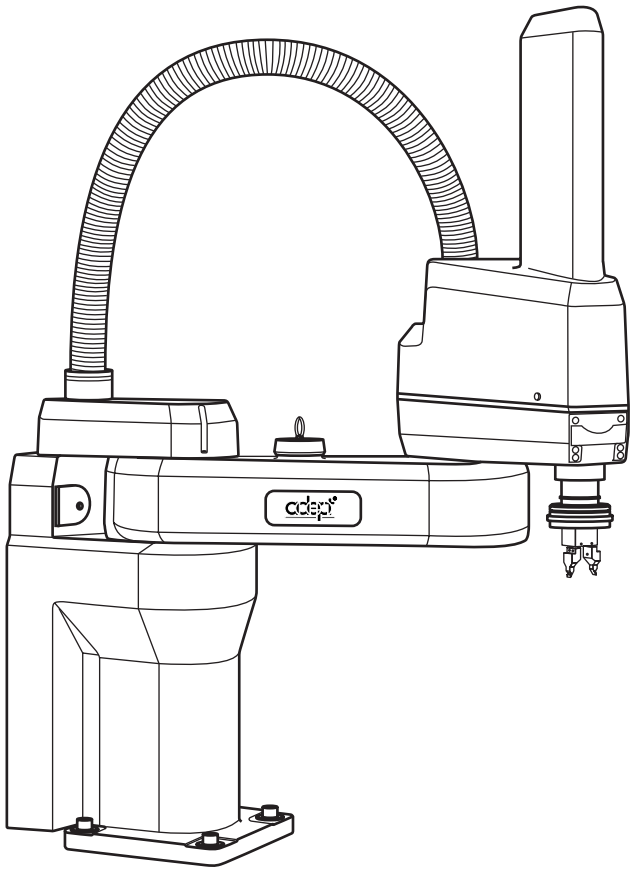
Instruction Handbook

Adept Cobra 600 and Adept Cobra 800 Robot



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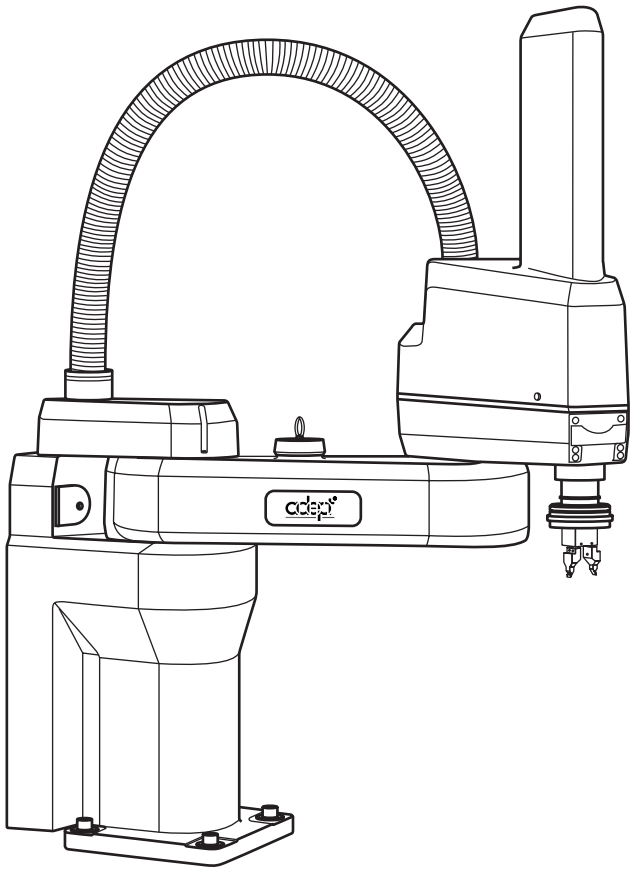

00560-00100, Rev. B
March 1999

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Manufacturer's Declaration / Herstellererklärung / Déclaration du Constructeur / Dichiarazione del Costruttore

We/Wir/Nous, **Adept Technology, Inc., 150 Rose Orchard Way, San Jose, California 95134, USA,** declare under our sole responsibility that the product / erklären in alleiniger Verantwortung, daß das Produkt / déclarons sous notre seule responsabilité que le produit:

System / Système / Sistema		**Adept Cobra 600**	**Adept Cobra 800**
Robot/Roboter:		30560-10100	30561-10301
Pendant/Handbediengerät/ Unità portatile:	MCP III	10332-11000	10332-11000
Control system/Steuerung/	Adept MV-4	30350-15000	30350-15000
Système de commande/	Adept MV-5	30340-10000, -30000	30340-10000, -30000
Sistema di comando:	Adept MV-10	30340-20000, -40000	30340-20000, -40000
	Adept PA-4	30336-31000	30336-31000
	C Amp	10338-53005	10338-53005
	CIP	30350-10350	30350-10350

to which this declaration relates is in conformity with the following standards.
/ auf das sich diese Erklärung bezieht, mit den folgenden Normen.
/ auquel se réfère cette déclaration est conforme aux normes.

Manufacturer's Declaration, as defined in Machinery Directive 89/392/EEC, Appendix IIB:

We declare that the machine in the form delivered by us, subject to the usage conditions specified below, complies with the relevant and fundamental safety and health requirements defined in EU Directive 89/392/EEC, Annex I, and the following standards. The machine must not be put into operation until all of the machinery into which it is incorporated has been declared in compliance with the provisions of the effective versions of the directives. This includes all supplementary equipment and protective devices.

EU/EEA:		**IEC/ISO:**
EN 55011:1991, Class A	(EMC: Emissions)	CISPR 11: 1990
EN 50082-2: 1995	(EMC: Immunity)	—
EN 292-2 +A1: 1995	(Safety of machinery)	—
EN 60204-1: 1997, IP20	(Electrical safety)	IEC 204-1: 1992
EN 775: 1992	(Robot safety)	ISO 10218: 1992
EN 954-1: 1996, Category 1	(Safety related parts of control systems)	—
EN 1050: 1996	(Risk assessment)	—

EU Directives / EG-Richtlinien / Directives Communautaire / Direttiva CE:

98/37	(Machinery)
89/336, 92/31, 93/68	(EMC)
73/23, 93/68	(Electrical Equipment)

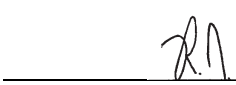
Usage and installation conditions

The product must be installed and used strictly in accordance with the *Adept Cobra 600/800 Robot Instruction Handbook* (document p/n 00560-00100). In particular, the Adept-supplied system components identified above provide a Category 1 control system as defined by EN 954. The robot system must be installed with user-supplied perimeter barrier interlocks to interrupt the AC supply to the PA-4 Power Chassis in the event of personnel attempting to enter the workcell when Arm Power is enabled in AUTO mode. Barrier interlocks should be designed and installed to provide a Category 3 level of control per EN 954.

The system must incorporate only those plug-in modules and accessories listed in Table 1 or Table 2. If modules or accessories listed in Table 2 are installed, the user must verify conformance to the EMC Directive after installation.

This Declaration applies only to those Adept product part numbers specifically listed in this declaration. The following changes may result in the system not complying with the applicable Directives, and would void this declaration unless additional testing and/or evaluation is performed by the user:

- unauthorized user modifications;
- substitution or addition of Adept parts not listed on this declaration;
- addition of user-supplied parts and accessories.



Richard J. Casler, Jr. (Vice President, Engineering)

San Jose, California, USA
17 Mar 1999

Declaration p/n:
01560-00050 Rev. B1

DEUTSCH: Herstellererklärung im Sinne der EG-Maschinenrichtlinie 89-392/EWG, Anhang II B

Hiermit erklären wir, daß die nachstehende Maschine in der von uns gelieferten Ausführung, den einschlägigen, grundlegenden Sicherheits- und Gesundheitsanforderungen der EG-Richlinie 89/392/EWG Anhang I, und den unten aufgefuehrten Standarts entspricht. Dies gilt nur wenn das Geraet unter den unten genannten Bedingungen verwendet wird. Wir weisen daraufhin, daß die Inbetriebnahme der Maschine solange untersagt ist, bis festgestellt ist, daß die Maschine, in die diese Maschine eingebaut werden soll, den Bestimmungen der Richtlinie in der jeweils gueltigen Fassung entspricht. Dies schließt die anwenderseitig in die Maschine zu installierenden Ergänzungen und Schutzeinrichtungen ein.

FRANÇAIS: Déclaration du Constructeur selon la Directive Communautaire relative aux machines 89/392/CEE, Annexe II B

Par la présente, nous déclarons que la machine décrite ci-dessous, livrée en l'état, est conforme à la directive communautaire 89/392/CEE, Annexe I, sur les impératifs fondamentaux en matière de santé et de sécurité. La machine ne pourra être mise en service avant que la machine dans laquelle elle sera incorporée ne soit déclarée complètement conforme aux dispositions des directives en cours de validité. Ceci comprend tout équipement complémentaire et dispositif de protection.

ITALIANO: Dichiarazione del Costruttore ai sensi della direttiva CE 89/392/EEC relativa a macchinari Appendice IIB

Si dichiara che la macchina, come da noi fornita, se utilizzata secondo le condizioni di seguito specificate, soddisfa i requisiti fondamentali definiti nella direttiva CE 89/392/EEC, Appendice I, in fatto di sicurezza e sanità. La messa in funzione della macchina resta vietata fintanto che l'intero sistema nel quale questa è incorporata sia stato dichiarato conforme alla versione vigente della suddetta normativa. Il sistemasi intende comprensivo di tutte le parti accessorie e dispositivi di sicurezza.

Bedienung und Installationsbedingugen

Das vorliegende Produkt muß strikt in Übereinstimmung mit der *Adept Cobra Roboter Betriebsanleitung* (Teilenummer 00560-00100) installiert und betrieben werden. Die in der Betriebsanleitung beschriebenen Komponenten stellen ein Steuerungssystem zur Verfügung, welches mit der Gefahrenklasse 1 der europäischen Norm EN 775 übereinstimmt. Die Maschine, in die die Adept Roboteranlage integriert wird, muß mit entsprechenden Verriegelungseinrichtungen versehen werden, die beim Öffnen der Sicherheitsabsprerrungen im Automatikmodus bei eingeschalteter Betriebsspannung der Motoren, die Spannungsversorgung zur PA-4 Verstärkereinheit unterbrechen. Verriegelnde Schutzeinrichtungen sollten so entworfen und installiert werden, daß alle Richtlinien für eine Übereinstimmung mit der Gefahrenklasse 3 bzgl. EN 954 eingehalten werden.

Die von Adept gelieferte Roboteranlage darf nur mit den MV-Einschubmodulen aus Tabelle 1 oder Tabelle 2 betrieben werden. Werden Einschubmodule aus Tabelle 2 verwendet, muß der Anwender die Übereinstimmung mit den Ansprüchen der EMV-Richtlinie nach der Installation überprüfen lassen und bestätigen.

Diese Konformiditätserklärung betrifft nur die Adept Produkte, die mit ihrer Teilenummer in den Tabellen 1 und 2 dieser Erklärung aufgelistet sind. Die folgenden Veränderungen der von Adept gelieferten Roboteranlage können dazu führen, daß die Anlage nicht mehr mit den entsprechenden Richtlinien übereinstimmt. Dies würde bedeuten, daß die Konformiditätserklärung erlischt. In diesem Fall muß der Anwender die Übereinstimmung mit den Ansprüchen der entsprechenden Richtlinie nach der Installation überprüfen lassen und bestätigen.

Veränderungen, die zum Erlöschen der Konformiditätserklärung führen können:

- nicht autorisierte Veränderungen durch den Benutzer;
- Ersatz oder Hinzufügen von Adept Teilen, die nicht in der Konformiditätserklärung aufgeführt sind;
- Hinzufügen von Teilen und Zubehör durch den Benutzer,

Conditions d'utilisation et d'installations

L'équipement doit être installé et utilisé en respectant scrupuleusement les instructions du manuel «Manuel d'utilisation du robot». En particulier, les équipements fournis par Adept et identifiés ci-dessus confèrent, selon la norme EN 954, un niveau de sécurité de catégorie 1. L'ensemble robotisé doit comporter une enceinte de sécurité, non fournie par Adept, sectionnant l'alimentation 380-400V du châssis d'alimentation des variateurs (PA-4) lors de l'intrusion d'une personne alors que le robot est asservi et en mode AUTO. Les barrières de sécurité doivent être conçues et installées pour fournir un niveau de sécurité de catégorie 3 conforme à la norme EN 954.

L'ensemble ne doit comporter que les cartes enfichables ou accessoires listés dans les tableaux 1 ou 2. Si des accessoires listés dans le tableau 2 sont installés, l'utilisateur devra, après installation, vérifier la conformité avec les directives EMC.

Cette déclaration ne s'applique que sur les produits Adept dont les numéros de référence sont spécifiquement listés dans cette déclaration. Les modifications suivantes sont susceptibles d'annuler la conformité des équipements avec les directives de sécurité a moins que de nouveaux tests ne soient effectués

- Modifications non autorisées des équipements,
- Substitution ou ajout de composants non listés dans cette déclaration,
- Ajout de composants ou accessoires par le client.

Condizioni d'uso ed istallazione:

Il prodotto dev'essere istallato ed usato in stretto accordo con il manuale di istruzioni del robot Adept Cobra. In particolare i componenti del sistema forniti da Adept compongono un sistema di controllo di Categoria 1 come definito dalla EN 954. Il sistema robot dev'essere installato con barriere perimetrali fornite dall'utente che interrompano l'alimentazione CA al telaio di potenza PA-4 nel caso che il personale cerchi di entrare nella cella di lavoro con il robot in potenza. Le barriere di sicurezza devono essere progettate ed istallate in osservanza della EN 954, tali da garantire un livello di sicurezza di Categoria 3.

Il sistema deve comprendere solo quei moduli ed accessori menzionati in Tabella 1 o Tabella 2. Se sono istallati dei moduli od accessori menzionati in Tabella 2, l'utente deve verificare, dopo l'istallazione, la loro rispondenza alle normative EMC.

Questa dichiarazione è valida solo per quei prodotti Adept menzionati in questa dichiarazione. I seguenti cambiamenti possono rendere il sistema non conforme alle direttive applicabili ed invalidano la presente dichiarazione, a meno che l'utente non esegua delle valutazioni e/o test addizionali:

- modifiche non autorizzate da parte dell'utente;
- sostituzione o aggiunta di componenti Adept non menzionati in questa dichiarazione;
- aggiunta di componenti o accessori forniti dall'utente.

Plug-in Modules and Accessories/Einschubmodule und Zubehör/ Modules enfichables et accessoires

Table 1: Table/Tabelle/Tableau 1

Description / Beschreibung	Name / Namen / Nom	Part Number / Teilenummer / Référence
VME Digital I/O Board / Digitales Ein-/Ausgabemodul / Carte d'entrées/sorties VME	DIO	10332-00800
VME Graphics Board / Graphik karte / Carte graphique VME	VGB	10332-10250
VME Joint Interface Board / Achssteuerkarte / Carte d'axe	EJI	10332-00505
VME Motion Interface Board / Achssteuerkarte / Carte d'interface Mouvement VME	MI3 MI6 MI3E MI6E	10332-11400 10332-12400 10332-11410 10332-12410
VME Processor Board / VME Prozessormodul / Carte processeur VME	AWC 040 AWC 060 AWCII 040 AWCII 060	10350-01040 10350-01060 10350-01044 10350-01064
VME Vision Board /Bildarbeitungskarte / Module d'interface vision VME	EVI	10332-00655
Camera / Kamera / Caméra	—	15600-00090
Floppy Disk Drive & IEEE 1394 Interface / Diskettenlaufwerk & IEEE 1394-Schnittstellen	FDD	15350-00001 15350-00002 15350-00003 15350-00004

Table/Tabelle/Tableau 2: Accessories/Zubehör/Accessoires

Description / Beschreibung	Name / Namen / Nom	Part Number / Teilenummer / Référence
Force-sensing kit/VFI Kraftsensor Ausrüstung / Capteur d'efforts	VFI	90211-00000, -08464, -00550
MP6 Kit / MP6 Ausrüstung/Kit MP6	MP6	90332-12400

NOTE: Products listed in Table 2 must be tested by the user in the final system configuration to assurre full compliance with the European EMC Directive.

BEMERKUNG: Die in Tabelle 2 aufgeführten Produkte müssen durch den Anwender in der endgültigen Systemkonfiguration getestet werden, um volle Übereinstimmung mit der europäischen EMV-Richtlinie zu gewährleisten.

NOTE: Les produits listés dans le tableau 2 doivent êtres testés par l'utilisateur après l'assemblage et la configuration finale des équipements afin de s'assurer que l'ensemble réponde aux directives Européennes EMC.

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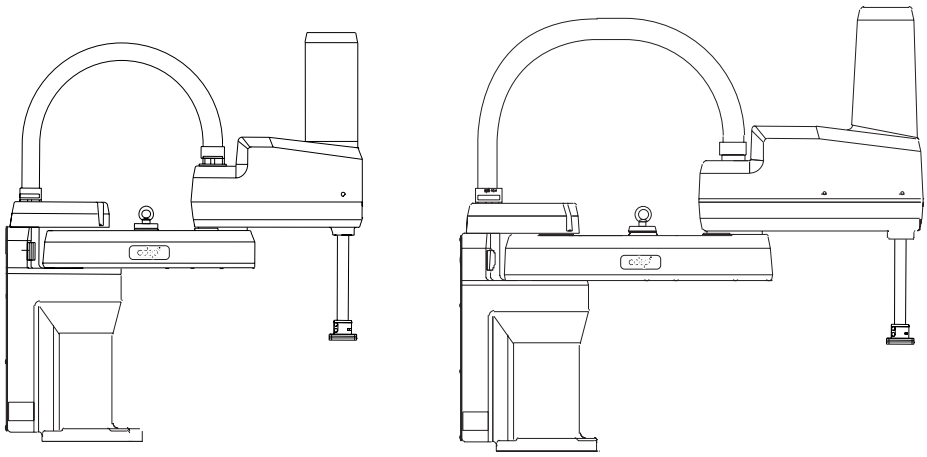
1 Safety

The Adept Cobra 600 and 800 robots are four-axis SCARA[1] robots (see Figure 1-1). Joints 1, 2, and 4 are rotational; joint 3 is translational. See Figure 1-2 for a description of the robot joint locations.

The Adept Cobra robots require an Adept MV series controller (MV-5 or MV-10,) and a PA-4 power chassis (see Figure 1-3 on page 26), or a Compact Controller (see Figure 4-1 on page 54). The robot is programmed and controlled using the Adept MV controller and PA-4 amplifier control system. Specifications for the Adept Cobra robots are provided in Chapter 10.



Adept Cobra 600 Robot

Adept Cobra 800 Robot

Figure 1-1. Adept Cobra Robots

[1] Selective Compliance Assembly Robot Arm

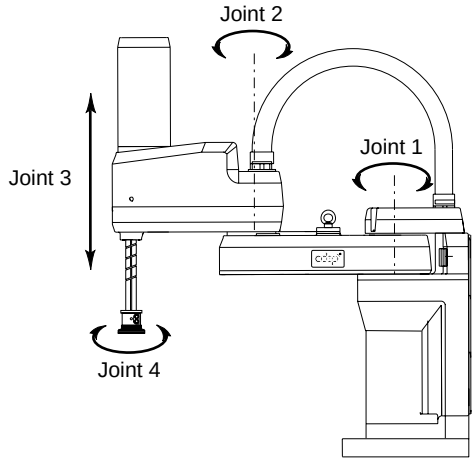
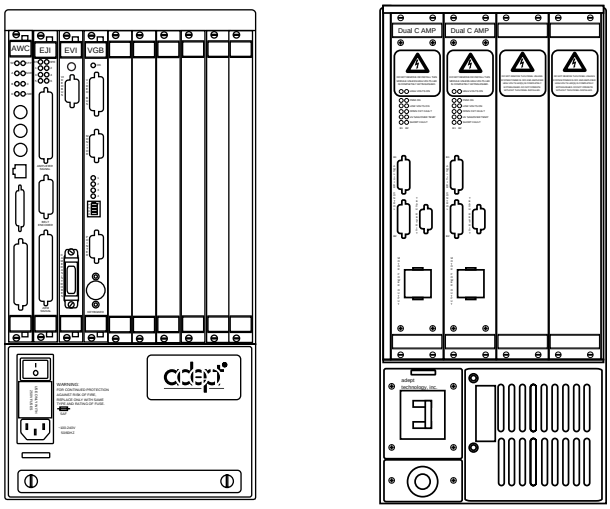


Figure 1-2. Adept Cobra Robot Joint Motions



MV Controller With AWC Board

Adept PA-4 Power Chassis

Figure 1-3. Adept MV-10 Controller and PA-4 Power Chassis

Definition of a Manipulating Industrial Robot

An automatically controlled, reprogrammable, multipurpose, manipulative machine with several degrees of freedom, which may be either fixed in place or mobile for use in industrial automation applications is called a manipulating robot. (ISO 10218:1992(E))

Adept Equipment Compatibility

The Adept robot system as described in this handbook must consist of the hardware and software listed in the following table. All new systems shipped from the factory will include the correct equipment as shown. If you have existing Adept equipment, this table can help distinguish new equipment from older equipment, especially since some of it is visibly similar. See the product data label for the robot, controller, and power chassis for model number or part number information.

For information on the V+ operating system, refer to the *V+ Operating System User's Guide*.

Table 1-1. Adept Hardware and Software Compatibility for Cobra Systems

Product	Required Model, Part, or Version Number
Adept Cobra 600 robot	Model Number 560 part number 30560-10100
Adept Cobra 800 robot	Model Number 561 part number 30561-10301
Adept MV-10 controller	part number 30340-40000
Adept MV-5 controller	part number 30340-10000
Adept Compact Controller C-40	part number 30350-61003
Adept Compact Controller C-60	part number 30350-61004
Adept PA-4 power amplifier chassis	part number 30336-31000
C power amplifier	part number 10338-53005
Controller Interface Panel (CIP)	part number 30350-10350 (Category 1)
Manual Control Pendant III	part number 90332-48050 (MCP III)
V+ operating system software	Version 13.0 or later

1.1 Notes, Cautions, and Warnings

There are four levels of special notation used in this instruction handbook. In descending order of importance, they are:

WARNING: If the actions indicated in a "WARNING" are not complied with, injury or major equipment damage could result. A Warning statement will typically describe the potential hazard, its possible effect, and the measures that must be taken to reduce the hazard.

WARNING: If the WARNING is indicated with a lightning bolt instead of an exclamation mark, an electrical danger or shock is possible for personnel working with the system.

CAUTION: If the action specified in the "CAUTION" is not complied with, damage to your equipment could result.

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

1.2 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.

Maximum Robot Forces and Torques

Adept robot systems include computer-controlled mechanisms that are capable of exerting considerable force. Like all robot and motion systems, and most industrial equipment, they must be treated with respect by the user and the operator (see Table 1-2 and Table 1-3).

CAUTION: Permanent joint 3 ball screw deformation may result from crashing the outer link, user flange, or payload into a solid object. Additionally, permanent joint 3 ball screw deformation may result if flange motion is restricted at the beginning of a move, i.e., due to a jammed part. Adept recommends the use of **breakaway** end-of-arm tooling to reduce the possibility of this occurring.

Table 1-2. Maximum Torques and Forces (Adept Cobra 600 and 800 Robot)

Torque	Force
Joint 1 maximum static torque	380 N•m (280 ft-lb)
Joint 2 maximum static torque	130 N•m (95 ft-lb)
Maximum static force applied by the robot in XY plane, measured at user flange	1175 N (260 lb)

Safety Barriers

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

The robot system integrator, or end user, must ensure that adequate safeguards, safety barriers, light curtains, safety gates, safety floor mats, etc., will be installed. The robot workcell must be designed according to the applicable local and national standards (see section 1.7 on page 36).

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 (see section 1.7 on page 36).

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 4 for information on safe and effective use of the robot.

Impact and Trapping Points

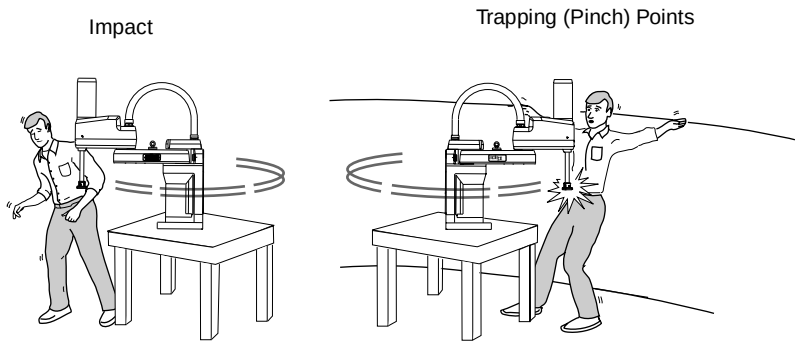


Figure 1-4. Adept Cobra Robot Impact and Trapping Point Hazards

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.

Hazards From Expelling a Part or Attached Tooling

The maximum joint tip speeds that can be achieved by Adept Cobra robots in a **runaway** situation are listed in Table 1-3. Any tooling, fixtures, end-effectors, etc., mounted to the user flange, outer link, or inner link of the robot must be attached by sufficient means to resist being expelled from the robot. Additionally, any payload must be held by the end-effector in a manner that prevents the payload from being expelled accidentally.

Table 1-3. Maximum Adept Cobra Robot Joint Velocities in Runaway Situations[a]

Joint Max Angular/Linear Velocity	Adept Cobra 600	Adept Cobra 800
Joint 1 maximum angular velocity	490 degrees/second	473 degrees/second
Joint 1 maximum linear velocity	2.8 meters/second	3.5 meters/second
Joint 2 maximum angular velocity	840 degrees/second	821 degrees/second
Joint 2 maximum linear velocity	6.8 meters/second	8.9 meters/second
Joint 3 maximum linear velocity	1700 mm/second	1700 mm/second
Joint 4 maximum angular velocity	2750 degrees/second	2750 degrees/second

[a] These velocities can occur only in a runaway or mechanical failure situation. These are *not* performance specifications (see Chapter 10 for robot performance specifications).

The safety fence or barrier constructed around the robot must be designed to withstand the impact of any item expelled accidentally from the robot. Projectile energy can be calculated using the formula $E = 1/2mv^2$. Here are two examples.

Example 1: On a Cobra 600 robot, 4 kg payload mounted to end-effector, joint 2 at 0° and all other joints stationary.

maximum possible projectile energy = $1/2\ (4\ kg)\ (6.8\ m/s)^2 = 92\ J\ (68\ ft\text{-}lb)$

Example 2: On a Cobra 800 robot, 5.5 kg payload mounted to elbow (Joint 2).

maximum possible projectile energy = $1/2\ (5.5\ kg)\ (3.5\ m/s)^2 = 34\ J\ (25\ ft\text{-}lb)$

Additional Safety Information

The standards and regulations listed in this handbook contain additional guidelines for robot system installation, safeguarding, maintenance, testing, start-up, and operator training. The table below lists some sources for the various standards.

Table 1-4. Sources for International Standards and Directives

BSI, British Standards Institute Sales Department Linford Wood Milton Keynes MK14 6LE United Kingdom Phone 0181 996 7000 Fax 0181 996 7001 http://www.bsi.org.uk

Table 1-4. Sources for International Standards and Directives (Continued)

Beuth Verlag GmbH 10722 Berlin Germany Phone 030 26 01 - 22 60 Fax 030 26 01 - 12 60 http://www.din.de/en/beuth/Beuth.html
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
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
Document Center, Inc. 1504 Industrial Way, Unit 9 Belmont, CA 94002, USA Phone 415-591-7600 Fax 415-591-7617 http://www.doccenter.com
Global Engineering Documents 15 Inverness Way East Englewood, CO 80112, USA Phone 800-854-7179 Fax 303-397-2740 http://global.ihs.com
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

1.3 Risk Assessment – Table Top Robots

Without special safeguards in its control system, Adept Cobra robots 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 1-5 lists some of the safety standards that affect industrial robots. It is *not* a complete list. You must comply with *all* applicable local and national standards for the location where the robot will be installed.

Table 1-5. 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 37), who must wear safety equipment (see "Safety Equipment for Operators" on page 38) and carry the Manual Control Pendant (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 Adept Cobra 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

Further, due to its small size, light payload capacity, and table-top mounting, it is likely that such personnel could avoid being hit by the robot even in a high-acceleration, runaway, failure condition. The programmer must carry the MCP when inside the work envelope, as the MCP 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.

WARNING: The Adept-supplied system components provide a Category 1 control system as defined by EN 954. The robot system must be installed with user-supplied interlock barriers. The interlocked barrier should interrupt the AC supply to the PA-4 Power Chassis 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 could result in injury or death.

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 (using brake release button for joint 3).
3. Copying 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 Adept Cobra robot control system described in this handbook employs hardware components in its safety system that meet or exceed the requirements of the *EU Machinery Directive* and *Low Voltage Directive*.

Furthermore, 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 and "soft-servo" mode has been incorporated to limit speed and impact forces on the Operator and production tooling when the robot is operated in Manual Mode.

In consideration of the above, the standard Adept Cobra Control System meets or exceeds the requirements imposed by the EN 954 specified Category 1 level of safety, as evidenced by the Manufacturer's Declaration at the front of this handbook.

1.4 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 1.7 on page 36).

The Adept Cobra 600 and 800 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, it is prohibited to make certain modifications to Adept robots (see section 1.5).

The Adept MV controller and the Adept PA-4 power chassis are component subassemblies of a complete industrial automation system. The controller and power chassis subassemblies must be installed inside a suitable enclosure. The controller and power chassis subassemblies must not come into contact with liquids. Additionally, a standard Adept Cobra 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 2-1 on page 42 for allowable temperature and humidity ranges.

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

Non-intended use of an Adept Cobra 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 Instruction Handbook

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

1.5 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, cameras, 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-controller cables.
- Modifying any robot access covers or drive system components.
- Modifying, including drilling or cutting, any robot casting.
- Modifying any robot electrical component or printed-circuit board.
- Routing additional hoses, air lines, or wires through the robot.
- Modifications that compromise EMC performance, including shielding.

1.6 Transport

Always use adequate equipment to transport and lift Adept products. See Chapter 2 for more information on transporting, lifting, and installing.

WARNING: Do not remain under the robot while it is transported.

1.7 Safety Requirements for Additional Equipment

Additional equipment used with the Adept Cobra 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.

1.8 Sound Emissions

The sound emission level of the Adept Cobra robot depends on the speed and payload. The maximum value is 90dB. (This is 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.

1.9 Thermal Hazard

WARNING: Thermal Hazard!
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 70°C (158°F).

1.10 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 1.12 on page 38) 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 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 1.11 for the specifications.

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

1.11 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 handbook, 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.

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

1. Has received the instruction handbook
2. Has read the instruction handbook
3. Understands the instruction handbook and
4. Will work in the manner specified by the instruction handbook.

1.12 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.

1.13 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.

1.14 Safety Aspects While Performing Maintenance

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

WARNING: During maintenance and repair, the power of the Adept PA-4 power chassis and the Adept MV controller must be turned off. Unauthorized third parties must be prevented from turning on power through the use of lockout measures.

1.15 Risks That Cannot Be Avoided

The Adept Cobra robot control system implementation has devices that disable High Power if a system failure occurs. However, certain residual risks or improper situations could cause hazards. The following situations may result in risks that cannot be avoided:

- Failure of software or electronics that may cause high-speed robot motion in Manual Mode
- Failure of hardware associated with enabling device or E-Stop system

1.16 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
- Ejection of work piece (see "Hazards From Expelling a Part or Attached Tooling" on page 29)

Take precautions to ensure that these situations do not occur.

1.17 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.

1.18 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 or hardware.

You can obtain this document through Adept On Demand. The phone numbers are:

(800) 474-8889 (toll free)
(503) 207-4023 (toll call)

Please request document number 1020.

1.19 Related Manuals

This manual covers the installation and maintenance of an Adept Cobra robot system. There are additional manuals that cover programming the system, reconfiguring installed components, and adding additional optional components. The following manuals (available on the documentation CD-ROM provided with each system) provide information on advanced configurations and system specifications.

Table 1-6. Related Manuals

Manual Title	Description
Adept MV Controller User's Guide 00330-01040	Describes the configuration and interface options for all Adept-supplied processor boards and components that can be installed in an Adept control system.
AdeptWindows User's Guide 00963-07300	Describes complex network installations, installation and use of NFS server software, the Adept Windows Offline Editor, and the AdeptWindows DDE software.
Instructions for Adept Utility Programs 00963-00000	Describes the utility programs used for advanced system configurations, system upgrades, file copying, and other system configuration procedures
V+ Operating System User's Guide 00963-02300	Describes the V+ operating system, including disk file operations, monitor commands, and monitor command programs.
V+ Language User's Guide 00963-01300	Describes the V+ language and programming of an Adept control system.

2 Installation Overview

This chapter covers the facility electrical and mechanical specifications and other general installation requirements.

The next several chapters cover the installation of the robot, the robot control system, optional Adept-supplied equipment, and optional user-supplied equipment. In general, a complete installation will proceed as described in the following chapters:

- Chapter 3 covers installing the robot.
- Chapter 4 covers installation of the control system and power amplifiers.
- Chapter 5 covers selection and installation of a user interface.
- Chapter 6 covers installation of optional equipment.

Once the physical installation is complete, the installation must be verified and the system must be commissioned.

- Chapter 7 covers verifying that the installation is correct and commissioning the system.

2.1 Hardware to Be Provided by User

The user must supply the following minimum hardware. Your system may include additional user-supplied equipment as described in Chapter 6.

- Proper mounting surface (see "Mounting Surface" on page 49)
- Installation tools (see "Tool and Equipment Requirements" on page 50)
- End-effector (see "Installing End-Effectors on an Adept Cobra Robot" on page 97)
- Safety barrier (see "Safety Barriers" on page 29)
- Ground wire for robot (see "Adept Robot Grounding" on page 84)
- Ground wire for robot-mounted equipment (see "Robot-Mounted Equipment Grounding" on page 84)
- Optional AC 10A contactor
- Optional 24VDC power supply (see "System Power Switch" on page 63)

2.2 Environmental and Facility Requirements

The Adept robot system installation must meet the operating environment requirements shown in Table 2-1. See Table 2-2 on page 43 for the Adept MV controller electrical requirements and Table 2-3 on page 44 for the PA-4 amplifier chassis electrical requirements.

Table 2-1. Robot System Operating Environment Requirements

Ambient temperature	
Adept Cobra 600/800 standard robot	5°C to 40°C (41°F to 104°F)
Cleanroom Option robot	5°C to 35°C (41°F to 95°F)
controller – while accessing floppy or hard drive	5°C to 40°C (41°F to 104°F)
controller – while not accessing floppy or hard drive	5°C to 50°C (41°F to 122°F)
power chassis	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)
Free space around Adept MV controller and power chassis (for proper cooling)	25 mm (1-inch) in front, 15 mm (1/2-inch) at top
Robot protection class	IP20 (NEMA Type 1)
Controller and power chassis subassembly protection class, unmounted	IP20 (NEMA Type 1)
Recommendations for customer-supplied enclosure for Adept controller and power chassis (mandatory for installations in EU or EEA countries).	Enclosure should meet EN 60204 (IEC 204) requirements and be rated at IP54. Also, enclosure must provide a method of locking the enclosure power-disconnect in the OFF position.
NOTE: See Chapter 10 for robot, Adept MV controller, and PA-4 power chassis dimensions.	

2.3 Power Requirements

Adept MV Controller Power Requirements

Table 2-2. Adept MV Controller Power Requirements

Auto-Ranging Nominal Voltage Ranges,	Minimum Operating Voltage[a]	Maximum Operating Voltage	Frequency/ Phasing	Recommended External Circuit Breaker (user-supplied)
100V to 120V and 200V to 240V	90V 180V	132V 264V	50-60Hz, 1-phase	10 amps
Power to the Adept MV controller and all amplifiers and motion devices must come from a single source.				

[a] The maximum interruption time (operating voltage below specification) tolerated by the controller is 16 milliseconds.

Facility Overvoltage Protection

The user must protect the controller 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 controller system (such as by interposing a transformer). See IEC 1131-4 for additional information.

PA-4 Power Chassis Power Requirements

Table 2-3. Adept PA-4 Power Chassis Power Requirements

Nominal Voltage Range	Frequency/ Phasing	Minimum Operating Voltage	Maximum Operating Voltage	Recommended External Circuit Breaker (user-supplied)
380 to 415 VAC	50-60Hz, 3-phase with neutral	342 VAC	424 VAC	20 amps
200 to 240 VAC	50-60Hz, 3-phase	180 VAC	245 VAC	20 amps
Power to the Adept MV controller and PA-4 power chassis must come from a single source.				

