled*
-3008	*Only one axis bit can be set while jogging*
-3009	*Cannot mix joint-coordinate location and pallet*
-3010	*Cannot move relative to a pallet*
-3011	*Illegal location number* Location n
-3012	*Illegal pallet number* Pallet n
-3013	*Illegal speed parameter* Speed n
-3014	*Illegal acceleration parameter* Acceleration n
-3015	*Undefined location* Location n
-3016	*Undefined pallet* Pallet n
-3017	*Unknown processor type* ID n
-3018	*MSG instructions not allowed*

PLC Server Error Messages (Alphabetical Listing)

Cannot mix joint-coordinate location and pallet **(-3009)**

A motion relative to a pallet has been requested, and the motion-qualifier bits (N30:4 or Adept_Motion_Qualifier) indicate that the specified location is defined by joint coordinates.

Cannot move relative to a pallet **(-3010)**

A relative motion has been specified by the motion-qualifier bits (N30:4 or Adept_Motion_Qualifier), and a pallet has been identified by the command register (N30:8 or Adept_Pallet_Number)

DF1 communication error: Illegal data string length **(-3003)**

A DF1 message has been received, or one is being sent, and the message has an odd character count other than 1.

DF1 communication error: ENQ count exceeded **(-3005)**

After sending a message to the PLC, two ENQ requests have been sent without a response.

DF1 communication error: NAK count exceeded **(-3004)**

After sending a message to the PLC, two NAK responses have been received.

***DF1 extended status error* Code n hex** **(-3006)**

After sending a message to the PLC, the response contained the extended status (EXT STS) error code shown in the message. Refer to your PLC manual for an explanation of the error codes.

E-stop due to lost serial communication **(-3002)**

This error occurs when the system has lost communication with the PLC Server for several seconds. Check that the serial cable is plugged in and functional and that the PLC's serial port settings are correct.

***Illegal acceleration parameter* Acceleration n** **(-3014)**

The acceleration parameter specified in N30:5 or Adept_Acceleration must be greater than 0.

Illegal command: More than one command bit enabled **(-3007)**

An error occurred because more than one of the main command bits was enabled at a time.

***Illegal location number* Location n** **(-3011)**

The location number specified in N30:6 or Adept_Location_Number is either less than one or larger than the maximum location number permitted.

***Illegal pallet number* Pallet n** **(-3012)**

The pallet number specified in N30:8 or Adept_Pallet_Number is either less than one or larger than the maximum location number permitted.

***Illegal speed parameter* Speed n** **(-3013)**

The motion speed specified in N30:4 or Adept_Speed is either less than zero for a regular robot motion, or outside the allowable range (-127 to 127) for jogging the robot.

MSG instructions not allowed **(-3018)**

After sending a message to the PLC, the response was a reply message.

Only one axis bit can be set while jogging **(-3008)**

More than one robot axis or coordinate direction is selected in N30:2 or Adept_Jog_Mode, which is permitted only in FREE mode.

System initialized and ready to run **(-3001)**

The PLC Server has completed its initialization and is ready for operation.

***Undefined location* Location n** **(-3015)**

An attempt has been made to use a location that has not been defined.

***Undefined pallet* Pallet n** **(-3016)**

An attempt has been made to use a pallet that has not been defined.

***Unknown processor type* ID n** **(-3017)**

The PLC Server software does not recognize the processor in the Adept PLC Server. That is, the PLC Server software in use is not compatible with the Adept PLC Server hardware.

7 Optional Robot Equipment Installation

7.1 Installing End-Effectors

The user is responsible for providing and installing any end-effector or other end-of-arm tooling. End-effectors can be attached to the user flange using four M6 screws. See **Figure 9-3 on page 161** for a detailed dimension drawing of the user flange.

A 6 mm diameter x 12 mm dowel pin (not supplied) fits in the through hole in the user flange and can be used as a keying or antirotation device in a user-designed end-effector.

If hazardous voltages are present at the end-effector, you must install a ground connection from the base of the robot or the outer link to the end-effector. See **“Robot-Mounted Equipment Grounding” on page 63**.

> **NOTE:** A threaded hole is provided on the user flange (see **Figure 9-3 on page 161**). The user may attach a ground wire through the quill connecting the outer link and the user flange.

7.2 Removing and Installing the User Flange

The user flange can be removed and reinstalled if this is required for a specific reason. If the flange is removed, it must be reinstalled in exactly the same position to avoid losing the calibration for the system.

There is a setscrew on the flange that holds the rotational position of the flange on the quill shaft. A ball bearing behind the setscrew contacts the shaft in one of the vertical-spline grooves in the shaft. Follow the procedures below to remove and replace the flange assembly.

Removing the Flange

1. Turn off High Power and system power to the robot.
2. Remove any attached end-effectors or other tooling from the flange.
3. Use a 2.5 mm Allen driver to loosen the setscrew (see **Figure 7-1 on page 138**). Note the vertical-spline groove that is in line with the setscrew. You must replace the flange in the same position.
4. Use a socket driver to loosen the two M4 socket-head screws.
5. Slide the flange down slowly until it is off the shaft. *Be careful* not to lose the ball bearing (3.5 mm) that is inside the flange behind the setscrew.

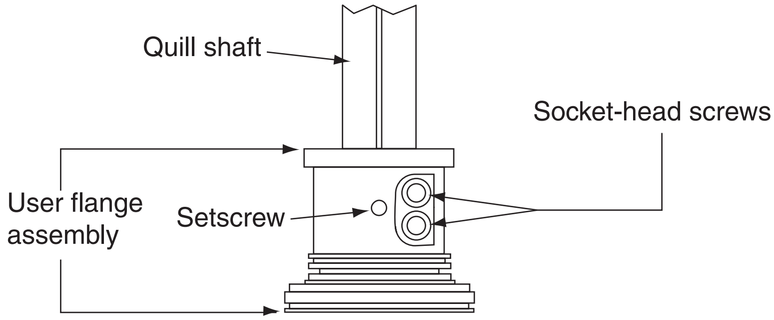


Figure 7-1. User Flange Removal Details

Installing the Flange

1. Make sure the ball bearing is in the setscrew hole inside the flange. Hold it in place with your finger as you get ready to install the flange.
2. Slide the flange up on the quill shaft as far as it will go, and rotate until the setscrew is lined up with the original vertical groove.
3. Support the flange while using a 2.5 mm Allen driver to tighten the setscrew to finger tight. Do not over-tighten the setscrew because this will cause the flange to be off-center from the quill shaft.
4. Use a socket driver to tighten one of the socket-head screws part of the way, then tighten the other one the same amount. Alternate between the two screws so there is even pressure on both once they are tight. The torque specification for each screw is 8 N•m (70 in-lb).

7.3 User Connections on Robot

User Air Lines

There are five user air line connectors on the robot user panel on the back of Joint 1 (see **Figure 7-2**). The five air lines run through the robot up to another set of five matching connectors on the top of the outer link (see **Figure 7-3**).

- The two larger connectors are 6 mm diameter.
- The three smaller connectors are 4 mm diameter.

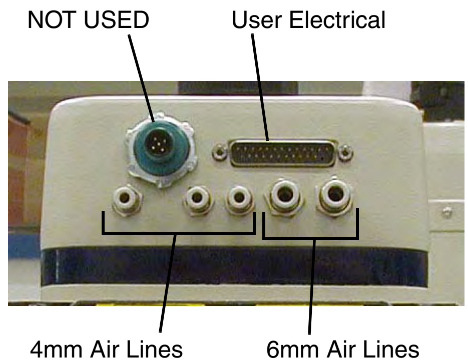


Figure 7-2. User Connectors on Joint 1

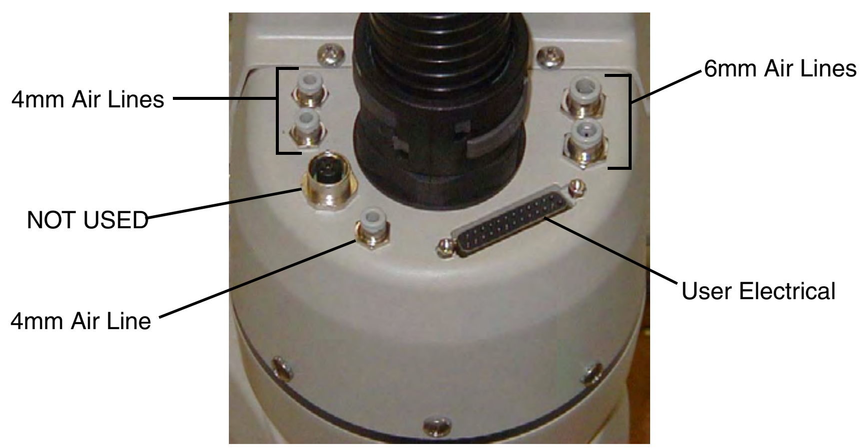


Figure 7-3. User Connectors on Joint 2

User Electrical Lines

There is a 25-pin male connector (24 conductor) on the robot user panel on the back of Joint 1 for user electrical lines (see **Figure 7-2**). This connector is wired directly to a 25-pin female connector on the top of the outer link (see **Figure 7-3**). These connectors can be used to run user electrical signals from the user panel, through the robot, and up to the outer link.

Specifications:

- Wire size: 0.1 mm^2 (12 pair, Pin Numbers 1-24)
- Maximum current per line: 1 Amp

7.4 Mounting Locations for External Equipment

Three locations are provided for mounting user external equipment on the robot arm. The first location is on the J1 Harness Support (top side of the inner link), a second is on the top side of the outer link, and a third is on the bottom side of the outer link. Each location has a set of four tapped holes. See **Figure 9-4 on page 162** for the dimensions.

NOTE: The cover on the outer link must be removed for maintenance (lubrication), so keep this in mind when mounting any external equipment to the outer link cover.

7.5 Installing Robot Solenoid Kit

Introduction

This procedure describes how to mount the 24V solenoid option kit on an Adept Cobra PLC robot. The solenoid kit is available as Adept P/N 02853-000.

The robot has been prewired to accommodate a bank of two 24 VDC solenoid valves. Power for the internal mounting is accessible via a connector mounted inside the outer link cover (see **Figure 7-4 on page 142**). The signals actuating the valves are directly switchable from the PLC. Refer to **Chapter 6** for register information. The Adept-supplied solenoids each draw a nominal 75 mA from 24 VDC.

The solenoid valve assembly consists of two independent valves (Valve #1 and Valve #2) on a common manifold. The manifold supplies air at the user's line pressure (28 psi (0.19 MPa) minimum to 114 psi (0.786 MPa) maximum). Each valve has two output ports, A and B. The output ports are arranged so that when Port A is pressurized, Port B is not pressurized. Conversely, when Port B is pressurized, Port A is not. In the Adept Cobra PLC robots, the air lines from Port A on each valve are plugged at the factory (at the solenoid assembly).

The Solenoid Kit for the Adept Cobra PLC robot is available through Adept. Contact your Adept Sales Representative for current price and availability.

The Solenoid Kit for the Adept Cobra s-series robot is available through Adept. Contact your Adept Sales Representative for current price and availability.

Table 7-1. Air Pressure

Air Pressure (Psi)	Air Pressure (MPa)
28 - 114	.19 - .786

Tools Required

- Assorted Allen drivers
- Tie-wraps
- Pair of diagonal wire cutters
- Solenoid Valve upgrade Kit (Adept P/N 02853-000)

Procedure

1. Turn off all power to the robot.
2. Remove two screws on the Cobra PLC 600 (three screws on Cobra PLC 800) on each side of the outer link cover. Remove two screws on top and remove the cover.
3. Connect the Internal Solenoid Valve Cable assembly to the Solenoid Manifold assembly, by plugging the SOL 1 connector into Valve 1 and SOL 2 into Valve 2.

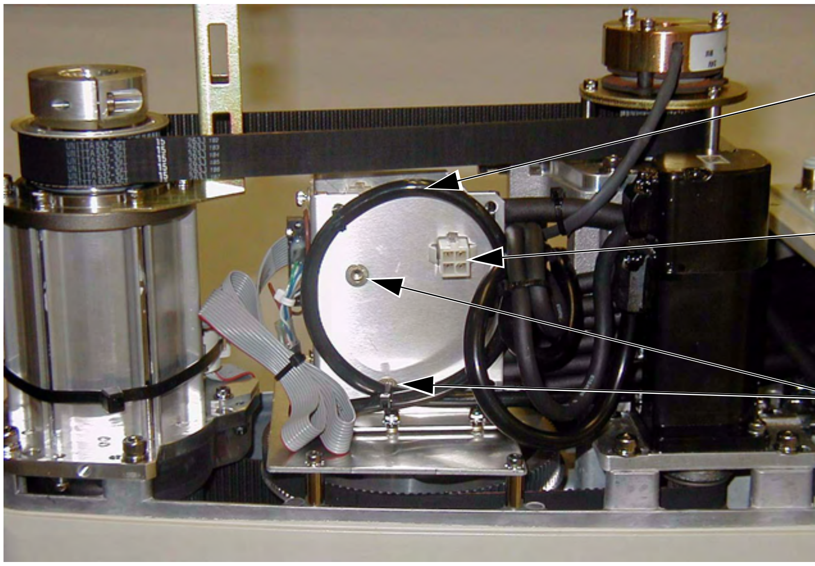


Figure 7-4. Solenoid Mounting Bracket With Connector and Spare Air Line

4. Cut and discard the tie-wraps holding the spare air line at the top of the mounting bracket. Move the air line away to facilitate the mounting of the solenoid manifold (see **Figure 7-4**).
5. Mount the solenoid manifold onto the bracket using the supplied M3 x 25 mm screws and washers (see **Figure 7-5 on page 143**).
6. Insert the spare air line into the air intake coupling of the solenoid manifold. Make sure the air line is pushed in all the way and secured in place by the intake coupling. Confirm by pulling the air line.
7. Plug the connector plug into the female connector jack (marked SOLND) on the bracket.
8. Use tie-wraps to secure air line to the bracket as needed.