2.4 Before Unpacking the Adept Equipment

Carefully inspect all shipping crates for evidence of damage during transit. If any damage is indicated, request that the carrier's agent be present at the time the container is unpacked.

2.5 Adept Shipment Specifications

Adept ships the equipment in a number of boxes and shipping crates, depending on the sales order. The boxes have different dimensions and weights. The following table gives an overview.

Table 2-4. Adept Shipping Crate Specifications

Product in Crate	Length	Width	Height	Weight
Adept Cobra 600 Robot	0.64 m (25 in.)	0.64 m (25 in.)	1.14 m (45 in.)	50 kg (110 lb)
Adept Cobra 800 Robot	0.82 m (32.5 in.)	0.44 m (17.5 in.)	1.19 m (47 in.)	50 kg (110 lb)
Adept MV Controller and PA-4 Power Chassis	0.89 m (35 in.)	0.64 m (25 in.)	0.96 m (38 in.)	66 kg (145 lb)
Monitor	0.54 m (21 in.)	0.51 m (20 in.)	0.51 m (20 in.)	23 kg (50 lb)

WARNING: The center of gravity of the robot shipping crates is not in the middle of the boxes. Pay attention when you transport the crates.

2.6 Transport and Storage

Shipping 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 2-1).

WARNING: Heavy load!
Do not attempt to transport the robot boxes by hand. Always use a pallet jack, forklift, etc.

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.

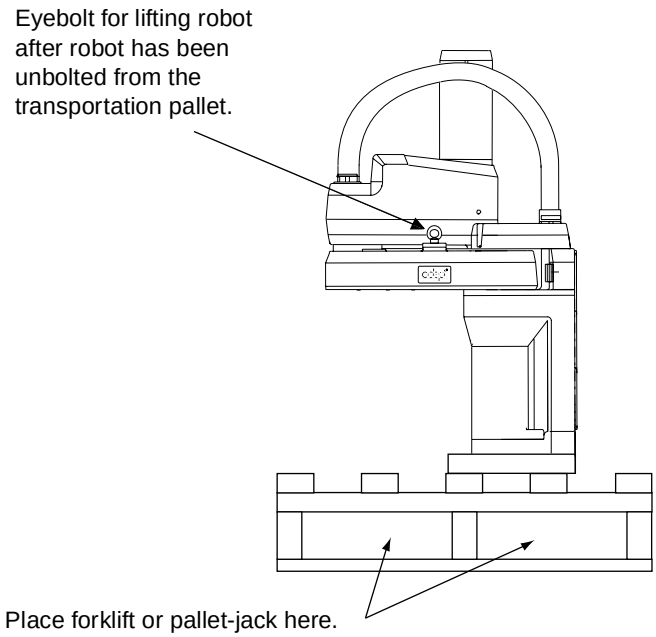


Figure 2-1. Cobra 600/800 Robot on a Transportation Pallet

2.7 Lifting and Handling

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.

2.8 Unpacking and Inspecting the Adept Equipment

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 "How Can I Get Help?" on page 39.).

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

2.9 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. 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. Specify this to the carrier if the robot is to be shipped.

2.10 Robot and Controller ID Labels

Identification (ID) labels are located on the left or back side of the controller and power chassis. On the label you will find the model and serial numbers and the voltage and current ratings (see Figure 4-22 on page 80). Smaller serial number labels are located on the front of the chassis near the On/Off switch.

The robot ID label is located at the top of the robot base, on the rear of the robot. You should always have this serial number available when you call Adept Customer Service for technical support.

3 Robot Installation

3.1 Mounting Surface

The Adept Cobra robot is designed to be mounted on a smooth, flat, level tabletop. The mounting structure must be rigid enough (Adept recommends 25 mm (1 in.) thick steel plate mounted to a rigid tube frame) to prevent vibration and flexing during robot operation. The maximum static and dynamic torque measured on the robot is listed in Table 1-2 on page 28. Excessive vibration or mounting flexure will degrade robot performance. Figure 3-1 shows the mounting hole pattern for the Adept Cobra robot.

> **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 3-1. Using locating pins could improve the ability to remove and reinstall the robot in the same position.

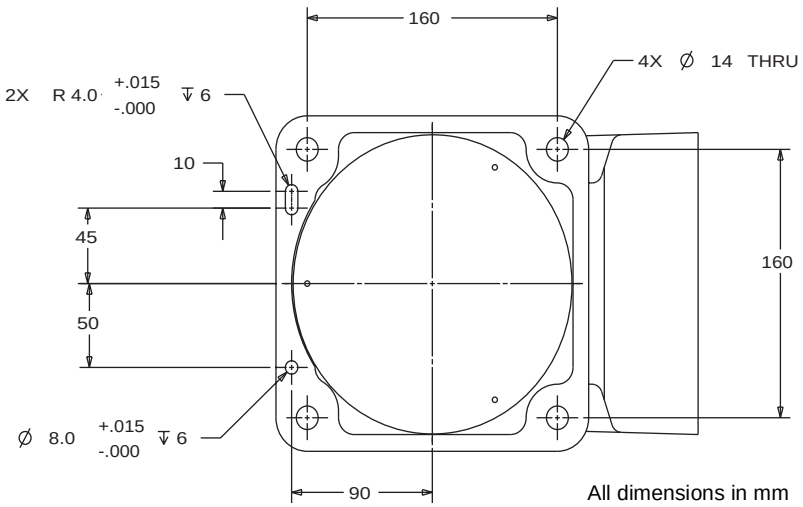


Figure 3-1. Mounting Hole Pattern (Robot-to-Mounting Surface)

3.2 Installing the Robot

Tool and Equipment Requirements

Common hand tools, plus the following items, are required to install the robot:

- Hydraulic lift
- Mounting structure, such as a tabletop or mounting spool
- Torque wrench

WARNING: The installation procedures in this chapter should be performed only by skilled persons, as defined in section 1.11 on page 37.

Mounting Procedure

1. Using the dimensions shown in Figure 3-1, 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 3-1 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 2-1 on page 45). Take up any slack, but do not lift the robot at this time.

WARNING: Impact Hazard
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.

WARNING: Impact Hazard
The robot may swing free if not lifted straight up. Stand clear of the robot at all times while it is supported by the lift.

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. Tighten bolts to torque specified in Table 3-1.

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 9 for periodic maintenance.

Table 3-1. 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	50 ft-lb

3.3 Using the Brake Release Button

Brakes

The power chassis has a dynamic braking feature which decelerates the robot in an emergency condition, such as when the emergency stop circuit is open or a robot joint passes its softstop. This braking feature 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 without turning on High Power. For such instances, a Brake Release button is located on the robot backplate (see Figure 4-13 on page 69). When system power is on, pressing the 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.

CAUTION: 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.

3.4 Limiting Joint Travel

The joint motion or travel is limited by both software and hardware limits. The programmable software limits are known as softstops; the fixed hardware limits are referred to as hardstops. See Table 10-3 on page 195 for the softstop and hardstop specifications.

Softstops

Softstops are used when the normal motion range of the robot must be limited (if other equipment is installed inside the envelope, for example). The softstops for each joint are set to their maximum value at the factory. To limit any joint's motion range, change the joint's softstop value using the SPEC utility program on the Adept Utility Disk supplied with the system. Refer to the *Instructions for Adept Utility Programs* for information regarding this utility program.

When you are using the MCP to move the robot, the robot will stop abruptly when it encounters a softstop. This abruptness does not mean a hardstop has been contacted.

Hardstops

Joints 1, 2, and 3 have hardstops at each end of the joint's travel.

Joint 4 does not have hardstops. However, its motion is limited by software, and its softstops can be set to further limit joint 4 motion (see above).

Cartesian Limit Stops

V^+ can detect collisions between the robot end-effector and static Cartesian obstacles. V^+ tests for collisions between the robot's tool tip, or its tool-mounting flange, and specified obstacles.

> **NOTE:** Collisions between other structural elements of the robot and the obstacles, or between two robots, are NOT detected.

For fixed structural elements of the workcell, the system automatically detects possible collisions in the following circumstances:

- When planning the end point for a straight-line or joint-interpolated motion
- When executing a straight-line motion (but not during a joint-interpolated motion)
- When moving the robot in tool, world, or joint mode using the MCP

Rectangular solids (boxes), cylinders, and spheres can be defined. Objects can be placed in any position and orientation relative to the base of the robot.

Four user obstacles can be defined and modified by the end user. The SPEC utility (see SPEC.V2 in the *Instructions for Adept Utility Programs*) is used to define obstacles.

For collision detection capability, see error message "*Obstacle collision detected* (-901)" on page 207.

Adept MV Controller Installation 4

4.1 Introduction

Adept MV-5 and MV-10 Controllers

The Adept Cobra 600/800 robots are delivered with an Adept MV-5 controller, an Adept MV-10 controller, or an Adept Compact Controller (see next section). The dimensions, installation, and cabling requirements of the Adept MV-5 and Adept MV-10 controllers are identical. The Adept MV-10 controller allows for additional option boards. The following sections apply whether you have an Adept MV-5 or Adept MV-10 controller. The same PA-4 power chassis is used with both controllers.

The controller chassis holds the backplane, power supply, and cooling fans required by the various processor boards. All systems include an AWC system processor (see Figure 4-2) and an EJI motion interface board (see Figure 4-17 on page 74). These boards are delivered with the configuration specified on your order; you should not have to perform any setup or initialization of these boards. If you need to alter the delivered configuration or are installing additional boards not supplied with the original order, see the *Adept MV Controller User's Guide* for complete details on installing and configuring boards.

Your system may contain additional optional boards that were included as part of your sales order. These boards also will be configured as ordered; you should not have to perform any additional setup or configuration. For a complete description of all Adept processor boards, see the *Adept MV Controller User's Guide*. The optional boards that might be in your system are:

- Additional AWC boards used as auxiliary processors
- EVI board for the AdeptVision system
- VGB board for the standard Adept graphical user interface
- SIO board for additional hard and floppy drives and additional serial ports
- MI6/MI3 boards for controlling non-Adept robots
- DIO for supplying additional digital input and output signals

The amplifier chassis holds the backplane, power distribution, and cooling fans required by the amplifiers. An amplifier chassis for an Adept Cobra series robot contains two dual-channel amplifiers (described in "Dual C Amplifier Module Overview" on page 56).

Adept Compact Controller

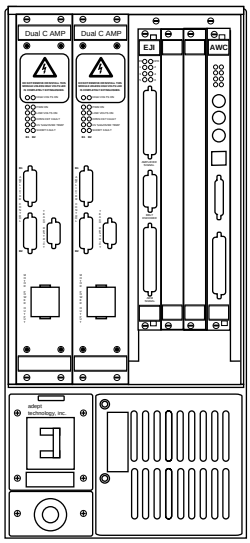


Figure 4-1. Adept Compact Controller

The Adept Compact Controller is designed for the Adept Cobra series of robots and the AdeptModules product line (up to four axes). It includes a PA-4 amplifier chassis with two dual amplifiers and a four-slot chassis, the Adept MV-4 insert, that fits into the remaining two slots of the PA-4 amplifier chassis.

The Adept Compact Controller requires one board, an AWC board in a 68040 or 68060 configuration. The AWC occupies backplane slot 1. The remaining slots can be populated with various combinations of optional Adept boards; see Figure 4-1.

Adept MV-4 Insert

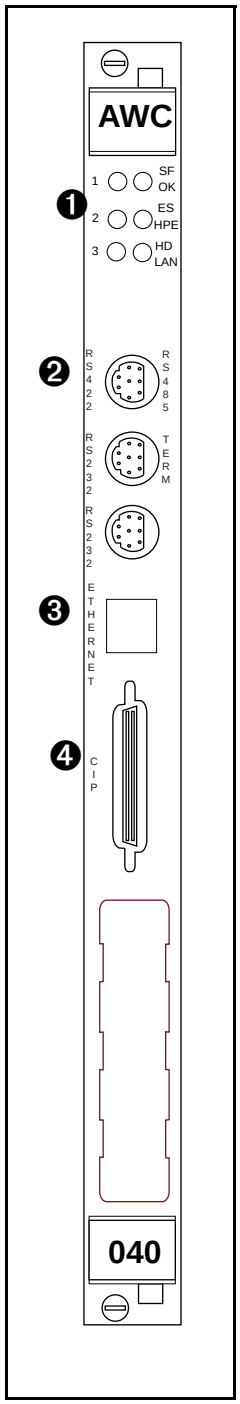
The MV-4 insert is a four-slot chassis with an integrated power supply. It plugs into the right two amplifier slots of a PA-4 amp chassis and receives its power from an amplifier receptacle in the PA-4 chassis. When the left slots of the PA-4 chassis are loaded with amplifiers, the whole unit becomes a small self-contained robot controller called the Compact Controller.

The basic MV-4 insert configuration has the AWC board in slot one (the far right slot rather than the far left slot as in other MV chassis) and a EJI board in slot 4, the leftmost slot. The two middle slots are available for other boards such as DIO, VGB, or EVI. Third-party boards may be installed in slot 3 (make sure you remove the P2 jumpers before installing a board).

The serial number of an MV-4 insert is printed on a label on its side and its front. This is the number used for licensing and tracking the Compact Controller.

AdeptWindows Controller (AWC) Board Connectors and Indicators

An AWC board (040 or 060) is required in every system. This section describes the basic features of the AWC board.



❶ Status LEDs.

Six bicolor LEDs indicate diagnostic test, power control, and communication status.

The right column of LEDs gives the following status information:

LED Label	Red LED	Green LED
SF/OK	System Fault	System O.K.
ES/HPE	E-Stop open	High Power Enabled
HD/LAN	Read/Write from CF	Ethernet access

During system bootup the red SF/OK and ES/HPE LEDs are lit and the red HD/LAN LED blinks. After system bootup, the SF/OK LED should show green. If the ES/HPE LED shows red, the E-Stop circuit is open. During compact flash reads and writes, the HD/LAN LED pulses red. When the AWC is active on an Ethernet network, the HD/LAN LED pulses green. See Table 7-1, "LED Status Indicators," on page 137 for details on the LEDs labeled 1 - 3.

❷ Two RS-232 ports and one RS-422/485 port (see the *Adept MV Controller User's Guide* for pin descriptions and locations).

❸ Ethernet connector: Shielded RJ-45 receptacle that supports 10 BaseT communications (see the *Adept MV Controller User's Guide* and the *AdeptNet User's Guide*).

❹ Controller Interface Panel (CIP) connector that accepts a standard 50-pin SCSI cable that routes signals and information to the CIP. Note that the CIP does not communicate in SCSI format (see sections 4.3 through 4.6 for basic installation details. See the *Adept MV Controller User's Guide* for complete details.)

Figure 4-2. AWC System Processor Board

Dual C Amplifier Module Overview

The Dual C Amplifier module is a plug-in module that contains the circuitry and amplifying components to drive two of the motors in an Adept Cobra robot.

In a typical Adept Cobra robot system, there are two identical Dual C Amplifier modules in the Adept PA-4 power chassis. The amplifier module on the left-hand side, called Module 1 (Amp # 1), drives motors 1 and 3. The amplifier module on the right-hand side, called Module 2 (Amp # 2), drives motors 2 and 4.

Connectors and Indicators

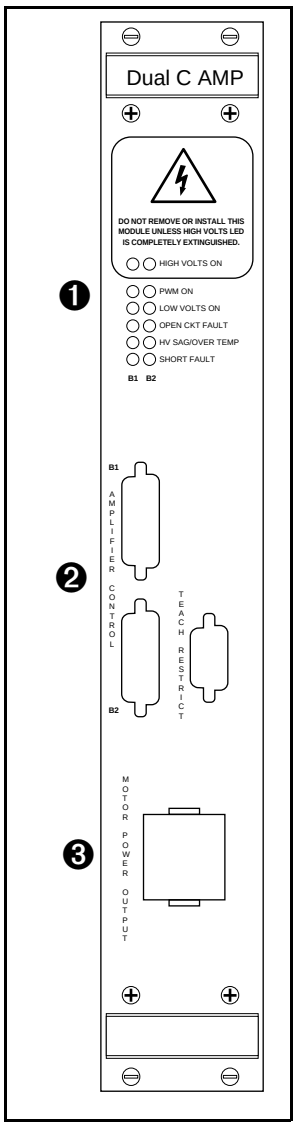


Figure 4-3. Dual C Amplifier

❶ Status LEDs. The left-hand column of LEDs is for the first motor controlled by this module; the right-hand column is for the second motor controlled by this board. When an LED is turned on it indicates the following conditions:

High Volts On indicates the high voltage to the amps is turned on.

PWM On indicates that current servo is on. It does not go on until calibration is complete.

Low Volts On indicates the low voltage supply in the power chassis is on.

Note: the three LED pairs below indicate faults and are visible momentarily before the system turns off.

Open Ckt Fault indicates that an open circuit in the motor leads has been detected.

HV Sag/Over Temp left-hand LED, when lit, indicates that the fault was caused by a sag in voltage. The right-hand LED when lit indicates the fault was caused by an over-temperature condition on the amplifier heat sink.

Short Fault indicates that an over-current in the motor leads has been detected.

❷ **Amplifier Control** connector – the EJI-to-Amp cable connectors are installed here.
Teach Restrict connector – not used with Adept Cobra robots.

❸ **Motor Power Output** connector – the Arm Power cable is installed here.

4.2 Mounting the Adept MV Controller and Power Chassis

NOTE: The Adept MV controller must be installed in a suitable enclosure that provides the environment (temperature, etc.) specified in Table 2-1, "Robot System Operating Environment Requirements," on page 42 and complies with applicable local and national regulations.

The enclosure must also provide a power disconnect with a method for user service personnel to lock the power in the OFF position. This is required for safety, including national and international standards, such as:

- OSHA 'Lockout/Tagout' (USA)
- IEC 204-1
- EN 60204-1

WARNING: Failure to provide and use a suitable disconnect device could cause death or injury to personnel.

Joining an Adept PA-4 Power Chassis to an Adept MV Controller

The Adept PA-4 power chassis can be joined to an Adept MV controller using the brackets and screws supplied in the accessory kit. Join the chassis and controller at the top *and* bottom, as described in the following paragraphs.

NOTE: Joining the chassis and controller allows rack mount of the chassis and controller in a 19-inch rack.

Joining at the Top

1. Turn off power to each unit and disconnect the power cord. Place the two units next to each other. Remove the top cover from both (see Figure 4-4).
2. Locate the C-shaped bracket in the accessory kit.
3. Slip the bracket under the lip of the top edge of the unit on the right-hand side and into the two slots in the edge of the chassis. Install two M4 x 8 mm flat-head screws into the lip and down into the bracket.
4. Install the other two M4 x 8 mm flat-head screws into the chassis on the left-hand side. Replace the cover on each unit.

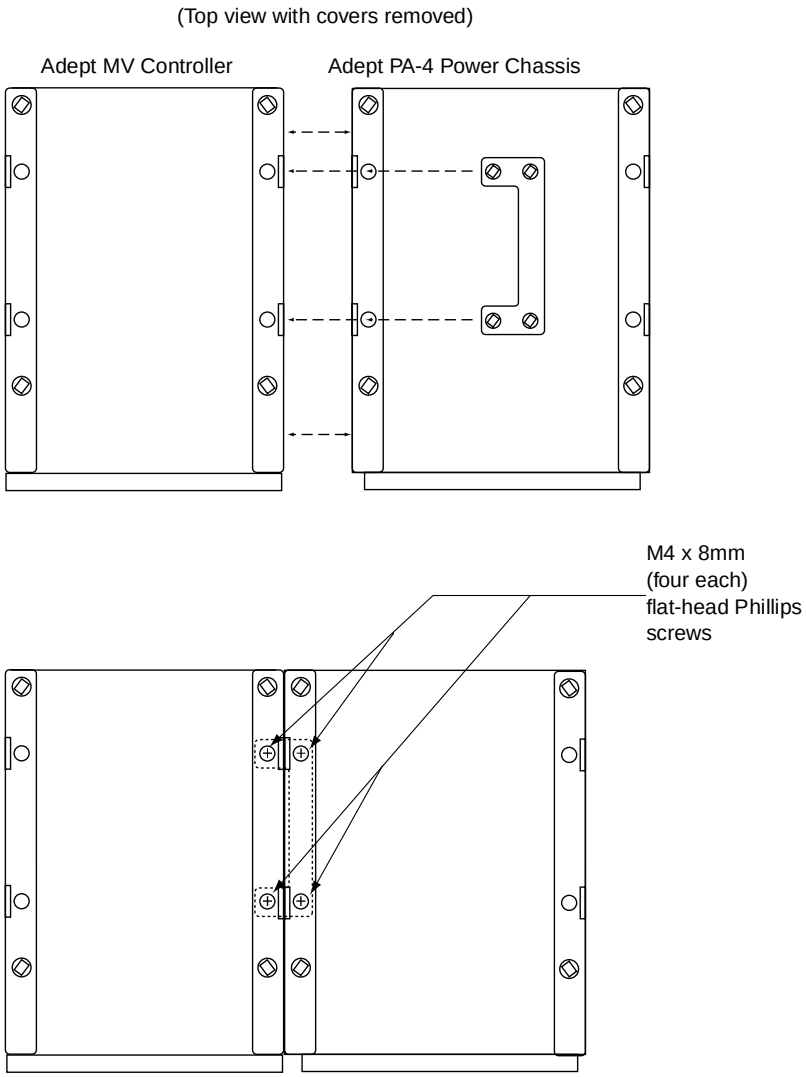


Figure 4-4. Joining the Power Chassis and Controller at the Top

Joining at the Bottom

1. Turn the two units over so you have access to the bottom side.
2. Locate the cutout bracket in the accessory kit.
3. Place the bracket over the feet of the units as shown in Figure 4-5.
4. Install the four M4 x 8 mm flat-head screws in the holes indicated in Figure 4-5 to secure the brackets.

CAUTION: Do not use screws longer than 8 mm to install the bracket. Doing so could cause damage to your equipment.

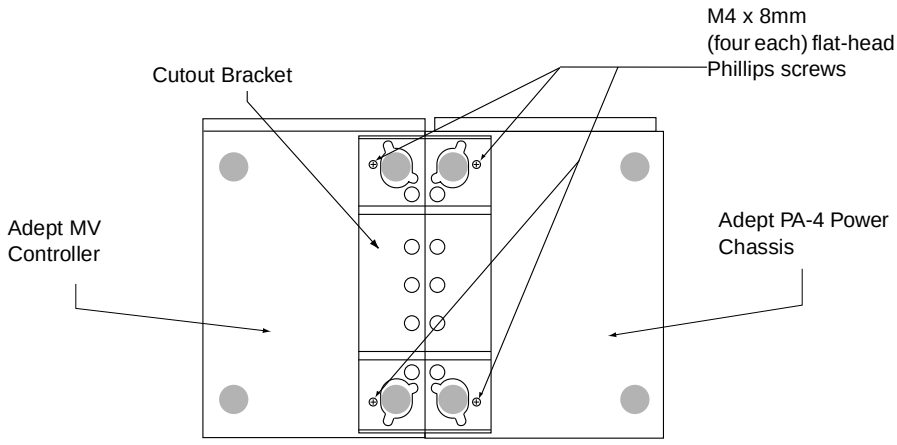


Figure 4-5. Joining the Power Chassis and Controller (Bottom View)

Space Around the Chassis

When the controller and power chassis are installed, you must allow 50 mm (2 in.) at the front of the power chassis and 25 mm (1 in.) at the top and bottom of the Adept MV controller for proper air cooling.

CAUTION: It is important to keep the air filters clean so the forced air cooling system can work efficiently. See section 9.5 on page 169 for details on cleaning the filters.

Rack or Panel Mounting

The power chassis and controller can be rack or panel mounted using the mounting brackets that are shipped in the accessories kit. The brackets can be attached at the rear of the controller/power chassis for panel mounting or they can be attached to the front of the controller/power chassis for rack mounting.

Panel Mounting

To panel mount the controller or power chassis, install one bracket on each side near the back of the chassis. Use the screws and washers from the accessories kit (see Figure 4-6 and Figure 4-7).

Rack Mounting

Use the mounting brackets, screws, and washers from the accessories kit to rack-mount the Adept PA-4 power chassis joined to an Adept MV controller in a standard 19-inch equipment rack. The brackets can be installed in two positions for rack mounting: “flush” and “set-back” (see Figure 4-6 and Figure 4-7).

To Install Mounting Brackets on an Adept MV Controller:

- Remove (and discard) three existing countersunk screws from the chassis side at locations shown in drawing.
- Place bracket in desired position and secure with indicated M4 screws and washers from the accessories kit.
- Repeat process for the other side of the controller. If the controller is joined to an Adept PA-4 power chassis, see Figure 4-7 for the location of the screws on the PA-4 power chassis.

Note: See Figure 10-9 on page 185 for dimensions of the controller and mounting brackets.

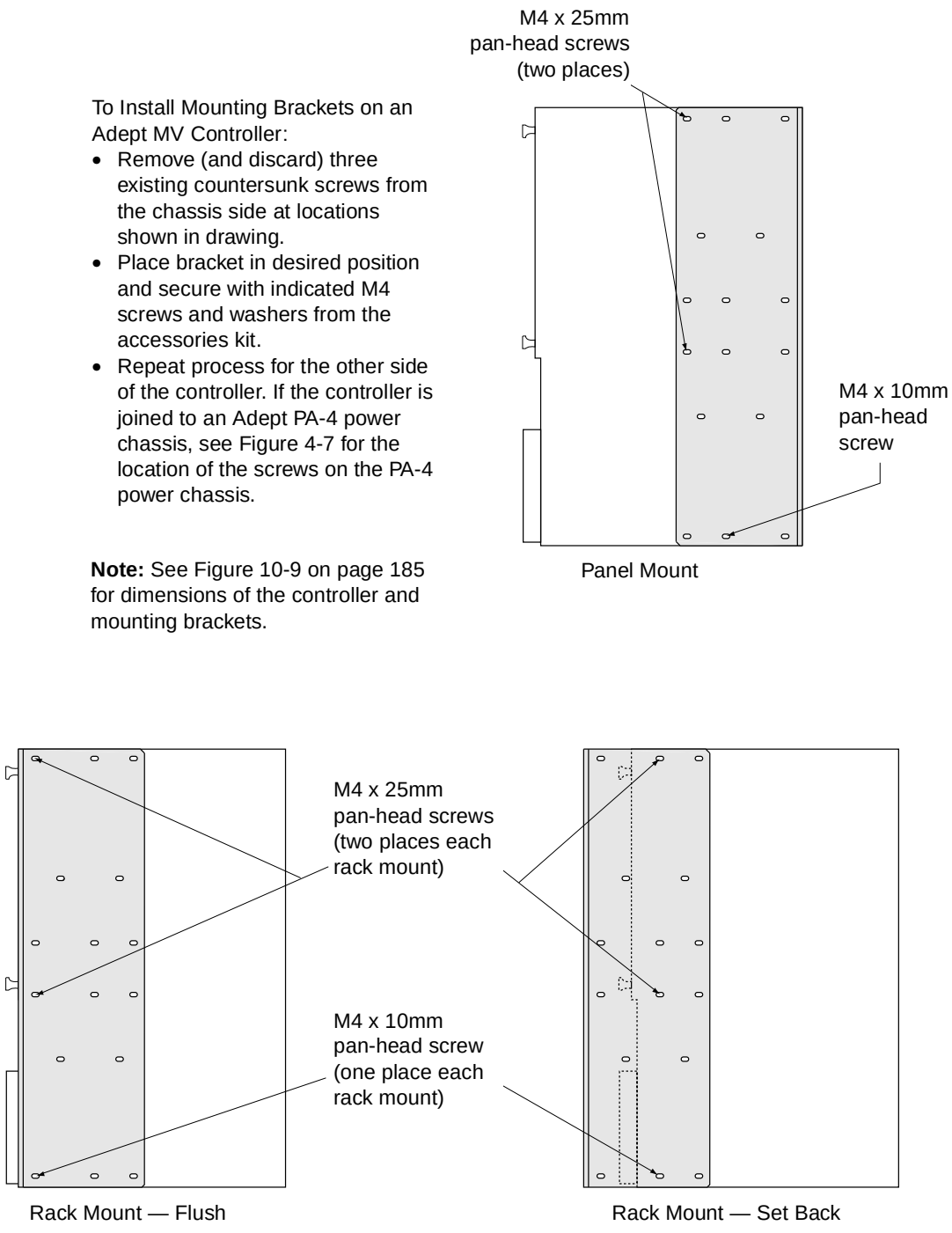
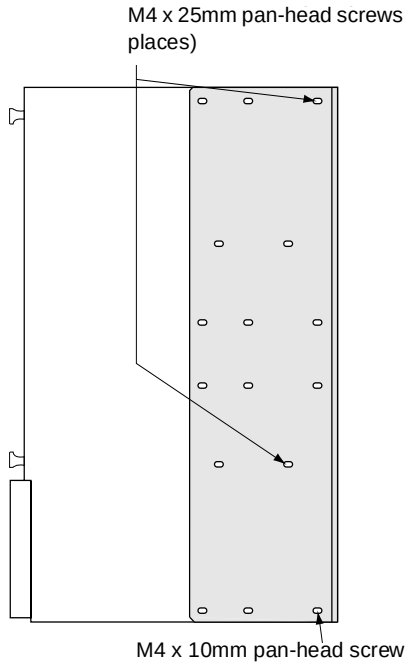


Figure 4-6. Installing Mounting Brackets on an Adept MV Controller

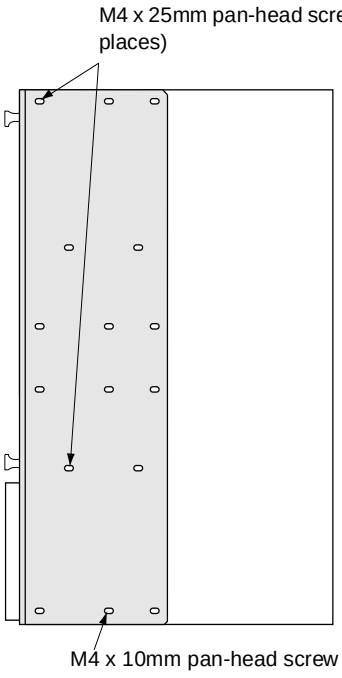
To Install Mounting Brackets on an Adept PA-4 Power Chassis:

- Remove (and discard) three existing countersunk screws from the chassis side at locations shown in drawing.
- Place bracket in desired position and secure with indicated M4 screws and washers from the accessories kit.
- Repeat process for the other side of the controller. If the controller is joined to an Adept MV controller, see Figure 4-6 for the location of the screws on the MV controller.

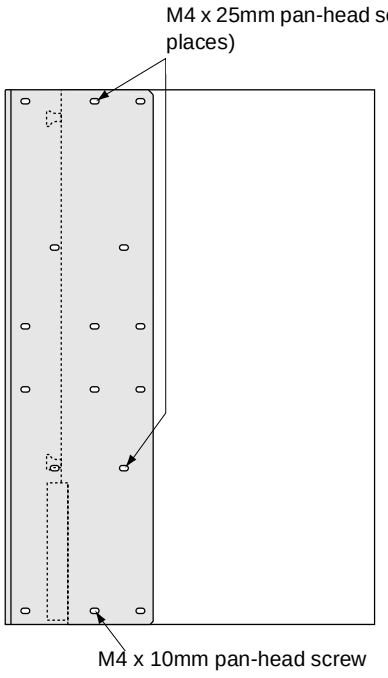
Note: See Figure 10-9 on page 185 for dimensions of the chassis and mounting brackets.



Panel Mount



Rack Mount — Flush



Rack Mount — Set Back

Figure 4-7. Installing Mounting Brackets on an Adept PA-4 Power Chassis

4.3 Controller Interface Panel Description

The CIP is the primary hardware interface to an Adept controller. The CIP can be face-gasket mounted (gasket not included).

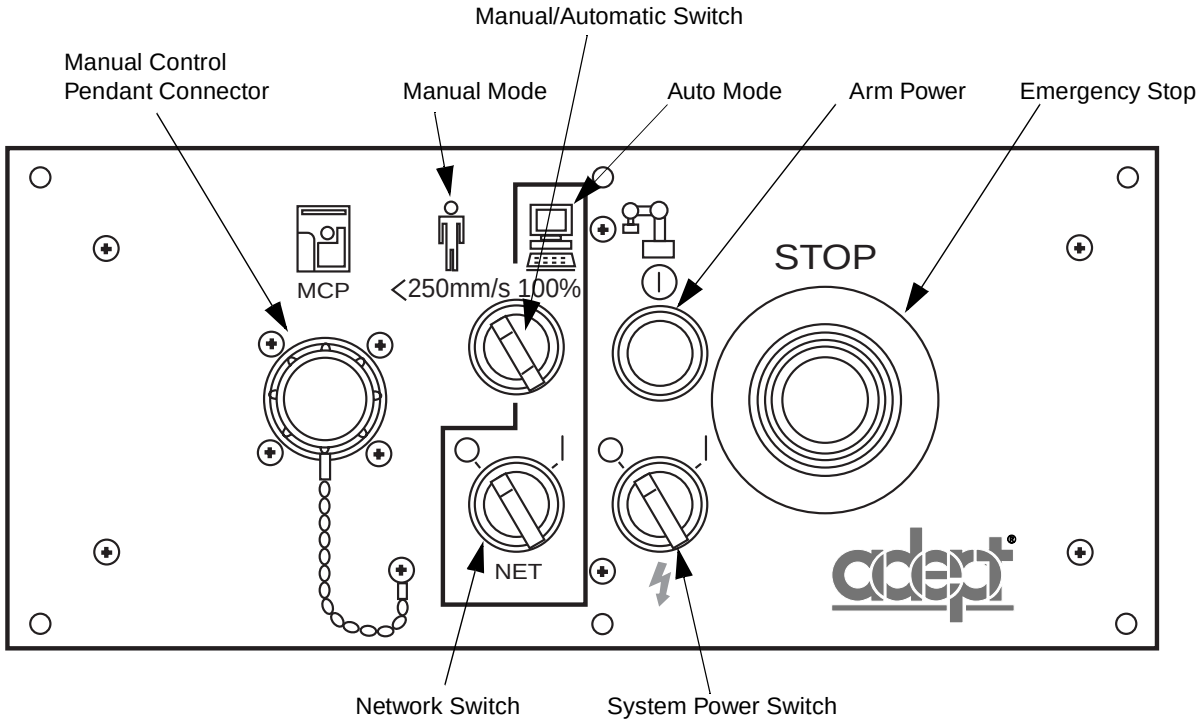


Figure 4-8. Controller Interface Panel (CIP)

Panel Switches and Indicators

Emergency Stop Switch

The E-Stop is a dual channel passive E-Stop that supports Category 3 CE safety requirements. It supports a customer-programmable E-Stop delay that maintains motor power for a programmed time after the E-Stop is activated. This allows the motors to assist in stopping the robot. The programmable E-Stop is described in a paper available through Adept On Demand (see "How Can I Get Help?" on page 39).

Manual/Automatic Mode Switch

In Automatic (AUTO) Mode, programs running on the system control the mechanism and the mechanism can be run at full speed. In Manual Mode the system limits mechanism speed and torque so that an operator can safely work in the cell. Manual mode initiates software restrictions on robot speed, commanding no more than 250 mm/sec as required by RIA and ISO standards.

High Power Enabling Switch/Lamp

This switch, marked with a robot figure and the international ON symbol (**I**), controls High Power, which is the flow of current from the amplifiers to the robot motors. Enabling High Power is a two-step process. An "Enable Power" request must be sent from the system terminal, an executing program, or the manual control pendant. Once this request has been made, the operator must press this button and High Power will be applied.

> **NOTE:** High Power **cannot** be enabled if this lamp is burned out. See section 9.6 on page 170 for details.

Manual Control Pendant (MCP) Connector

The MCP plugs into this connector. The CIP works only with the MCP III, P/N 10332-11000 (Assembly Number 90332-48050). Other Adept pendants will **not** work because they do not incorporate the dual E-Stop channels. See "Connecting the MCP to the CIP" on page 67 for details.

> **CAUTION:** Damage may result if an MCP III is plugged into older Adept controller systems that contain a VME Front Panel (VFP). Damage may also result if older MCPs (part numbers other than 10332-11000) are plugged into a CIP.

System Power Switch

This switch, marked with a lightning bolt, allows you to switch a relay or other power switching equipment to control power to the Adept controller and other equipment. The two independent, normally open contacts on this switch come out of the User connector. They are for customer use only. See "Connecting the System Power Switch to the CIP" on page 121 for details on using these connections.

NET Switch

This switch should be left in the "**O**" position.

Side Connectors

See Figure 4-9 on page 64 for the location of the following connectors:

AWC Interface (JAWC)

Connects the CIP to the AWC board. The JAWC connector accepts a standard 50-pin SCSI cable (see Figure 4-11 on page 67). Note that the CIP does not communicate in SCSI format. See "Connecting the CIP to the AWC" on page 66 for details.