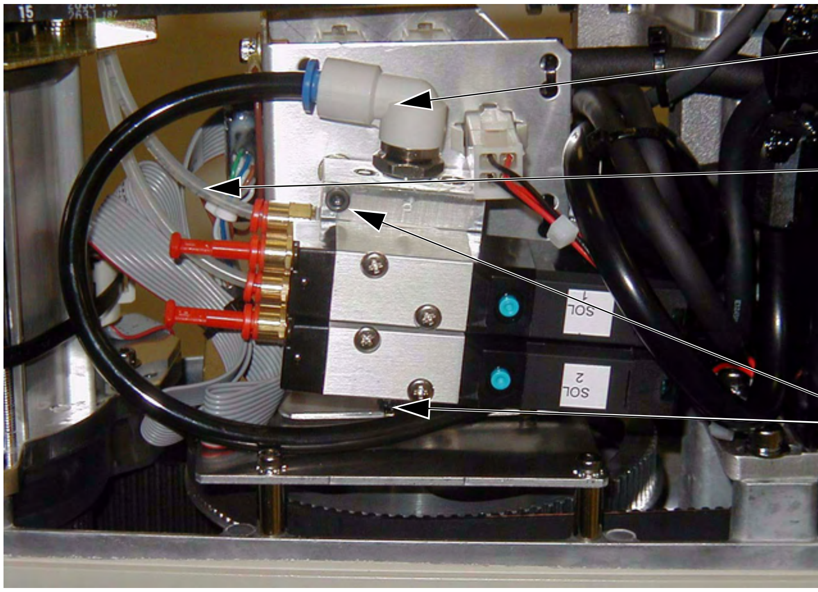


Figure 7-5. Solenoid Placement Using Mounting Hardware

9. Install the appropriate lengths of 5/32 inch plastic tubing (supplied) into the two output ports on the manifold. Route the tubing up along the tower bracket next to the quill and down through the center of the quill. Use tie-wraps as needed to secure the tubing.
10. Remove the four screws for the Joint 1 cover and lift the cover up so you have access to the tubing under the cover. See **Figure 7-6**.

Figure 7-6. Connecting Spare Air Line to User Connector

11. Disconnect the tubing from the 6mm User Air fitting shown in **Figure 7-6**. Fold the tubing out of the way and restrain using tie-wraps.

12. Locate the spare air line contained in the tubing bundle inside the front end of the cover. Remove the spare air line from the bundle.
13. Insert the spare air line into the back of the empty 6mm User Air fitting.

    NOTE: This 6mm User Air connector and the 6mm User Air connector at the top of **Figure 7-2 on page 139** are not functional for other uses after this modification.

14. Replace the Joint 1 cover, taking care to insure that all tubing is inside the cover and nothing gets crimped or pinched while pushing the cover into position. Replace four screws to secure the cover. Tighten the screws to 1.6 N•m (14 in-lb) of torque.
15. Replace the outer link cover and tighten the screws to 1.6 N•m (14 in-lb) of torque.
16. Connect the factory air supply to the modified 6mm User Air connector.
17. Turn on system power and boot the system. Once the system boot has completed, you can toggle the outputs from the PLC. Refer to **Chapter 6** for register information.

WARNING: Disconnect robot air pressure until this test has been done to prevent unsecured pneumatic lines from accidentally injuring personnel.

7.6 DeviceNet Pass-Through Cable

DeviceNet is a communications link that connects industrial I/O devices to a message packeting network. All devices connect to the same backbone cable, eliminating the need for individual wiring for each I/O point.

NOTE: The DeviceNet cable in the robot is strictly for pass-through. If DeviceNet is used, it must be implemented from the user-supplied PLC. The PLC Server does not support DeviceNet.

Adept incorporates the following DeviceNet ready hardware in the Adept Cobra PLC robot:

- Female connector for the robot tower; Micro-style 12 mm thread DIN female connector (see **Figure 7-7 on page 145**)
- Male Micro-style 12 mm thread DIN connector at the robot base.

- A nonstandard DeviceNet cable consisting of two shielded twisted pairs that connect the above connectors. Adept considers this cabling to be a drop line with a maximum total length of 6 meters and therefore uses the following wire sizes:

Wire	Adept	DeviceNet "thin cable"
Power pairs	24 AWG ($0.25\ mm^2$)	22 AWG ($0.34\ mm^2$)
Signal pairs	28 AWG ($0.08\ mm^2$)	24 AWG ($0.25\ mm^2$)

This means that total current on the power pairs must be limited to 2A instead of the standard 3A in a DeviceNet trunk line. Because this is intended to be a DeviceNet "drop line" with a maximum of 6 meters (16.5 feet), the full data rate should be achievable. However, Adept has tested the internal cable only at 125k baud.

Recommended Vendors for Mating Cables and Connectors

A variety of vendors have molded cable assemblies for the "Micro-style" connector including **Brad Harrison, Crouse Hinds, Lumberg, Turk,** and others. In addition, **Hirshmann, Phoenix Contact,** and **Beckhoff** have mating micro connectors that have screw terminals in the plug to allow the user to make custom cables.

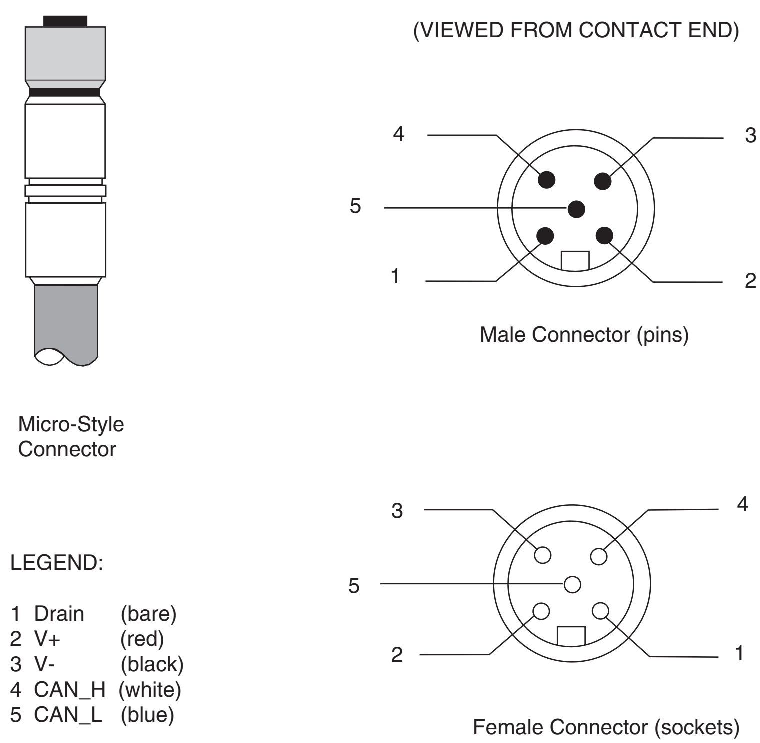


Figure 7-7. Micro-Style Connector Pinouts for DeviceNet

Maintenance 8

8.1 Periodic Maintenance Schedule

Table 8-1 gives a summary of the preventive maintenance procedures, and guidelines on how often they should be performed.

Table 8-1. Inspection and Maintenance

Item	Period	Reference
Check E-Stop, enable and key switches, and barrier interlocks	6 months	See Section 8.2.
Check robot mounting bolts	6 months	See Section 8.3.
Check for signs of oil around of harmonic drive area.	3 months	See Section 8.4
Lubricate Joint 3 (Z-axis) ball screw	3 months	See Section 8.5.
Replace Encoder battery	18 months to 3 years	See Section 8.7

NOTE: The frequency of these procedures will depend on the particular system, its operating environment, and amount of usage. Use the times in Table 8-1 as guidelines and modify the schedule as needed.

WARNING: Lockout and tagout power before servicing.

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 access covers on the robot are not interlocked – turn off and disconnect power if covers have to be removed.

8.2 Checking of Safety Systems

These tests should be done every six months.

1. Test the operation of:
   - E-Stop button on Front Panel
   - E-Stop button on MCP
   - Enabling switch on MCP
   - Auto/Manual switch on Front Panel

   NOTE: Operating **any** of the above switches should disable High Power.

2. Test the operation of any external (user supplied) E-Stop buttons.
3. Test the operation of barrier interlocks, etc.

8.3 Checking Robot Mounting Bolts

Check the tightness of the base mounting bolts every 6 months. Tighten to 85 N•m (63 ft-lb). Also check the tightness of all cover plate screws.

8.4 Check Robot for Oil Around Harmonic Drive

The Cobra PLC robots use oil in the harmonic drive components for lubrication. It is a good idea to periodically inspect the robot for any signs of oil in areas outside of the harmonic drive. Check these locations:

- the area around Joint 1
- the area around Joint 2
- inside the base of the robot, by opening the AIB chassis and inspecting internally. Be sure to remove all power to the robot before opening the AIB chassis.

Contact Adept if you find any signs of oil in these areas.

8.5 Lubricate Joint 3 Ball Screw

Required Grease for the Robot

Ball Screw/Spline Assembly Grease
LG-2 Lubricating Grease Lithium Soap, Synthetic Hydrocarbon
Adept part number: 90401-04029

CAUTION: Using improper lubrication products on the Adept Cobra PLC 600 or PLC800 robot may cause damage to the robot.

Lubrication Procedure

1. Turn off main power to the PLC Server and robot.
2. Remove the outer link cover by removing six screws located on the sides and top of the cover. Carefully remove the cover.
3. Move Joint 3 to the top of its travel. Remove any existing grease with a soft cloth.
4. Using a syringe, apply a small bead of grease to the Joint 3 ball screw grooves (see Figure 8-1 on page 150).
5. Move Joint 3 to the bottom of its travel. Remove any existing grease with a clean, lint-free, soft cloth.
6. Apply a thin film of grease to any grooves of the ball screw that you did not reach in step 4.
7. Move Joint 3 up and down several times to spread the grease evenly.
8. Replace the outer link cover and tighten the screws to 1.6 N•m (14 in-lb) of torque.

WARNING: When the Outer link cover is removed, you see the label shown in Figure 2-3 on page 23. Do not remove the J3-ENC or J4-ENC encoder cable connectors from their sockets. If they are removed, the calibration data will be lost and the robot must be run through a factory calibration process, which requires special software and tools.

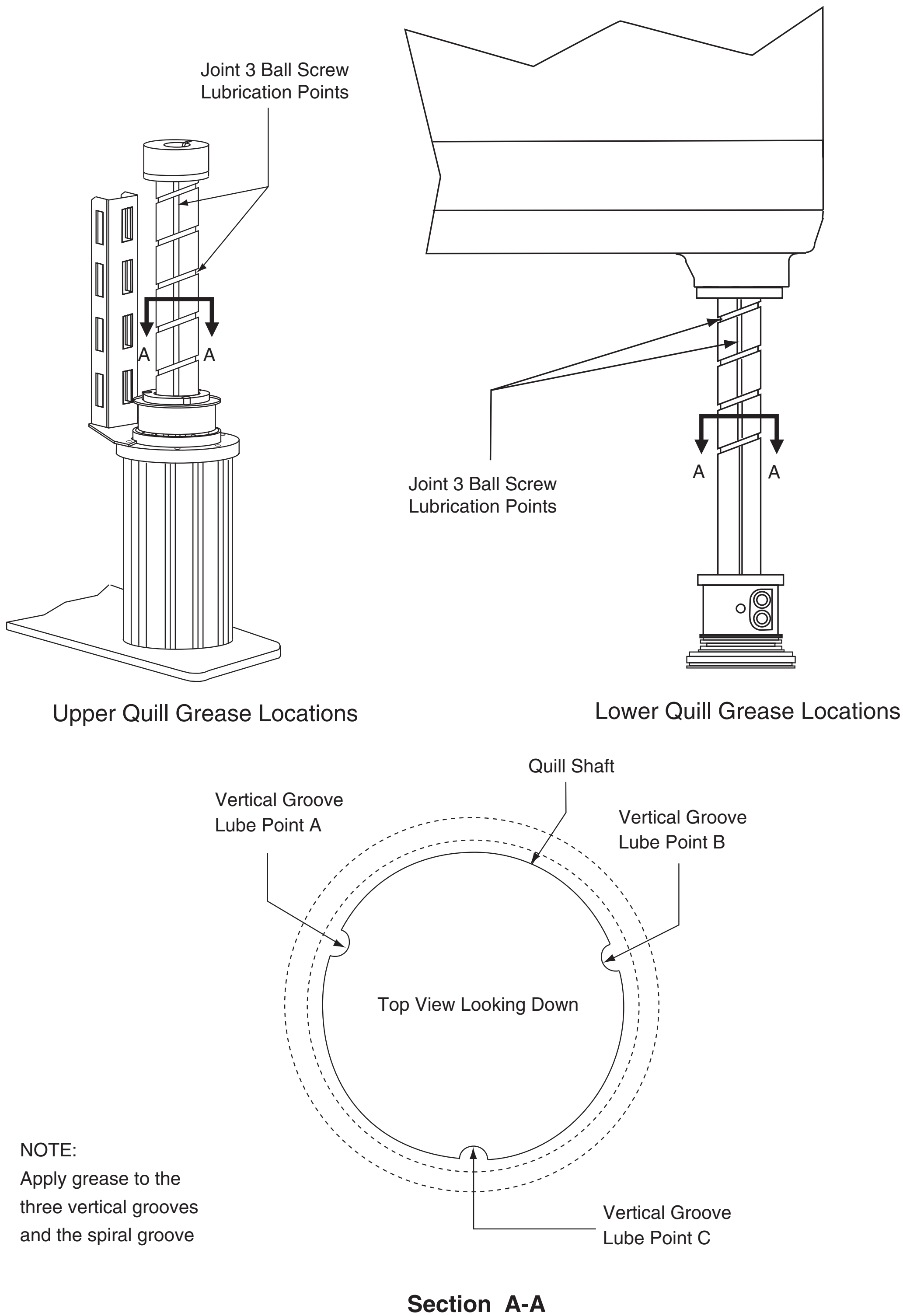


Figure 8-1. Lubrication of Joint 3 Quill

8.6 Replacing the SmartAmp AIB Chassis

This procedure provides details on how to replace the SmartAmp AIB chassis on a Cobra PLC robot.

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

Removing the SmartAmp AIB Chassis

1. Switch off the PLC Server.
2. Switch off the 24 VDC input supply to the chassis.
3. Switch off the 200/240VAC input supply to the chassis.
4. Disconnect the 24 VDC supply cable from the chassis +24 VDC input connector. See Figure 4-2 on page 48 for locations of connectors.
5. Disconnect the 200/240VAC 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, RS-232, or any others.
9. Using a 5 mm Allen key, carefully unscrew the chassis securing screw. See Figure 8-2. Note that 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.

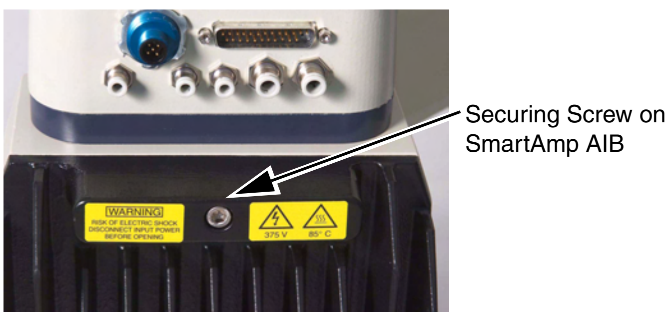


Figure 8-2. Securing Screw on SmartAmp AIB Chassis

10. While holding the chassis heat sink, carefully and slowly lower the chassis down (see Figure 8-3 on page 152), so that enough access is available to remove the internal cables. The chassis can be laid flat or placed to the right side of the robot for better access.

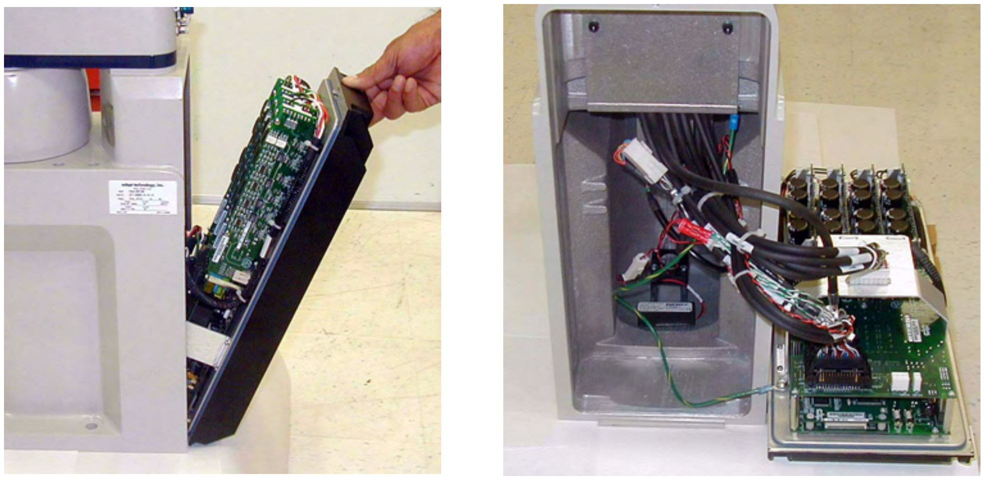


Figure 8-3. Opening and Removing AIB Chassis

11. Disconnect the “white” amplifier cable from the amplifier connector located on the chassis bracket. See **Figure 8-4**.

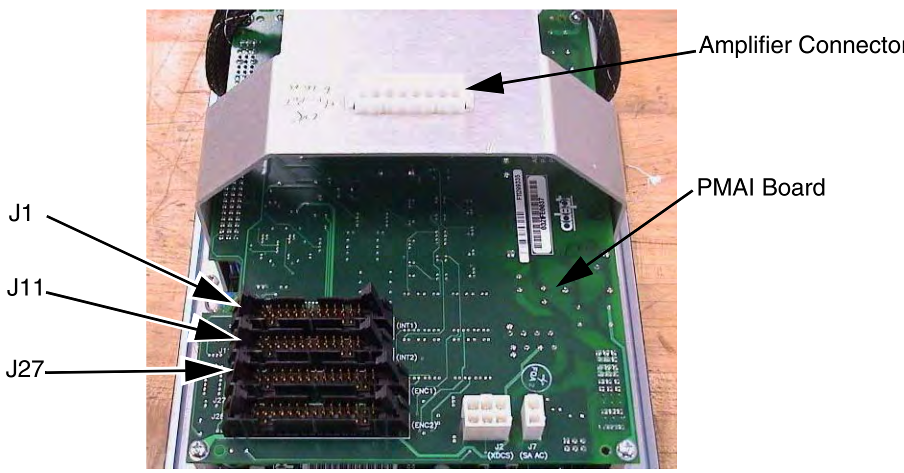


Figure 8-4. Connectors on AIB Chassis

12. Carefully disconnect the J1 cable from the J1 connector on the PMAI board, by disengaging the securing latches.
13. Carefully disconnect the J11 cable from the J11 connector on the PMAI board, by disengaging the securing latches.
14. Carefully disconnect the J27 cable from the J27 connector on the PMAI board, by disengaging the securing latches.
15. Using a 5MM Allen key, disconnect and remove the ground wire from the chassis. Keep the screw for reassembly later. See **Figure 8-5 on page 153**.

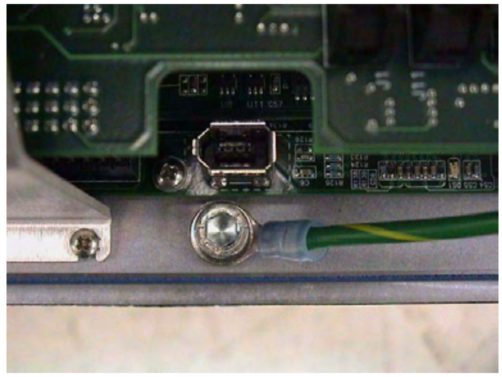


Figure 8-5. Ground Screw on AIB Chassis

16. Carefully remove the chassis from the robot, and place it aside. Tag it with the appropriate fault diagnosis faults/errors and robot serial number information.

Installing a New SmartAmp AIB Chassis

1. Carefully remove the new chassis from its packaging, check it for any signs of damage, and remove any foreign packing materials or debris from inside the chassis.
2. Carefully place the chassis next to the robot.
3. Using a 5mm Allen key, carefully connect the ground wire to the chassis.
4. Carefully connect the J27 cable to the J27 connector on the PMAI, and engage the securing latches.
5. Carefully connect the J11 cable to the J11 connector on the PMAI, and engage the securing latches.
6. Carefully connect the J1 cable to the J1 connector on the PMAI, and engage the securing latches.
7. Carefully connect the “white” amplifier cable to the amplifier connector located on the chassis bracket.

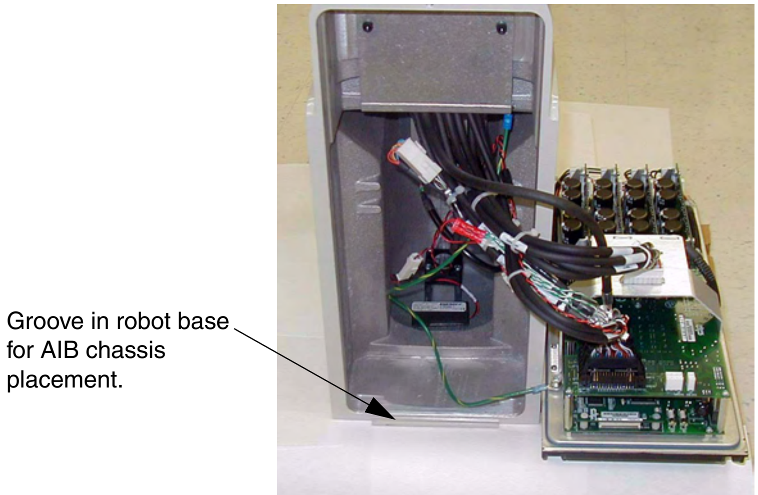


Figure 8-6. Installing AIB Chassis in Robot Base

8. Carefully insert the chassis into the robot base in the groove at the bottom of the base - see **Figure 8-6**. Tilt the chassis up and into place against the robot, 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 8-2 on page 151** for details.
10. Connect the 200/240VAC supply cable to the chassis AC Input connector.
11. Connect the XSLV cable to the chassis XSLV connector.
12. Connect the 1394 cable to the chassis SmartServo connector.
13. Connect any other cables, which may be connected to the chassis, such as XIO, RS-232, or any others.
14. Connect the 24 VDC supply cable to the chassis +24 VDC input connector.
15. Switch on the 200/240VAC input supply to the chassis.
16. Switch on the 24 VDC input supply to the chassis.
17. Switch on the PLC Server.
18. Once the system has completed booted, test the system for proper operation.

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 battery only with 3.6 V, 8.5 Ah lithium battery, Adept part number: 02704-000. Battery information is located in the base of the robot.

Battery Replacement Time Periods

If the robot is kept in storage and not in production, or the robot is turned off (no 24 VDC supply) most of the time, then the battery should be replaced every 18 months.

NOTE: Dispose of the battery according to all local and national environmental regulations regarding electronic components.

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 three years. For example, if the robot is typically turned off only on weekends, the battery would need to be replaced every four years.

Battery Replacement Procedure

1. Obtain the replacement battery. Adept part number: 02704-000.
2. Switch off the PLC Server.
3. Switch off the 24 VDC input supply to the robot.
4. Switch off the 200/240VAC 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 48** for locations of connectors.
6. Disconnect the 200/240VAC supply cable from the robot AC Input connector.
7. Using a 5mm Allen key, carefully unscrew the AIB chassis securing screw. See **Figure 8-2 on page 151**. Note that 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.
8. While holding the chassis heat sink, carefully and slowly lower the chassis down (see **Figure 8-3 on page 152**), so there is access to the battery. See **Figure 8-7**.

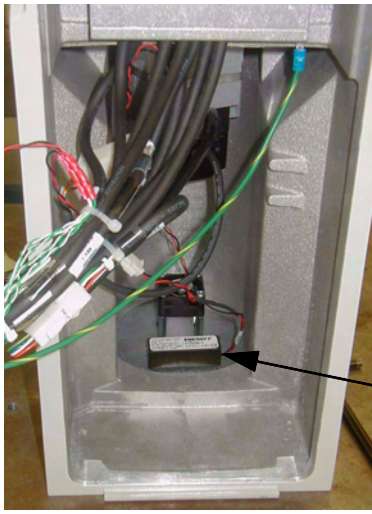


Figure 8-7. Location of Encoder Battery

9. The battery cable assembly has two sets of connectors. Locate the secondary battery cable in the wire bundle in the base area.

CAUTION: Do not short the connectors together.