User Connector (JUSER)

All switch functions on the CIP can be duplicated external to the CIP using signals from this connector. For example, an external E-Stop can be connected to the User connector; this will behave exactly like the E-Stop on the CIP. Similarly, there is an output on the User connector that can be used to stop external equipment when the CIP E-Stop is pressed (see "Remote E-Stop Circuit" on page 123 for details). See the *Adept MV Controller User's Guide* for details on the other remote functionality available through this connector.

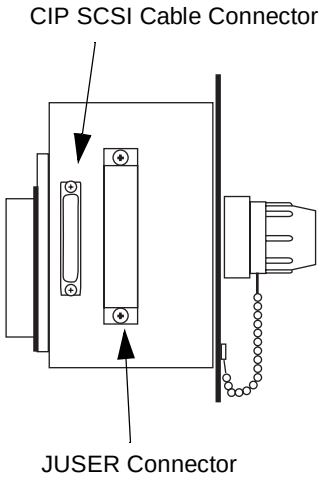


Figure 4-9. Controller Interface Panel (CIP) Side View

Back Panel Connectors

See Figure 4-10 for the location of the following connectors:

RS-232 (JCOM)

There is one RS-232 connector on the back of the CIP. It is a DB9 connector. This RS-232 has no hardware handshake lines. See "RS-232 (JCOM) Connector" on page 111 for details.

Manual Mode Safety Package (MMSP)

Not used with Adept Cobra robot systems.

AUX (JEXT)

This connector is reserved for Adept internal use.

CIB (JSLV)

This connector is reserved for Adept internal use.

DeviceNet (JDVC)

DeviceNet is a field bus for industrial devices. This standard supports a variety of products, including sensors, digital I/O, analog I/O, RS-232, and PLCs. Adept directly supports Digital I/O devices and has currently qualified DeviceNet products from Wago and Beckhoff. In the future, Adept will offer direct support for Analog I/O. Other DeviceNet product types, such as keypads and displays, can be controlled using the V+ FCMD program instructions (see the *V+ Language Reference Guide* for details).

See "DeviceNet Communication Link" on page 109 and the *Adept MV Controller User's Guide* for details on DeviceNet installations.

Digital I/O Connections

There are 44 digital inputs and 40 digital outputs available on the CIP. See "Connecting User-Supplied Digital I/O Equipment" on page 126 for details. Additional digital I/O can be added using DIO boards. See the *Adept MV Controller User's Guide* for details.

JSIO This connector includes 20 signal pairs; eight 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. The single channel E-Stop input, and passive E-Stop output are also included on this connector.

JDIO 1-4 These four connectors duplicate the function of one DIO board with 32 inputs and 32 outputs (700 mA max.), a total of 64 I/O points. The digital outputs are short-circuit protected and protected from thermal overload. Note that if a DIO board is installed and addressed as DIO board #1, the JDIO connectors on the CIP are inactive. In order to use the JDIO signals, the first DIO board must be addressed as DIO board #2. See the *Adept MV Controller User's Guide* for details on DIO boards.

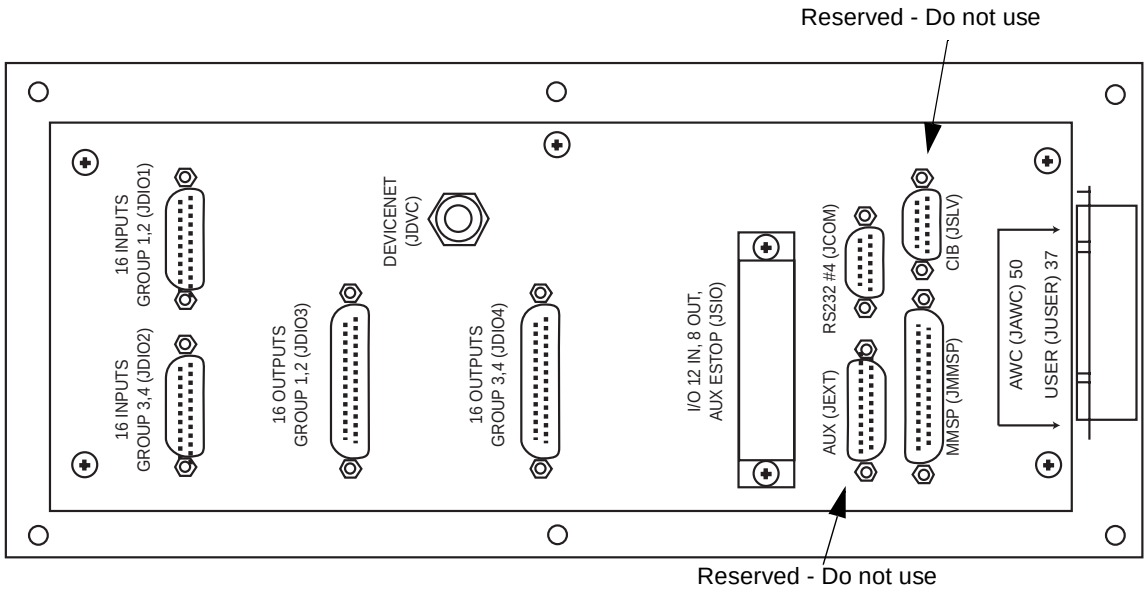


Figure 4-10. Controller Interface Panel (CIP) Back Panel View

4.4 Mounting the Controller Interface Panel (CIP)

All the user connections to the AWC, except for the serial ports and the Ethernet connectors, are made through the CIP. The CIP provides connections for digital I/O, fast inputs, one RS-232 serial port, DeviceNet, and the user interface to the E-Stop circuitry. See "Connecting Customer-Supplied Safety and Power Control Equipment to the CIP" on page 114 for details on connecting user E-Stop circuitry. See the *Adept MV Controller User's Guide* for details on the other connections.

Location of the CIP

The CIP contains features that prevent dangerous motions while an operator is in the workcell. In order for the installation of the CIP to conform with RIA and European standards for power control functions, the CIP must be mounted outside the robot enclosure. Mount the CIP on the same enclosure as the controller, or on a separate, protected enclosure (see page 184 for CIP dimensions).

4.5 Connecting the CIP to the AWC

The CIP connects to the AWC through the JAWC connector. The AWC to CIP cable is a 1.8 m (6 ft.) SCSI-2 50-wire cable with a male Micro D50-pin shielded connector on each end. The Micro D-connector has two rows of 25 pins spaced at 1.27 mm (0.050 inches) apart.

To connect the CIP to the AWC (see Figure 4-11 on page 67):

1. Turn off the Adept MV controller power switch, and disconnect main power.
2. Plug one end of the CIP interface-panel cable into the CIP connector on the AWC board. Plug the other end into the SCSI connector (JAWC) on the left side of the CIP. Be sure the spring latches are engaged.
3. When not using the MCP, install the optional MCP bypass plug into the MCP connector on the face of the CIP. If an MCP is being used, see "Connecting the MCP to the CIP" on page 67 for more information.
4. In order to enable High Power, plugs with appropriate jumpers or contacts must be attached at the JSIO and JUSER connectors.

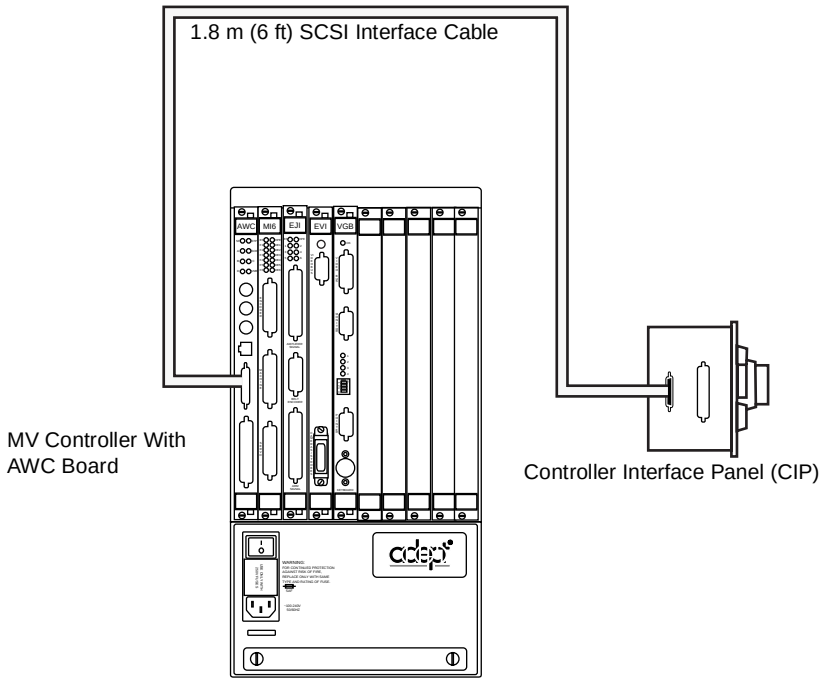


Figure 4-11. Connecting the CIP to the AWC

Extended Length CIP-to-AWC Cable

A custom cable, not to exceed 10 m (33 ft.), may be fabricated. It should be made to the ANSI SCSI Parallel Interface 2 (SPI-2) standard and should incorporate twisted pair wires of a minimum of 0.08 mm^2 (28 AWG) size. The connectors should be wired so that pin 1 goes to pin 1, pin 2 goes to pin 2, and so on. The twisted pairs in the cable must be wired to physically opposing contacts in the connector. That is, the first twisted pair goes to pins 1 and 26, the second to pins 2 and 27 and so on. A shielded Micro D50 male connector should be used on both ends. The entire cable must be shielded with a foil and drain wire. See the *Adept MV Controller User's Guide* for the connector pin descriptions and locations.

4.6 Connecting the MCP to the CIP

The MCP is connected to the system at the pendant connector on the CIP. The controller does not have to be turned off to connect or disconnect the MCP. Note that if the MCP or the MCP bypass plug is removed, High Power will be turned off. The JUSER connector allows you to install a remote MCP connector. See "Connecting User-Supplied Digital I/O Equipment" on page 126 and the *Adept MV Controller User's Guide* for details.

WARNING: The CIP has two key switches. Before the MCP can be used in the workcell, the operating key switch must be set to MANUAL and the NET switch to LOCAL (O). This will prevent program execution from being started from keyboard or terminal.

CAUTION: The coiled cable on the MCP III has been tested to withstand 500V of repetitive electrical bursts per EN61000-4-4. Exposing the MCP to voltages higher than 500V may cause the robot to shut down. In this event, it may be necessary to unplug, then reconnect, the MCP to restart the robot.

CAUTION: Damage may result if an MCP III is plugged into older Adept controller systems that contain a VME Front Panel (VFP). Damage may also result if older MCPs (part numbers other than 10332-11000) are plugged into a CIP.

Plug the MCP into the connector marked MCP on the CIP. The jack and plug are keyed to ensure proper connection. The CIP connector is an AMP 16-pin circular plastic male connector. A female connector is used on MCP cable.

MCP Cradle

The MCP is stored in the MCP cradle when it is not being held by an operator. The cradle has a retaining clip that keeps the enabling switch closed. The MCP cradle ***must*** be installed outside of the robot workcell. See Figure 10-11 on page 187 for the dimensions of the cradle.

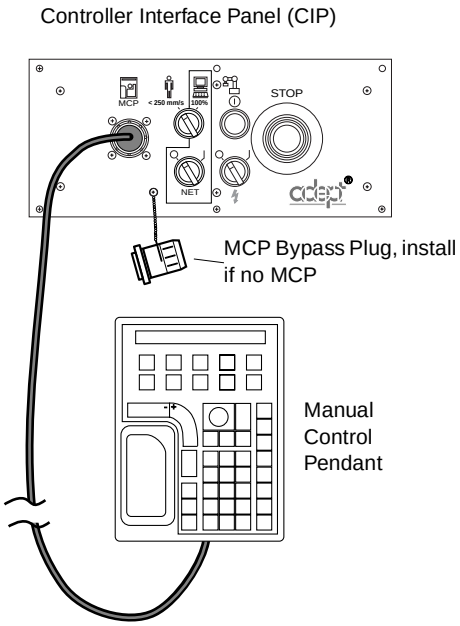


Figure 4-12. MCP Connection

MCP Bypass Plug

The MCP Bypass plug is optional and must be installed when not using the MCP. The Adept part number for this bypass plug is P/N 10335-01060.

4.7 Robot and Control System Cable Installation

This section covers the installation of all required power and signal cables for the robot and controller. Figure 4-13 shows the cabling between the robot and the control system. Table 4-1 on page 72 lists the lengths of all cables.

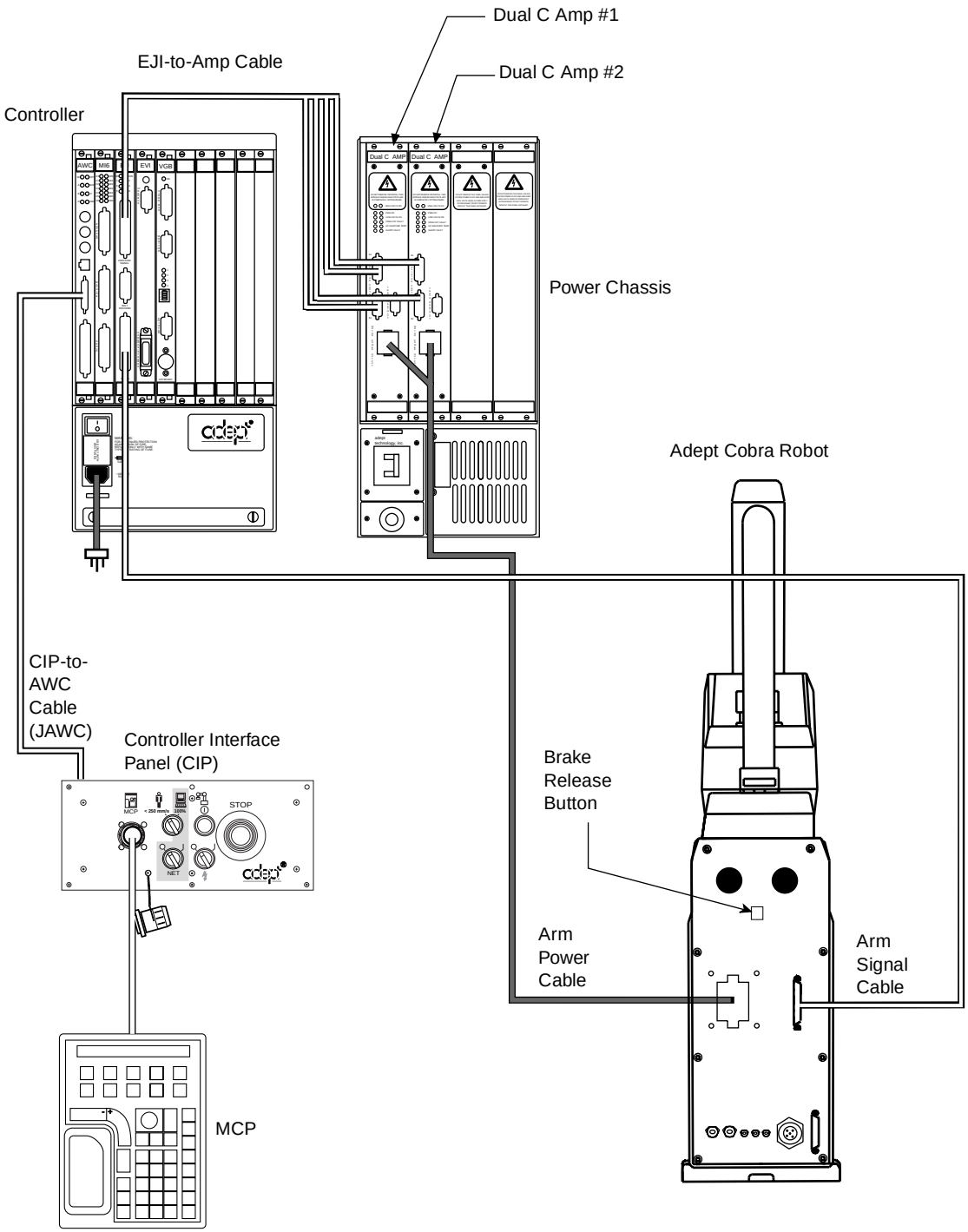


Figure 4-13. Adept Cobra System Cable Installation With MV Controller

Figure 4-14 shows the cable installation for an Adept Cobra system with a Compact Controller.

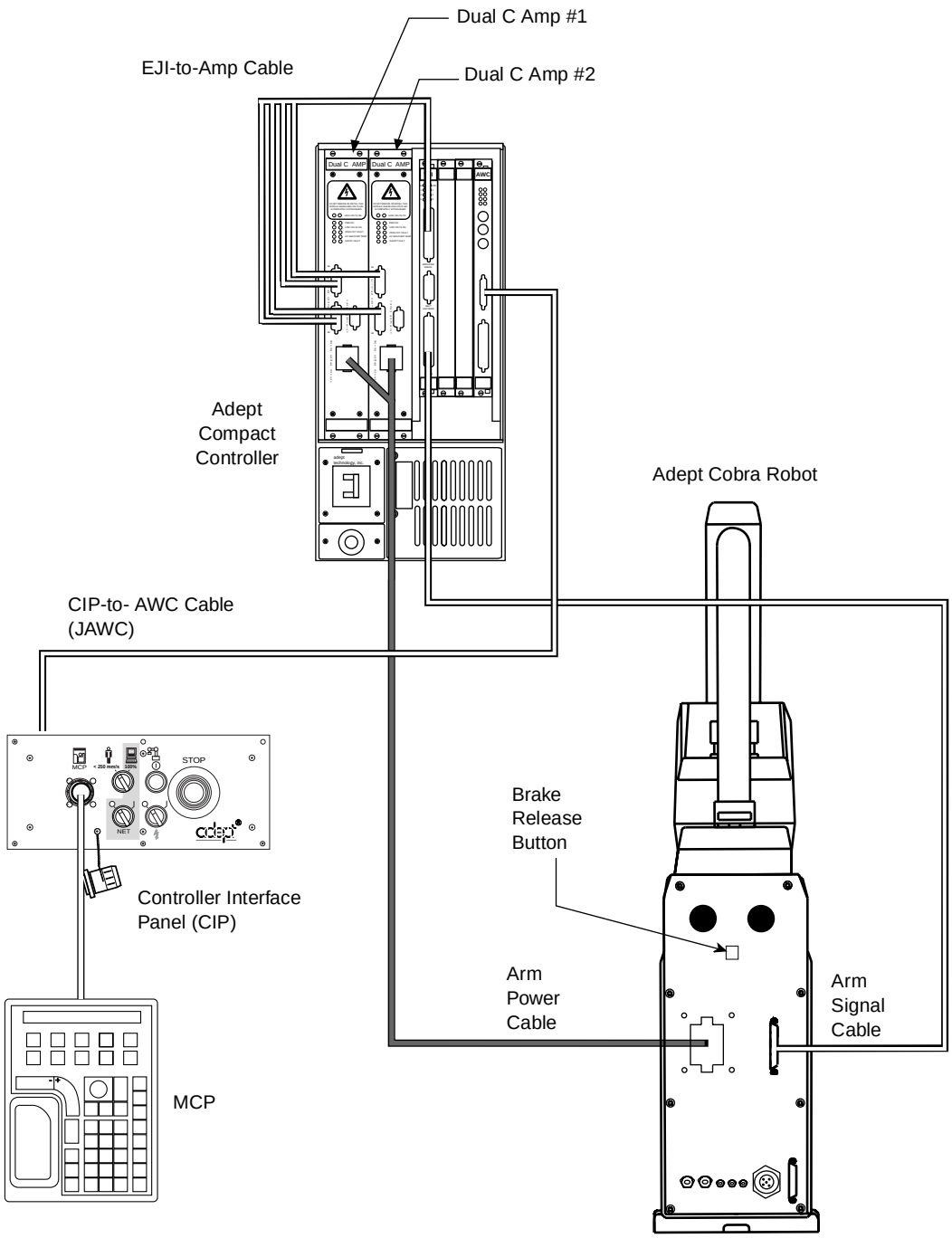
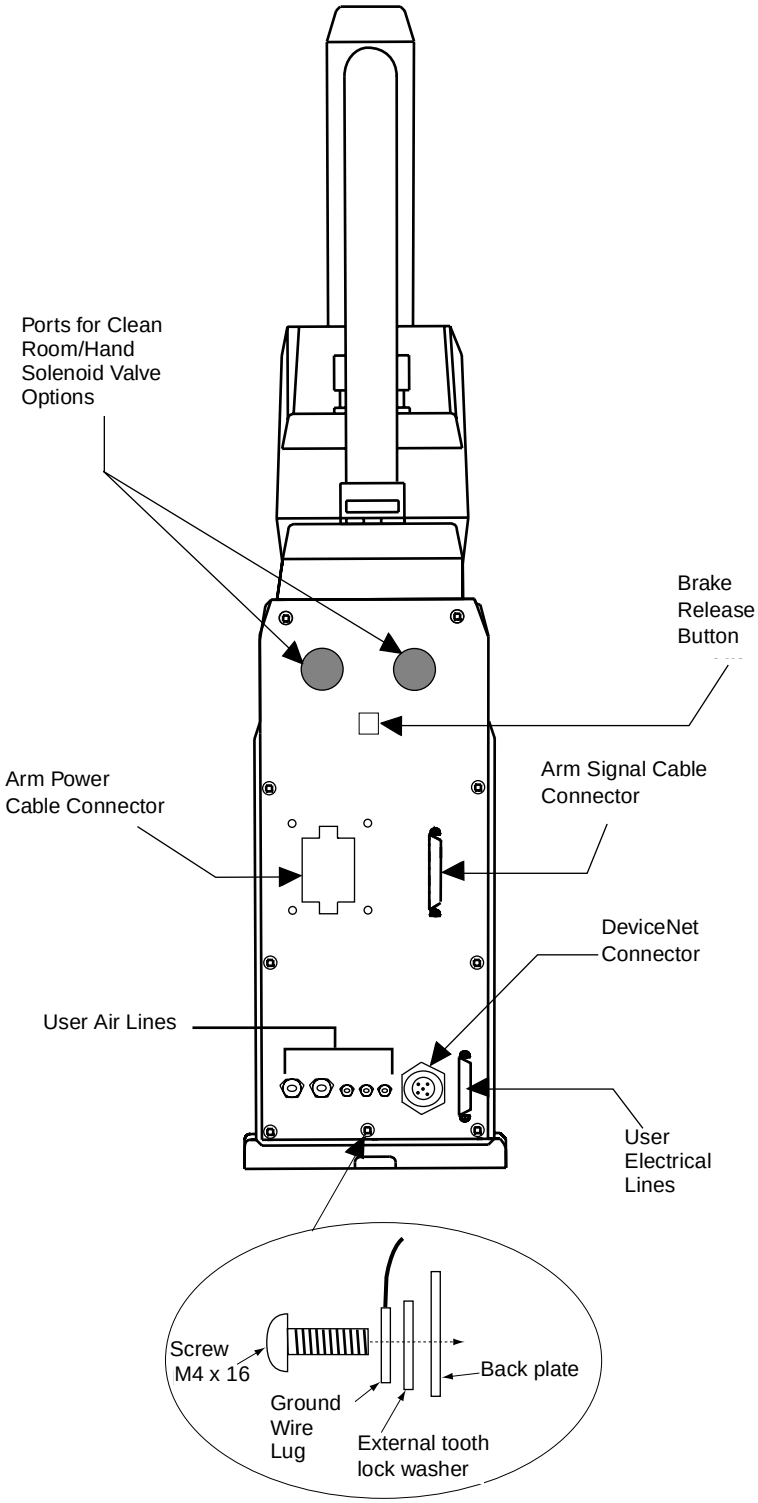


Figure 4-14. Adept Cobra System Cable Installation With Compact Controller



NOTE: For ground wire installation (see "Adept Robot Grounding" on page 84).

Figure 4-15. Adept Cobra Robot Rear Panel

System Cable Lengths

Table 4-1. System Cable Lengths

Cable	Length
Arm Power and Arm Signal	Standard 5 m (16.5 ft) Optional 8 m (26.3 ft) and 15 m (49.3 ft)
EJI-to-Amp	MV-10 = 1 m (3 ft)
Controller Interface Panel (CIP-to-AWC)	2 m (6.5 ft)
PA-4 Power Cord	2.9 m (9.5 ft)
Adept MV Power Cord	3 m (10 ft)
MCP Cable	1.6 m (5.4 ft)

Connecting the Robot to the Power Chassis

The cable between the robot and power chassis is called the Arm Power cable. The robot end of the cable has a single large rectangular Harting connector with four slotted screws. This cable carries high-voltage DC power to the motors. This independent DC circuit can be isolated only by using the circuit breaker on the front of the Adept PA-4 power chassis (see Figure 4-13 on page 69).

WARNING: Turn off the power to the power chassis before installing or removing any cables. Failure to observe this warning could cause injury or damage to your equipment.

Do not turn on the power chassis without installing the motor power cables. Dangerous AC and DC voltages may be present at the "Motor Power Output" connectors on the amplifier modules.

NOTE: The system integrator must add adequate strain relief for the Motor Power cable connectors at the amplifier modules.

1. Connect the Harting connector of the Arm Power cable to the Arm Power connector on the back plate of the robot. Tighten the four captive screws securely.
2. Connect the other end of the Arm Power cable to the two matching connectors on the amplifier modules in the following order (see Figure 4-16 on page 73).
   a. Install the plug labeled **C Amp #1** in the connector marked "Motor Power Output" on **Amp Module 1**.
   b. Install the plug labeled **C Amp #2** in the connector marked "Motor Power Output" on **Amp Module 2**.
3. Pull gently on the connector bodies to ensure they are securely latched.

WARNING: Verify that all connectors are secure and fully inserted. Failure to do this could cause unexpected robot motion.

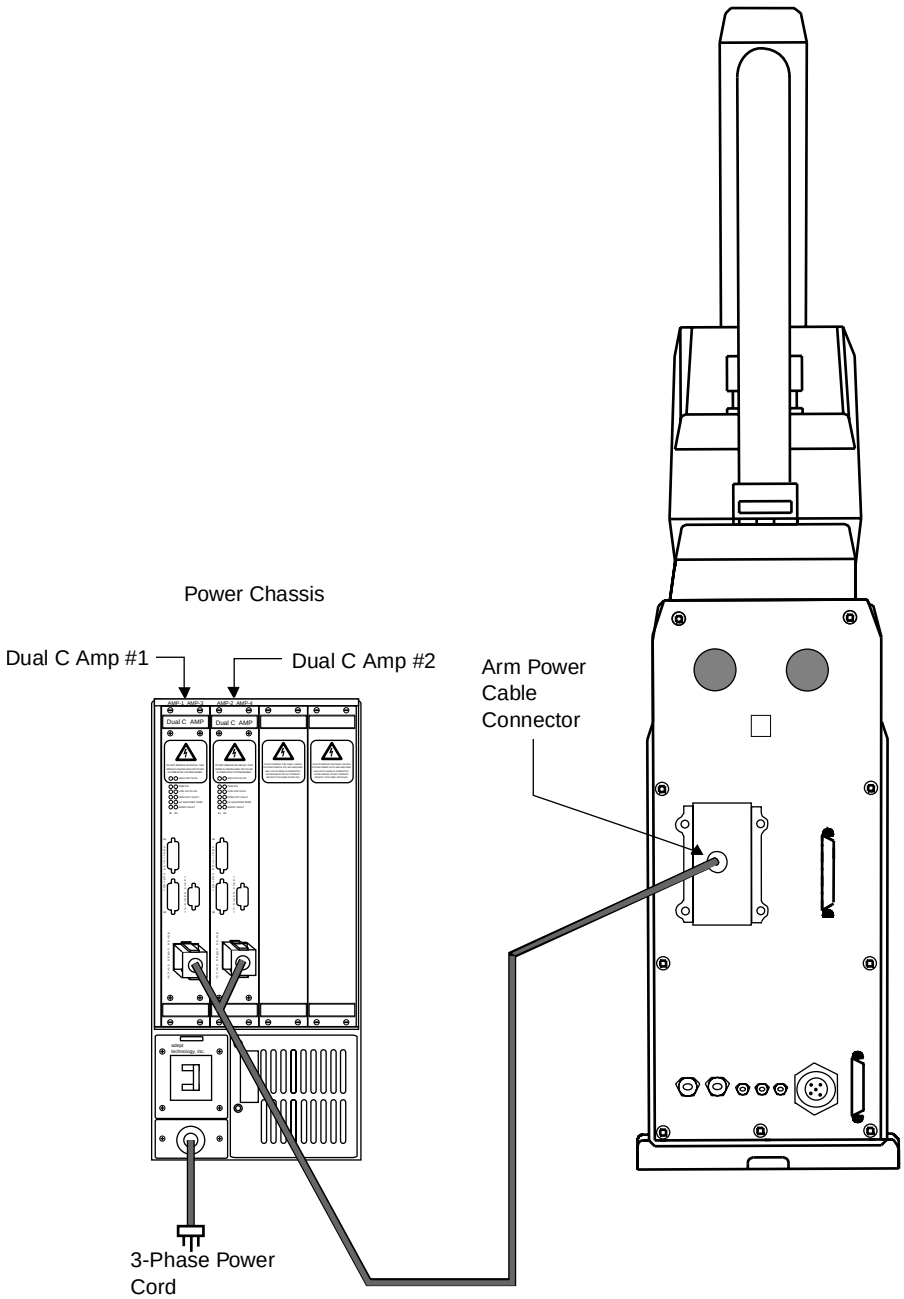


Figure 4-16. Arm Power Cable Installation

Connecting the Robot to the MV Controller

The cable between the robot and the EJI module in the Adept MV controller is called the Arm Signal cable. The robot and the controller each have a 50-pin D-sub connector (see Figure 4-13 on page 69).

1. Connect the straight-end connector of the Arm Signal cable to the Arm Signal connector on the back of the robot. Tighten the two captive screws securely.
2. Connect the other end (right-angle connector) of the Arm Signal cable to the Arm Signal connector (lower) on the EJI module. See Figure 4-17. Tighten the two captive screws securely.

WARNING: Verify that all connectors are fully inserted and screwed down. Failure to do this could cause unexpected robot motion. Also, a connector could be pulled out or dislodged unexpectedly.

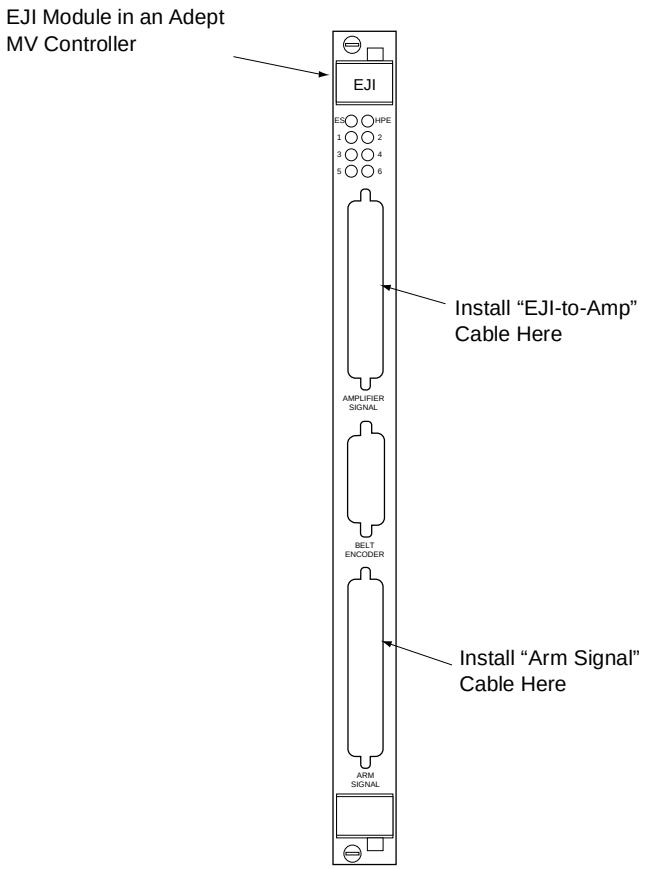


Figure 4-17. Robot-to-EJI Cable Installation

Connecting the Adept MV Controller to the Power Chassis

The EJI-to-Amp cable must be installed between the controller and the power chassis. This cable assembly has a single plug on one end (for the EJI) and four plugs on the other end (for the amplifiers).

1. Connect the cable end with the single connector to the connector marked "Amplifier Signal" (upper) on the EJI module. Tighten the screws. See Figure 4-13 on page 69 and Figure 4-17 on page 74.
2. The other end of the cable with four plugs must be connected in the following *special* pattern. See Figure 4-18 on page 76.
    a. Connect the plug labeled Amplifier Control Connector 1 to the B1 connector on Module 1.
    b. Connect the plug labeled Amplifier Control Connector 3 to the B2 connector on Module 1.
    c. Connect the plug labeled Amplifier Control Connector 2 to the B1 connector on Module 2.
    d. Connect the plug labeled Amplifier Control Connector 4 to the B2 connector on Module 2.
3. Verify that all connectors are secure and fully inserted and installed in the correct location.

WARNING: Verify that all connectors are fully inserted and screwed down. Failure to do this could cause unexpected robot motion. Also, a connector could get pulled out or dislodged unexpectedly.

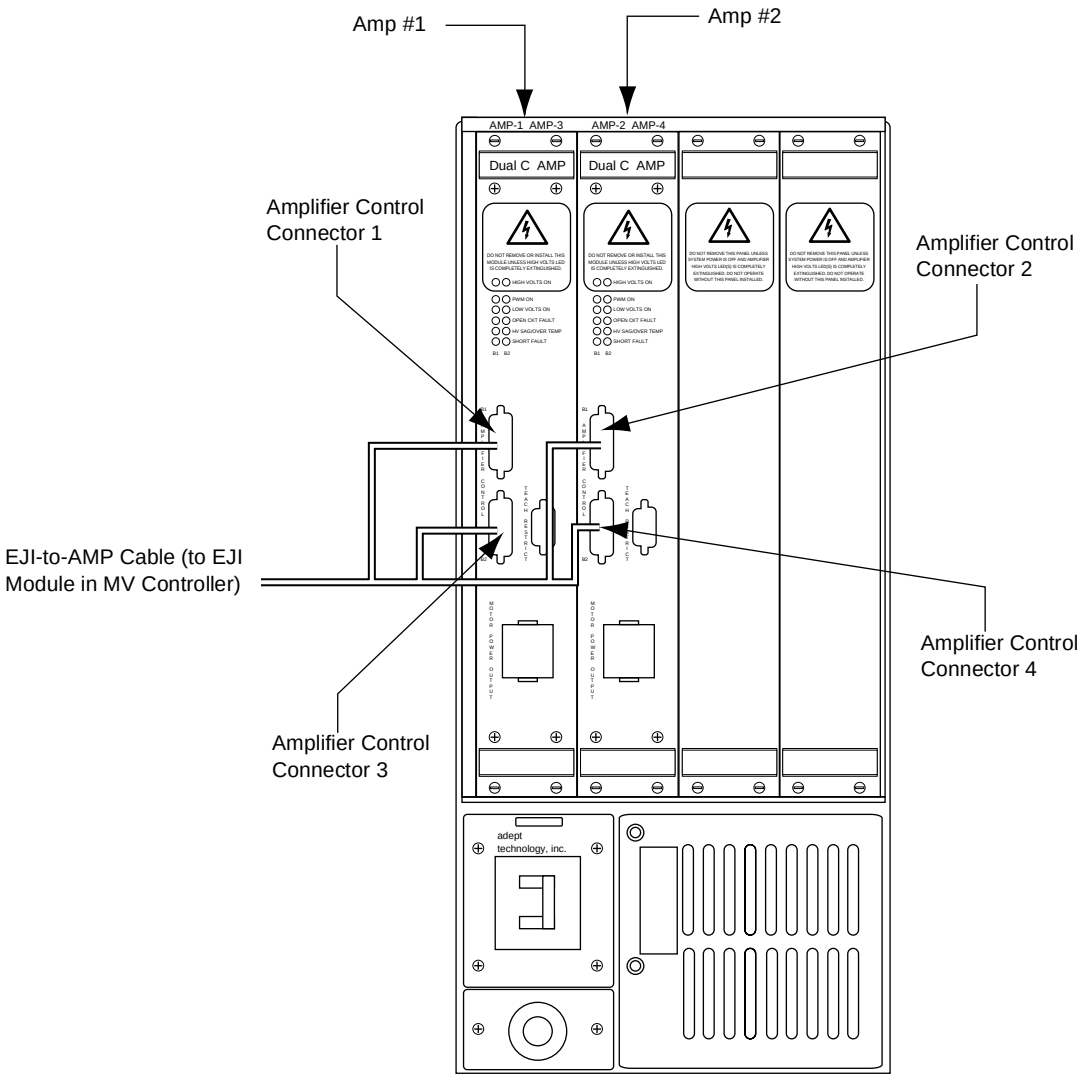


Figure 4-18. Power Chassis to EJI Cable Installation

4.8 Connecting AC Power to the Adept MV Controllers

The Adept MV controllers have auto-ranging power supplies that operate at either 100-120 VAC or 200-240 VAC single phase. The power supply must meet the requirements detailed in Table 2-2, "Adept MV Controller Power Requirements," on page 43.