10. Place the new battery next to the original one, but do not disconnect the original one.
11. Connect the new battery to the connectors on the secondary battery cable. Make sure to verify the positive and negative connections are correct.
12. Once the new battery is connected, you can disconnect and remove the original battery.
13. Place the new battery in the original location on the base of the robot.
14. Close the robot by reversing the steps in the beginning of this procedure.

8.8 Changing the Lamp in the High Power Indicator

The system is equipped with circuitry to detect the potentially dangerous condition of a burned out High Power indicator on the optional Front Panel. If this lamp is burned out, you cannot enable High Power until the lamp has been replaced. Follow this procedure to replace the High Power indicator bulb. The Adept part number for the lamp is 27400-29006.

1. Turn off system power to the PLC Server.
2. Disconnect the cable between the Front Panel and the PLC Server.

3. Remove the Front Panel from its mounting location.
4. Remove the two screws on the back of the Front Panel.
5. Carefully pull the front cover away from the body of the Front Panel. You will encounter some resistance as there are three plug-type connectors that you need to disconnect as you pull the front cover away from the body.

   NOTE: Separate the cover from the body slowly to avoid damaging the two wires that go between the LED and the PC board inside the body. Pull the front cover as straight away as possible. You do not have to disconnect the wires from the PC board, although you can if needed.

6. Locate the lamp body in the center of the back side of the front cover. Turn the lamp body approximately 20° in either direction and then pull straight back.
7. The lamp body is now free. You can remove the old lamp and insert a new one.
8. Replace the lamp body by pushing it straight into the lamp housing receptacle. Make sure the contacts on the lamp body are properly oriented. See **Figure 8-8 on page 157**.
9. Make sure to reconnect the wires from the LED if you disconnected them earlier. Push the front cover into the body, taking care to align all of the plug-type connectors. Verify that the wires do not get crimped as you reinstall the cover.
10. Replace the two screws on the back of the body.
11. Reinstall the Front Panel in its mounting.
12. Reconnect the cable between the Front Panel and the PLC Server.

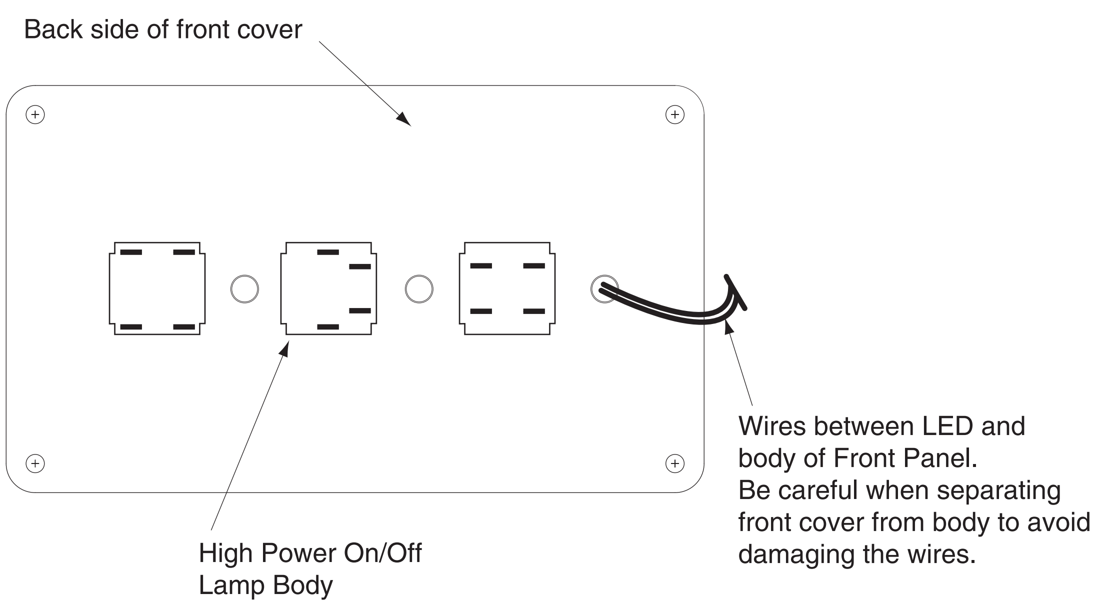


Figure 8-8. Lamp Body Contact Alignment

Technical Specifications 9

9.1 Robot Dimension Drawings

This section shows the dimensions of the Adept Cobra PLC600 and PLC800 robots.

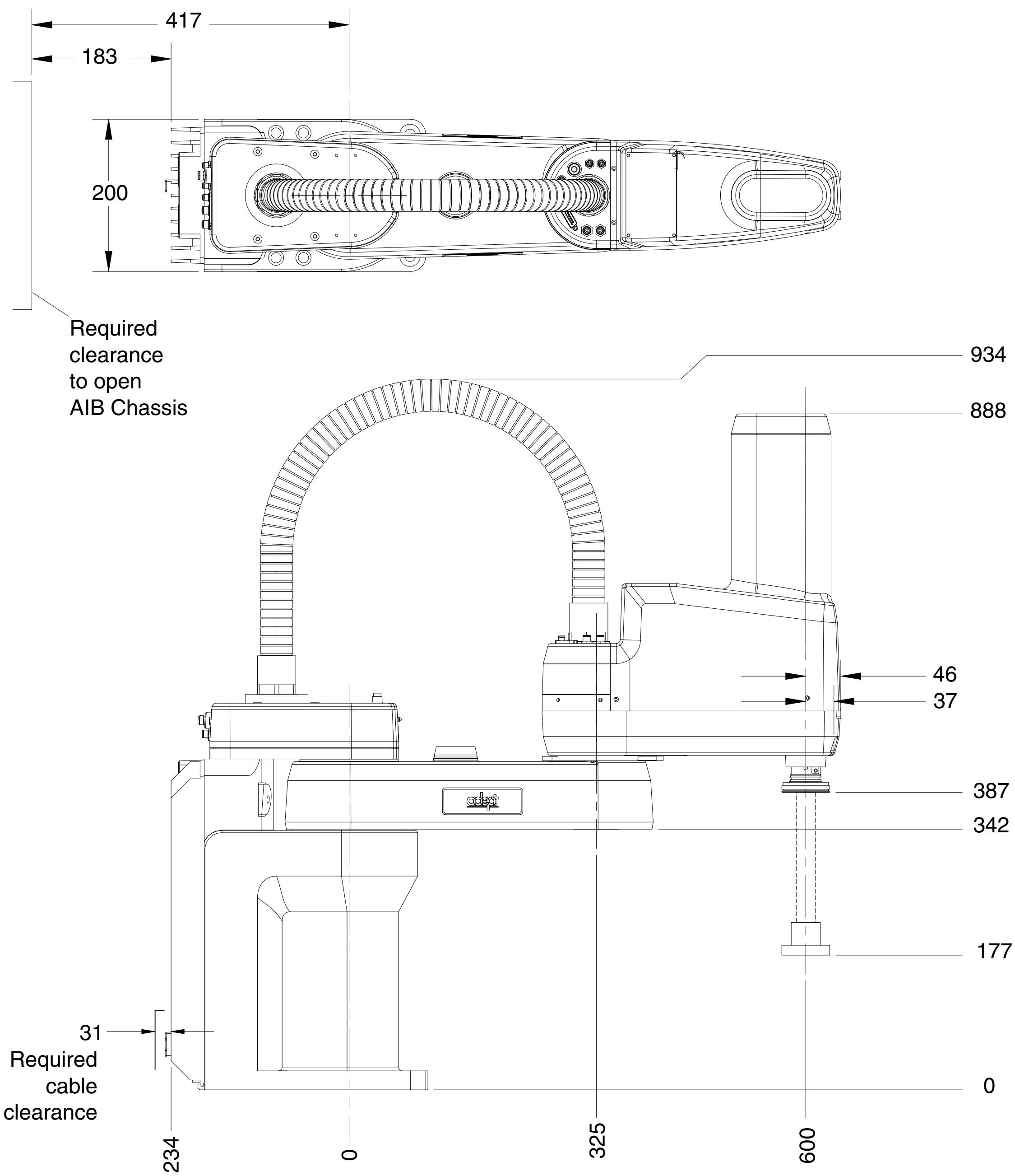


Figure 9-1. Adept Cobra PLC600 Robot Top and Side Dimensions

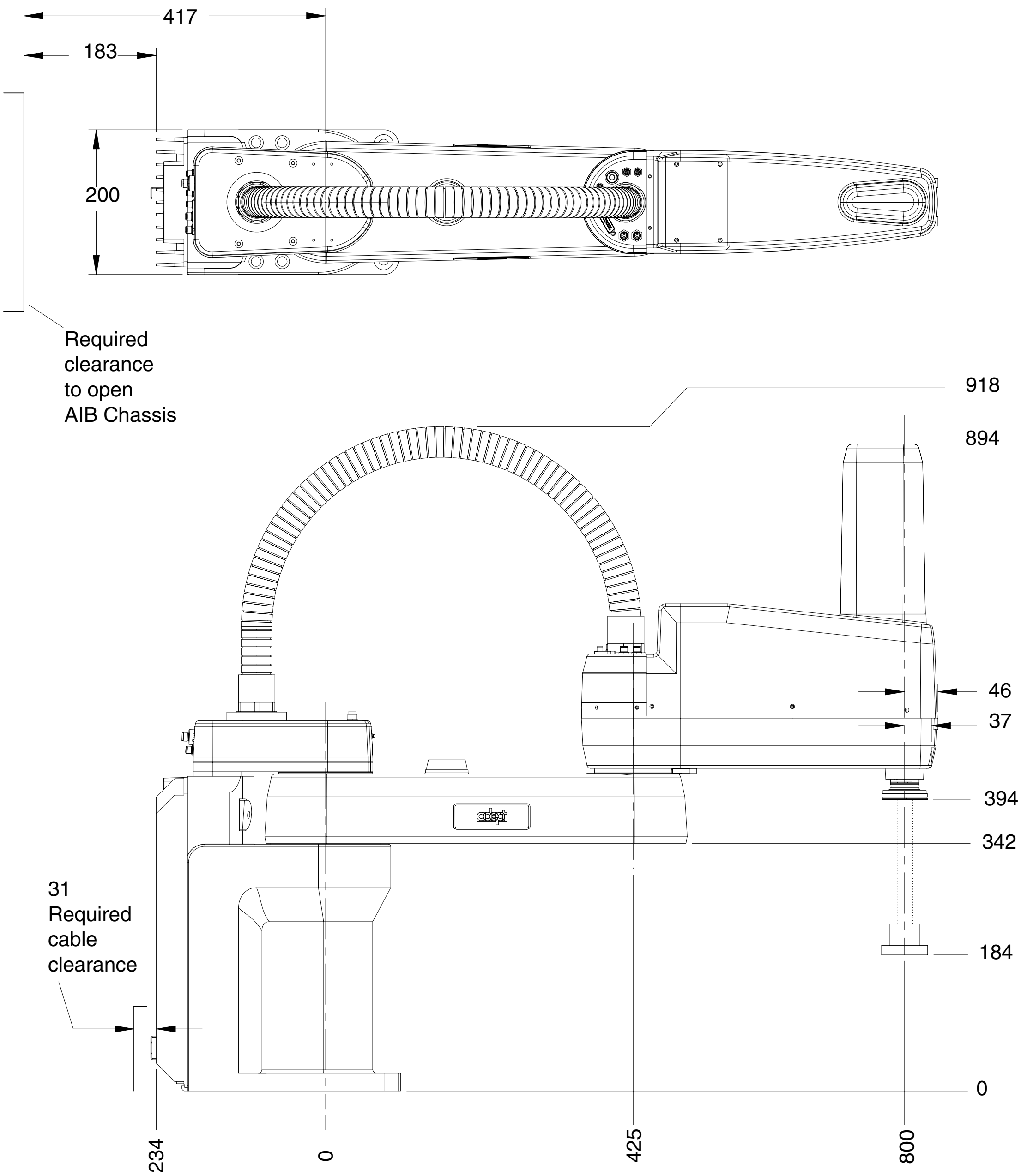


Figure 9-2. Adept Cobra PLC800 Robot Top and Side Dimensions

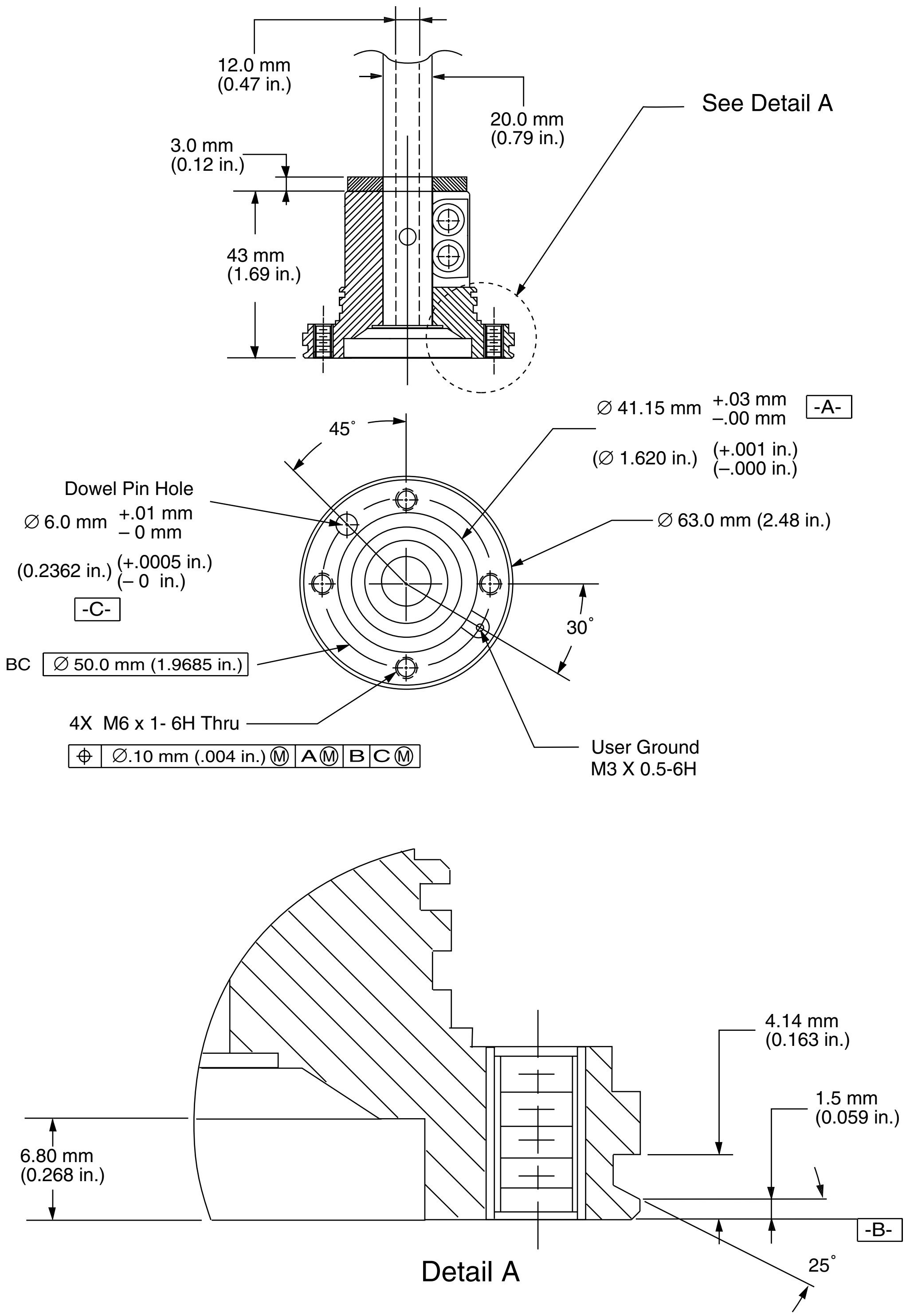


Figure 9-3. Tool Flange Dimensions for Adept Cobra PLC Robots

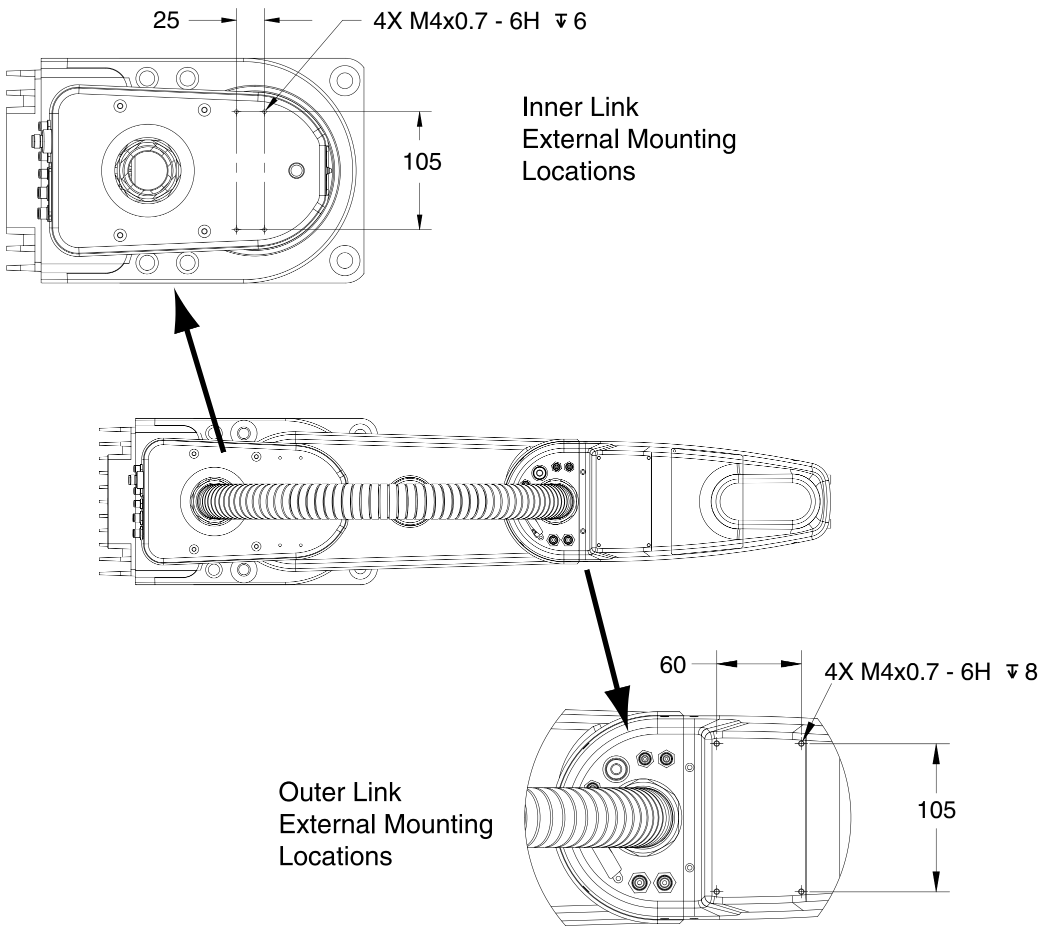


Figure 9-4. External Tooling on Top of Robot Arm

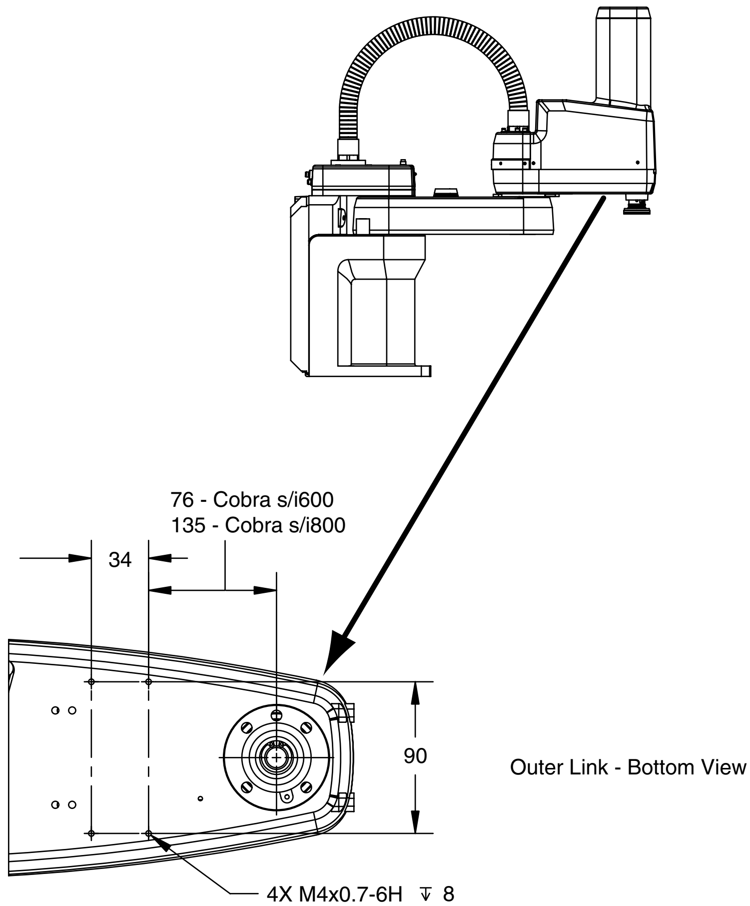


Figure 9-5. External Tooling on Underside of Outer Link

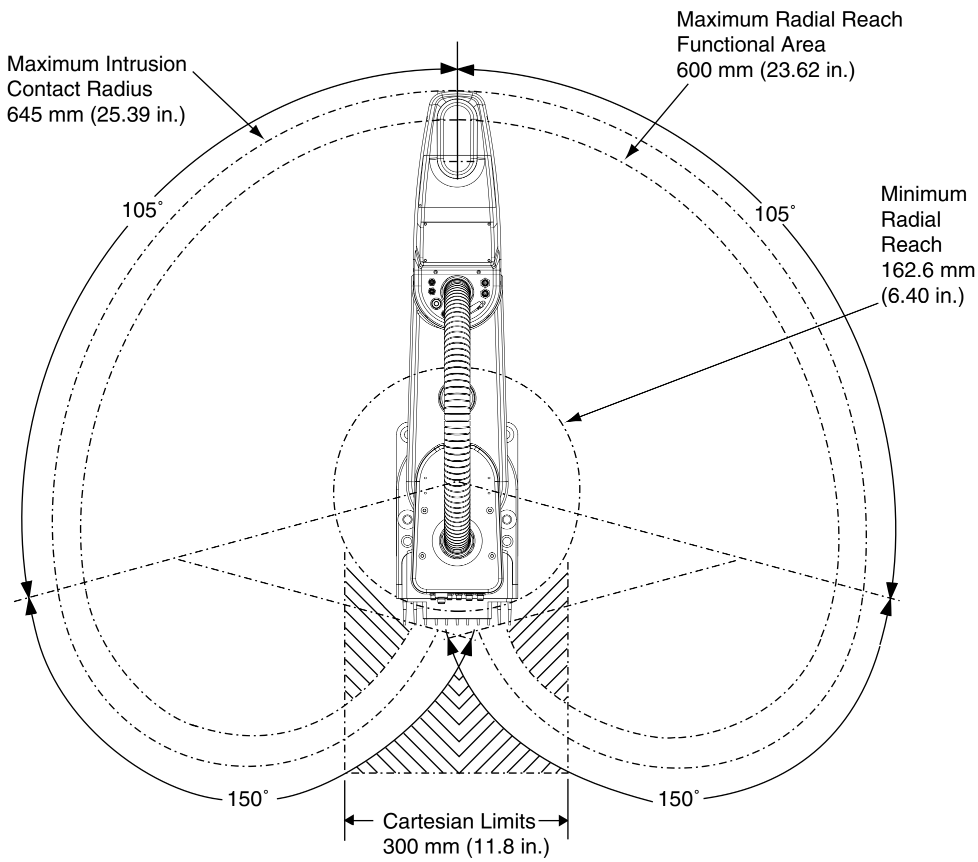


Figure 9-6. Adept Cobra PLC 600 Robot Working Envelope

9.2 Cobra PLC600/PLC800 Internal Connections

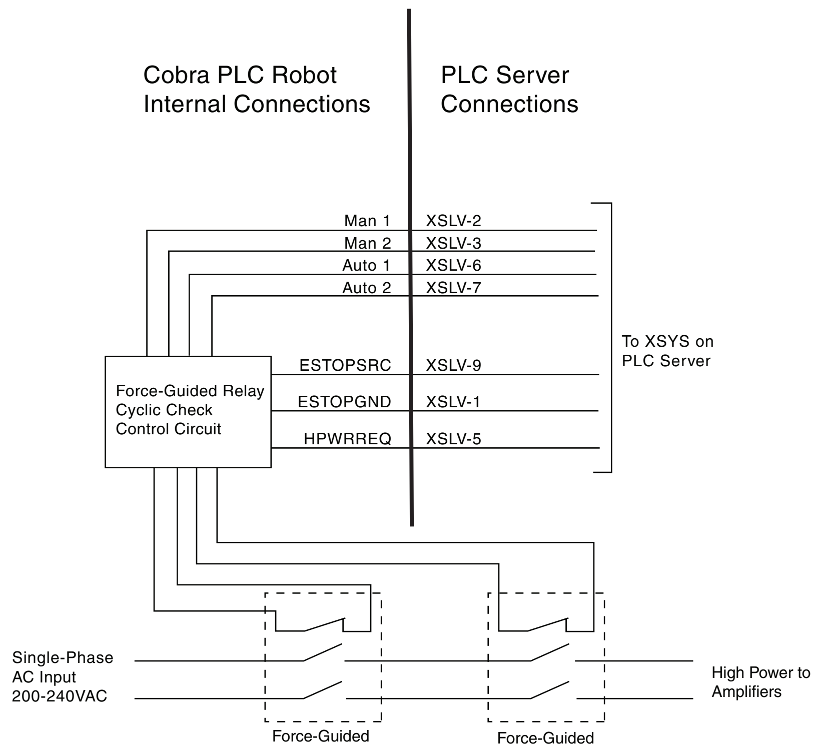
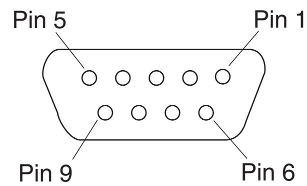


Figure 9-7. Adept Cobra PLC600/PLC800 Internal Connections Diagram

9.3 XSLV Connector

Table 9-1. XSLV Connector Pinout

Pin #	Description	Comment	Pin Location
1	ESTOPGND	ESTOP System Ground	 XSLV1/2 Connector as viewed on Cobra
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	
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			

9.4 PLC Server Dimensions

This section shows the dimensions of the PLC Server.