Power Entry Board

The power entry board is located on the front of the controller. It contains:

- On/Off power switch (**I** = On, **O** = Off)
- Fuse holder containing the two incoming AC line fuses (The spare fuses are stored in the fuse holder; see Figure 4-19.)
- AC power cord socket

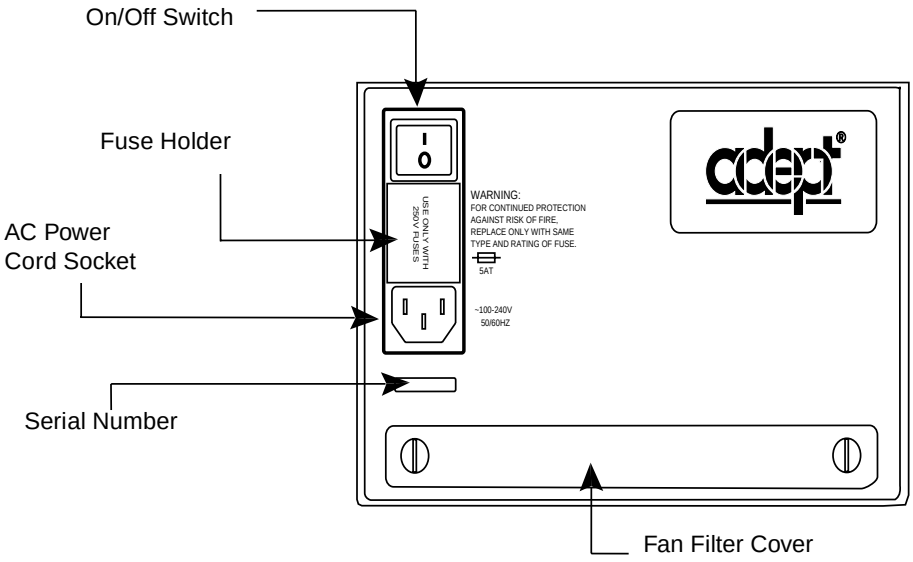


Figure 4-19. Adept MV Controller Power Entry Board

Connecting AC Power Cord

The AC power cord is included in the accessory kit. The controller end of the power cord is fitted with an IEC 320 connector.

WARNING: Electrical hazard!

The installation of the power cord must be done by a skilled person. The power supply can injure or kill the person who installs the cord. An incorrect installation can injure or kill anybody who touches the equipment in the robot workcell.

Connect each conductor of the power cord securely to your AC power source, using the color code below. You must provide a suitable plug or other facility connection in accordance with all applicable local and national standards and regulations. See section 4.11 on page 84 for important information on system grounding.

Table 4-2. Adept MV Controller Power Cord Specifications

Cord length	3 meters ±0.1 m (9 ft. 10 in. ±4 in.)
Cord rating	10 amps
Number and size of conductors	3 x 1.00 mm^2
Color code: line neutral ground	 brown blue green/yellow

System Grounding Information

The detachable three-wire power cord is used for connection to both the power source and protective ground. The protective ground conductor (colored green/yellow) in the power cord is internally connected to the exposed metal parts of the Adept MV controller. To ensure electrical-shock protection, the protective ground conductor must be connected to a properly grounded power source. See section 4.11 on page 84 for proper grounding procedures.

WARNING: Ensure that a proper protective ground connection exists before turning on the power.

4.9 Changing the Power Chassis Voltage Setting

This section covers changing the voltage selection for systems that need a different voltage setting for the PA-4 power chassis.

Changing From 380-415 VAC to 200-240 VAC

Complete the following procedure to change the AC voltage setting from 3-phase 380-415 VAC to 3-phase 200-240 VAC. (Also see "Connecting AC Power to the Adept PA-4 Power Chassis" on page 82).

WARNING: Electrical hazard!
Changing the voltage setting in the power chassis must be done by a skilled person. The power supply can injure or kill a person who does not perform this procedure correctly.

Part 1 – Insulating Power Chassis Power Cord

WARNING: High AC voltage is coupled through capacitors to the blue wire of the PA-4 power chassis power cord. If you change the voltage setting from 380-415 VAC to 200-240 VAC, you must add additional insulation to the blue wire according to the directions provided below. Failure to do this could result in injury or death.

1. Make sure the power chassis and controller are turned off. Disconnect the controller and the PA-4 chassis from the AC power source. Verify that power remains off during all parts of this procedure.
2. If a 5-wire plug has already been installed, remove the plug.
3. Locate the two pieces of shrink tubing in the accessory kit; one is 7 mm (1/4-inch) diameter, the other is 19 mm (3/4-inch).
4. Place the 7 mm (1/4-inch) shrink tubing over the end of the blue wire in the power cord and use a heat gun to apply it (see Figure 4-20).
5. Fold the blue wire back (see Figure 4-20).
6. Place the 19 mm (3/4-inch) shrink tubing over the blue wire and the power cord insulation and use a heat gun to apply it (see Figure 4-20).
7. Install a 4-wire plug (or wire directly to an appropriate service disconnect) according to the 200-240 VAC section in Table 4-3 on page 82.

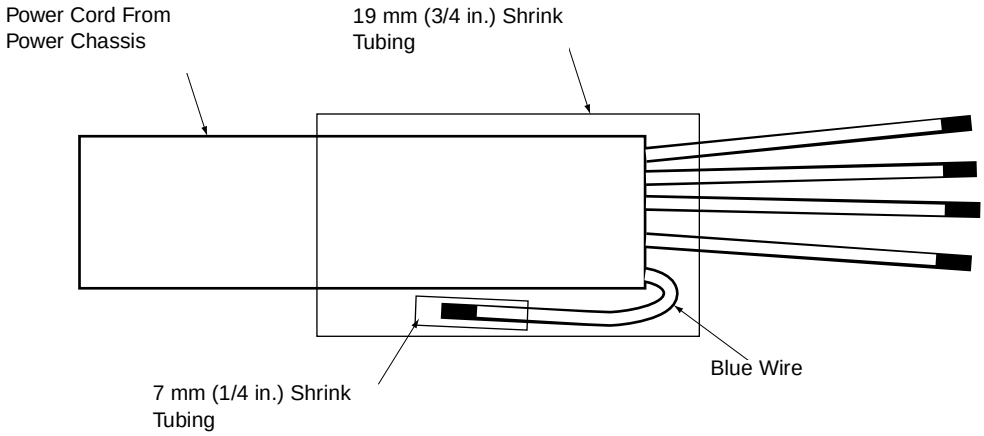


Figure 4-20. Insulating Blue Wire in Power Cord (200-240 VAC)

Part 2– Rotating Voltage Selector in Power Chassis

1. Open the front air-intake grill on the power chassis by loosening two screws and swinging the grill out.
2. Inspect the voltage setting; it is marked on the front of the voltage selector plug. To change the voltage setting, remove the selector, rotate it 180 degrees so the required setting is shown, and replace it. See Figure 4-21 on page 80.
3. Close the grill and secure the two screws.
4. Clearly mark or alter the ID label, on the side of the PA-4 chassis, to show the new voltage configuration (see Figure 4-22 on page 80).

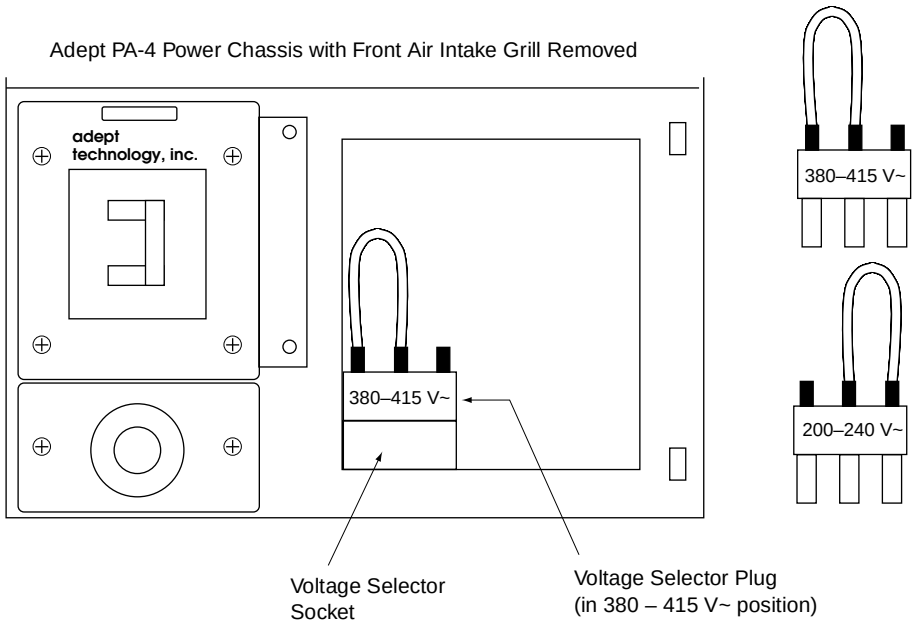


Figure 4-21. Changing Voltage in Power Chassis

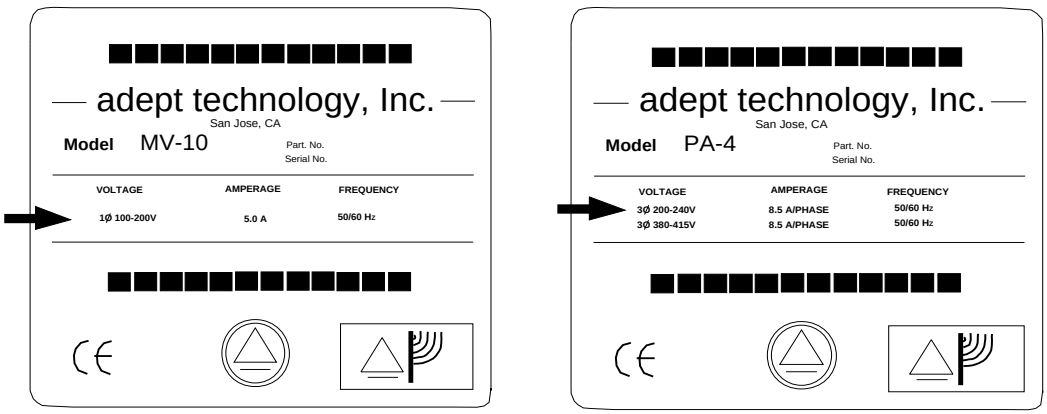


Figure 4-22. Power Labels

Changing From 200-240 VAC to 380-415 VAC

To change the AC voltage setting from 3-phase 200-240VAC to 3-phase 380-415VAC, follow the two-part procedure below. (Also see "Connecting AC Power to the Adept PA-4 Power Chassis" on page 82).

WARNING: Electrical hazard!
Changing the voltage setting in the power chassis must be done by a skilled person. The power supply can injure or kill a person who does not perform this procedure correctly.

Part 1– Rotating Voltage Selector in Power Chassis

1. Open the front air-intake grill on the power chassis by loosening two screws and swinging the grill out.
2. Inspect the voltage setting; it is marked on the front of the voltage selector plug. To change the voltage setting, remove the selector, rotate it 180 degrees so the required setting is shown, and replace it (see Figure 4-21 on page 80).
3. Close the grill and secure the two screws.
4. Clearly mark or alter the ID label, on the side of the PA-4 power chassis, to show the new voltage configuration (see Figure 4-22 on page 80).

Part 2– Insulating Power Chassis Power Cord

WARNING: High AC voltage is coupled through capacitors to the blue wire of the PA-4 power chassis power cord. If you change the voltage setting from 200-240 VAC to 380-415 VAC, you must add additional insulation to the blue wire according to the directions provided below. Failure to do this could result in injury or death.

1. Make sure the power chassis and controller are turned off. Disconnect the controller and the PA-4 power chassis from the AC power source. Verify that power remains off during all parts of this procedure.
2. If installed, remove the 4-wire plug.
3. Remove and discard the 19 mm (3/4-inch) shrink tubing from the end of the power cord.
4. Remove and discard the 7 mm (1/4-inch) shrink tubing from the end of the blue wire in the power cord (see Figure 4-23).
5. Place the 19 mm (3/4-inch) piece of shrink tubing from the accessory kit over the end of the power cord. Use a heat gun to apply the shrink tubing (see Figure 4-23).
6. Install a 5-wire plug (or wire directly to an appropriate service disconnect) according to the 200-240VAC section in Table 4-3 on page 82.

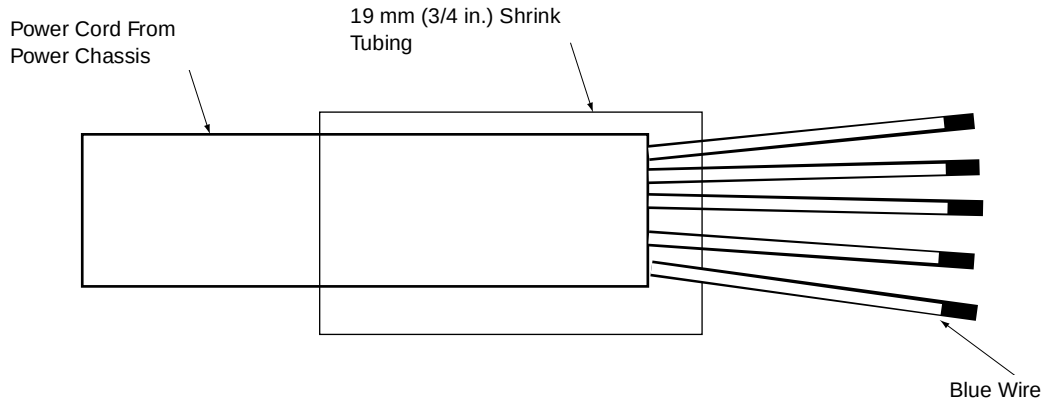


Figure 4-23. Insulating Blue Wire in Power Cord (380-415 VAC)

4.10 Connecting AC Power to the Adept PA-4 Power Chassis

The Adept PA-4 power chassis is shipped from the factory configured for either 380-415 VAC or 200-240 VAC operation, depending on your sales order. A voltage setting label is located on the front of the chassis below the circuit breaker. The voltage setting is also shown on the ID label on the side of the chassis. Verify that the setting matches your facility power before installation. This chassis is designed for 3-phase operation only.

If you need to change the AC voltage setting from 380-415 VAC to 200-240 VAC, or vice versa, see section 4.9.

WARNING: Electrical hazard!
Verify the voltage settings are correct before turning on power. Operating the Adept PA-4 power chassis with incorrect voltage settings can cause damage or injury.

Connecting the Power Chassis AC Power Cord to AC Supply

The user end of the cord is unterminated. Connect each conductor of the power cord securely to your AC power source, using the color code shown in Table 4-3. The installation must meet all applicable European, international, and national standards and regulations.

Table 4-3. AC Power Cord Specifications for Power Chassis

Cord length	3 meters ±0.1 m (9 ft. 10 in. ±4 in.)
Cord rating	25 amps
Number and size of conductor size	5 x 2.5 mm^2
Color code: 380 - 415 VAC	
line 1	black
line 2	black
line 3	brown
neutral	blue
ground	green/yellow
Color code: 200 - 240 VAC	
line 1	black
line 2	black
line 3	brown
no connection	**blue** (must be insulated; see page 78)
ground	green/yellow

WARNING: Electrical hazard!
The installation of the power cord must be done by a skilled person. The power supply can injure or kill the person who installs the cord. An incorrect installation can injure or kill anyone that touches the equipment in the robot workcell.

The protective ground conductor (colored green/yellow) of the Adept PA-4 power chassis is internally connected to the accessible metal parts of the power chassis. To ensure electrical-shock protection, this must be connected to a properly grounded power source.

WARNING: Ensure that a proper protective ground connection exists before turning on the power. The Adept PA-4 power chassis and the Adept MV controller must be connected to the same earth ground.

Typical AC Power Installation Diagrams

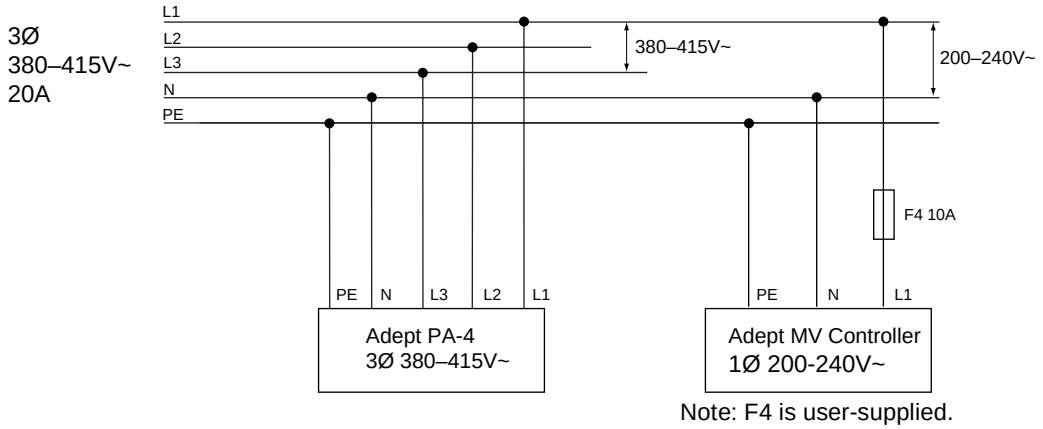


Figure 4-24. Typical 380-415 VAC Connection for Category 1 System

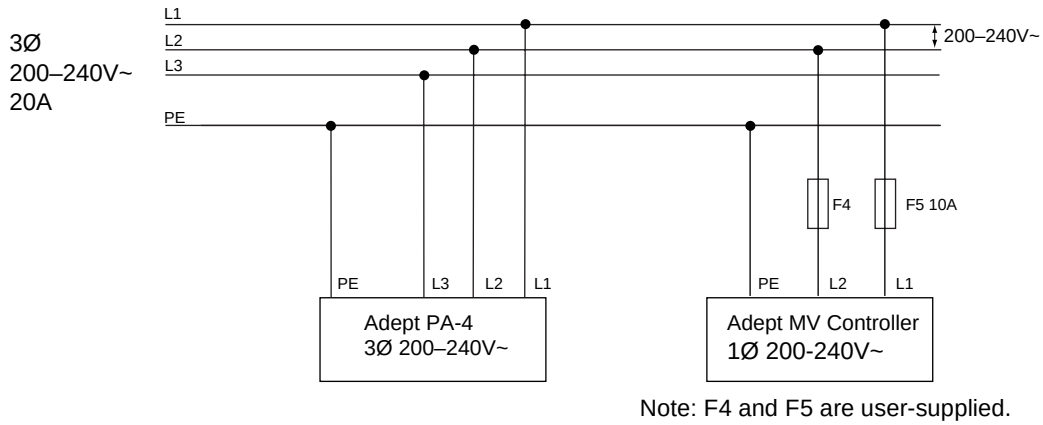


Figure 4-25. Typical 3-Phase 200-240 VAC Connection for Category 1 System

4.11 Grounding the Adept Robot System

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

Adept Robot Grounding

The major structural parts of the robot are connected to the ground point on the base of the robot (see Figure 4-15 on page 71). Install a ground wire at this point to ground the robot. The user should provide a screw and external tooth lockwasher. Make sure to tighten the screw on the ground wire to create a proper ground connection.

Robot-Mounted Equipment Grounding

The following parts of an Adept Cobra 600/800 robot are not grounded to protective earth: the joint 3 quill, the tool flange, and all access covers. 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 10-4 on page 180 for the grounding point on the tool flange.

WARNING: 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.

5 User Interface Installation

There are three different user interface options for the Adept MV controllers:

- An ASCII interface using a Wyse terminal (or equivalent)
- A graphical user interface using the Adept VGB board, an SVGA monitor, a standard PC-style keyboard, and a serial pointing device.
- A graphical user interface using the AdeptWindows PC software running on a PC (Windows95®, Windows98®, or WindowsNT®).

Installing the three different operator interfaces is covered in this chapter. You need to read only the sections that cover the type of interface you are installing.

The type of interface that V+ expects when it initializes depends on the options ordered with your system. If your system was ordered with the AdeptWindows PC option, V+ will initialize and expect the operator interface to be made using a PC computer equipped with the Adept Windows PC software (see section 5.3).

If your system is not ordered with the AdeptWindows PC option, V+ will initialize and expect the operator interface to be made using either:

- A user-supplied terminal connected to the RS-232/TERM connector on the AWC board (see section 5.2) or
- The monitor, keyboard, and pointing device connected to the optional VGB board (see section 5.1).

  (Systems without the AdeptWindows PC option will automatically select the correct one of these two options depending on what hardware you connect.)

  NOTE: The system start-up behavior is determined by the configuration DIP switch on the AWC board and the "software" DIP switch settings in the controller NVRAM. The instructions in this section assume that both of these DIP switches have been left in their factory default settings. If you have changed these settings or wish to change the start-up behavior of the system, see the *Adept MV Controller User's Guide* for details on the AWC DIP switch settings and the *Instructions for Adept Utility Programs* for details on the "software" DIP switch settings.

5.1 Graphical User Interface Using the VGB Board

If you ordered this type of interface, the VGB board is already installed. There is no hardware or software configuration. You simply install the monitor, keyboard, and pointing device. The user interface will be available as soon as you turn on the system.

> **NOTE:** The keyboard and monitor supplied by Adept are intended for use in light industrial conditions. In more severe conditions, they should be protected with a suitable enclosure.

Installation Procedure

Connect the color monitor and extended keyboard with built-in trackball to the VGB board (see Figure 5-1).

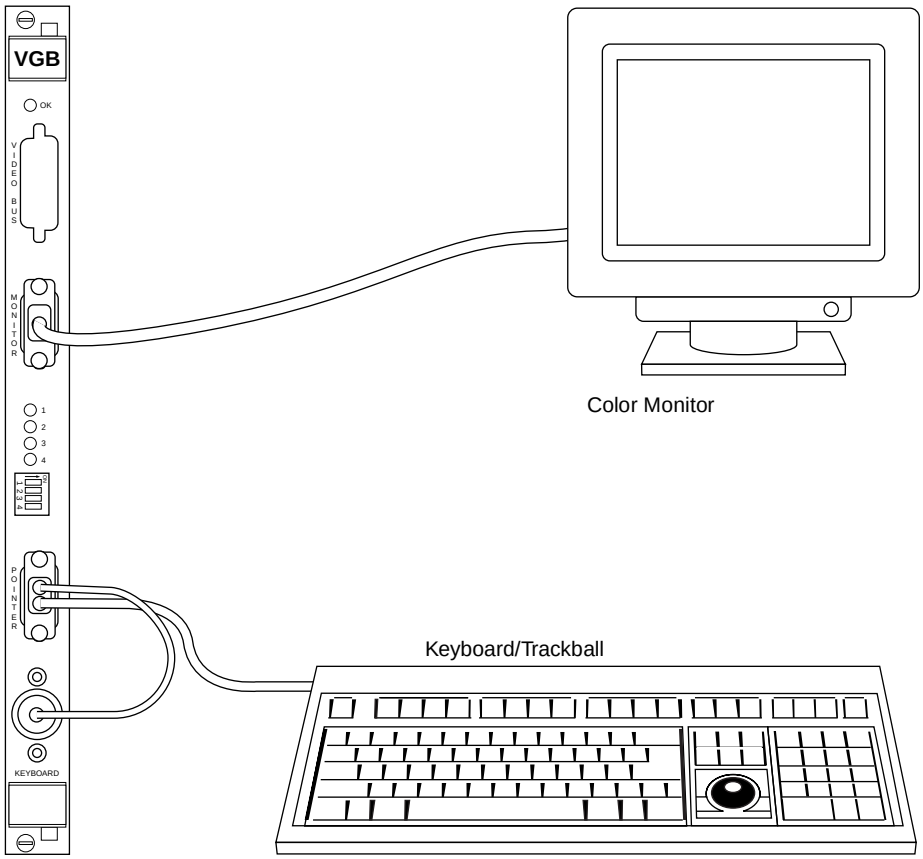


Figure 5-1. Connecting the Monitor and Keyboard

1. Make sure the controller is turned off before making any connections. Connect the monitor signal cable to the MONITOR connector on the VGB board.

   See the *Adept MV Controller User's Guide* for monitor specifications for user-supplied monitors.

2. Verify that the voltage range marked on the monitor is compatible with your local voltage source. Connect the monitor AC power cord to the monitor, then plug it into an appropriate voltage source.

3. Connect the double-ended keyboard cable to the KEYBOARD connector and the POINTER connector on the VGB board. A standard PC-style 101 key keyboard can be used instead of the Adept-supplied keyboard. A pointing device that is compatible with Microsoft serial mouse protocols can be used instead of the Adept-supplied integrated trackball.

For systems with the optional AdeptVision system, camera output will be displayed at full frame rates in the vision window on the monitor. If you have purchased the AdeptVision option, the system is installed. If you are adding the AdeptVision option to an existing system, see the *Adept MV Controller User's Guide* for installation details.

5.2 Text-Based Interface Using a Terminal

With an Adept MV controller system that does not have one of the graphical user interface options, the customer must supply the terminal and cable to interface to the controller. The terminal must be a Wyse Model 60 or 75 with an ANSI keyboard, or a compatible terminal. You may also be able to use a computer with suitable terminal emulation software. For DOS or Windows-compatible computers, the programs "Procomm+" or "Procomm for Windows" (available from many computer stores) include software emulation for the Wyse-75.

This type of interface is not suitable for any graphics-based programming, graphics-based application programs such as AIM, or systems equipped with the vision option.

Recommended Terminal for Text-Based Systems

The recommended terminal for use with the Adept MV controller is the Wyse WY-60. You must also specify the Wyse ANSI/VT100 style keyboard (Wyse p/n 900127-02 or 900128-02). Note: The WY-60 is also available with ASCII and IBM Enhanced PC keyboards. These are ***not*** Adept-compatible. You must make sure you order the correct keyboard. The WY-60 is available in both 220V and 110V versions.

Installation Procedure

1. Make sure the controller is turned off before making any connections.
2. Verify the voltage range marked on the terminal is compatible with your local voltage source. Connect the AC power cord to the terminal, then plug it into an appropriate voltage source.
3. Connect a suitable serial cable between the terminal and the RS-232/TERM connector on the AWC board. (If you need to fabricate this cable, see the *Adept MV Controller User's Guide* for the RS232/TERM pin location and description.)
4. If the terminal is a Wyse 60, use the setup mode to set the personality to "WY-75". If you are using terminal emulation software on a computer, set the software to "WY-75" emulation. If "WY-75" is not available, try "VT102" or "VT100" (you will not be able to use all of the function keys).
5. Set the terminal baud rate to 9600, the default rate for the Adept system. To change the baud rate, refer to the information on CONFIG_C in the *Instructions for Adept Utility Programs*.

5.3 Graphical Interface Using AdeptWindows PC

The AdeptWindows PC Microsoft Windows® based program allows full programming and control of the robot from an IBM compatible personal computer. The computer can be connected to the Adept controller using a serial cable or an Ethernet link.

This section details the simple connection of one PC to one Adept controller. AdeptWindows software allows for more complex installations on a network. For instructions on installing and configuring more complex installations, see the *AdeptWindows User's Guide*. The following instructions assume that the configuration DIP switches and network section of the Adept system configuration have been left as delivered.

Installing an AdeptWindows PC-based user interface involves the following steps:

- Install the AdeptWindows PC software on the customer-supplied PC.
- If you are using an Ethernet connection:
  - Set up the TCP/IP interface.
  - Connect the Adept controller to the PC using a customer-supplied network hub or an Ethernet crossover cable. (A crossover cable can be purchased from Adept.)
- If you are using a serial connection:
  - Connect the Adept controller to the PC using a standard serial cable. Use the RS232/TERM serial port on the AWC board.

Installing the AdeptWindows Software

The AdeptWindows software for the PC is distributed on one diskette. The disk contains an installation program to properly install the software on the PC. The following programs will be installed:

- AdeptWindows PC
- AdeptWindows Off-line Editor
- AdeptWindows DDE Server
- AdeptWindows TFTP Server

After installation, each of these programs can be started from the Windows Start menu bar.

> **NOTE:** All the above applications are installed. However, only AdeptWindows PC is required for the operator interface.

To install the software:

1. Make a note of the keyword on the AdeptWindows Installation Disk and insert the disk in the 3.5" floppy drive (typically drive A) of your PC.
2. From the Start menu bar in Windows:

   Start ➡ Run

The following dialog box is displayed:

Figure 5-2. AdeptWindows Installation

3. Type A:\SETUP in the text box.
4. Choose **OK** to start the installation process. By default, the software is installed into the subdirectory

   ```
   C:\Adept\AdeptWindows
   ```

   on the hard drive of your PC. You can specify a different directory if desired.

   Additionally, during installation, the software automatically creates the sub-directory

   ```
   C:\Adept\Disks\Disk_C
   ```

   which can be mounted as an NFS directory by the Adept controller. See the *AdeptWindows User's Guide* for details.
5. When the installation program prompts you for the keyword, enter the characters noted in Step 1 from the label on your AdeptWindows disk.

   NOTE: Do not confuse the keyword for the AdeptWindows software on the PC with the password for the AdeptWindows license on the Adept controller.

Setting Up the TCP/IP Interface (Ethernet Connection)

The IP address is the logical means by which the higher level Ethernet software identifies a specific node. The IP address must be unique for each node within a LAN.

The network address and sub-net mask of the PC must be set to:

```
IP Address:     172.16 .200. xx
Subnet Mask:    255.255. 0 . 0
```

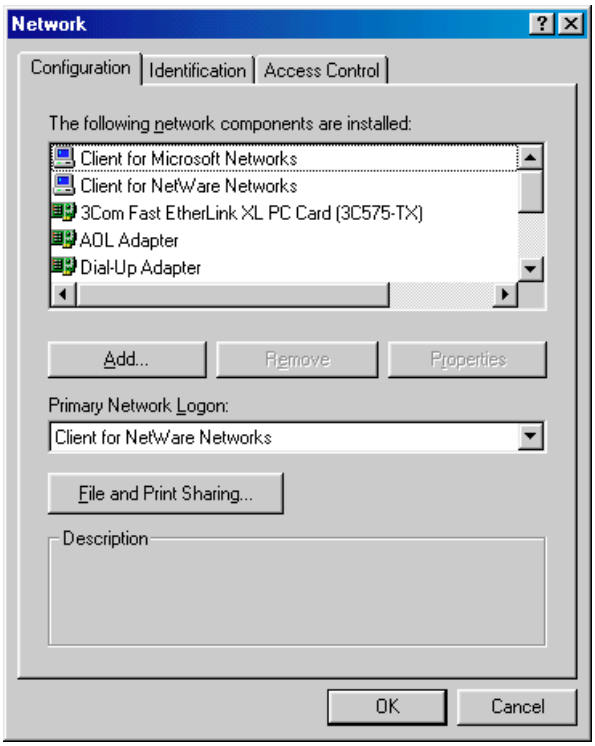
Where "xx" can be any number from 1 to 255.

To set up the TCP/IP interface on your computer:

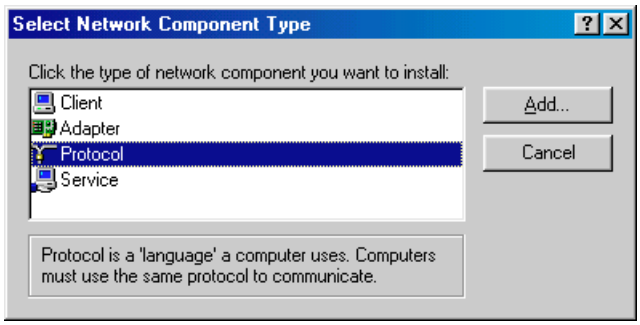
1. Make sure the network interface card on your computer is properly installed and then start your PC.
2. Open the Network parameters window:

   Start ➡ Settings ➡ Control Panel ➡ Network

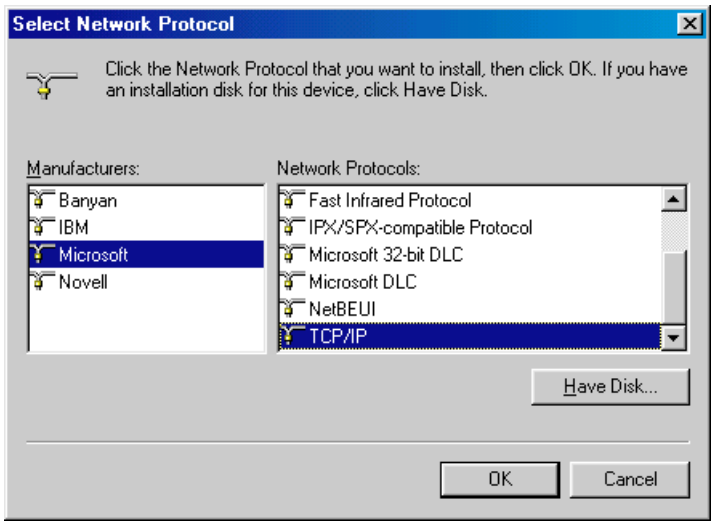
The following window is displayed:



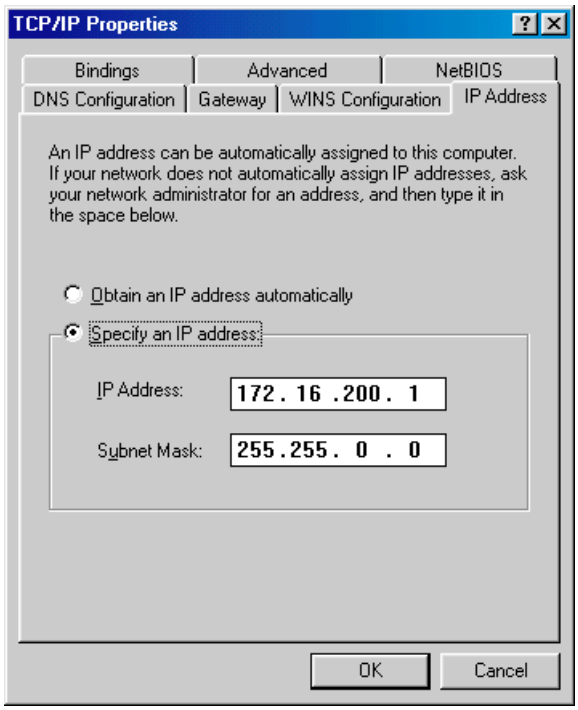
3. Click on the **Add** button, and the following window is displayed:



4. Click on Protocol and then click on the **Add** button, and the following window is displayed:



5. Click on **Microsoft** in the left scrolling window and then scroll down the right scrolling window until you can click on **TCP/IP**. Click on the **OK** button. The network parameters window is redisplayed. Click on the TCP/IP protocol that you have just added and then click on **Properties**. When the TCP/IP Properties windows is displayed, select the **IP Address** tab. The following window is displayed:



6. Click on **Specify an IP address** and then enter the numbers shown above. Click on the **OK** button.
7. Restart your computer.

See the documentation provided with your PC for further details on installing a TCP/IP protocol and setting the network address and sub-net mask.

The IP address for the AWC board is already set based on the board's serial number (the board serial number is *not* the same as the controller's serial number). The default IP address will be:

```
172.16.1xx.1yy
```

where "xx" and "yy" are the last 4 decimal digits of the AWC board's serial number.

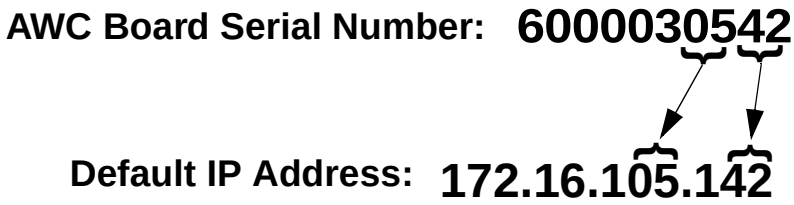


Figure 5-3. The Controller IP Address

NOTE: The AWC board serial number is located on the top front of the AWC board and on a bar code label attached to the bus connectors at the rear of the board.

As shown in Figure 5-3, if the AWC board serial number is 6000030542, the Adept controller's default IP address will be:

```
172.16.105.142
```

Connecting One PC and One Controller

As shown in Figure 5-4, there is one PC networked to one Adept controller. The AWC board can be connected to the PC using one of the three cabling options shown below.