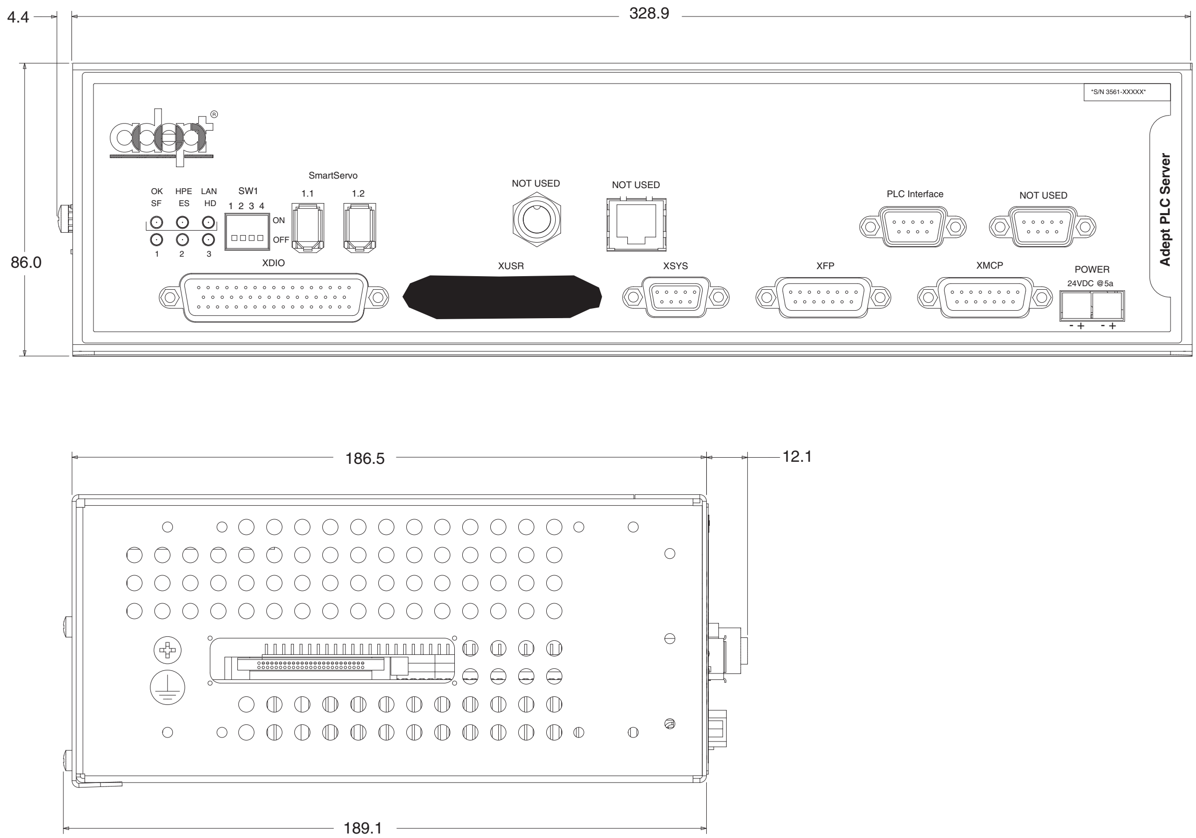


Figure 9-8. PLC Server Dimensions

9.5 Adept Front Panel Dimensions

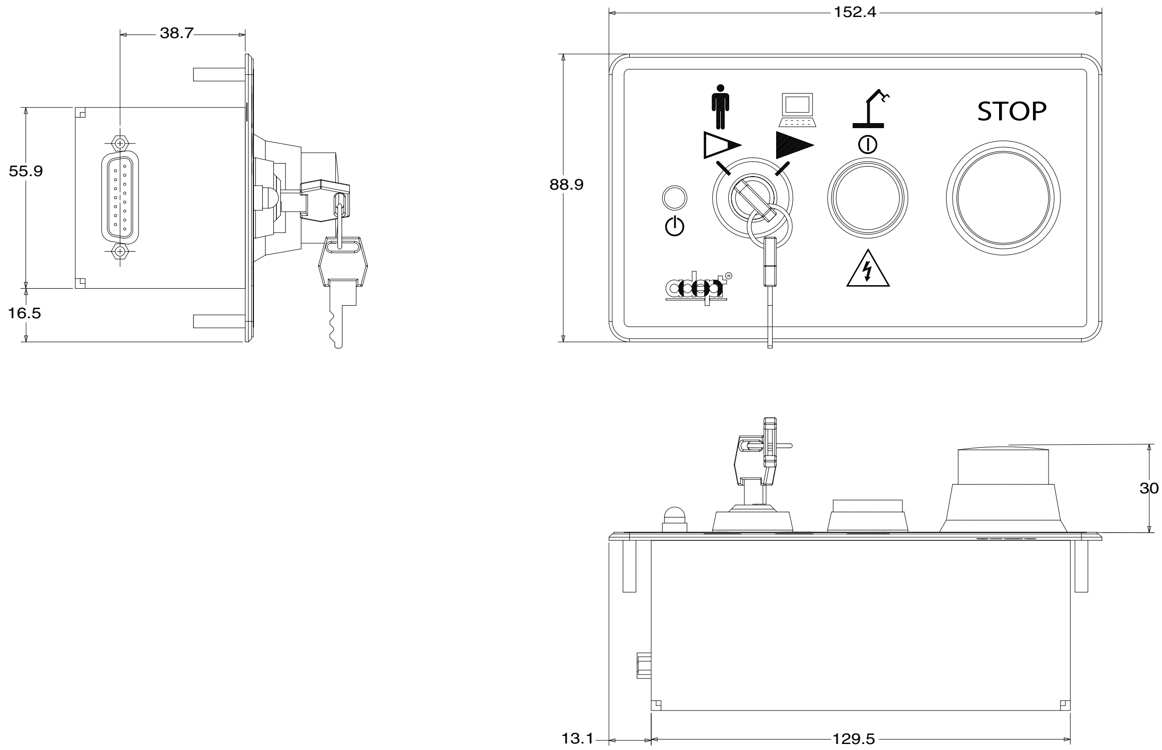


Figure 9-9. Adept Front Panel Dimensions

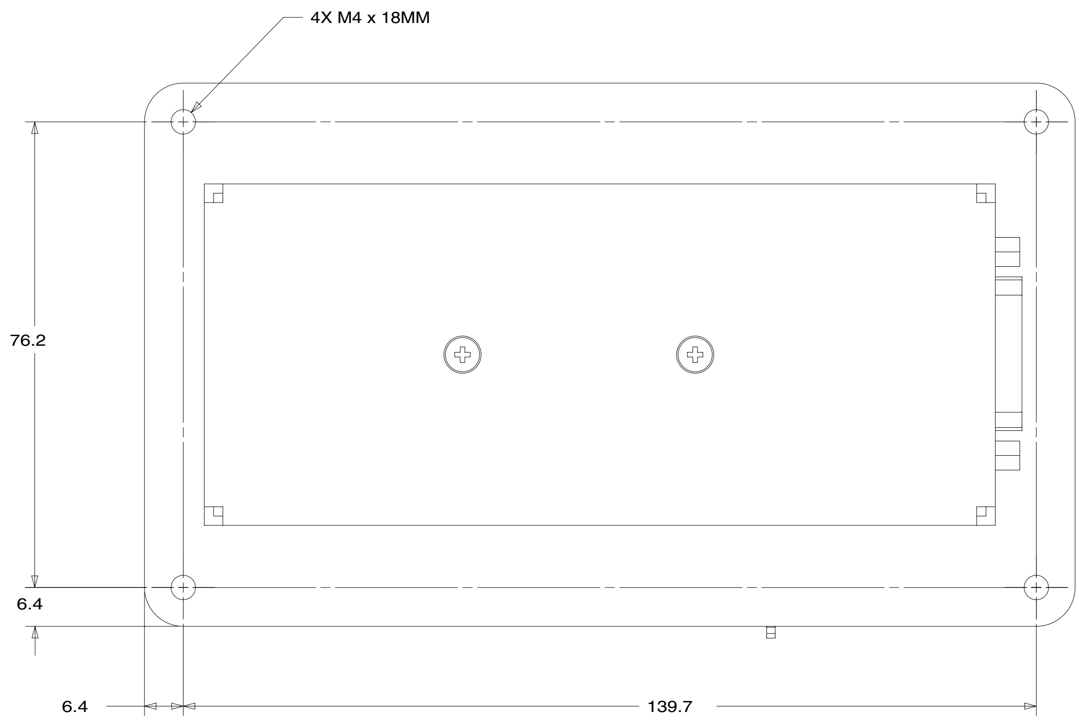


Figure 9-10. Adept Front Panel Back View

9.6 Mechanical Specifications

Table 9-2. Adept Cobra PLC600 Mechanical Specifications

Reach	600 mm (23.6")
Footprint	272mm (10.7 in) x 200 mm (7.9 in)
Payload	2.0 kg (4.4 lb) - rated
	5.5 kg (12.1 lb) - maximum
Moment of Inertia	Joint 4 - 450 kg-cm² (150 lb-in²) - max
Downward Push Force (no load)	35 kg (77 lb) - maximum
Repeatability	XY: ±0.017 mm (±0.0007 in)
	Z: ±0.003 mm (±0.00012")
	Theta: ±0.019°
Joint Range	Joint 1: ±105°
	Joint 2: ±150°
	Joint 3: 210 mm (8.3")
	Joint 4: ±360°
Joint Speed (maximum)	Joint 1: ±386°/sec
	Joint 2: ±720°/sec
	Joint 3: 1100 mm/sec (43 in/sec)
	Joint 4: 1200°/sec
Encoder type	Absolute
Robot Brakes	Joints 1, 2, and 3: Dynamic
	Joint 4: Electric
Airline pass-through (quantity)	6 mm diameter (2), 4 mm diameter (3)
Electrical pass-through	24 conductors (12 twisted pair)
DeviceNet pass-through	1
Weight (without options)	34 kg (75 lb)

Robot Concepts 10

10.1 Understanding Robot Motion Parameters

When programming a robot, there are several factors that play an important part in performance. In order to achieve optimum performance from your robot, it is helpful to have an understanding of how these factors work.

Speed, Acceleration, and Deceleration

Robot speed is usually specified as a percentage of normal speed, not as an absolute velocity. The speed for a single robot motion is set in N30:4 or Adept Speed (see page 85) for each individual location. Note that the result obtained by the speed value depends on the operating mode of the robot - joint-interpolated versus straight-line (see "Joint-Interpolated Motion vs. Straight-Line Motion" on page 174 for details). Whether in joint-interpolated mode or straight-line mode, the maximum speed is gated by the slowest-moving joint during the motion, since all the joints are required to start and stop at the same time. For example, if a given motion requires that the tool tip is rotated during the motion, which requires joint 4 to rotate, that joint could gate the maximum speed achieved by the other joints, since joint 4 is the slowest-moving joint in the mechanism. Using the same example, if joint 4 was not rotated, the motion could be faster without any change to the speed value.

> **NOTE:** The motion speed specified in N30:4 or Adept_Speed must always be greater than zero for a regular robot motion, or in the range -127 to 127 when jogging the robot. Otherwise, an error will be returned.

You can use the acceleration parameter to control the rate at which the robot reaches its designated speed and stops. Like speed, the acceleration/deceleration rate is specified as a percentage of the normal acceleration/deceleration rate. To make the robot start or stop less abruptly, set N30:5 or Adept_Acceleration to a low value. To make the robot accelerate and decelerate more quickly, set N30:5 or Adept_Acceleration to a higher value.

> **NOTE:** The value of N30:5 or Adept_Acceleration must always be greater than 0. Otherwise, an error will be returned.

The speed and acceleration parameters are commonly modified for cycle-time optimization and process constraints. For instance, abrupt stops with a vacuum gripper may cause the part being held to shift on the gripper. This problem could be solved by lowering the robot speed. However, the overall cycle time would then be increased. An alternative is to slow down the acceleration/deceleration rate so the part does not shift on the gripper during motion start or stop. The robot can still move at the maximum designated speed for other movements. Another case would be a relatively high payload and inertia coupled with tight positioning tolerances. A high deceleration rate may cause overshoot and increase settling time. Higher acceleration/deceleration rates and higher speeds don't necessarily result in faster cycle times.