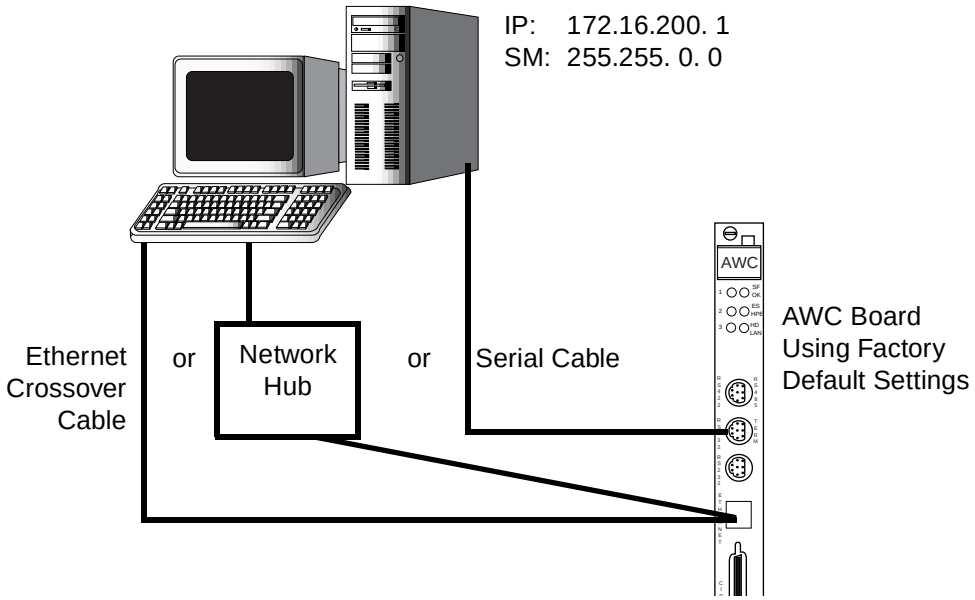


Figure 5-4. One PC, One Controller

To create the network shown in Figure 5-4, complete the following steps:

1. Install the AdeptWindows software on the PC. See "Installing the AdeptWindows Software" on page 89.
2. If you are making an Ethernet connection:
   a. Connect the Adept controller to your PC using a network hub or a crossover cable.
   b. Install a TCP/IP protocol on the PC using the IP address and subnet mask shown in Figure 5-4. See "Setting Up the TCP/IP Interface (Ethernet Connection)" on page 90 and the documentation for your PC for details.

   If you are making a serial connection:
   a. Connect the Adept controller to your PC using a serial cable. Plug one end of the cable into the RS232/TERM connector on the AWC board and the other end into an available serial port on the PC.
3. Start the Adept controller.
4. Start the PC.

WARNING: Since the entire robot installation has not yet been verified, *do not* turn on the PA-4 power chassis.

5. Start AdeptWindows on the PC and make a logical connection to the controller. If you are using an Ethernet connection:

a. Select the **File ➡ Scan Ethernet** option. If the configuration of your PC is correct, you will see the IP address of the Adept controller.

b. Select **File ➡Connect Via Ethernet**. Enter the controller IP address and click on **OK**. (The AdeptWindows PC software will present the last used IP address as the default.)

If you are making a serial connection:

a. Select **File ➡Connect Via COM port**.

b. Select the COM port being used on your PC and press **OK**.

6. The V^+ monitor window will be displayed.

Optional Equipment Installation 6

6.1 Installing End-Effectors on an Adept Cobra Robot

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 either four M6 screws or a ring clamp; hardware for both is supplied in the accessories kit.

An M6 x 12 mm dowel pin is also supplied in the accessories kit. This dowel pin 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 84.

> **NOTE:** A threaded hole is provided on the user flange (see Figure 10-4 on page 180). The user may attach a ground wire through the quill connecting the outer link and the user flange.

6.2 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 6-1). Note the vertical-spline groove that is in line with the setscrew. You must replace the flange in the same position.
4. Use a Torx 25 driver to loosen the two M4 Torx-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.

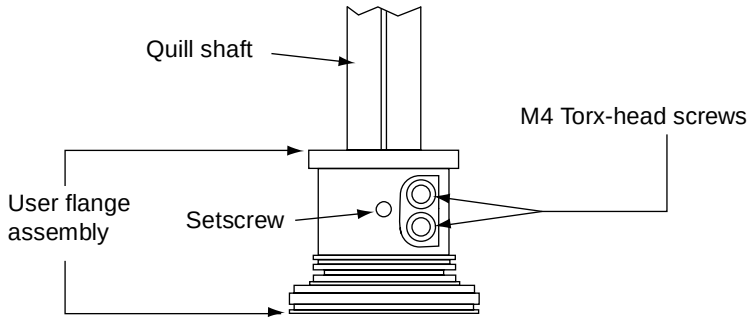


Figure 6-1. User Flange Removal Details

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 Torx 25 driver to tighten one of the Torx-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).

6.3 User Connections on Robot

User Air Lines

There are five user air line connectors on the robot back panel (see Figure 4-15 on page 71). 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 6-2 on page 99).

The two larger connectors are 6 mm diameter.

The three smaller connectors are 4 mm diameter.

User Electrical Lines

There is a 25-pin male connector (24 conductor) on the back panel of the robot for user electrical lines (see Figure 4-15 on page 71). This connector is wired directly to a 25-pin female connector on the top of the outer link (see Figure 6-2). These connectors can be used to run user electrical signals from the back panel, through the robot, and up to the outer link.

Wire size: 0.1 mm^2 (12 pair, Pin Numbers 1-24)

Maximum current per line: 1 Amp

6.4 External Routing of User Connections

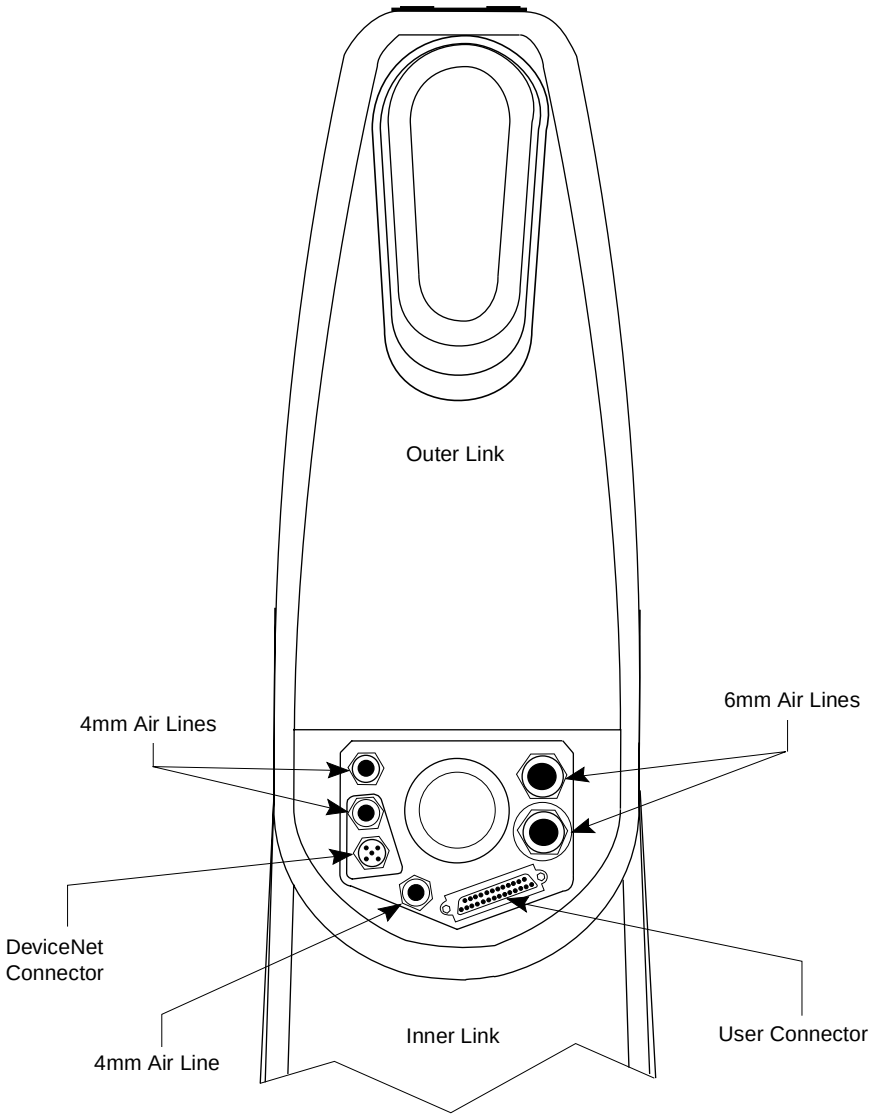


Figure 6-2. Outer Link Air and Electrical Connectors

6.5 Internal Routing of User Connections

To route user lines inside the outer link and out through the quill, you must reposition the harness support bracket, as described in the following procedure.

1. Remove the outer link cover.
2. Remove four M4 screws (two on each side) that hold the harness support bracket (see Figure 6-3).
3. Fold down the harness support bracket and install four screws as shown in Figure 6-4 on page 101.
4. Install the User Line cover plate.
5. You can now connect user lines to the connectors on the harness support bracket and route them out to the quill.

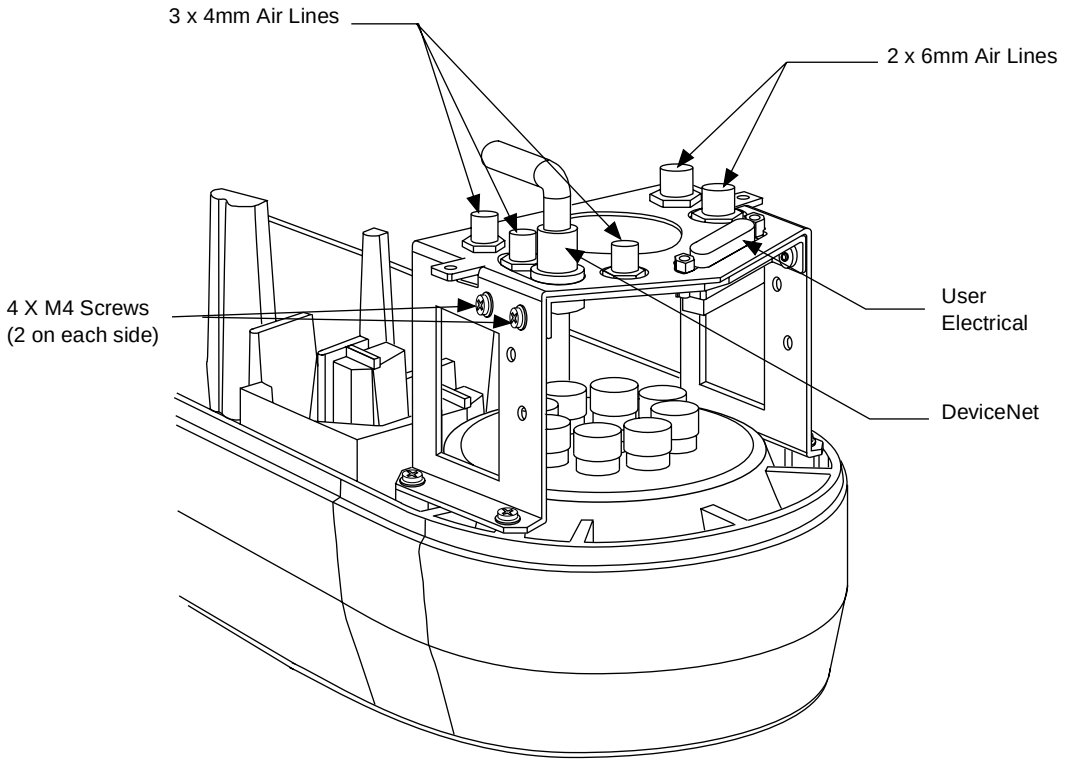


Figure 6-3. Outer Link Harness Support Bracket (Standard Configuration)

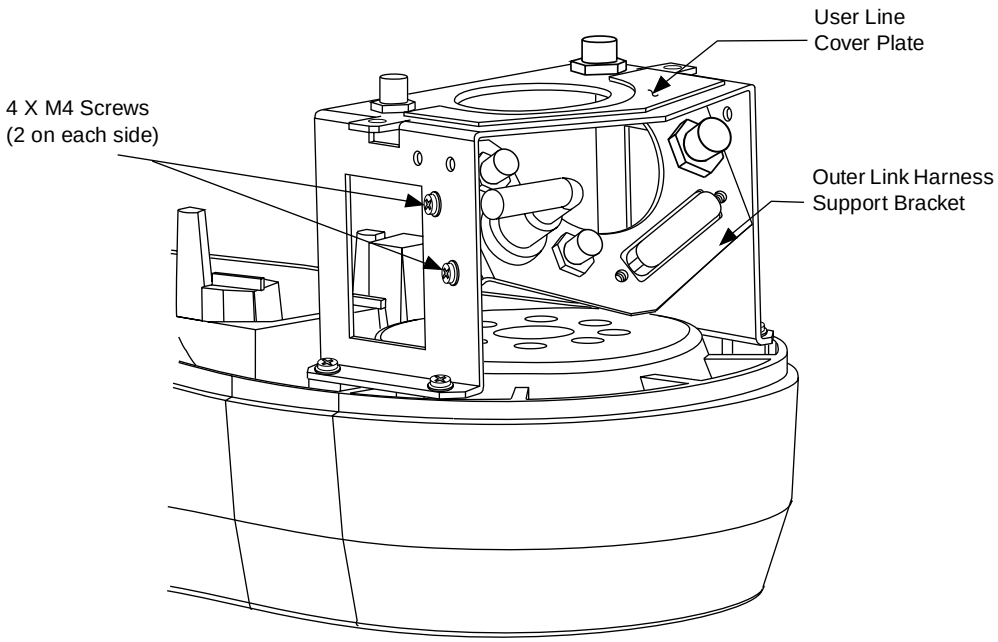


Figure 6-4. Outer Link Harness Support Bracket (Internal Routing Configuration)

6.6 Mounting Locations for External Equipment

Three locations are provided for mounting user's 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 10-5 on page 181 for the dimensions.

Also see section 6.8 on page 107 for information on mounting cameras on the robot.

6.7 Installing Robot Solenoid Kit

Introduction

This procedure provides the necessary description to mount the 24V solenoid option kit on an Adept Cobra robot. The solenoid kit is available as Adept P/N 90560-12000.

> **NOTE:** The valves may be mounted inside the outer link cover or external to the robot near the RSC back panel. A longer solenoid cable is provided in the kit to mount the solenoid manifold externally.

The robot has been prewired to accommodate a bank of two 24 VDC solenoid valves. Power for the internal mounting is accessible via a Molex connector mounted inside the outer link cover (see Figure 6-5 on page 103). Power for the external mounting is available from the RSC (robot signature card). The signals actuating the valves are directly switchable from V^+ utilizing software signals 3001 and 3002. Refer to the SIGNAL command in the *V^+ Language Reference Guide* for additional information. Each driver is designed to handle 24 VDC solenoids at a nominal 75 mA per valve.

The solenoid valve assembly (supplied) Adept P/N 30560-12100 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 minimum to 114 psi 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 robot the air lines from Port A on each valve are plugged at the factory (at the solenoid assembly).

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

Tools Required

- Phillips screwdriver #2
- Tie-wraps
- Pair of diagonal wire cutters
- Solenoid Valve upgrade Kit (Adept P/N 90560-12000)
- Open-end wrenches (7/8 in.)

Installation Time

Approximately one hour.

Procedure

1. Remove all power to the robot.
2. Remove four screws on either side of the outer link cover and remove cover. Pull the cover back over the conduit and place it upon the Joint 1 harness support during the course of this procedure.

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.

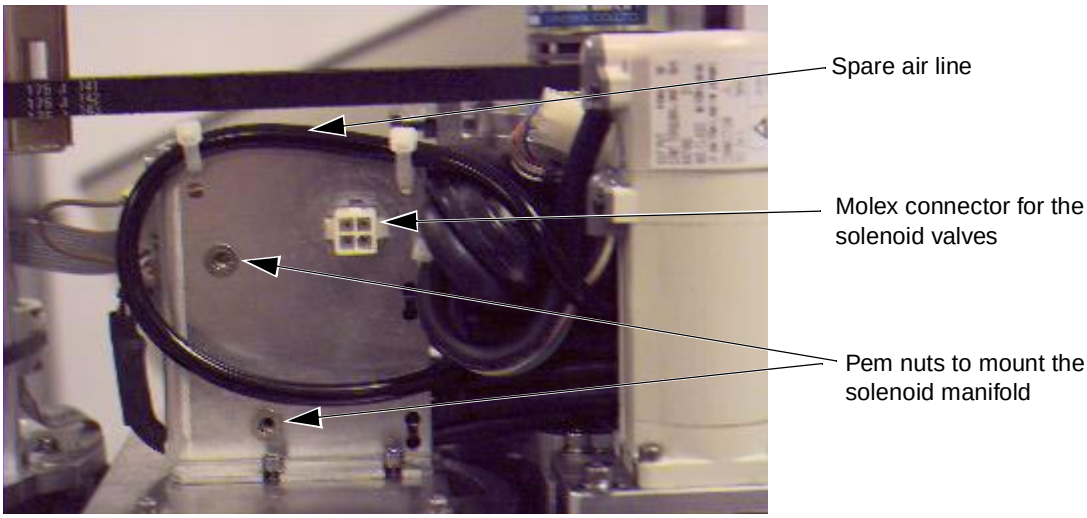


Figure 6-5. Solenoid Mounting Bracket With Connector and Spare Air Line

4. Cut and discard the two 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 6-5).
5. Mount the solenoid manifold onto the bracket using the supplied M3 x 25 mm screws (see Figure 6-6 on page 104).
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 Molex connector plug into the female connector jack (marked HV1/2) on the bracket (see Figure 6-5).
8. Use tie-wraps to secure air line to the bracket as needed.
9. Install the appropriate lengths of 5/32 inch plastic tubing 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. Verify that the air filter has been installed as detailed in the procedure on page 105, and connect the air supply to the input on the rear panel. Turn on system power and boot the system. Once the system boot has completed, at the V^+ dot prompt, type in the following command to activate the solenoids one at a time.

    .Signal 3001, 3002

CAUTION: The robot air pressure may be disconnected until this test has been done to prevent unsecured pneumatic lines from accidentally injuring personnel.

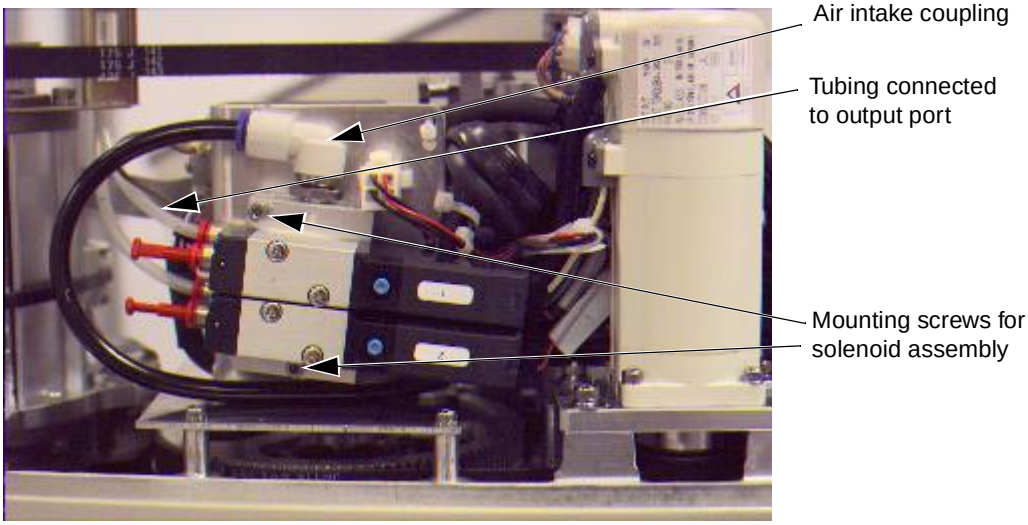


Figure 6-6. Solenoid Placement Using Mounting Hardware

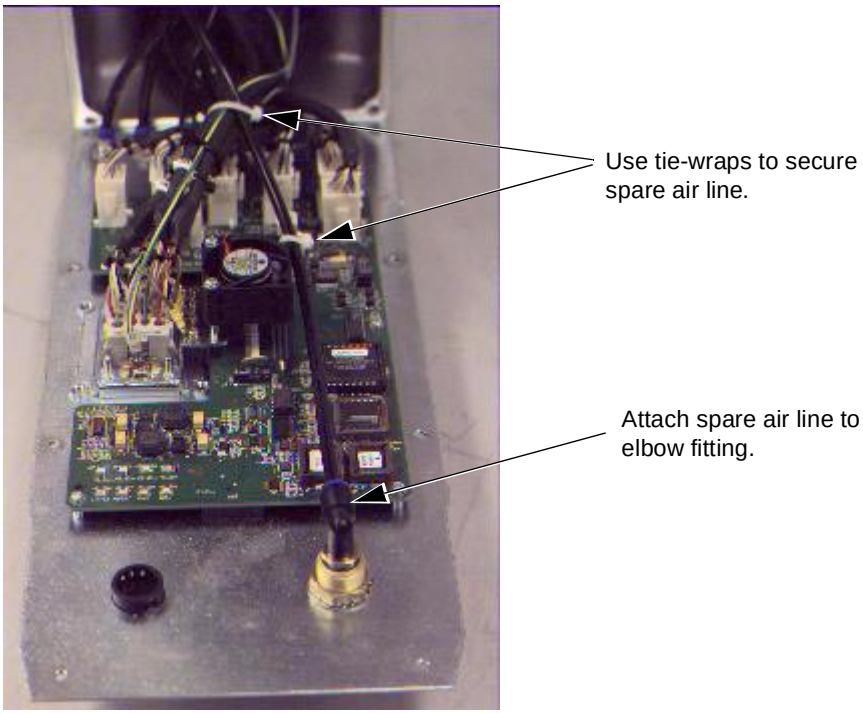


Figure 6-7. Adept Cobra Rear Panel Cover (Inside View)

How to Mount the Air Filter to the Rear Panel

The Air Filter Assembly, Adept P/N 30440-03200, provided as part of the upgrade kit must be mounted to the rear panel of the robot using hardware (also provided). The filter has an air trap and will prevent dust and other debris from entering the pneumatic lines and plugging the system.

CAUTION: The filter has a porous plastic filter element rated for 5 micrometer filtration and is adequate for most applications. This filter drain reservoir must be drained periodically. Failure to do so will affect the filtration process and introduce oil or other contaminants to the system. Sluggish or erratic solenoid operation is a symptom of poor air filter maintenance.

1. Remove nine screws on the rear panel and fold the panel down.
2. The Air Bulkhead Assembly, Adept P/N 30560-12010, is installed through the right-hand knockout on the rear panel.
3. Remove the mounting nut from the bulkhead fitting assembly and insert the assembly through the opening in the rear panel of the robot. See Figure 6-8 on page 106. Insert the washer and screw in the mounting nut from the inner side of the rear panel.
4. Locate the spare air line inside the base of the robot. Attach the spare air line to the elbow fitting. See Figure 6-7 on page 104. Use tie-wraps to secure the spare line.
5. Replace the rear panel and secure using the nine screws removed in step 1.
6. Attach the filter assembly to the bulkhead assembly at the quick disconnect.
7. Attach the air supply pressure line to the air coupling of the inlet and test for air leaks. Any air leaks directly affect the performance of the system and must be repaired before commissioning the cell to production.

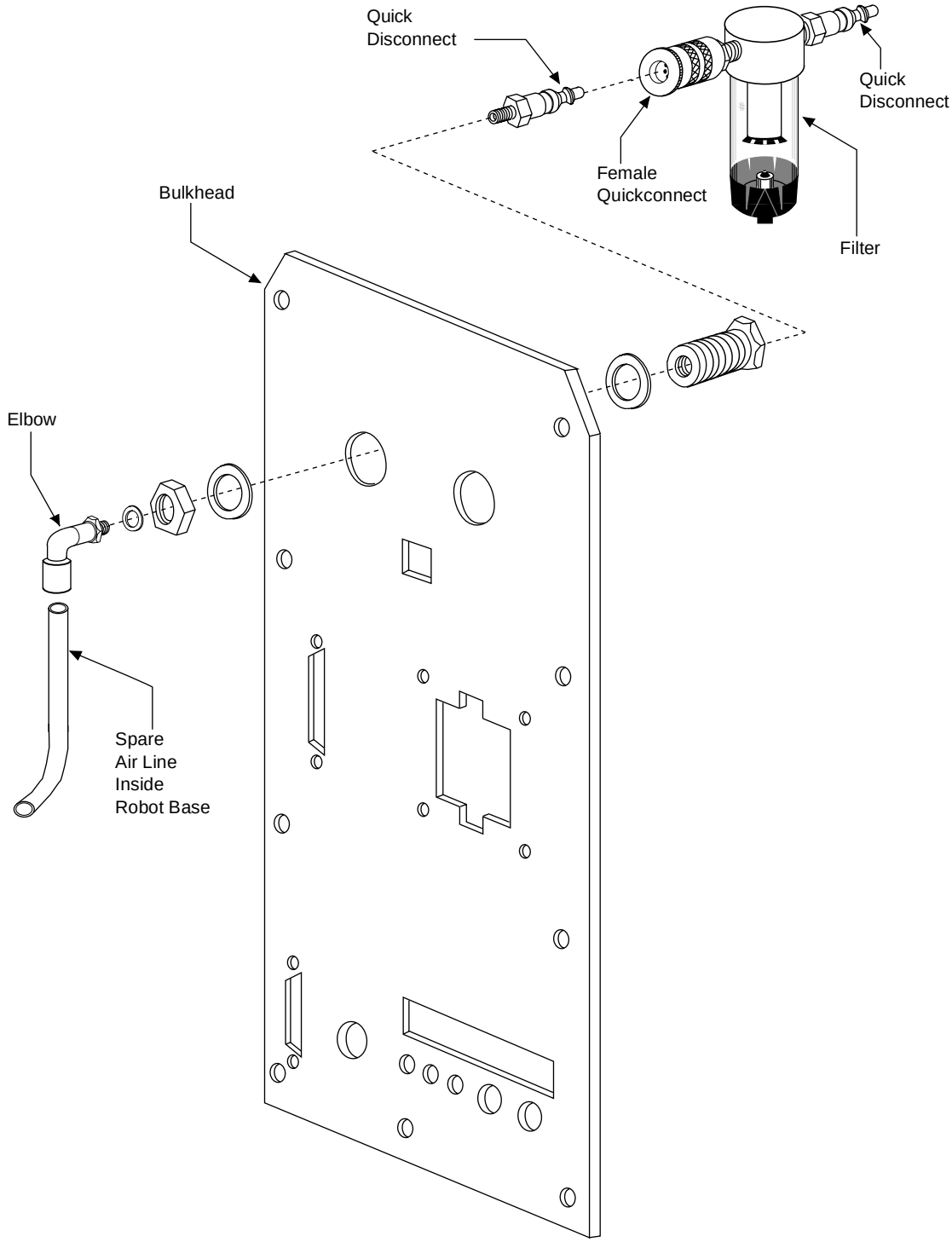


Figure 6-8. Cobra Air Filter Assembly

How to Attach Cables to the External Solenoids

A longer external cable is provided in the Solenoid Kit to mount the solenoid valves externally. Use the external solenoid valve assembly cable, Adept P/N 10560-12101, for this purpose. The cable supplies 24 VDC power and the appropriate signals for actuating the valves.

1. Remove nine screws on the rear panel and fold the panel down.
2. Mate the P9 female connector on the cable with the J9 male connector on the Robot Signature Card (RSC) and verify that the connectors lock in place.

CAUTION: Improper connections may cause power arcing and/or introduce electrical noise in the system.

3. Use tie-wraps supplied in the Solenoid Kit to attach the cable to the internal harness and route the cable away from the cooling fan blades.
4. Use the bushing supplied in the kit to route the cable through the port in the rear panel.
5. Replace the rear panel and secure using the nine screws removed in step 1.

NOTE: The Adept Cobra robot will support a total of four valves (two internal and two external).

6.8 Robot Camera Bracket Kit

Introduction

The Adept Cobra Robot Camera Bracket Kit provides a convenient way of mounting cameras to the outer link of the robot. The kit consists of the following:

- One camera plate
- Two camera brackets
- One camera mount slide bracket
- One camera mount channel
- M4 X 12 mm screws
- M4 stainless steel flat washers
- M5 X 12 mm screws

Tools Required

- M4 Allen wrench
- M3 Allen wrench

Installation Time

Approximately 10 minutes.

Procedure

1. Install the camera plate to the outer link with four M5 X 12 mm screws (see Figure 6-9 as you perform this procedure).
2. Install the two camera brackets to the camera plate with two stainless steel washers and two M4 X 12 mm screws for each bracket. (The camera brackets are not required unless you are mounting more than one camera.)
3. Mount the camera channel to the camera brackets or camera plate with M4 x 12 mm screws.
4. Mount the camera to the camera mount.
5. Mount the camera and camera mount to the camera channel using M5 x 12 mm screws.

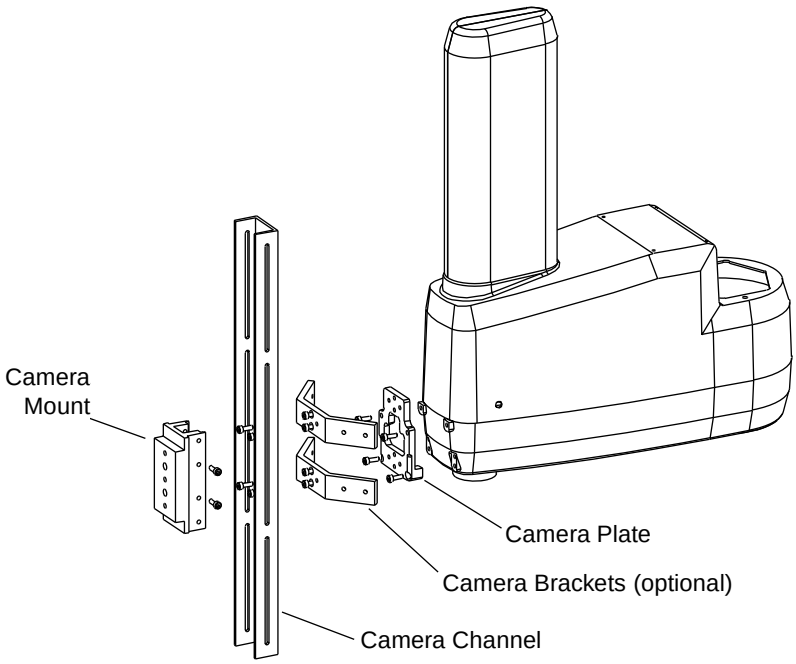


Figure 6-9. Mounting a Camera on the Cobra Robot

6.9 DeviceNet Communication Link

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.

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

- Female connector for the robot tower; Micro-style 12 mm thread DIN female connector (see Figure 6-10 on page 110)
- 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:

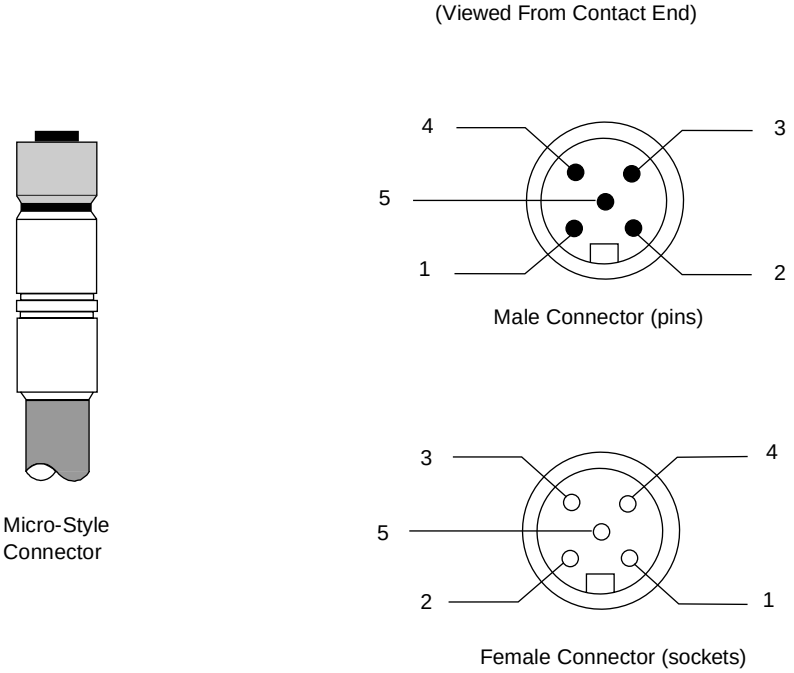
Wire	Adept	DeviceNet "thin cable"
Power pairs	24	22
Signal pairs	28	24

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.

See *Adept MV Controller User's Guide* for physical installation. See the *Instructions for Adept Utilities Program* for software setup.

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.



Legend:

1 Drain	Bare
2 W+	Red
3 W –	Black
4 CAN_H	White
5 CAN_L	Blue

Figure 6-10. Micro-Style Connector Pinouts

6.10 Ethernet Connections

The Ethernet connector is a shielded RJ45 receptacle (see Figure 6-12 on page 112 for the location of the Ethernet connection). See the *AdeptNet User's Guide* for details on TCP/IP, FTP, and NFS capabilities. Adept strongly recommends the use of shielded twisted pair cables to eliminate interferences from motor, amplifier, and other sources of electromagnetic radiation. Ethernet packet transmissions can be greatly impaired when shielded cable is not used.

6.11 Connecting User-Supplied Serial Communications Equipment

RS-232 (JCOM) Connector

There is one RS-232 serial port (JCOM) for general-purpose serial I/O functions on the CIP (see Figure 4-10 on page 65 for the location of the JCOM connector). This serial port is referred to as device LOCAL:SERIAL:4. This serial port can be accessed by any AWC board configured to run V+. The connector is a 9-pin DB-9 male receptacle. The signal and pin information are shown in Table 6-1.

See the *V+ Language User's Guide* for information on serial I/O. See the *Instructions for Adept Utility Programs* for setting the default serial port configuration using the CONFIG_C program. The serial port on the CIP can be configured for use at up to 38,400 bps.

Table 6-1. JCOM Connector Pin Assignments

Pin	Signal	Pin	Signal
1	Not used	6	Not used
2	RXD	7	Not used
3	TXD	8	Not used
4	Not Used	9	Not used
5	SG (Signal Ground)		

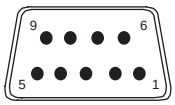


Figure 6-11. JCOM Pin Locations

NOTE: The serial port on the CIP does not provide hardware handshaking signals.

AdeptWindows Controller (AWC) Board Serial I/O Ports

The AdeptWindows Controller (AWC) board has three serial I/O connectors, two RS-232 and one RS-422/485 port (see Figure 6-12). Systems using a programmer's terminal (ASCII) connect through the RS-232/Term port on the AWC board.

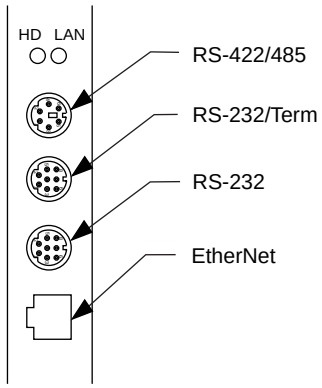


Figure 6-12. AWC User Communication Connectors

Serial Port 2 (RS-232)

This connector is identical to the RS-232/Term connector. This connector can be used for general serial communication but not for connecting any user-supplied terminals. This port is designated LOCAL.SERIAL:3.

To configure the port speed and other communications parameters, use the CONFIG_C utility program, the V+ FSET program instruction, or the FSET monitor command.

Table 6-2. RS-232/Term Connector Pin Assignments

Pin	Signal	Type
1	DTR	Output
2	CTS	Input
3	TXD	Output
4	GND	Ground
5	RXD	Input
6	RTS	Output
7	DCD	Input
8	GND	Ground

RS-422/485 Connector

The RS-422/485 connector is a 6-pin circular mini DIN female connector (see Figure 6-12). The pin assignments are shown in Table 6-3. RS-422/485 is a point-to-point protocol for connecting to a single destination. This port can also be configured as a multi-drop port (RS-485).

To change the configuration of the RS-422/485 port, use the CONFIG_C utility program or the V+ FSET program instruction. This port is designated LOCAL.SERIAL:1.

Table 6-3. RS-422/485 Connector Pin Assignments

Pin	Signal	Type
1	GND	Ground
2	GND	Ground
3	TXD–	Output
4	RXD+	Input
5	TXD+	Output
6	RXD–	Input

SIO Board Serial Ports

If your system includes an SIO board, there are three additional serial ports that can be accessed by any AWC board configured to run V+. See the *Adept MV Controller User's Guide* for details.