Approach and Depart

When approach and depart heights are specified, the robot moves in three distinct motions. In the first motion (approach), the robot moves to a location directly above the specified location. The height above the location is specified in N30:7 or Adept_Approach_Height (see page 85). For the second motion, N30:7 or Adept_Approach_Height is set to zero, and the robot moves to the actual location and the gripper is activated. In the third motion (depart), the robot moves to a point directly above the location. The depart motion uses the height specified by N30:7 or Adept_Approach_Height.

Approach and depart heights are used to make sure that the robot approaches and departs from a location without running into any other parts in the assembly being built (or any other obstructions in the robot envelope). Approaches and departs are always parallel to the Z-axis of the tool coordinate system. Notice that all the motion parameters that apply to a motion to a location also can be applied to approach and depart motions. This allows you to move at optimum speed to the approach height above a location, then move more slowly when actually acquiring or placing the part, and finally depart quickly.

> **NOTE:** Each of the three motions -- approach, move-to, depart -- must be commanded separately by the PLC

Arm Configuration

Another motion characteristic that you can control is the configuration of the robot arm when moving to a location. However, configuration options apply only to specific types of robots. For example, the lefty/righty option applies to SCARA-type robots (such as the Adept Cobra PLC), but the above/below option does not apply to those robots.

Figure 10-1 shows how a SCARA robot can reach a point with the elbow pointing in two different directions. The Lefty/Righty arm configuration is specified in N30:3/13 or Adept_Motion_Qualifier.13.

> **NOTE:** Other arm configuration bits are supported by the PLC Server (see N30:3/13-15 or Adept_Motion_Qualifier.13-15). However, only the lefty/righty bit applies to a SCARA robot, such as the Cobra PLC robot.

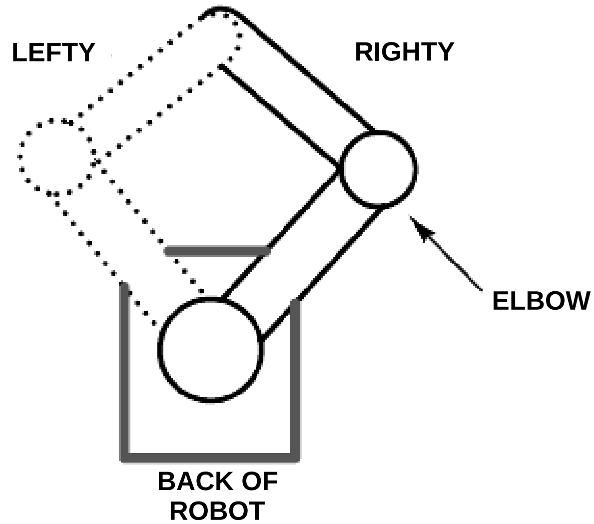


Figure 10-1. Left/Right Robot Arm Configuration

Continuous-Path Motion

When a single motion instruction is processed, the robot begins moving toward the location by accelerating smoothly to the commanded speed. Sometime later, when the robot is close to the destination location, the robot decelerates smoothly to a stop at the location. This motion is referred to as a single motion segment, because it is produced by a single motion instruction.

When a continuous-path sequence of two motion instructions is executed, the robot begins moving toward the first location by accelerating smoothly to the commanded speed just as before. However, the robot does not decelerate to a stop when it gets close to the first location. Instead, it smoothly changes its direction and begins moving toward the second location. Finally, when the robot is close to the second location, it decelerates smoothly to a stop at that location. This motion consists of two motion segments since it is generated by two motion instructions.

Making smooth transitions between motion segments without stopping the robot motion is called continuous-path operation. If desired, the robot can be operated in a non-continuous-path mode (see **“Breaking Continuous-Path Operation” on page 174**, for details). When continuous-path operation is not used, the robot decelerates and stops at the end of each motion segment before beginning to move to the next location. The stops at intermediate locations are referred to as “breaks” in continuous-path operation.

> **NOTE:** Breaking continuous-path operation does not affect forward processing (the parallel operation of robot motion and program execution).

Continuous-path transitions can occur between any combination of straight-line and joint-interpolated motions (see **“Joint-Interpolated Motion vs. Straight-Line Motion” on page 174**).

Breaking Continuous-Path Operation

The "basic" method of moving the robot (see **page 85**) causes program execution to be suspended until the current robot motion reaches its destination location and comes to a stop. This is called breaking continuous path. This method is useful when the robot must be stopped while some operation is performed (for example, closing the gripper or applying a dot of adhesive).

Joint-Interpolated Motion vs. Straight-Line Motion

The path a motion device takes when moving from one location to another can be either a joint-interpolated motion or a straight-line motion. A joint-interpolated motion moves each joint at a constant speed (except during the acceleration/deceleration phases-see **"Speed, Acceleration, and Deceleration" on page 171**). With a rotationally-jointed robot, the robot tool tip typically moves along a curved path during a joint-interpolated motion. Although such motions can be performed at maximum speed, the nature of the path can be undesirable.

Straight-line motions ensure that the robot tool tip traces a straight line. That is useful for cutting a straight line, or laying a bead of sealant, or any other situation where a totally predictable path is desired.

> **NOTE:** For X, XY, XYZ, or XYZT devices, straight-line motion and joint-interpolated motion result in identical paths, because the (positioning) joints all move in straight lines themselves.

When bit N30:3/9 or Adept_Motion_Qualifier.9 is OFF, the robot uses joint-interpolated motion; when that bit is ON, the robot uses straight-line motion.

Performance Considerations

Things that may impact performance in most applications include robot mounting, cell layout, part handling, and programming approaches.

Robot Mounting Considerations

The mounting surface should be smooth, flat and rigid. Vibration and flexing will affect performance. It is recommended that a minimum 25mm (1 inch) steel plate with a rigid tube frame be used. When positioning a robot in the workcell, take advantage of moving multiple joints for faster motions. On a SCARA robot, the "Z" and "theta" axes are the slowest, and motion of these joints should be minimized whenever possible. This can be accomplished by positioning the robot, and setting conveyor heights and pick and place locations, to minimize Z-axis motion.

Cell Layout Considerations

Regarding cell layout and jointed arms, the same point-to-point distance can result in different cycle times. Moving multiple joints combines the joint speeds for faster motion. If the same distance is traversed using motion of a single joint, the motion of that joint will be longer, and therefore will take more time.

Part Handling Considerations

For part handling, settling time while trying to achieve a position can be minimized by centering the payload mass in the gripper. A mass that is offset from the tool rotation point will result in excess inertia that will take longer to settle. In addition, minimizing gripper mass and tooling weight will improve settling time. This could include using aluminum versus steel, and removing material that is not needed on tooling.

Programming Considerations

The use of joint-interpolated versus straight-line motion has to be evaluated on a case-by-case basis. In general, joint-interpolated motion is more efficient.

Nulling tolerances should be as loose as the application will permit. This has a direct impact on cycle time.

Lastly, on jointed arms, changing the arm configuration (for example, lefty versus righty for a SCARA robot) generally requires more time than maintaining the current configuration during a motion.

10.2 The Coordinate System and Reference Frames

What is the World Coordinate System?

A robot location specifies the position and orientation of the robot tool tip in 3-dimensional space. By default, the tool tip is the center of the mounting flange of the robot. Locations are, by default, relative to the base of the robot. See **Figure 10-2** for an example using an Adept SCARA robot. For a default (world) location, the coordinate offsets are from the origin of the world coordinate system (which is located at the base of the robot).

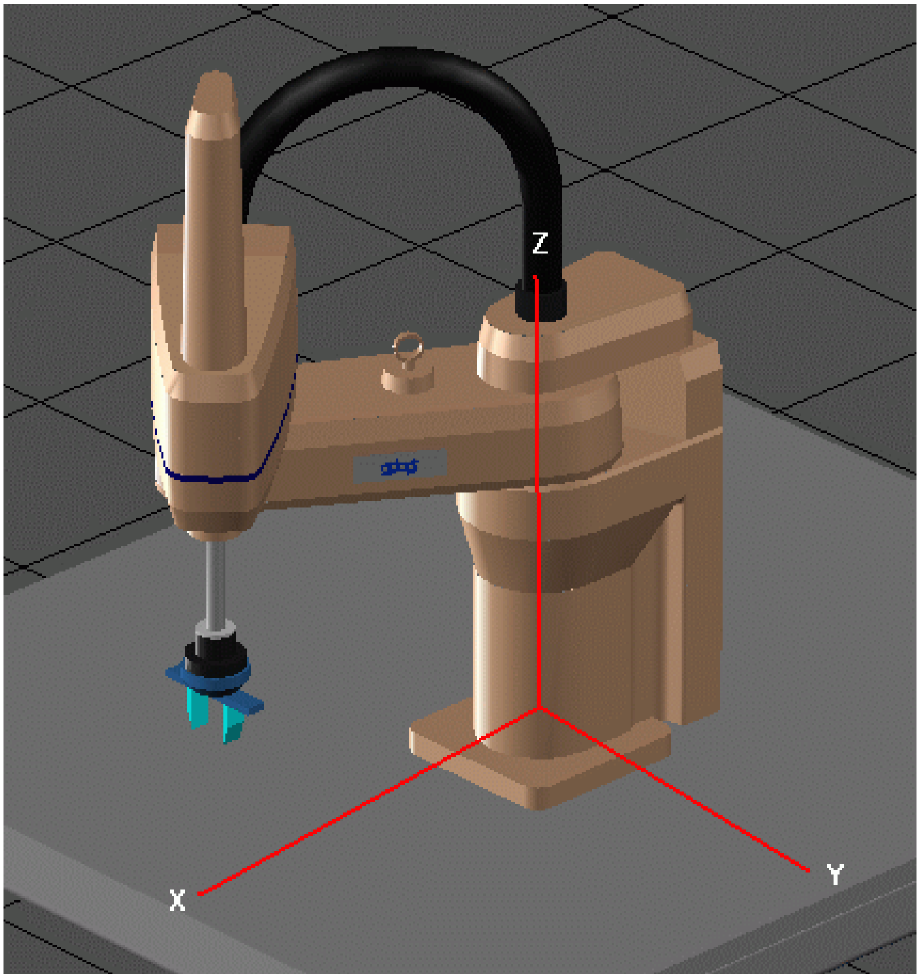


Figure 10-2. World Coordinate System

Defining a Location

Locations are defined using the World Coordinate System (see above) or by specifying the positions of the individual robot joints. When defining a location, each of the values described in Table 10-1 must be entered into the Location Registers (F32:0-5 or Adept_Location.0-5).

> **NOTE:** Failure to enter all of the values, as described below, for each location, may result in an “invalid orientation” or similar error when the robot attempts to access that location.

Table 10-1. Values Describing a Cartesian Location

Coordinate	Cartesian Coordinates	
	Absolute Motion (see Figure 10-2)	**Relative Motion (see Figure 10-3)**
X	Defines a distance (in mm) from the World origin (base of the robot) along the X axis.	Defines offset distance along the X axis. The offset is added to the X component of the current position of the robot (if it is stopped) or the destination of the current motion.
Y	Defines a distance (in mm) from the World origin (base of the robot) along the Y axis.	Defines offset distance along the Y axis. The offset is added to the Y component of the current position of the robot (if it is stopped) or the destination of the current motion.
Z	Defines a distance (in mm) from the World origin (base of the robot) along the Z axis.	Defines offset distance along the Z axis. The offset is added to the Z component of the current position of the robot (if it is stopped) or the destination of the current motion.
y	For SCARA robots (such as the Cobra PLC), this value must be 0.0.	For SCARA robots (such as the Cobra PLC), this value must be 0.0.
p	For SCARA robots (such as the Cobra PLC), this value must be 180.0.	For SCARA robots (such as the Cobra PLC), this value must be 0.0.
r	Defines a rotation in degrees about the Z axis.	Defines a rotation in degrees about the Z axis, which is added to the r component of the current position of the robot (if it is stopped) or the destination of the current motion.

Table 10-2. Values Describing a Joint Location

Joint	Joint Coordinates	
	Absolute Motion (see Figure 10-4)	**Relative Motion (see Figure 10-4)**
J1	Defines translational (mm) or rotational (deg) position for Joint 1. For SCARA robots this is a rotational joint angle.	Defines a change in translational (mm) or rotational (deg) joint position for Joint 1. The change is added to the current position of the robot joint (if it is stopped) or the joint position at the destination of the current motion.

Table 10-2. Values Describing a Joint Location

Joint	Joint Coordinates	
	Absolute Motion (see Figure 10-4)	**Relative Motion (see Figure 10-4)**
J2	Defines translational (mm) or rotational (deg) position for Joint 2. For SCARA robots this is a rotational joint angle.	Defines a change in translational (mm) or rotational (deg) joint position for Joint 2. The change is added to the current position of the robot joint (if it is stopped) or the joint position at the destination of the current motion.
J3	Defines translational (mm) or rotational (deg) position for Joint 3. For SCARA robots this is a translational joint position in millimeters.	Defines a change in translational (mm) or rotational (deg) joint position for Joint 3. The change is added to the current position of the robot joint (if it is stopped) or the joint position at the destination of the current motion.
J4	Defines translational (mm) or rotational (deg) position for Joint 4. For SCARA robots this is a rotational joint angle.	Defines a change in translational (mm) or rotational (deg) joint position for Joint 4. The change is added to the current position of the robot joint (if it is stopped) or the joint position at the destination of the current motion.
J5	Defines translational (mm) or rotational (deg) position for Joint 5. For a 4-axis SCARA robot, this is not used.	Defines a change in translational (mm) or rotational (deg) joint position for Joint 5. The change is added to the current position of the robot joint (if it is stopped) or the joint position at the destination of the current motion.
J6	Defines translational (mm) or rotational (deg) position for Joint 6. For a 4-axis SCARA robot, this is not used.	Defines a change in translational (mm) or rotational (deg) joint position for Joint 6. The change is added to the current position of the robot joint (if it is stopped) or the joint position at the destination of the current motion.

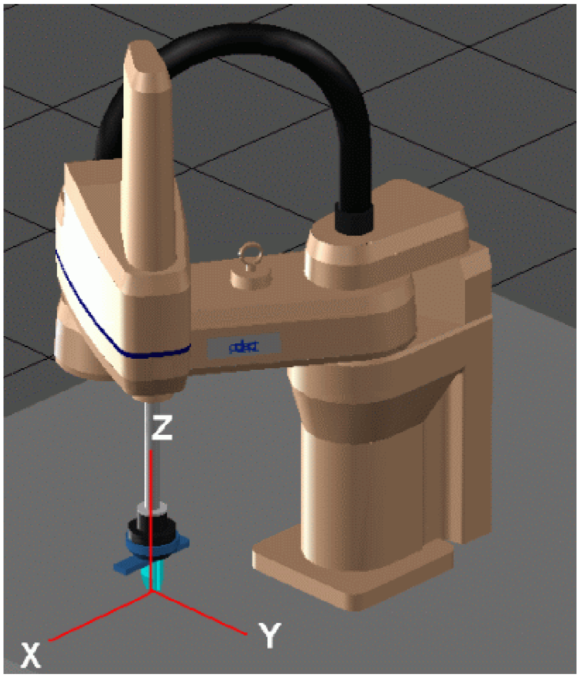


Figure 10-3. Relative Location

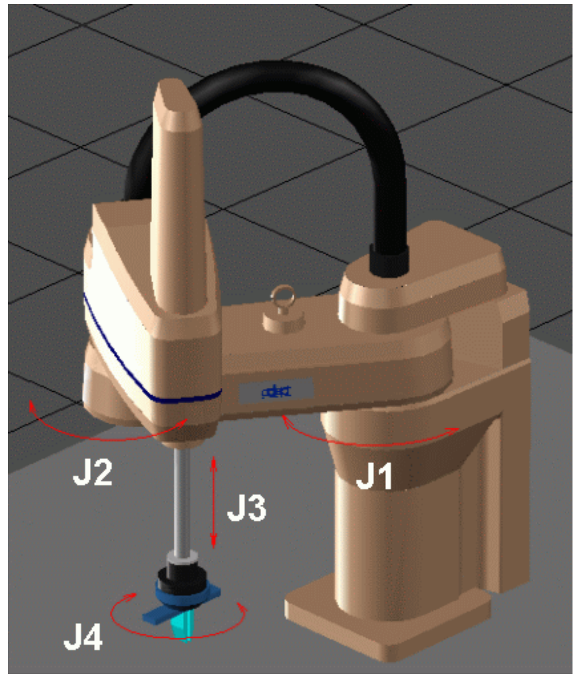


Figure 10-4. Joint Angles

10.3 What is a Reference (Pallet) Frame?

The coordinate system in **Figure 10-5** has its origin at the starting location of a pallet.

> **NOTE:** N30:9, N30:10, and N30:11 values start at 0. Therefore a 3 row, 3 column, 1 layer pallet would be entered as N30:9 = 2, N30:10 = 2, N30:11 = 0.

The distance between pallet locations is 40 millimeters. Notice that, if we're picking from the first row in the Y axis, the second part is offset from the reference frame by 40 millimeters in the Y-direction. Therefore, only the Y-component has a nonzero value. The part location is:

X	Y	Z	y	p	r
0.000	40.000	0.000	0.000	0.000	0.000

The middle row, third part is offset from the reference frame in both the X- and Y-directions. Consequently, these two components have nonzero values.

X	Y	Z	y	p	r
40.000	80.000	0.000	0.000	0.000	0.000

If this pallet were brought into the workcell at a different location, merely updating the reference frame to reflect its new location would allow you to use any locations created relative to that frame without further modifications.

Reference frames can be moved and rotated in three dimensions. In this example the reference frame is rotated exactly 90 degrees. You should note that you could move a reference frame to a point where the locations relative to that frame would be out of range for the robot.

This example shows no rotation of the end-effector. In fact, if this were an assembly with several different parts being placed with different orientations of the end-effector, the orientation components of the location also would have nonzero values.

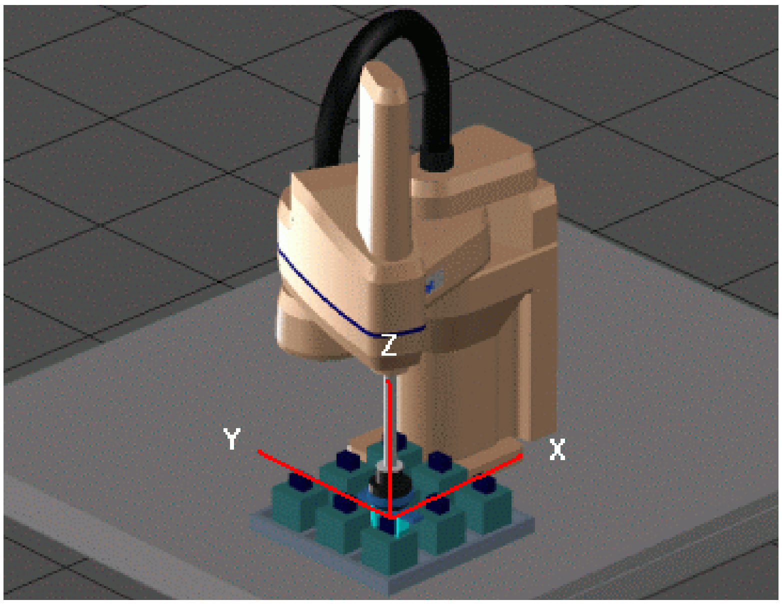


Figure 10-5. Pallet Frame Orientation

Defining a Reference Frame

When defining a reference frame, you are teaching three points: the frame origin, a location on the X axis, and a location on the Y axis. See **Figure 10-5** above. For example, assuming a 40mm part spacing, the pallet in **Figure 10-5** would be defined as follows:

	X	Y	Z	y	p	r
Pallet origin	350.000	350.000	54.000	0.000	180.000	0.000
Location on X axis	270.000	350.000	54.000	0.000	180.000	0.000
Location on Y axis	350.000	270.000	54.000	0.000	180.000	0.000

NOTE: Make sure that you review the section **"Why is Gripper Orientation Important?" on page 181**. It is necessary to understand this concept, so that your parts are picked/placed correctly.

After the above locations have been entered, the system automatically computes the orientation of the frame; in this example, the frame is a pallet frame. At this point, each part on the pallet can be referenced from the pallet origin.

Note that reference frames apply to more than just pallets. However, a pallet provides a good visual starting point for understanding this concept. Also note, when working with pallets, that you typically need to define the row count, column count, row spacing and column spacing. After these parameters have been defined, the system has all of the information it needs to pick all of the parts from the pallet (or, to place parts into a pallet).

Why is Gripper Orientation Important?

When teaching locations, remember that the gripper to part orientation is important. For example, consider the figures below. In **Figure 10-6** the robot is in the pallet frame origin (starting position) - note the orientation of the gripper to the part.

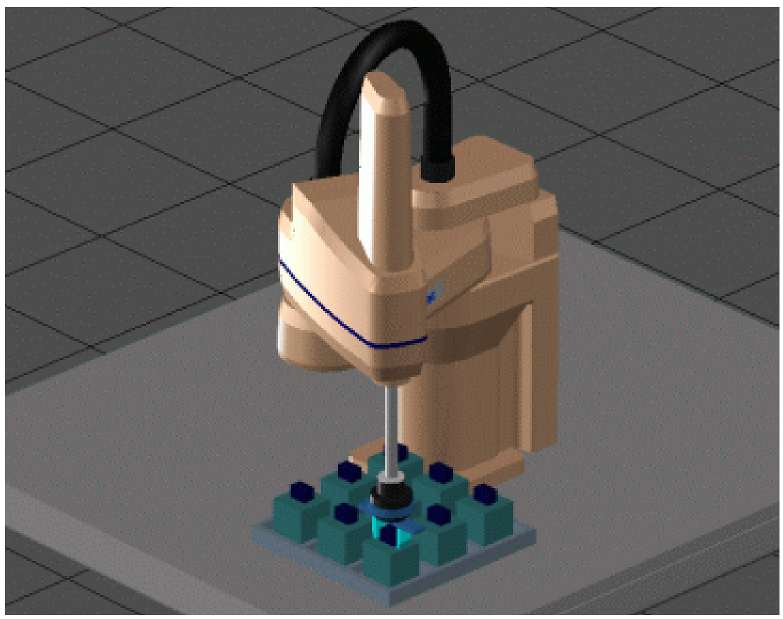


Figure 10-6. Pallet Frame Origin

In **Figure 10-7** the robot is at a part location on the pallet X axis; however, the gripper to part orientation is the same as in **Figure 10-6**

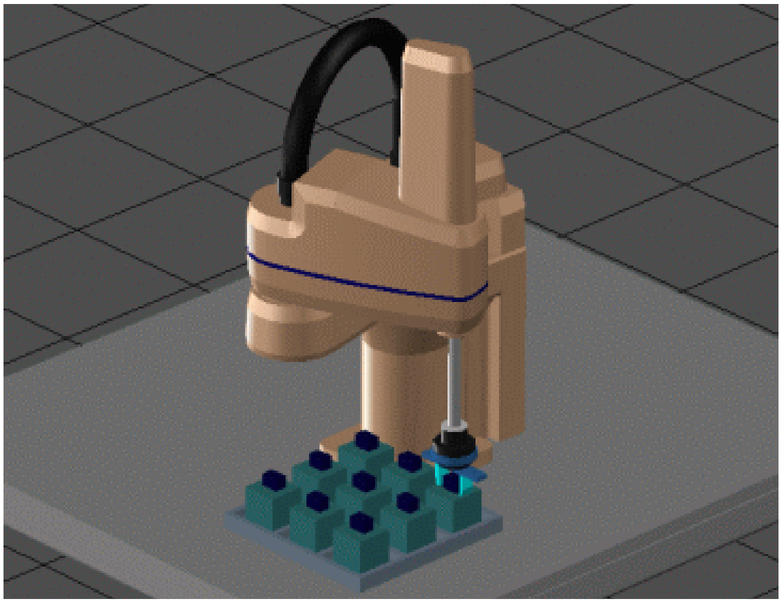


Figure 10-7. Pallet X Part Location

Finally, in **Figure 10-8**, the tool is at a point on the pallet Y axis; however, the gripper to part orientation is still the same as in **Figure 10-6** and **Figure 10-7**.

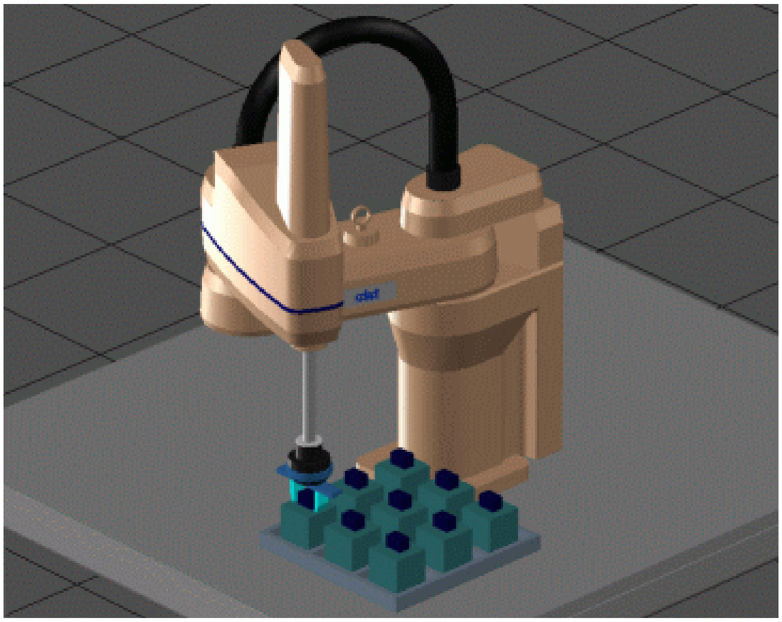


Figure 10-8. Pallet Y Part Location

Index

C

E

F

G

H

I

J

K

L

S

P/N: 04866-000, Rev C

3011 Triad Drive
Livermore, CA 94551
925•245•3400