6.12 Connecting Customer-Supplied Safety and Power Control Equipment to the CIP

The connection of the customer-supplied safety and power control equipment to the CIP is through the JUSER connector. This connector is a 37-pin female D-sub connector located on the side panel of the CIP. Refer to Table 6-4 and Table 6-5 for the JUSER pin-out explanations. See Figure 6-13 and Figure 6-14 for the wiring diagram.

.

Table 6-4. Contacts Provided by the JUSER Connector

Pin Pairs	Description	Comments	Shorted if NOT Used
Voltage-Free Contacts Provided by User			
1,20	Remote High Power on/off momentary PB	used to enable High Power	No
4,23	User E-Stop CH 1 (mushroom PB, safety gates, remote MCP E-stop, etc.)	N/C contacts	Yes
5,24	User E-Stop CH 2 (same as pins 4 and 23)	N/C contacts	Yes
6,25	Remote ENABLE (hold-to-run)	N/O contacts (make to enable). Use for Remote MCP	Yes
7,26	Remote ENABLE (hold-to-run)	N/O contacts (make to enable). Use for Remote MCP	Yes
8,27	Muted Safety Gate CH 1 (causes E-Stop in AUTOMATIC mode only)	N/C contacts	Yes
9,28	Muted Safety Gate CH 2 (same as pins 8 and 27)	N/C contacts	Yes
10,29	Remote MANUAL/AUTOMATIC switch CH 1. MANUAL = Open AUTOMATIC = Closed	CIP's MANUAL/AUTOMATIC switch must be in AUTOMATIC mode	Yes
11,30	Remote MANUAL/AUTOMATIC switch CH 2. MANUAL = Open AUTOMATIC = Closed	CIP's MANUAL/AUTOMATIC switch must be in AUTOMATIC mode	Yes
Voltage-Free Contacts Provided by Adept			
12,31	System Power Switch Contacts. Use with external relay circuit to turn on AC Power	Mainly used to turn on MV-5/10 AC power with System Power switch on CIP	
13,32	E-Stop indication CH 1	Contacts are closed when CIP, MCP, and user E-Stops are *not* tripped	
14,33	E-stop Indication CH 2 (same as pins 13 and 32)	Contacts are closed when CIP, MCP, and user E-stops are *not* tripped	
15,34	MANUAL/AUTO indication CH 1	Contacts are closed in AUTOMATIC mode	

Table 6-4. Contacts Provided by the JUSER Connector (Continued)

Pin Pairs	Description	Comments	Shorted if NOT Used
16,35	MANUAL/AUTO indication CH 1	Contacts are closed in AUTOMATIC mode	
Nonvoltage-Free Contacts			
2,21	Adept-Supplied 5 VDC and GND for High Power On/Off Switch Lamp	Use with Remote High Power On/Off switch above. See "Remote High Power Control" on page 120 for current limits.	
3,22	User-Supplied 24 VDC for Central Control High Power on/off	Active only in AUTO and REMOTE (NET=1) modes	

Table 6-5. Remote MCP Connections on the JUSER Connector

Pin JUSER	Pin MCP	Description
37	1,9	Logic GND
17	3	MCP TXD
18	2	MCP RXD
19	5	+12 VDC (max 350mA)
36	8	–12 VDC (max 50mA)
4,23 (Note 1)	6,7	MCP E-Stop PB CH 1
5,24 (Note 2)	11,12	MCP E-Stop PB CH 2
6,25 (Note 2)	13,15	MCP Enable CH 1 (Hold-to-run)
7,26 (Note 2)	14,16	MCP Enable CH 2 (Hold-to-run)

Note 1: Must be used in User E-Stop circuit.
Note 2: Must be used in User Enable circuit.

NOTE: There is an E-Stop loop on the robot outer link that may be useful in wiring E-Stop switches to end-of-arm tooling (for example, to detect a break-away gripper). See section 6.13 on page 124. Also, information on the "AmpLoop" emergency stop circuitry is available from the FAXBack number listed in "How Can I Get Help?" on page 39.

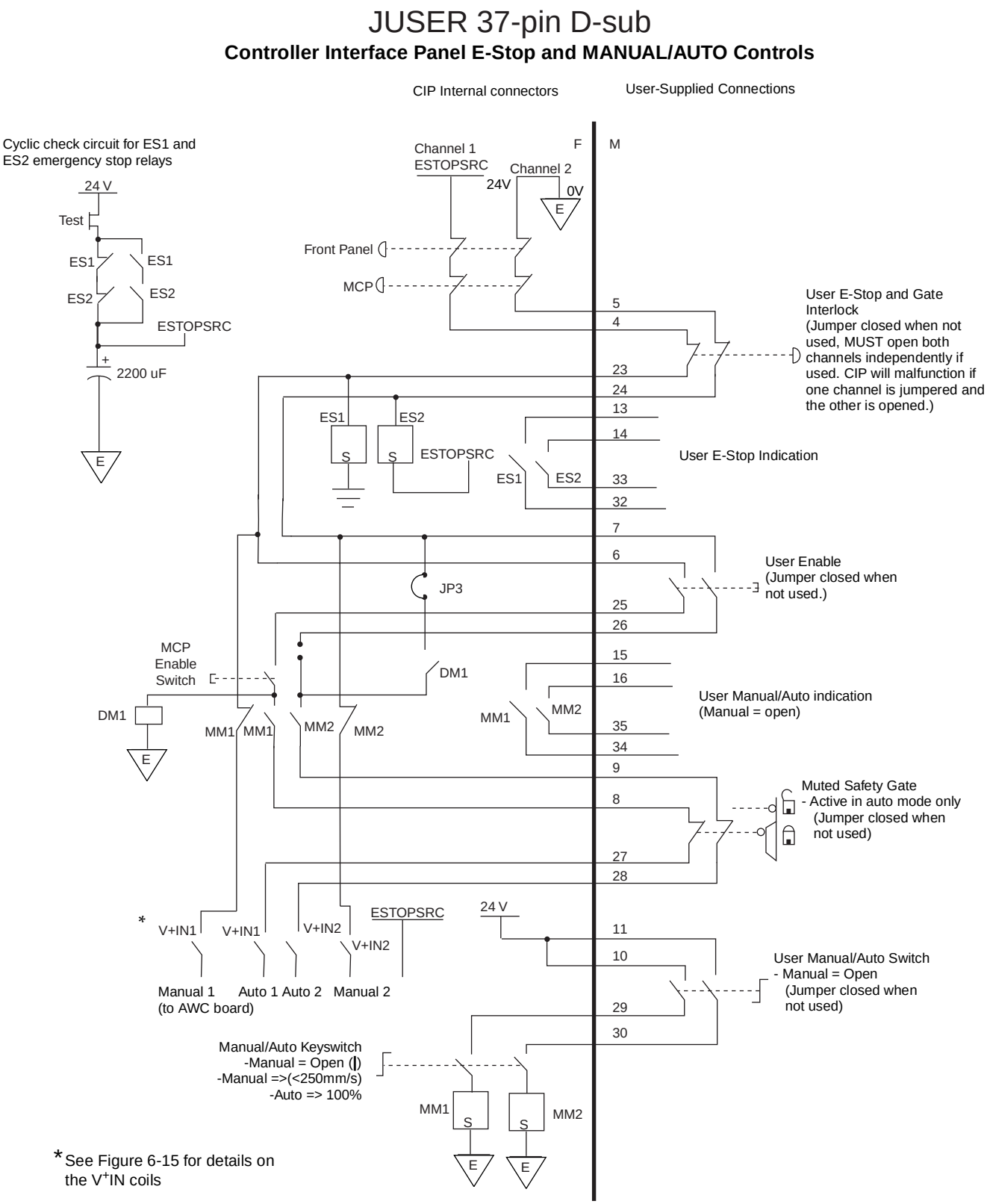


Figure 6-13. JUSER 37 Pin D-sub Connector

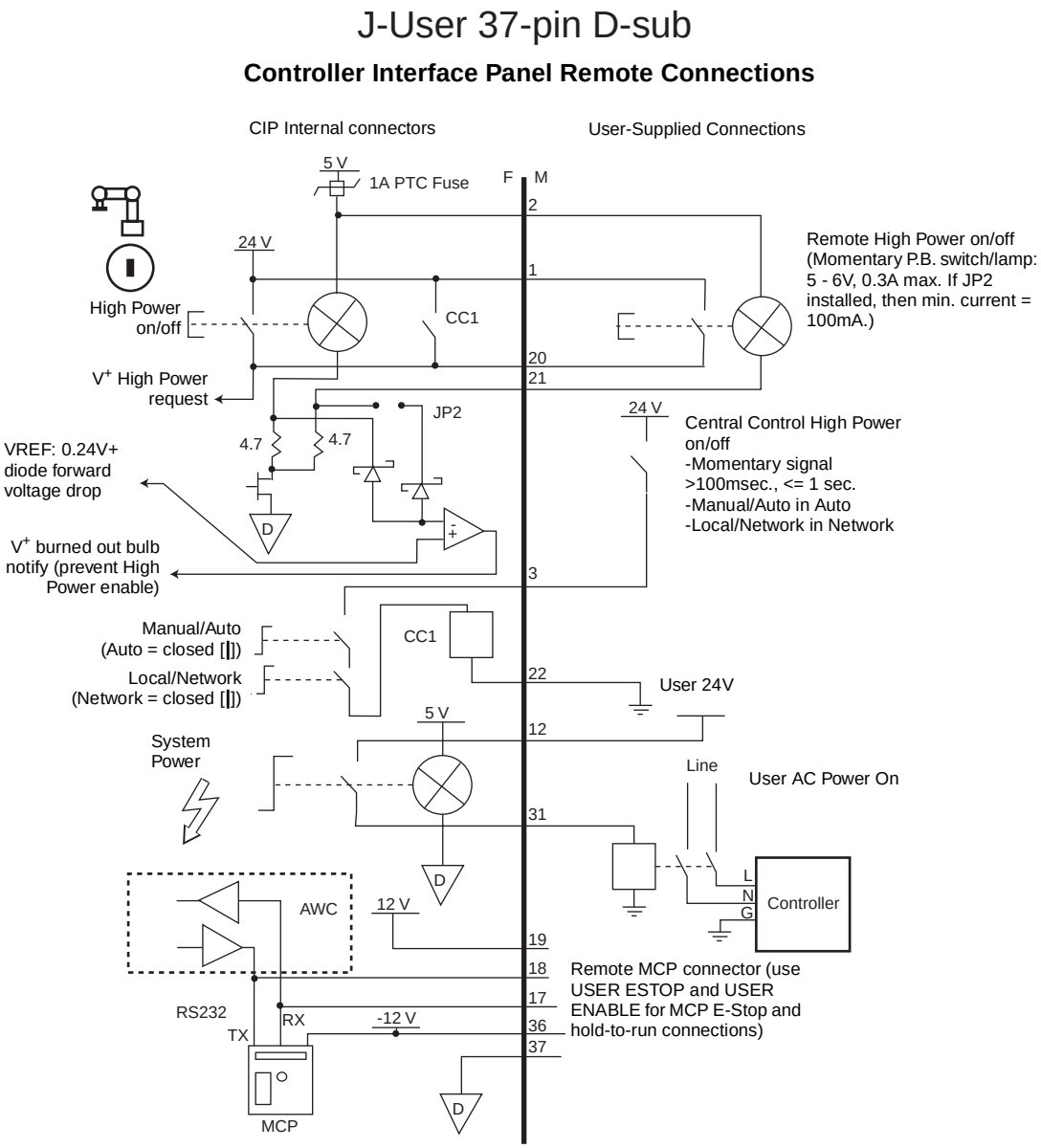


Figure 6-14. J-User 37 Pin D-sub Connector

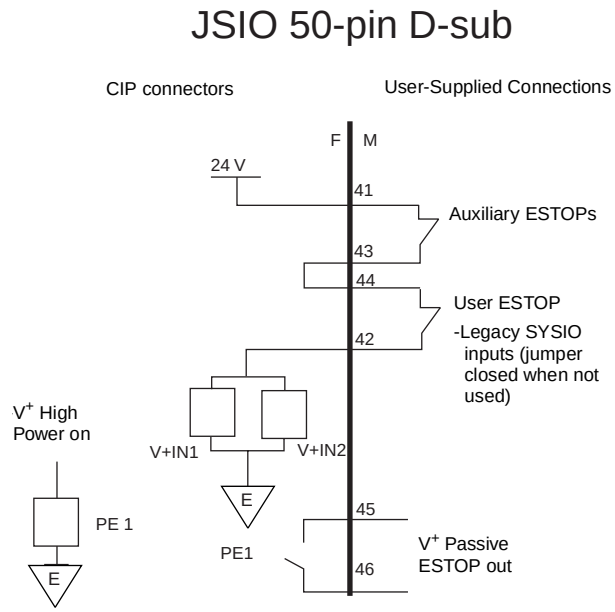


Figure 6-15. JSIO Emergency Stop Circuit

Emergency Stop Circuit

The CIP provides two methods for user-supplied emergency stop circuits. This gives the AWC system the ability to duplicate E-Stop functionality from a remote location using voltage-free contacts. Both the JUSER connector and the JSIO connector provide external E-Stop connections into the CIP.

The JUSER connector has a two-channel E-Stop input on pins 4 to 23 and 5 to 24.

The JSIO connector provides a single channel E-Stop that controls two relays in the CIP. This E-Stop is for compatibility with legacy applications using the 50-pin connector on the SIO board. These JSIO pins are 41 to 43 and 42 to 44 (see Figure 6-13, Figure 6-14, Figure 6-15, and Table 6-4 for the customer E-Stop circuitry). The two required connections will be arranged in series.

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

Remote Sensing of CIP, MCP, and User E-Stop Push Button Switches

A method has been provided to indicate the status of the E-Stop chain, inclusive of the CIP E-Stop push button, the MCP E-Stop push button, and the user emergency stop contacts.

> **NOTE:** These contacts do not indicate the status of any contacts below the User E-Stop contacts. Thus, they will not indicate the MCP ENABLE contacts or the Manual mode teach restrict sensor contacts.

Two pairs of pins on the JUSER connector (pins 13,32 and 14,33) 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). You may use these contacts to generate an E-Stop for other equipment in the workcell. The load on the contacts should not exceed 40 VDC or 30 VAC 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 6-13, Figure 6-14, and Table 6-4 for the customer emergency stop circuitry).

Muted Safety Gate E-Stop Circuitry

See the *Adept MV Controller User's Guide*.

JSIO E-Stop Circuitry

Six pins provide two single-channel E-Stop inputs and a single-channel output. The output relay contact, Passive E-Stop Output, is different from the E-Stop outputs described above. This contact closes only when High Power is on, not when the E-Stop circuit is closed.

CAUTION: These are single channel contacts and are not suitable for EN-954-1 Category 3 operation.

The two pairs of pins on the JSIO connector (pins 41, 42 and 43, 44) provide connections for user and auxiliary emergency stop circuitry (see Figure 6-13, Table 6-4, and Table 6-5 for the customer emergency stop circuitry).

NOTE: These pins must be jumpered closed if not used.

The High Power On contacts and JSIO connector pins 45 and 46 are called the "Passive E-Stop Output" because they are compatible with older Adept equipment. The load on the contacts should not exceed:

Maximum Voltage 40 VDC, 30 VAC
Maximum Current 1A

Remote Manual Mode Control

The CIP also provides a connection for a user-supplied Manual Mode circuit (see Figure 6-13, Figure 6-15, Table 6-4, and Table 6-5 for the customer Manual Mode circuitry).

This circuitry must be incorporated into the robot workcell to provide a "Single Point of Control" (the operator) when the controller 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 controller does not receive commands from devices other than from the MCP, the single point of control.

The two channel Manual/Automatic Mode select circuit is designed to fail to the highest safety condition. If either channel is open, the controller will be in Manual mode. This requires that the User Remote Manual Mode Control electrical contacts be in series with the contacts on the CIP Auto/Manual mode selector switch. To select Automatic mode, *both* the Remote Manual Mode Control and the CIP Auto/Manual Switch must be in Automatic mode (both switches must be closed).

The CIP provides connections for a remote user panel circuitry that allows a second user panel at another location (see Figure 6-13, Figure 6-14, Table 6-4, and Table 6-5 for the customer remote user panel circuitry).

Two separate inputs on the JUSER connector (10,29 and 11,30) provide connections for remote MANUAL/AUTOMATIC functionality.

- MANUAL = Open
- AUTOMATIC = Close

NOTE: These pins must be jumpered if not used.

Two pairs of pins on the JUSER connector (pins 15, 34 and 16, 35) provide a voltage-free contact to indicate whether the CIP and/or remote AUTOMATIC/MANUAL switches are closed. The customer may use these contacts to control other mechanisms (e.g., conveyor, linear modules, etc.) when MANUAL mode is selected. The load on the contacts should not exceed 40 VDC or 30 VAC at a maximum of 1A.

Remote High Power Control

The CIP also provides a connection for an additional user-supplied High Power enable circuit (see Figure 6-13, Figure 6-14, Figure 6-15, Table 6-4, and Table 6-5 for the customer High Power circuitry). The CIP has two different methods of remote operation of the High Power push button located on the CIP. These connections are optional.

The first method allows relocating the push button switch to a more convenient location. The second allows the start-up of multiple robots from a central control computer that can communicate with the robot controllers. Implementation of either method must conform to EN standard recommendation.

The European standard, EN 775, Ind. Robots, Part 6, Recommendations for Safety: Item 7.2.5 Emergency Stop, reads: “Each robot system operator station shall have a readily accessible emergency stop device. The manual intervention and reset procedure to restart the robot system after an emergency stop shall take place outside the restricted space”.

Thus, it is important that the remote High Power push button be located outside of the protected space of the robot.

Pins 1 and 20, 2 and 21, and 3 and 22 of the JUSER connector provide this remote capability. The first two circuits allow the duplication of the CIP High Power push button/lamp with no difference in operation. Pins 2 and 21 provide power for the lamp, +5 VDC and ground, respectively. Pins 1 and 20 are inputs for voltage-free N/O contacts from a user-supplied momentary push button switch.

The user-supplied remote High Power switch drives a relay in the CIP. The contact of the relay generates a V^+ High Power request signal, which is used internally. The electrical characteristics are as follow:

- **Coil**: 24 VDC at 1440 Ω, including a parallel "flyback" diode.
- **Timing:** the High Power signal transition will be seen only if the signal is off at least 32 milliseconds followed by on for at least 32 milliseconds. After a positive transition, there must be no positive transitions for at least 2 seconds before another positive transition will be recognized.

Remote High Power On/Off Lamp

The CIP High Power On/Off Lamp will cause a V^+ 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.

This feature can be added to the remote High Power lamp as well. A jumper must be installed on JP2 inside the CIP. See "Changing the Lamp on the CIP High Power Enable Switch" on page 170 for details on accessing the JP2 jumper. The remote High Power lamp current limitations are:

Maximum current, 300 mA at 5V.
Minimum current, 100 mA if JP2 is installed. Otherwise, there is no minimum current.

The third pair of pins, which provides for more restricted operation, complying with the EN 775 recommendation, will prevent the use of the "Central Control High Power On/Off" when the system is in Manual Mode. This function will work only when the keyswitches on the CIP are in the following positions:

- Operating keyswitch is in the Automatic Mode
- Network keyswitch is in the (|) position

The user-supplied voltage to provide a "Central Control High Power On/Off" function drives a relay in the CIP with the following electrical characteristics:

- **Coil**: 24 VDC at 1440 Ω, including a parallel "flyback" diode.
- **Timing**: the High Power signal transition will be seen only if the signal is off at least 32 milliseconds followed by on for at least 32 milliseconds. After a positive transition, there must be no positive transitions for at least 2 seconds before another positive transition will be recognized.

Connecting the System Power Switch to the CIP

The CIP also provides a connection for a user-supplied system power circuit (see Figure 6-13, Figure 6-14, Table 6-4, and Table 6-5 for the customer system power switch circuitry).

The CIP includes support for turning on and off system power to the controller. If you use this switch, you must provide an AC contactor with the following electrical characteristics:

- 12V or 24V, AC or DC coil, limited to less than 500 mA

The user connection for system power is at the JUSER connector (pins 6 and 24). You will need to provide a power supply to match the coil voltage of the external contactor.

See Figure 6-16 for details on wiring through the CIP.

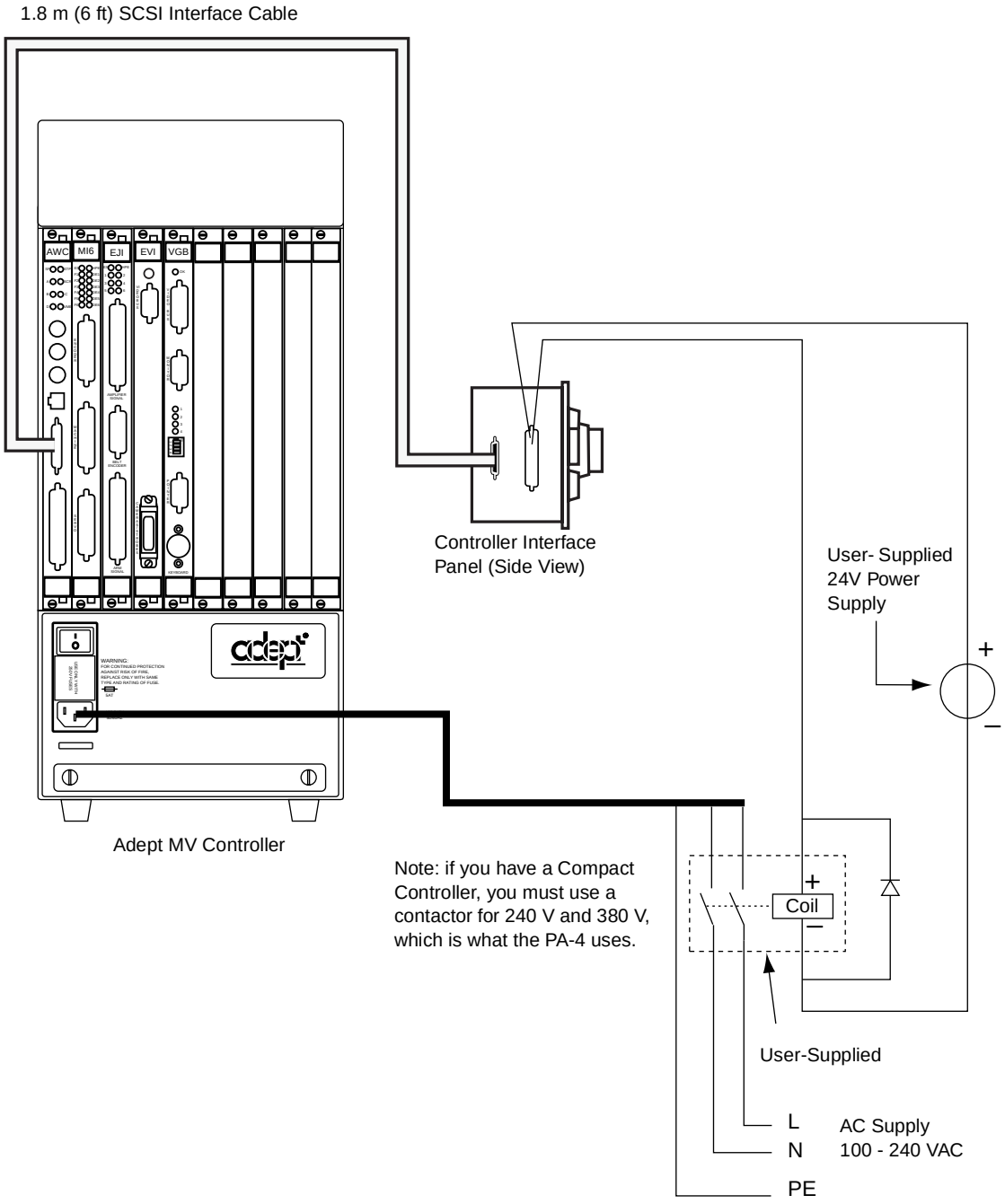


Figure 6-16. System Power Switch Circuit

Manual Mode Safety Package (MMSP) Connector

Not used with Adept Cobra robots.

Remote User Panel Connections

The CIP provides connections for a remote user panel circuitry that allows a second user panel at another location (see Figure 6-13, Figure 6-14, Table 6-4, and Table 6-5 for the customer remote user panel circuitry).

Remote MCP Connections

For the following remote MCP connections see Figure 6-13 and Figure 6-14, and refer to Table 6-4 and Table 6-5 for the customer remote MCP circuitry.

> **NOTE:** If a remote MCP connection has been added through the JUSER connector, the optional MCP bypass plug (P/N 10335-01060) must be installed in the MCP connector on the CIP.

Remote E-Stop Circuit

When using a remote connector for the MCP, the MCP E-Stop push button contacts (red mushroom switch) must be wired in series with any other E-Stop contacts on the "USERESTOP CH1"(pins 4 and 23) and "USERESTOP CH2" (pins 5 and 24).

Remote Enable Switch Connections

Two pairs of pins on the JUSER connector (pins 6, 25 and 7, 26) provide connection for an MCP enable switch (momentary push button). This input duplicates the functionality of the MCP Enable switch on MCP. Electrically, the enable switch is wired in series with the MCP enable switch connections on the CIP. If the MCP is connected remotely using the remote MCP connection on the JUSER connector, wire the MCP enable switch of the MCP to these pins.

> **NOTE:** These pins must be shorted if not used.

> **NOTE:** The MCP III uses only one switch channel for the Enable function. (The MCP E-Stop button uses two channels.) The MCP Enable switches E-Stop channel 1 directly while channel 2 is switched by a sense relay (DM1 in Figure 6-13).
>
> This means that only channel 1 of the remote Enable switch is active! Please contact Adept for custom modifications of the MCP III or MCP bypass plug if you need a two-channel MCP enable function.

6.13 Outer Link E-Stop Access (High Power Shutdown) Circuitry/User Power

The Outer Link E-Stop Access Circuitry function has been provided so that customers can cause a high power shutdown from the outer link area. If the user, for example, wanted a break-away gripper to shut down power, the user would have to run the User E-Stop signal out to the gripper to effect the shutdown if this feature were not provided. This feature allows the user to disable high power via a user relay circuit inside the robot. In addition, 12 VDC power (400 mA maximum) is available for other user purposes if the function is not used.

The user is provided with a 4-socket AMP Mini-Universal latched header (AMP P/N 172159-1) mounted on the electrical bulkhead panel in the outer link (see Figure 6-17 and Table 6-6 on page 125). This header provides the user 12VDC power and access to the coil contacts of the RSC relay. The RSC E-Stop relay is normally jumpered on the RSC by the zero ohm resistor R2 which is located on the top left-hand edge of the RSC (see Figure 6-18 on page 126).

Instructions to Access 12 VDC User Power

Connect Pins No. 1 and No. 2 to access 12 VDC. This is fused at the RSC to provide 400 mA maximum.

Instructions to Implement Outer Link E-Stop Access

Remove the R2 (0 ohm) resistor on the RSC. Connect the user break-away switch (normally closed) to Pins No. 1 and No. 3. Connect Pin No. 2 to Pin No. 4.

> **NOTE:** Removing resistor R2 on the RSC will not void warranty. However, Adept recommends adding a label to the RSC to note that this modification has been performed. If the RSC is ever replaced with a standard unmodified RSC, the user's break-away gripper would be jumpered and rendered ineffective.

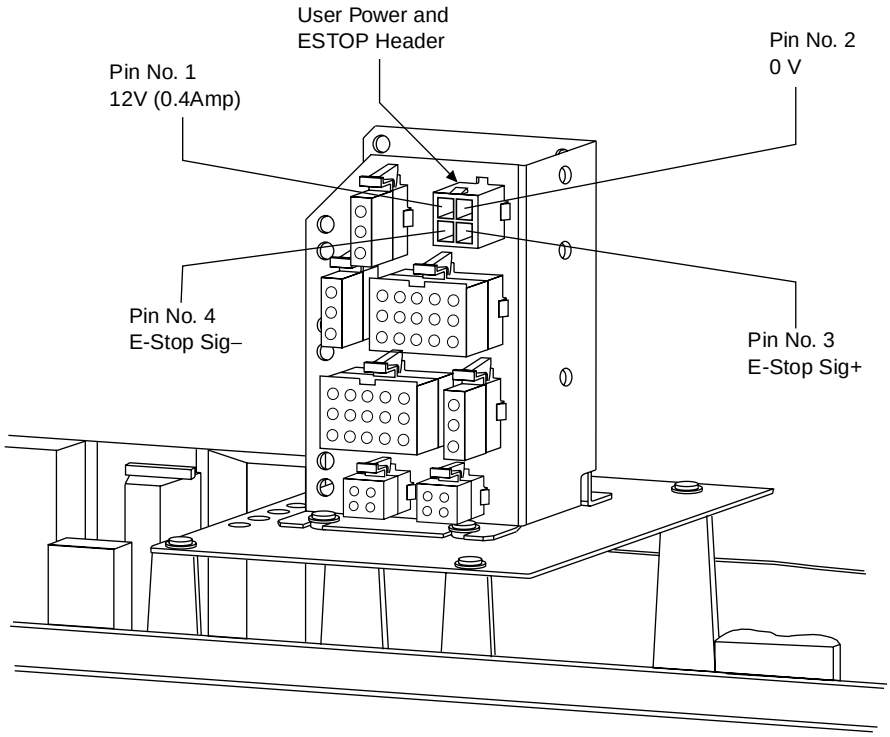


Figure 6-17. Outer Link Bulkhead

Table 6-6. Outer Link E-Stop Access Circuitry Pin Assignments

Pins	Amp P/N	Function
Mating Connector	172167-1 (UL 94 U-O)	
Mating Pins	170359-1	
Pin No. 1		+ 12 VDC
Pin No. 2		12 VDC Return
Pin No. 3		E-Stop Sig +
Pin No. 4		E-Stop Sig –

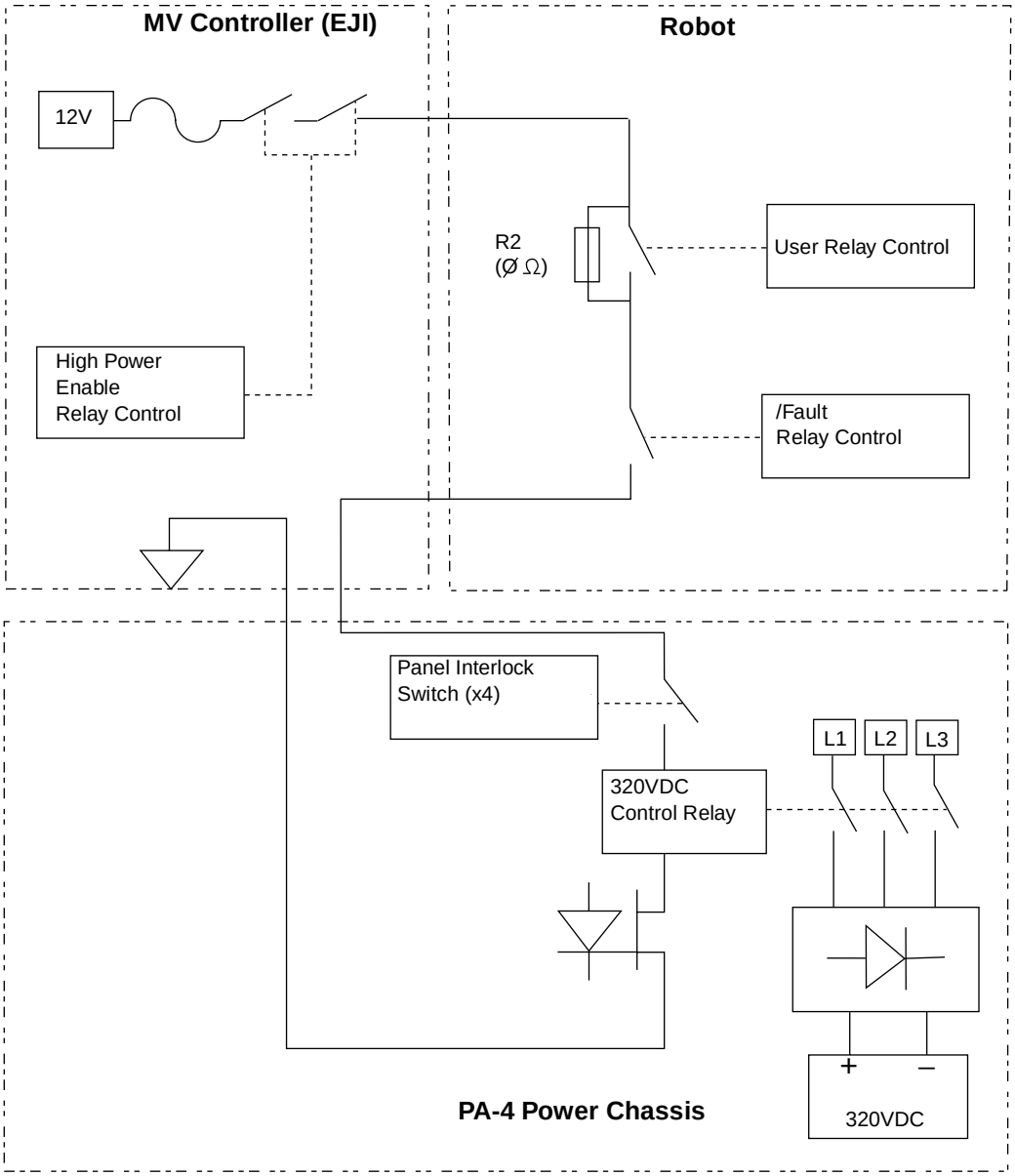


Figure 6-18. Outer Link High Power Access Circuitry

6.14 Connecting User-Supplied Digital I/O Equipment

There are two sets of digital I/O connections on the CIP. The JSIO connector accesses the first set, a group of 12 inputs and 8 outputs. The signals are numbered 1001 through 1012 for the inputs and 1 through 8 for the outputs. In the JSIO group, all the signals have independent source and ground connections. This group of inputs contains the four high-speed inputs that are used by the system for interrupts and latching. The outputs, although independent, have a lower current rating of only 100mA compared to 700mA for the extended outputs (described in the next section).

The second group of digital I/O connections, or extended DIO, uses four connectors: 32 inputs on JDIO1 and JDIO2 and 32 outputs on JDIO3 and JDIO4. The signals are numbered 1033 through 1064 for the inputs and 33 through 64 for the outputs. The extended DIO are arranged in groups of eight signals with a common ground connection for each group and a common source for each output group. However, the groups are independent of each other and do not share sources or grounds. The electrical characteristics of the inputs are similar to the JSIO signals, but the outputs have a higher voltage rating (30 VDC vs. 24 VDC) and a higher current rating than the JSIO outputs. See the *Adept MV Controller User's Guide* for details on wiring extended DIO signals. See the *V+ Language User's Guide* for information on digital I/O programming.

JSIO Connector

The JSIO connector on the CIP is a 50-pin, standard density D-Sub female connector (see Figure 4-10 on page 65 for location). There are 12 inputs and 8 outputs, each optically isolated from the circuitry of the CIP. The connector also provides access to a single channel emergency stop circuit (E-Stop input and Passive E-Stop output). To access this connector, a user-supplied cable with a 50-pin male, D-Sub connector at one end is required.

Input Signals The JSIO connector handles input signals 1001 to 1012. Each channel has an input and a corresponding return line. See Table 6-7 for input specifications. The connector pinouts are shown in Table 6-9.

Table 6-7. DIO Input Circuit Specifications (JSIO Connector)

Operational voltage range	0 to 24 VDC
"Off" state voltage range	0 to 3 VDC
"On" state voltage range	10 to 24 VDC
Typical threshold voltage	V_{in} = 8 VDC
Operational current range	0 to 6 mA
"Off" state current range	0 to 0.5 mA
"On" state current range	2 to 6 mA
Typical threshold current	2.5 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)	5 µsec maximum
Software scan rate/response time	16 ms scan cycle/ 32 ms max latency[a]
Turn off response time (hardware)	5 µsec maximum
Software scan rate/response time	16 ms scan cycle/ 32 ms max latency

[a] See "Fast Input Signals 1001 to 1004" below for exceptions.

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

In Figure 6-19 on page 128, 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. Any of the three methods can be used on any channel.

REACT Input Signals 1001 to 1012

Inputs 1001 to 1012 (only) may be used by the V+ REACT and REACTI instructions. See the *V+ Language Reference Guide* for information on these instructions. If you are going to use these instructions, you should plan your digital I/O channel usage accordingly. (Inputs on the optional DIO board or CIP JDIOx connectors cannot be used by the REACT and REACTI instructions.)

Fast Input Signals 1001 to 1004

In addition to functioning as normal input signals, signals 1001 to 1004 can have the following special uses:

- Fast DIO V+ interrupt events (INT.EVENT)
- Robot and encoder position latch
- Vision trigger

NOTE: When the program task priorities are properly set, there is a 2 ms maximum latency for fast inputs 1001 to 1004 when used with V+ INT.EVENT instruction (requires the optional V+ Extensions License). See the *V+ Language Reference Guide* for a description of the INT.EVENT instruction.

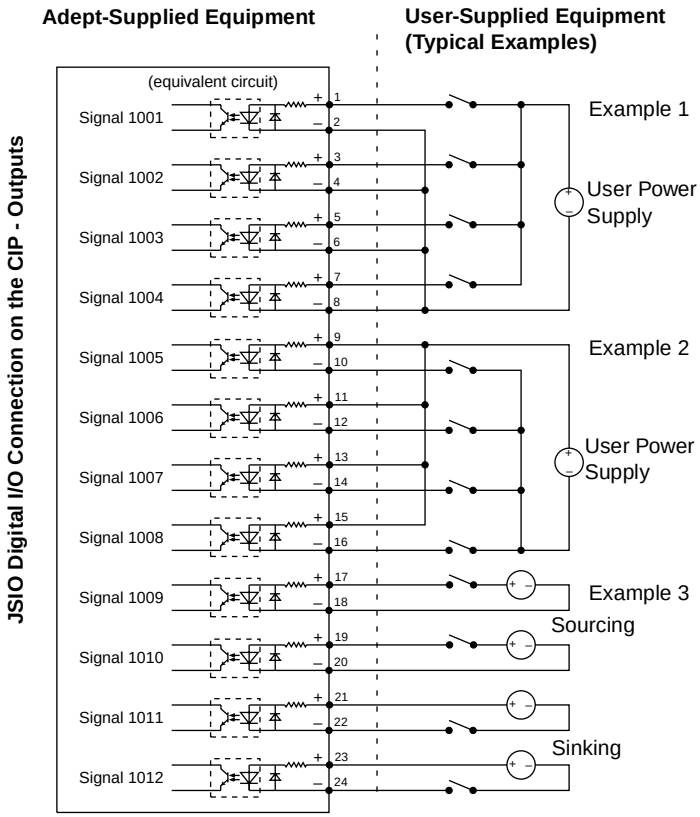


Figure 6-19. Digital Input Wiring Examples (JSIO Connector)

Output Signals

The JSIO connector handles output signals 0001 to 0008. Refer to Table 6-8 for output specifications. The locations of the signals on the connector are shown in Table 6-9. The JSIO 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 6-8. DIO Output Specifications (JSIO 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 6-20 shows two examples of different connections to the digital outputs on the JSIO connector. The examples are negative common and positive common.

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.

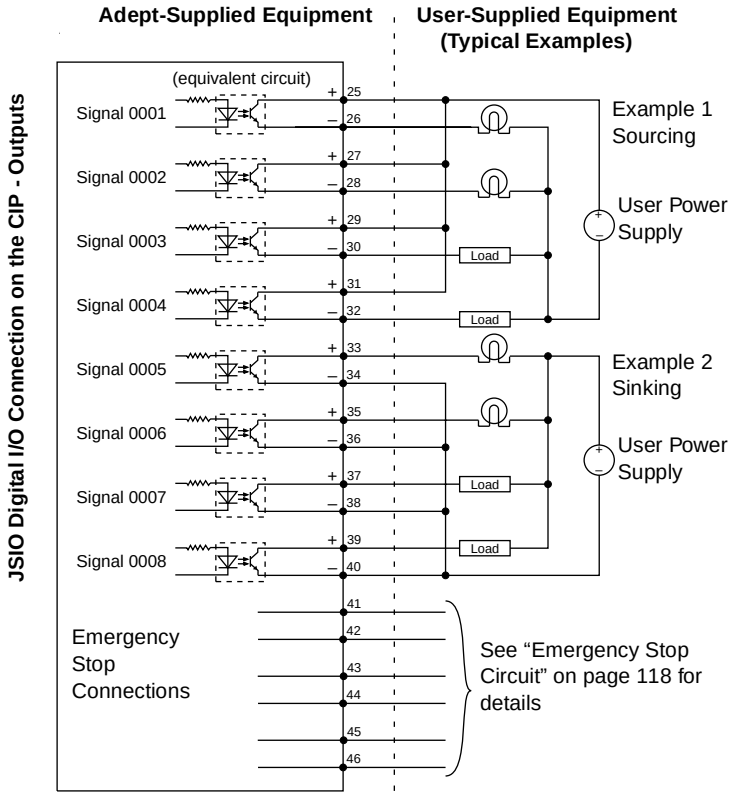


Figure 6-20. Digital Output Wiring for JSIO Connector

Table 6-9. JSIO Digital I/O Connector Pin Assignments

Pin	Signal Name	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[a]	Auxiliary E-Stop input+	42[a]	External E-Stop input–
17	Input 1009	18	1009 return	43[a]	Auxiliary E-Stop input –	44[a]	External E-Stop input +
19	Input 1010	20	1010 return	45	Passive E-Stop output+	46	Passive E-Stop output–
21	Input 1011	22	1011 return	47	Not used	48	Not used
23	Input 1012	24	1012 return	49	Not used	50	Not used
25	Output 0001+	26	Output 0001–				

[a] Pins 41, 42, 43, and 44: See Figure 6-15 on page 118 for more information.

6.15 Extended Digital I/O Signals

The extended digital I/O signals are 64 optically isolated digital I/O channels (32 input and 32 output). They are wired to connectors JDIO1 through JDIO4, which are located on the back of the CIP (see Figure 4-10). The electrical specifications for the inputs are similar to the JSIO inputs but have a different wiring configuration. In addition, they may not be used for REACTI programming, high-speed interrupts, or vision triggers. The outputs have a higher current carrying capacity than the JSIO. See the *Adept MV Controller User's Guide* for details on using extended digital I/O.

> **NOTE:** The signals on the JDIOx connectors can be superseded by a DIO board that is installed and addressed as DIO board #1. To use both the JDIOx signals and DIO boards, address the first DIO board as DIO board #2. See the *Adept MV Controller User's Guide* for details on DIO boards.

Verifying the System Installation 7

Verifying that the system is correctly installed and that all safety equipment is working correctly is a three-step process. This chapter covers the first two steps. Step one covers starting the control system for the first time and verifying that all components have been correctly installed. Once the safe initialization of the control system has been verified, the second step (referred to as "commissioning the system") is to verify that all safety equipment is working properly. The last step is to verify that the robot moves correctly. The Manual Control Pendant is used for this step and is covered in Chapter 8.

WARNING: 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.

7.1 Installation Check List

Before using the robot, make the following checks to ensure that the robot and controller have been properly installed.

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.

AC Power to the Adept Components Checks

Verify that the Adept MV controller and the Adept PA-4 power chassis are correctly connected to their AC power supplies.

1. Make sure that AC power is shut off to both the Adept MV controller and the PA-4 power chassis.
2. Verify that the three-phase AC power (180-264 VAC for 4-wire, 380 VAC for 5-wire) is connected to the Adept PA-4 power chassis.
3. Verify that the single phase AC power (180-264 VAC) is connected to the Adept MV controller.

4. If the System Power On/Off switch on the CIP is used, check the connections to this switch.
5. Verify that all voltages and voltage frequencies are within range (see section 2.3 on page 43).

Board and Cable Installation Checks

Make sure that all the boards in the Adept PA-4 power chassis and Adept MV controller are secured and the connection cables are correctly installed.

1. Secure all boards and blank front panels to the Adept MV controller chassis. Tighten both the top and bottom mounting screws on each front panel. This ensures proper grounding of the controller from an EMC standpoint and ensures good connection to the controller backplane.
2. Secure all amplifier modules and blanking plates on the Adept PA-4 power chassis. Tighten both the top and bottom mounting screws on each front panel. This ensures proper grounding of the amplifier controller subsystems from an EMC standpoint and ensures good connection to the drawer connectors at the rear of the chassis. The drawer connectors carry power and interlock signals from/into the power chassis from the amplifiers.

   NOTE: There is a safety interlock built into the Adept PA-4 power chassis that prevents power from being applied if the amplifier modules are not correctly screwed into place.

3. Secure the cable connections from the EJI board to the amplifiers in the Adept PA-4 power chassis. Tighten the screws on the D-sub connectors on the EJI-to-Amp cable assembly. This is especially important in systems including the Compact Controller. If the EJI board is not connected properly to the amplifiers, the fans in the power chassis will not operate. If the Adept PA-4 Power Chassis is turned on and the fan is not operating, the AWC will overheat.
4. Tighten the screws on the cable connections from the EJI board and other motion boards to the mechanisms to ensure integrity of signal connections, especially encoder feedback, and to ensure integrity of shields and other EMC measures.
5. Tighten the screws on the cable connections from the amplifiers to the mechanisms to ensure integrity of power connections and to ensure integrity of safety grounds and shields.
6. Secure the cable connection between the AWC and CIP. Verify that the plug is latched on both ends of the cable.
7. If you are using the AdeptWindows PC user interface, connect a shielded Ethernet cable from the hub (or server) to the shielded RJ45 connector on the AWC board. Unshielded cables will degrade the integrity of the AdeptWindows PC link, particularly when power is applied to the robot or mechanism. Use "straight" cables to a hub or a "crossover" cable to a stand-alone PC.

Cable Connection Summary

Check to make sure all the following cables are correctly installed:

- Robot to power chassis (Arm Power Cable)
- CIP to MCP (install bypass plug if not used)

- CIP (JAWC) to AWC board
- Robot to controller (Arm Signal Cable)
- Controller to power chassis (EJI-to-Amp Cable)
- JUSER to user-supplied equipment (install jumper plug if not used)

User-Supplied Safety Equipment on JUSER and JSIO Connector Checks

Check the following safety equipment connected to the JUSER and JSIO connectors on the CIP:

1. There are eight pairs of contacts that must be connected on the JUSER connector (see Table 6-4, "Contacts Provided by the JUSER Connector," on page 114) to ensure proper continuity of the emergency stop circuitry. Verify that these connections are secure and reliable and that a redundant pair of contacts is installed, one for each E-Stop channel. Double check that the state of the contacts on each pair matches and the contacts are closed. Each contact is separately connected to its respective E-Stop channel. Inadvertent connection between the E-Stop channels will short the E-Stop power supply, making it impossible to apply High Power.
2. There are two pairs of contacts in the JSIO connector that must be connected to ensure proper continuity of the emergency stop circuitry. Verify that these connections are secure, reliable, and closed prior to enabling power.
3. Make sure that guarding around the workcell is properly connected to either the Muted Safety gate inputs on the JUSER connector or, if appropriate, to the User E-Stop connections on the JUSER connector. Make sure that all gate, E-Stop push button switches, and other interlocks have two independent electrical poles. Make sure that a pair of redundant contacts is installed and that these contacts are separately connected to their respective E-Stop channels. Make sure that all interlock or emergency stop devices are wired in series (not in parallel) before connecting to the User E-Stop connections. Identify all wiring with Channel 1 or Channel 2. Inadvertent connection between the channels will short the E-Stop power supply, making it impossible to apply High Power.
4. Make sure that workcell components have been properly interlocked to avoid hazards when the robot/motion system is operated in Manual Mode. (Per "ISO 10218 Manipulating Robots Safety", the robot control system must employ a "single point of control" when operated in Manual Mode.)

E-Stop Button and Switch Checks

1. Verify that the red E-Stop push buttons on the CIP, MCP, and User Panel (if installed) are in the normal, unlatched (electrically closed) position.
2. Verify that the MCP is mounted on a rack that holds the MCP Enable switch in the ON position.
3. Verify that the user panel enable contacts are closed, that a pair of redundant contacts is installed and that these contacts are separately connected to their respective E-Stop channels. Inadvertent connection between the channels will short the E-Stop power supply, making it impossible to apply High Power to the robot.

7.2 Applying Power to the Adept Control System

After you have made the checks listed above you are ready to turn on system power.

WARNING: All safety systems must be in place and operating before applying power to the system. Extra care should be taken during the initial tests of the robot system.

1. Turn the AC power switches on the Adept MV controller and PA-4 power chassis to the ON (I) position.
2. Turn the System Power switch on the CIP, if used, to the ON (I) position.
3. The AWC will execute its boot sequence. When the boot sequence has completed, the SF/OK LED should be green. If this LED is red, the AWC has not booted properly. Turn off power to the controller and reboot. If the problem persists, call Adept Customer Service. Note the state of the LEDs marked 1 to 3, which indicate the problems shown in Table 7-1.
4. The other LEDs should be off. If the ES (E-Stop) LED on the AWC board is flickering red, this could result from:
   a. AWC systems may occasionally oscillate after the software has tested the E-Stop channels. If this occurs, toggle (press and release) the E-Stop push button on the CIP. The E-Stop LED should now be off (unless there are other problems in the E-Stop circuitry).
   b. The oscillation may also be the result of a mismatch between the contacts forming a “pair of contacts” in the two E-Stop channels. Perhaps on one channel, the user E-Stop contacts are closed, and on the other they are open. Check each pair of contacts to make sure that they match and that they are all closed per Table 6-4, “Contacts Provided by the JUSER Connector,” on page 114.
   c. Also, a short between the two E-Stop channels may sometimes result in this oscillating red ES LED. If the problem persists, call Adept Customer Service.
5. If the E-Stop LED is continuously red, then at least one pair of E-Stop contacts is open or the E-Stop contacts on the JSIO connector are open. Review the checklist items above to resolve the problem. If the problem persists, call Adept Customer Service.

LED Status Indicators on the AWC

The LEDs on the front of the AWC indicate the following conditions:

O = off G = green R = red

Table 7-1. LED Status Indicators

LED Display	Error #	Description
O-O-O	0	No error
O-O-R	1	System clock is dead or too fast. Clock interrupts are not being received.
O-R-O	2	Hardware configuration error. Address switches/SYSCTL wrong
O-R-R	3	Graphics board failure. VGB not responding
R-O-O	4	Memory test failure. Free storage error
R-R-O	6	Software serial I/O configuration error
G-O-O	C	Uninitialized trap
G-O-G	D	Bus error detected

If the AWC displays any of the above errors, contact Adept Customer Service (see "How Can I Get Help?" on page 39).

7.3 Checks After Applying Power

1. Verify that High Power can be enabled:
   a. Enter the following command at the monitor window:

      ```
      ENABLE POWER
      ```

      Or press the COMP/PWR button on the MCP

   b. When the High Power push button/light on the CIP begins flashing, press and hold the push button for 1 - 2 seconds. When you release the push button, the light should remain lit continuously indicating that High Power has successfully been enabled.

   c. If the light does not stay on, the High Power enable process has failed and a message will be displayed on the monitor and MCP indicating why.

2. Verify that all E-Stop devices are functional (MCP, CIP, and user supplied). Test each mushroom button, safety gate, light curtain, etc., by enabling High Power and opening the safety device. The High Power push button/light on the CIP should go out and the red ES LED on the AWC should be lit.

7.4 Calibrate Robot

1. Before calibrating, make sure the robot is in a safe position within its envelope as it may move suddenly when you calibrate.
2. Verify that you have enabled power as described above.
3. Type **calibrate** at the dot prompt in the V+ monitor.

WARNING: The robot will move when you type **calibrate**. During calibration the robot moves to the Joint 1 and Joint 2 calibration target locations, the J3 upper hardstop and the J4 zero position. Observe all safety precautions.

NOTE: If Joint 4 is rotated more than three revolutions from the factory calibrated zero position, the joint may advance an additional five turns maximum during calibration. This is caused by the dynamic coupling of Joints 3 and 4. Air or electrical lines routed to an end-effector may be twisted and/or damaged during this process.

When calibration is complete, the monitor displays the dot prompt. This means the system is ready for operation.

About Calibration

Each robot has specific parameters that locate the zero degree position for each joint. The zero degree position is based on the ROUGH and FINE calibration procedure that occurs at Adept during factory calibration. This information is read from the robot's Robot Signature Card (RSC).

The HOME position is a fixed point stored in the RSC. The Joint angle/location of the HOME position are: J1 = – 43°; J2 = 97°; J3 = 10 mm; J4 = 54° (see Appendix D for user utility to change values).

The first step in calibration is to "twang" the motor of each joint. Twanging energizes the three phases of the motor to find the commutation point of each motor and verifies that the arm power cable and EJI-to-Amp cables are installed correctly. The motor then moves the joint toward its calibration target location or hardstop, then back to its HOME position. The robot jerks slightly during twanging.

7.5 Robot Configuration Utility Program

The CFG_COBR utility Utility Program allows users to change the J1 and J2 calibration target locations and orientations (LEFTY/RIGHTY) and change the HOME position (see Appendix D).

7.6 Learning to Operate and Program the Adept Cobra Robot

When the robot has been calibrated, you should go to Chapter 8 to learn how to move the robot with the MCP.

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

For programming information you need to refer to the following list of optional manuals:

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

Using the Manual Control Pendant (MCP) 8

The final step in verifying that the system is installed and working correctly is to move the robot through its range of motion using the MCP. The following sections tell you how to move all of the joints of the robot.

8.1 Robot Operating Modes

To safely move the robot you must understand the robot's two different operating modes, Manual and Automatic. The CIP has a two-position key switch that controls the robot's operating mode. For safety reasons, High Power is automatically disabled when the operating mode is changed.

Manual Operating Mode

In the Manual (<250 mm/s) position, robot motion can be initiated only from the MCP. In Manual mode, the operator cannot initiate a motion with the system keyboard, and executing programs that require robot motion will halt when a motion instruction is processed. This protects the operator in the workcell from unexpected motions of the robot.

In Manual mode the maximum speed of the tool center point and the joints of the robot is reduced to less than 250 mm per second (10 inches per second). Also, the motors run at reduced torque. This speed and torque reduction is implemented in the software. See section 1.12 on page 38 for a description of safety equipment for an operator who is working in the robot workcell.

In Manual mode, the contacts of the Customer Safety Barrier (Mute) are muted and the safety function of these contacts is disabled. This permits a skilled operator to enter the workcell while High Power is enabled.

Automatic Operating Mode

The Automatic mode (100%) position permits computer control of the robot. A program that is currently running the robot or motion device may cause it to move at times or along paths you may not anticipate. When the white High Power light on the CIP is illuminated, do not enter the workcell because the robot or motion device might move unexpectedly.

WARNING: Impact Hazard!
In Automatic mode no personnel are allowed in the workcell. The robot can move at high speeds and exert considerable force.

NOTE: The MCP can be used while the CIP is in either Automatic (AUTO) or Manual Mode. For example, it is possible to initiate calibration of the robot or to enable High Power from the MCP when the CIP is in Automatic (AUTO) mode.

8.2 Manual Control Pendant Basics

Adept motion systems are designed to allow control of the robot or motion device from the Manual Control Pendant (MCP). There are two styles of MCPs, the operator's pendant and the programmer's pendant. The programmer's pendant is designed for use while an application is being written and debugged (a programmer's pendant cannot be used inside the robot work envelope). The operator's MCP is designed for use during normal system operation. Figure 8-1 shows how to hold the MCP.

The pendant has a palm-activated enabling switch that is connected to the remote emergency stop circuitry of the controller. Whenever this switch is released, High Power is removed from the motion device. When the MCP is not being used, the operator must place it in the special cradle provided or remove it from the controller and install the pendant jumper plug. The cradle retaining clip will keep the enabling switch depressed when the pendant is not in use. Figure 8-2 shows how to place the pendant in its cradle.

To operate the MCP, put your left hand through the opening on the left-hand side of the pendant and use your left thumb to operate the pendant speed bars. Use your right hand for all the other function buttons. The various button groupings of the pendant are reviewed in this section.

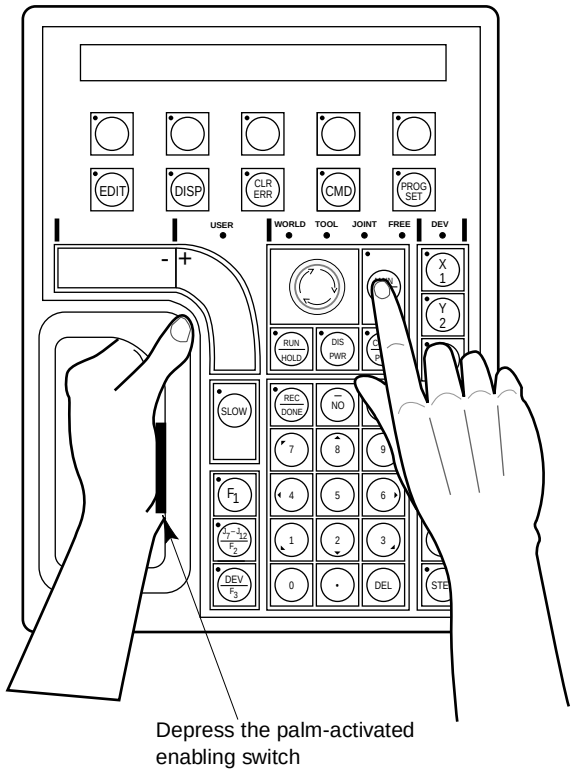


Figure 8-1. Holding the MCP

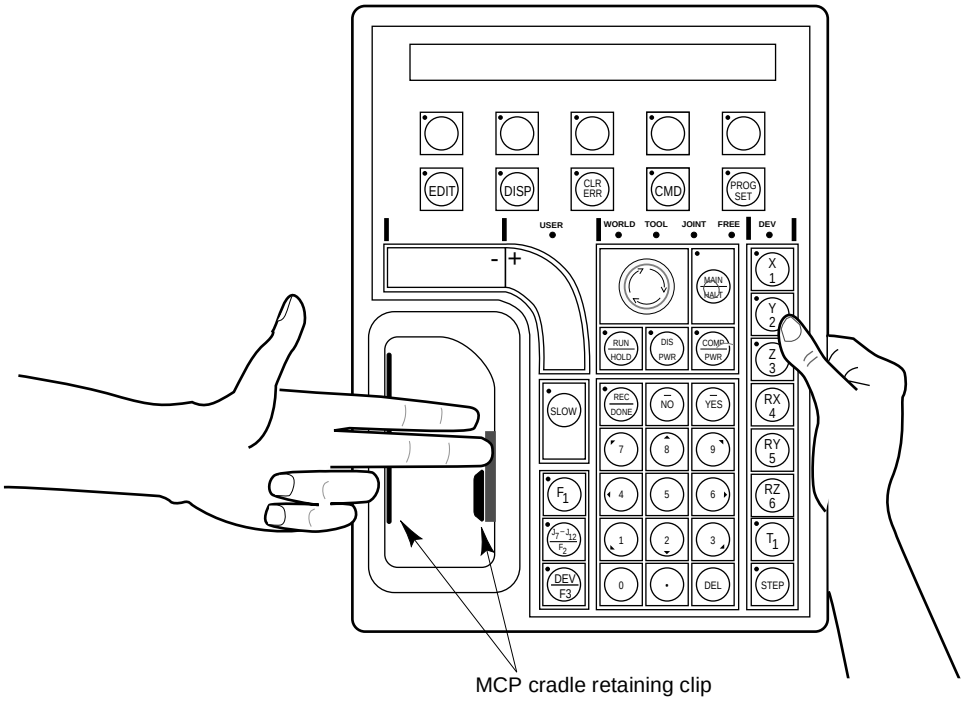


Figure 8-2. Cradling the MCP

WARNING: The cradle for the pendant MUST be mounted outside of the robot or motion device work envelope.

Connecting the MCP

The MCP is connected to the 16-pin connector marked MCP on the CIP (see "Connecting the MCP to the CIP" on page 67). The pendant E-Stop button and the palm-activated enabling switch are wired into the emergency stop circuitry. Therefore, either the pendant or the optional pendant bypass plug must be attached to this connector. If neither one is connected, you cannot enable High Power. If the pendant or bypass plug is removed, High Power is turned off.

NOTE: The CIP design allows for an external MCP connection. If this connection is installed and used, the MCP bypass plug must be installed on the CIP MCP connector.

CAUTION: Do not modify or extend the MCP cable. Doing this will void the warranty on the MCP and the CIP.

CAUTION: Use only the MCP III, P/N 10332-11000 (Assy # 90332-48050), with a CIP. Other MCPs will not work with the CIP because they do not incorporate the dual E-Stop channels. Damage may result if an MCP III is plugged into older Adept controller systems that contain a VME Front Panel (VFP). Damage may also result if older MCPs (part numbers other than 10332-11000) are plugged into a CIP.

WARNING: The Auto/Manual keyswitch on the CIP *must* be set to Manual if the MCP is to be used inside the robot workcell. This enables important safety features to protect the operator by limiting the speed of the robot.

MCP Layout

The major areas of the MCP are shown in Figure 8-3.

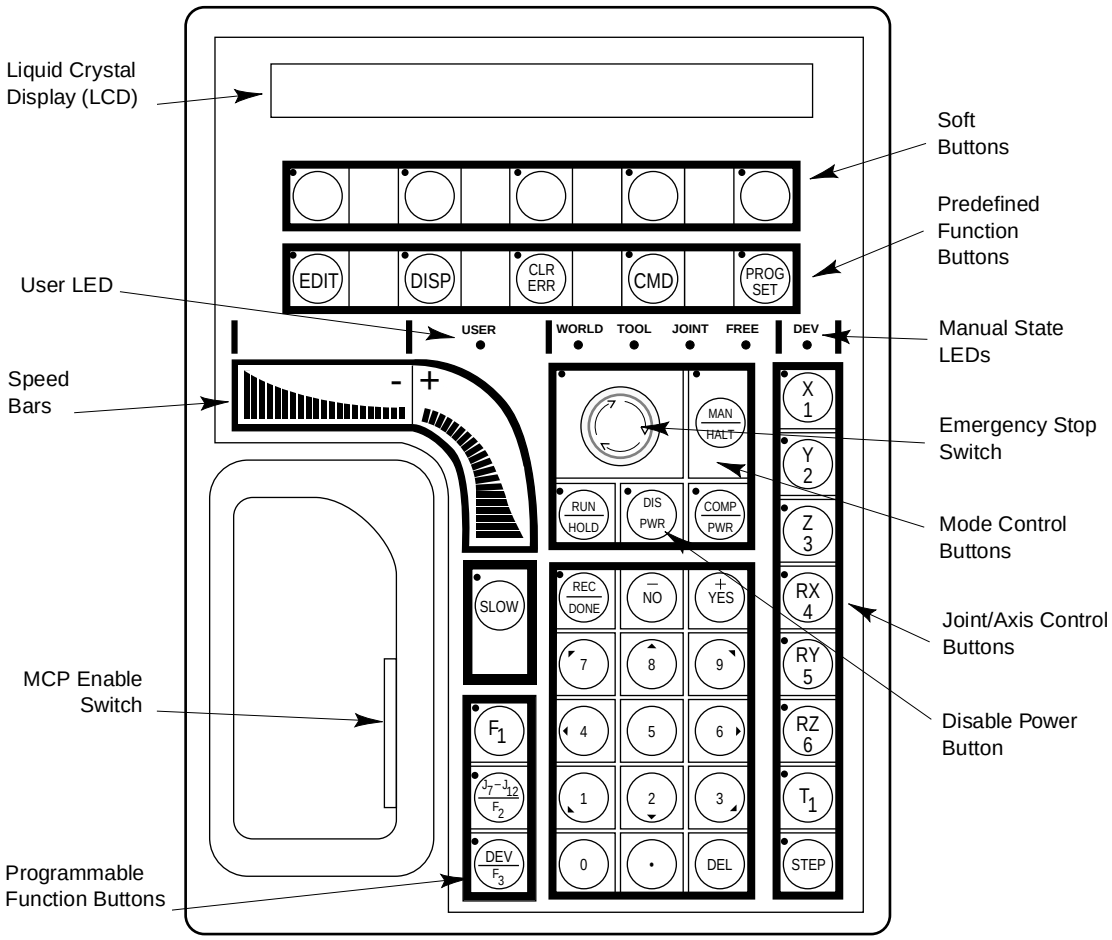


Figure 8-3. MCP Layout

Soft Buttons

The soft buttons have different functions depending on the application program being run, or the selection made from the predefined function buttons. Whenever a soft button is active, its function is shown on the bottom line of the pendant display. Because these buttons do not have fixed labels (the labels are defined by the program using the buttons), they are referred to as soft buttons. (Programming the MCP is covered in the *V+ Language User's Guide*.) Figure 8-3 shows the soft buttons.

Function Buttons

The predefined function buttons have specific, system-wide functions assigned to them. These functions are covered in "MCP Predefined Functions" on page 147. The programmable function buttons are used in custom application programs, and their functions will vary depending upon the program being run. See the documentation for your application programs for details on these buttons. Figure 8-3 shows the function buttons.

Data Entry Buttons

The data entry buttons shown in Figure 8-4 are used to input data, normally in response to prompts that appear on the pendant display. The data entry buttons include, +/YES, –/NO, DEL, the numeric buttons (0-9), the decimal point, and the REC/DONE button. These buttons are similar to the numeric keypad on a standard keyboard.

REC/DONE Button Behaves like the Return or Enter key on a standard keyboard. When data entry is complete, pressing REC/DONE sends the entry to the controller. In many cases, application programs have users press the REC/DONE button to signal that they have completed a task.

DEL Button Behaves like the backspace key on a standard keyboard. When data is being entered, it will appear on the pendant display. DEL will delete any characters that appear on the pendant display but have not been entered using the REC/DONE button. Application programs may also assign special functions to the DEL button.

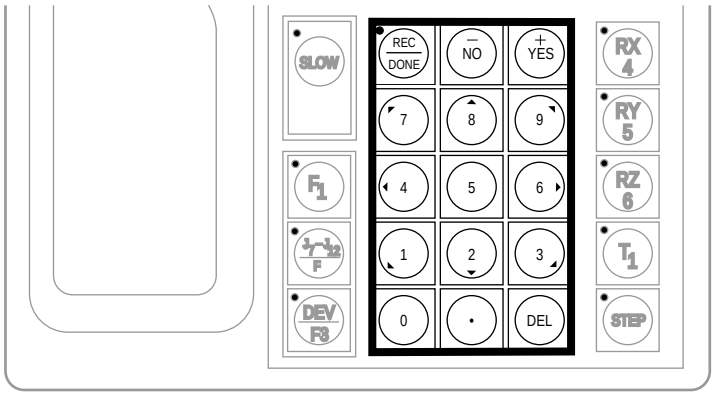


Figure 8-4. Data Entry Keys

Mode Control and Joint/Axis Control Buttons

The mode control and joint/axis control buttons are used to control the robot from the pendant. The use of these buttons is covered in "Moving a Robot or Motion Device With the MCP" on page 154.

Speed Bars and Slow Button

The speed bars and slow button are used primarily to move the robot when it is in Manual mode. These options are described in "Moving a Robot or Motion Device With the MCP" on page 154.

In some cases, application programs will make special use of the speed bars. See the documentation for any application program for details on how it uses these buttons.

Emergency Stop From the MCP

To immediately halt program execution and turn off High Power, press the E-Stop button on the MCP. This switch has the same effect as pressing the E-Stop button on the controller.

To reenable High Power after pressing the MCP E-Stop button, turn the E-Stop button to the right (clockwise). The switch is spring loaded and will return to its normal position. Depress the enabling switch. High Power can now be reenabled by pressing the COMP/PWR button (mode control group), or by entering the ENABLE POWER command from the keyboard and then pressing the white High Power push button/lamp on the CIP.

Background Mode

The pendant is in background mode when the USER LED is not lit and none of the predefined functions are being used. The USER LED is lit whenever an application program is making use of the MCP. The MCP will not return to background mode until the program completes execution or is aborted. The LEDs above the predefined function buttons indicate whether the functions are being used. If one of the LEDs is lit, the MCP can be returned to background mode by pressing the REC/DONE key (more than one press may be necessary). The predefined functions are described below in section 8.3.

When the MCP is in background mode, the viewing angle of the LCD can be changed. There are three different angles. Press the “2”, “5”, or “8” button to select a different viewing angle.

8.3 MCP Predefined Functions

Introduction

This section describes the manual control pendant functions related to:

- Loading and starting programs
- Editing global variables
- Displaying system status

Predefined Function Buttons

The MCP has five predefined function buttons. They are listed and explained below.

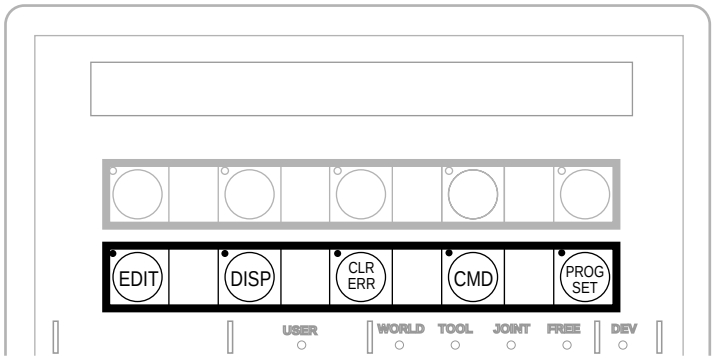


Figure 8-5. MCP Predefined Function Buttons

The Edit Function

The Edit function button allows editing of location variables and real variables that are used by V+ programs.

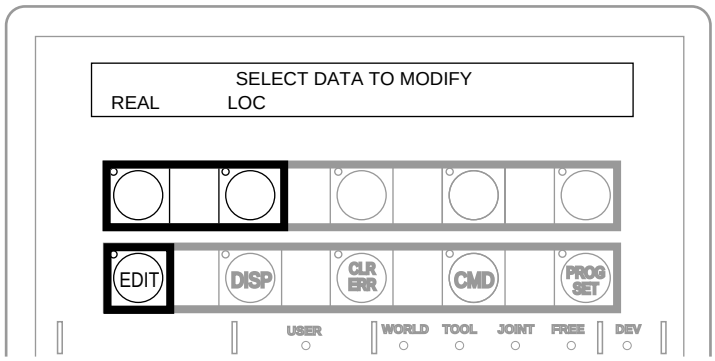


Figure 8-6. EDIT Function Button

Real Press the REAL soft button and the LCD displays:

```
SELECT REAL VARIABLE TO EDIT
var1    var2    var3    var4    <MORE>
```

var1, var2, etc., are global variable names. Press the soft button under the variable name to edit that variable. The <MORE> soft button is shown only when there are more than five global real variables in system memory. When a variable has been selected, the LCD will display:[1]

```
var.name = xxx
CHANGE    TRUE    FALSE
```

[1] If the variable being edited is from an array, an additional soft button is displayed that allows you to specify the index of the variable to edit.

Press the TRUE soft button to set the variable to the Boolean value of true (–1). Press FALSE to set the variable to false (0). To change the value of the variable press the CHANGE soft button. The LCD displays:

```
var.name = _
CHANGE    TRUE    FALSE
```

The typing cursor replaces the variable value. Use the data entry buttons to input a new value, and complete the entry by pressing REC/DONE.

Loc Press the LOC soft button and the LCD displays:

```
SELECT LOCATION VARIABLE TO EDIT
loc1    loc2    loc3    loc4    <MORE>
```

Press the soft button under the variable name to edit that variable. The <MORE> soft button is shown only when there are more than five global location variables in system memory. When a variable has been selected, the LCD will show:[1]

```
loc.name: X = 500
CHANGE    NEXT    HERE
```

If a precision point is selected, the LCD will show:

```
#loc.name: Jt1 = -210
CHANGE    NEXT    HERE
```

Press the CHANGE soft button to change the displayed component of the location variable. The value will disappear and be replaced with the typing cursor. Use the data entry buttons to enter a new value, and complete the entry by pressing REC/DONE.

Press the NEXT soft button to show the next component of the location variable. The location's X, Y, Z, y, p, and r values will be shown in succession. X, Y, and Z values are given in millimeters; y, p, and r values are given in degrees. If a precision point is being edited, the joint values for all the joints in the robot will be shown in succession.

Press the HERE soft button to record the current robot location in the variable being edited.

WARNING: Be extremely careful when changing location values. When the robot moves to a modified location, it could damage equipment in the workcell.

[1] If the variable being edited is from an array, an additional soft button is displayed that allows you to specify the index of the variable to edit.

The Display Function

The Display function button allows either the current joint values, the current world location, the system status, the digital I/O status, or the last error message to be displayed on the MCP.

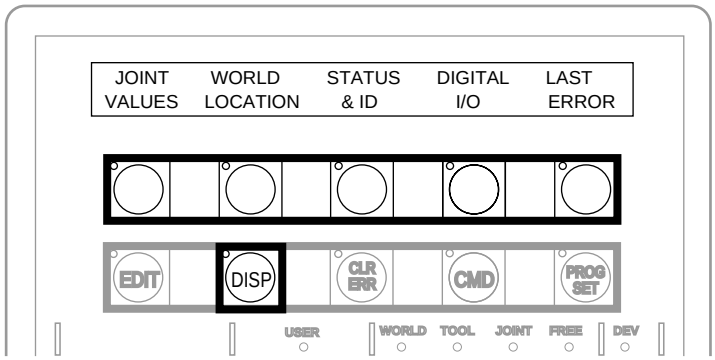


Figure 8-7. DISPLAY Function Button

Joint Values When this button is pressed, the display shows:

```
J1 = x.xx    J2 = x.xx    J3 = x.xx
J4 = x.xx    J5 = x.xx    J6 = x.xx
```

These values represent the current joint positions of the robot or motion device. Values will be shown only for joints the robot or motion device actually has. Rotational joint values are expressed in degrees, and translational joint values are expressed in millimeters.

World Location When this button is pressed, the display shows:

```
X = xxx.xxmm     Y = xxx.xxmm     Z = xxx.xxmm
y = xxx.xx°      p = xxx.xx°      r = xxx.xx°
```

The values represent the current location of the robot or motion device in world coordinates. See “Moving a Robot or Motion Device With the MCP” on page 154 for details on world coordinates.

Status & ID When this button is pressed, the display shows:

```
Status     SOFTWARE     CNTRLR       ROBOT
ID         ID           ID           'S
```

The **Status** button displays:

```
program.name     50         1        0
Program        Speed      Cycle    Left
```

Program shows the name of the currently executing or most recently executed program. Speed shows the current monitor speed. Cycle shows the total number of cycles specified when the program was executed. Left shows the number of cycles of the program remaining to execute.

The **Software**, **Controller**, and **Robot** ID buttons display the ID information for those items.

Digital I/O When this button is pressed, the display shows:

```
---- ---- ---- ---- ---- ---- 0000 0011
 + 0032-0001 -       OUT     IN    SOFT
```

The top line shows the status of the range of digital I/O signals indicated on the second line (1-32 in the above example). A "–" indicates the channel is not installed, a "1" indicates the signal is on, and a "0" indicates the signal is off. The type of signal that is being displayed is indicated by the LED on the soft buttons labeled OUT, IN, and SOFT. The above example shows digital output signals in the range 1 to 32. Signals 1-2 are on, signals 3-8 are off, and no other signals in this range are installed.

To display a different range of signals, press the soft buttons under the "+" or "–" labels. The next or previous range of signals will be displayed. Press the OUT, IN, and SOFT soft buttons to display input, output, or soft signal ranges. See "Connecting User-Supplied Digital I/O Equipment" on page 126 for details on digital I/O signal ranges for the CIP. Also see "Extended Digital I/O Signals" on page 131 for details on digital I/O signal ranges for the optional DIO board.

Last Error Press LAST ERROR to display the error messages generated by V^+ during the current session. The most recent error will be displayed. The rightmost soft button will be labeled <MORE>. Pressing this button will cycle back through the error messages generated during the current session.

The Clear Error Function

If the MCP is in the Manual position, or the system switch MCP.MESSAGES is enabled, error messages are sent to the MCP. When an error is sent to the MCP, the MCP will beep, display a blinking error message, and light the LED on the CLR ERR button, shown in Figure 8-8.

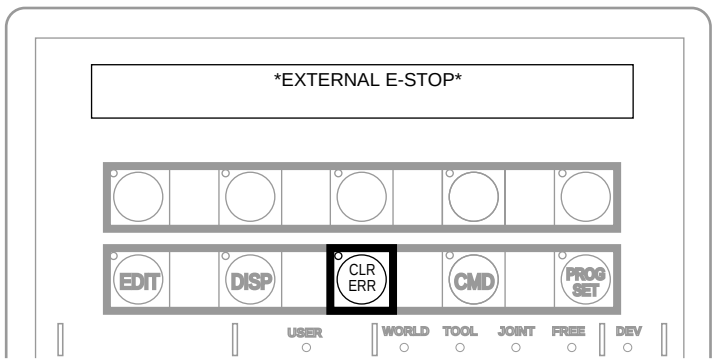


Figure 8-8. CLEAR ERROR Function Button

The CLR ERR button must be pressed for operation to continue. Pressing the CLR ERR button will clear the error message from the display and return the MCP to the state it was in before the error.

The CMD Function

The CMD function button displays the options AUTO START, CALIBRATE, STORE ALL, CMD1, and CMD2, as shown in Figure 8-9.

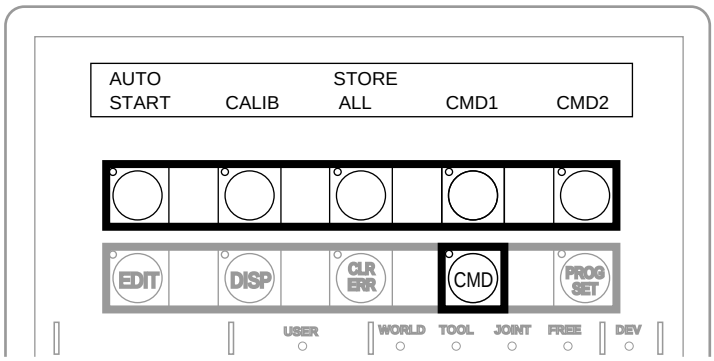


Figure 8-9. Command (CMD) Function Button

The AUTO START, CALIB, CMD1, and CMD2 functions require the MCP to be in Auto mode. If one of these function buttons is pressed while the MCP is in Manual mode, the MCP prompts you to place the keyswitch in the Auto position. The operation is halted and you must press the function button again. The programs started by these buttons may include a WAIT.START instruction, in which case the program will pause and the MCP will display START and CANCEL buttons over the two right soft buttons. Pressing START allows the program to continue. Pressing CANCEL halts program execution.

The programs started by these functions run in task 0. Therefore, High Power must be enabled and the robot must be calibrated.

Auto Start When AUTO START is pressed, the pendant display shows:

```
Enter last two digits of file name:
auto_
```

Enter one or two digits and press REC/DONE. The system attempts to load the file AUTOxx.V2 from the default disk, and COMMAND the program "autoxx" (xx refers to the digits you entered). The program file AUTOxx.V2 must reside on the default disk, and it must contain a monitor command program named "autoxx". If the file does not exist, or does not contain a correctly named program, the operation will be aborted and the appropriate error message will be displayed on the LCD. For example, if you had entered "9", the system would attempt to load the file AUTO9.V2 and COMMAND the program "auto9".

Calib When CALIB is pressed, the robot calibration procedure begins (High Power must be enabled).

Store All When STORE ALL is pressed, the pendant displays:

```
Enter last two digits of file name:
STORE auto_
```

Enter one or two digits, press REC/DONE, and all programs and variables in system memory will be stored to a file on the default disk with the name autoxx.v2. For example, if you had entered "11", the file AUTO11.V2 would be created, and all programs and global variables in system memory would be stored to that file.

CMD1 and CMD2 When CMD1 is pressed, the system attempts to load the file CMD1.V2 from the default disk, and COMMAND the program CMD1. The program file CMD1.V2 must reside on the default disk, and it must contain a command program named "cmd1". If the file does not exist, or does not contain a correctly named program, the operation will be aborted and the appropriate error message will be displayed on the LCD. If CMD2 is pressed, the file CMD2.V2 will be loaded and "cmd2" will be COMMANDed.

Prog Set Function

Using the Prog Set button, you may select a new program to execute, set the starting step number, set how many cycles of the program to perform, set the monitor speed, and start a memory-resident application program. See Figure 8-10.

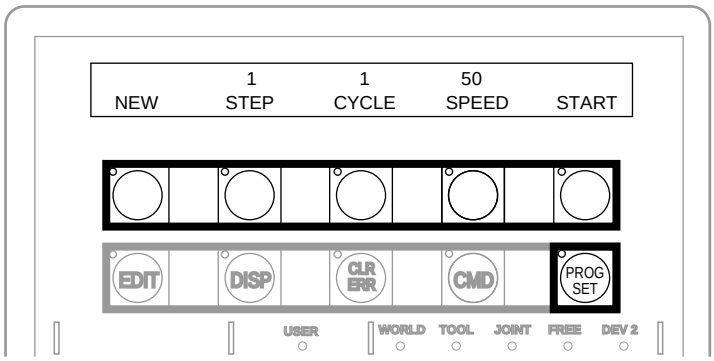


Figure 8-10. Program Set Function Button

New Press the NEW soft button and the LCD displays:

```
SELECT A NEW PROGRAM
prog1     prog2     prog3     prog4     <MORE>
```

To select a different program, press the soft button under the program name. To see additional programs (if there are more programs), press the <MORE> soft button.

Step Press STEP and the step number will blink, and the typing cursor will appear next to the step number. Use the data entry buttons to enter the program step to start execution. Complete the entry by pressing REC/DONE.

Cycle Press CYCLE and the cycle count will blink, and the typing cursor will appear next to the cycle count. Use the data entry keys to enter the number of program cycles to execute. Complete the entry by pressing REC/DONE.

Speed Press SPEED and the current monitor speed will blink, and the typing cursor will appear next to the monitor speed. Use the data entry keys to enter a new monitor speed. Complete the entry by pressing REC/DONE.

Start The Start button works only when High Power is enabled (this option cannot be used with DRY.RUN enabled). Press START and the program displayed above the NEW soft button will begin execution.

8.4 Moving a Robot or Motion Device With the MCP

Introduction

The MCP is used with a robot or motion device primarily to teach robot locations for use in application programs. The MCP is also used with custom applications that employ teach routines that pause execution at specified points and allow an operator to teach or reteach the robot locations used by the program. The Adept AIM software system makes extensive use of the pendant for teaching robot locations.

When you move the robot using the MCP, motion will be in world state, tool state, joint state, or in free state.

When moving in world state, directions are sent from the MCP to move the robot in a Cartesian coordinate system centered at the base of the robot. When moving in tool state, directions are sent from the MCP to move the robot in a Cartesian coordinate system centered at the robot's end-of-arm tooling location.

In joint state, directions are sent from the MCP to move individual robot joints. In free state, selected joints of the robot are "freed" from servo control so they can be moved by hand.

Mode Control Buttons

The mode control buttons, Figure 8-11, change the state being used to move the robot, switch control of the robot between the MCP and application programs, and enable High Power (when necessary).

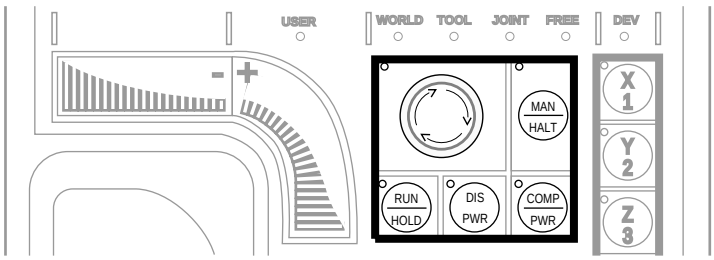


Figure 8-11. Mode Control Buttons

Emergency Stop Button

The emergency stop button will stop program execution and turn off High Power. If your robot is equipped with brakes, they will be activated.

COMP/PWR Button

If High Power is enabled, the COMP/PWR button selects computer mode. If the system is in AUTO mode and High Power is disabled, the COMP/PWR button enables High Power and selects computer mode. In computer mode, an executing program or the system terminal has control of the robot.[1] After you press the COMP/PWR button to enable High Power, the High Power lamp begins blinking and the LCD prompts you to press the High Power button. You must press this button within the allowed time (this time is programmable) or High Power will not be enabled.

If the system is in Manual mode and you press the COMP/PWR button to enable High Power, you need to take the following actions:

- release the MCP enable switch
- press and hold the MCP enable switch
- press the High Power button within the allowed time.

MAN/HALT Button

When there is no program executing, or a program has paused for a pendant teach routine, pressing the MAN/HALT button selects manual mode. In manual mode, the MCP has control of the robot. If a program is executing, the MAN/HALT button will stop program execution (without shutting off High Power).

Manual mode cannot be entered if High Power is off (the E-Stop button LED is not illuminated). To enable High Power, press the COMP/PWR button. The MCP is in manual mode when:

1. The LED on the MAN/HALT button is illuminated, and
2. One of the manual state LEDs is also illuminated (the manual state LEDs indicate the type of manual motion that has been selected, either World, Tool, Joint, or Free).

The system will remain in Manual mode until High Power is turned off or the COMP/PWR button is pressed. When you have finished moving the robot manually, press the COMP/PWR button to return control to the controller. If a program attempts to execute with the MCP in manual mode, the error "Comp mode disabled" will be displayed.

When the MAN/HALT button is pressed the first time, the MCP will be in world state. Pressing the MAN/HALT button again selects the next state to the right (tool, joint, free), eventually wrapping back to the leftmost state (world). If manual mode is terminated and reentered (without turning off system power) the last active state is selected.

As an additional safeguard, when High Power is enabled and the CIP switch is turned to Manual, High Power is disabled and any Manual mode selection is canceled.

[1] If the robot has not been calibrated and High Power is turned on, the MCP E-Stop switch LED will be lit, and both the COMP/PWR and MAN/HALT LEDs will be off.

DIS PWR Button

The Disable Power button will shut down High Power to the robot or motion device when pressed. Unlike the E-Stop Button, the Disable Power Button initiates a controlled stop, where the robot is decelerated under software control. After the robot has stopped, power is turned off.

RUN/HOLD

When the RUN/HOLD button is initially pressed, it will stop the robot and pause the executing program (task 0). If you then press and hold down the button, the program proceeds until the button is released. When the button is released, the robot stops and the executing program pauses until the button is released. When the button is released, the robot stops and the executing program pauses until the button is pressed again.

Joint/Axis Control Buttons

The buttons on the far right side are the joint/axis control buttons. When the MCP is in manual mode, these buttons select which robot joint will move, or the coordinate axis along which the robot will move. The X/1, Y/2, Z/3, RX/4, RY/5, and RZ/6 buttons are covered starting on page 157. (The MCP must be in manual mode before a joint/axis control button can be selected.)

STEP Button

When the CIP keyswitch is set to Manual, V+ programs cannot initiate motions unless you press the STEP button and speed bar on the MCP. To continue the motion once it has started, you can release the STEP button but must continue to press the speed bar. Failure to operate the STEP button and the speed bar properly results in the following error message:

```
*Speed pot or STEP not pressed*
```

```
*Speed pot or STEP not pressed*
```

Once a motion has started in this mode, releasing the speed bar also terminates any belt tracking or motion defined by an ALTER program instruction.

Motions started in this mode have their maximum speeds limited to those allowed in Manual mode.

Programs designed to allow moving the robot in Manual mode should read the status of the STEP button and speed bars before starting the move. The program should prompt the user as required.

Speed Bars

In World, Tool, and Joint Mode

The speed bars are used to control the robot's speed and direction. The joint(s) that will move when the speed bars are pressed depends on the "state" selected with the MAN/HALT button. Press the speed bars with your left thumb. Pressing the speed bars near the outer ends will move the robot faster; pressing the speed bar near the center will move the robot slower. See "Robot States" below for details on positive and negative directions.

In Comp Mode

See the description of the STEP Button above.

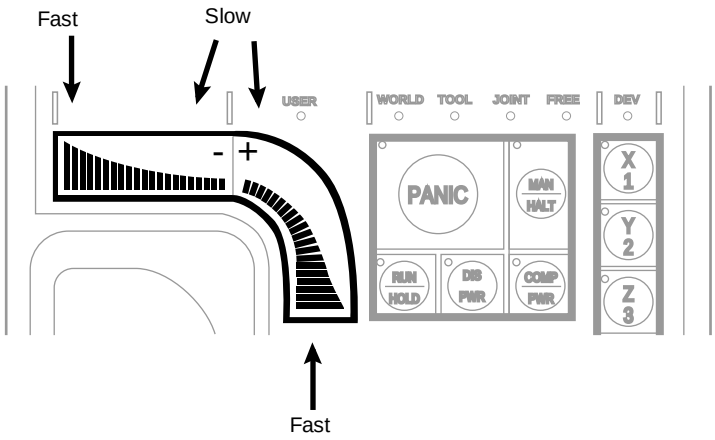


Figure 8-12. Speed Bars

Slow Button

The slow button selects between the two different speed ranges of the speed bars. When the slow button LED is lit, the slower speed range is selected. This slower speed is 25% of the normal MCP speed.

Robot States

World State

When world state is selected, movement in the X, Y, or Z direction is parallel to an axis of the world coordinate system. Before the speed bars will move the robot, an axis of motion must be selected from the manual control buttons. The world coordinate system for a SCARA robot is shown in Figure 8-13. If X1 is selected, pressing the "+" speed bar will move the robot tool flange in the positive X direction. Pressing the "–" speed bar will move the flange in the negative X direction.

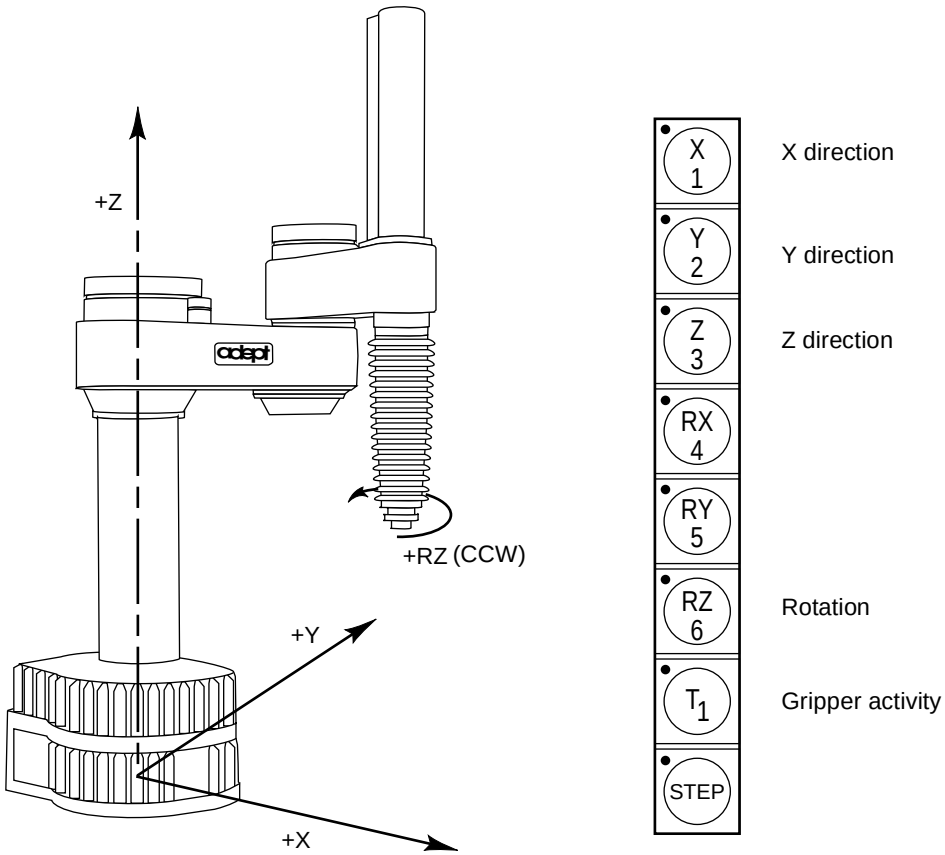


Figure 8-13. WORLD State (Four-Axis SCARA)

The T_1 button cycles the gripper solenoids. Press anywhere on the "+" side of the speed bar to open the gripper, on the "–" side to close the gripper.

> **NOTE:** This is the most common gripper setup. The gripper solenoids may be configured so they operate differently (or they may not be configured at all). Place your robot in a safe location and cycle the gripper to verify which side of the speed bar opens the gripper.[1]

Tool State

When tool state is selected, movement in the X, Y, or Z direction is along an axis of the tool coordinate system. The tool coordinate system is centered at the robot tool flange with the Z axis pointing away from the flange. On most robots, the positive X axis is aligned with the center of the tool flange keyway. Before the speed bars will move the robot, an axis of motion must be selected from the manual control buttons. If X1 is selected, pressing the "+" speed bar will move the robot tool flange in the positive X direction. Pressing the "–" speed bar will move the flange in the negative X direction.

In a four-axis robot, positive rotation of the gripper (RZ) is clockwise as viewed from above. Figure 8-14 shows the tool coordinate system for a four-axis SCARA robot.

[1] The SPEC utility is used to configure gripper activity. See the *Instructions for Adept Utility Programs*.

Figure 8-15 shows the tool coordinate system on a six-axis robot.

NOTE: Figure 8-14 and Figure 8-15 are drawn with the assumption that the TOOL transformation is set to NULL (all values are 0). If a TOOL transformation is in effect, the tool coordinate system will be offset and rotated by the value of the TOOL transformation. Any motion in tool state will now be relative to the offset coordinate system, and not the center of the tool flange. See the *V+ Language Reference Guide* for details on TOOL transformations.

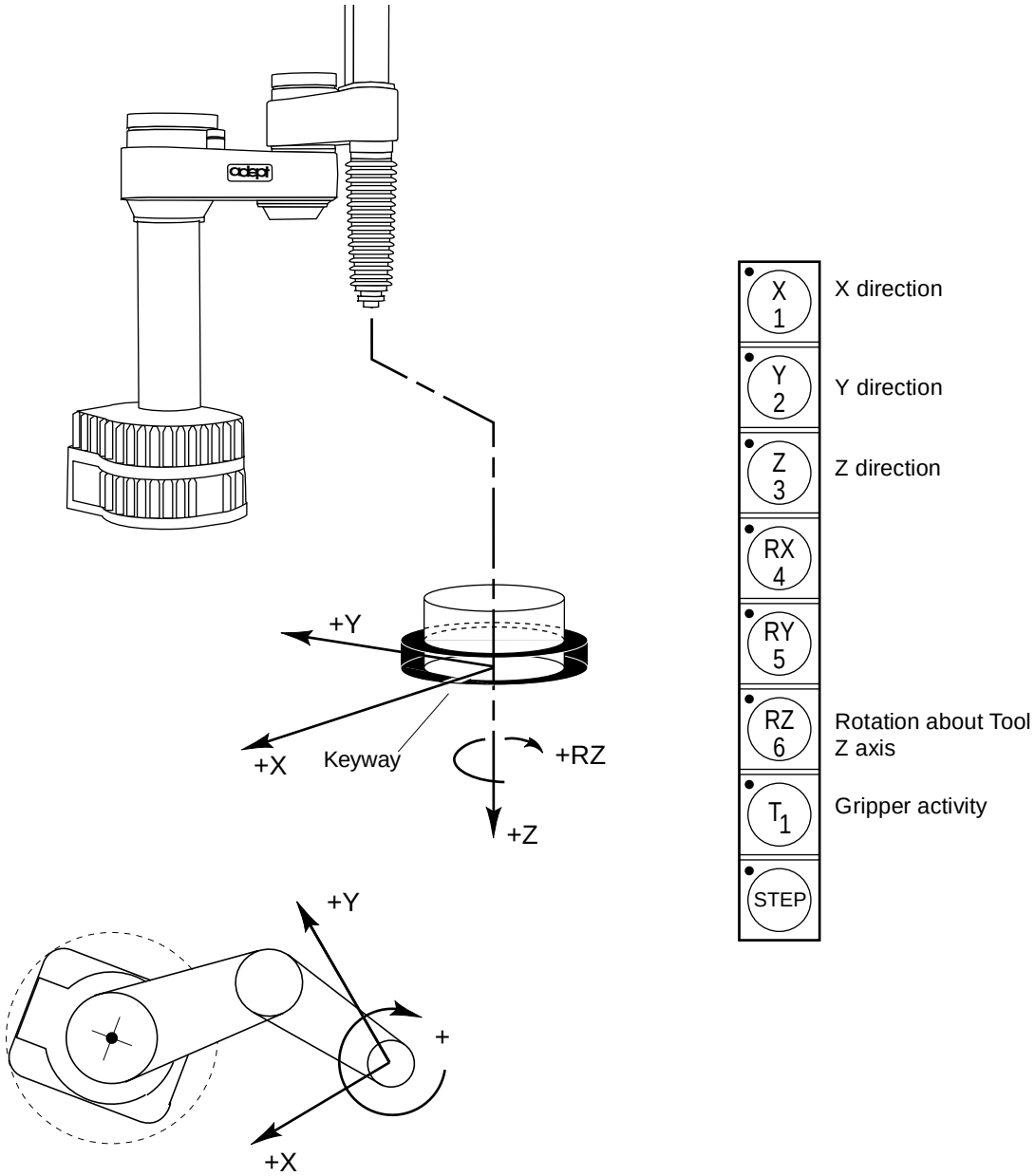


Figure 8-14. TOOL State (Four-Axis SCARA)

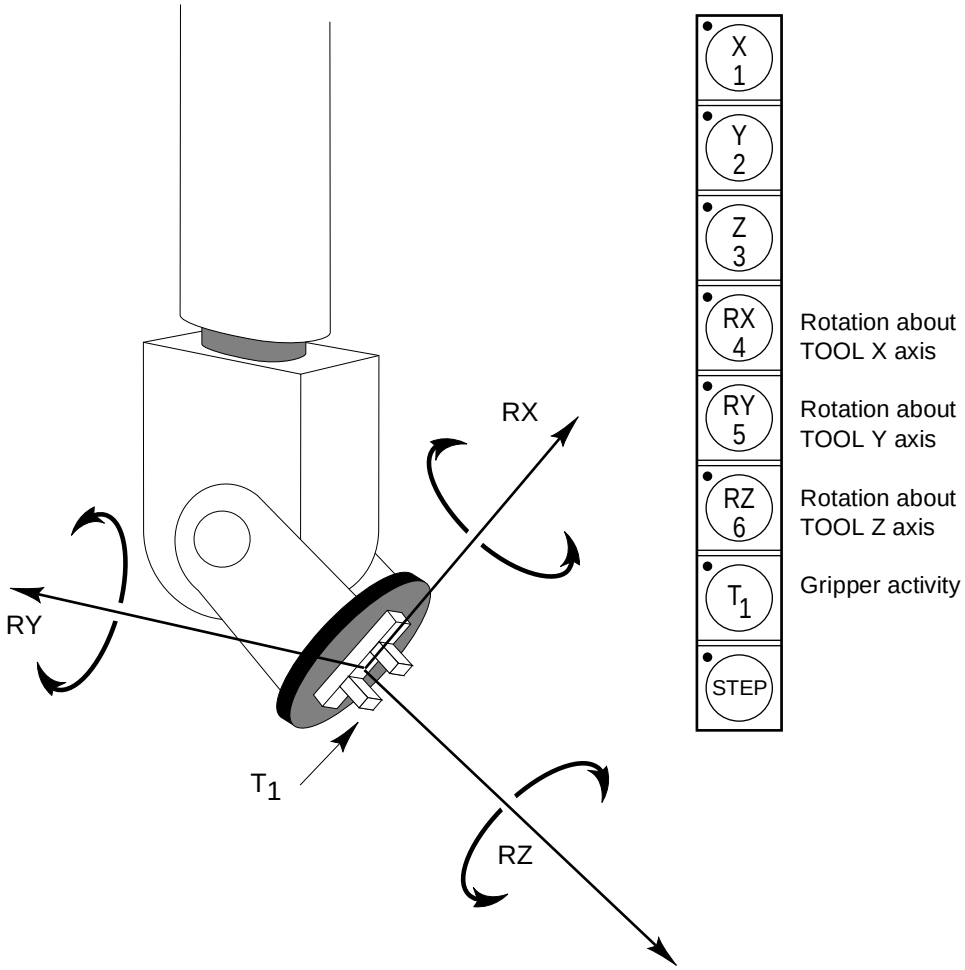


Figure 8-15. TOOL State (Six-Axis Robot)

Joint State

When joint state is selected, movement is about the axis of the specified joint. Figure 8-16 shows an Adept SCARA robot with three rotational joints (joints 1, 2, and 4) and one translational joint (joint 3). Positive rotation of joints 1 and 2 is counterclockwise as viewed from above. Positive rotation of joint 4 is clockwise as viewed from above. Positive movement of joint 3 is downward. Before the speed bars will move a joint, the correct joint must be selected from the manual control buttons.

Different robots or motion devices will have the different joint numbers assigned to their joints. When you first move an unfamiliar robot using joint state, set the monitor speed to 10 or lower, put the robot in a safe area, and carefully move the robot using the different joint numbers to verify how the MCP moves the robot. See the documentation for the motion devices you are using for details on their joint assignments.

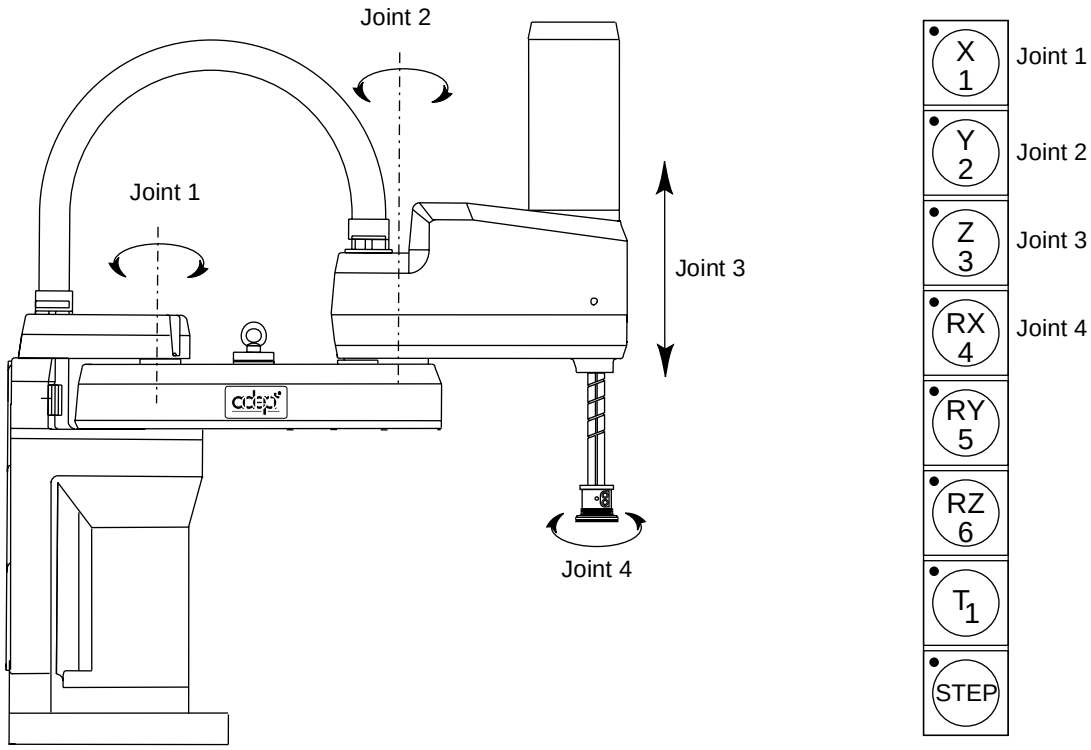


Figure 8-16. JOINT State (Four-Axis SCARA)

Figure 8-17 shows the joint assignments for a typical six-axis robot (as always, the first time you move a robot, carefully verify the joint assignments).

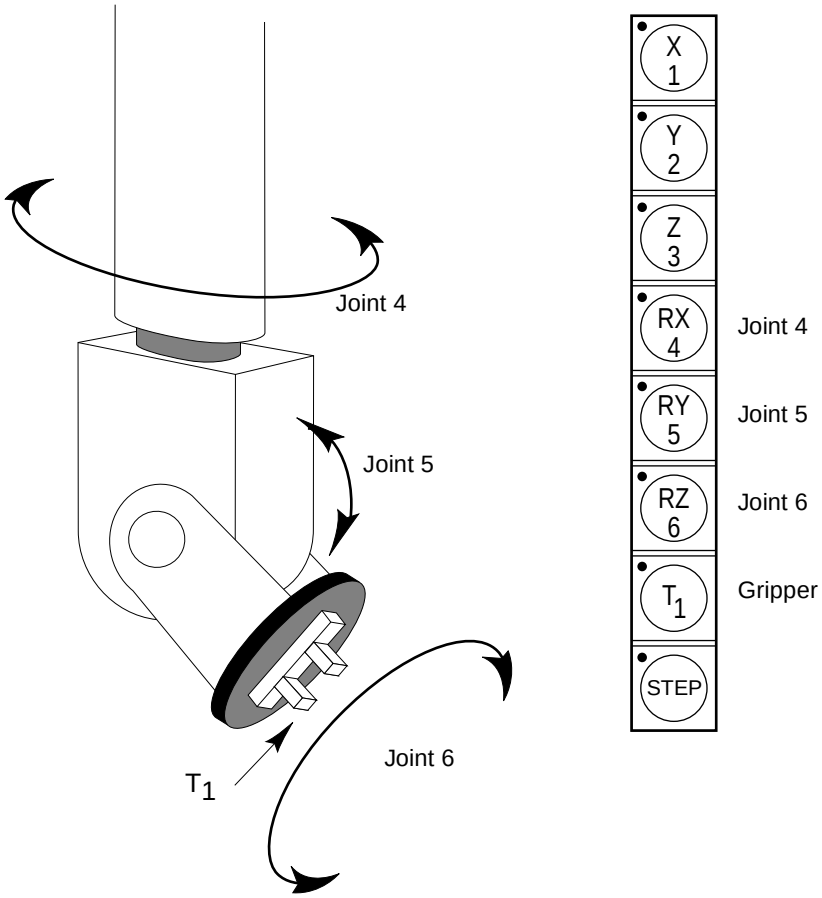


Figure 8-17. JOINT State (Six-Axis Robot)

Free State

When free state is selected, individual joints are freed from servo control, and the robot brakes (if any) are released. Unlike the other states, you can make multiple selections from the manual control buttons to free as many joints as required. In some cases, such as joints 1 and 2 on an AdeptOne/AdeptThree robot, multiple joints are freed by selecting a single button. On some robots Free mode may have been disabled by the manufacturer on some or all joints.

As soon as the COMP/PWR button is pressed, or another selection is made from the manual control buttons, all joints are placed back under servo control and will not move freely.

Figure 8-18 shows the free state for a four-axis SCARA robot. The joint assignments in the free state are the same as the joint assignments in joint state.

WARNING: As soon as a joint is selected from the manual control buttons, the related joint is free to move (in some cases, multiple joints may be freed up). In many cases the weight on the joint will be sufficient to move the joint and cause damage or harm. For example, when joint 3

on a SCARA or Cartesian robot is freed, the joint is free to fall to the end of its travel. In articulated robots, multiple links of the robot may be free to fall when a single joint is freed up. Be extremely careful when selecting a joint in Free mode.

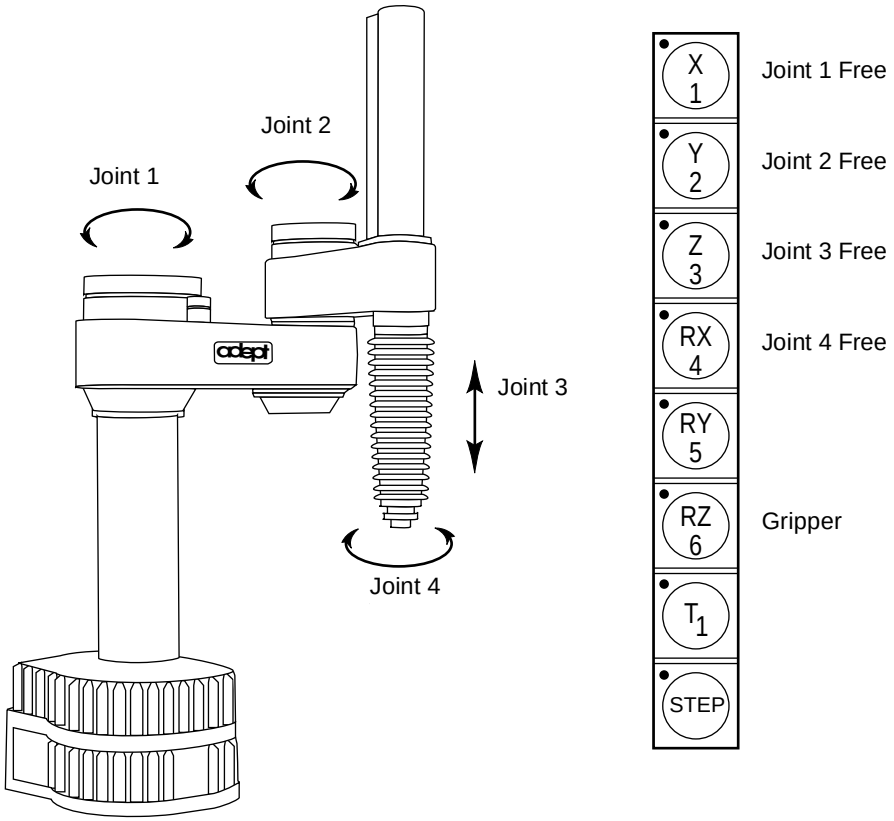


Figure 8-18. FREE State (Four-Axis SCARA)

Controlling More Than One Robot

Like the monitor and each program task, the MCP also can have a robot attached. When moving a robot from the MCP or displaying joint values or world locations by pressing the DISP key, only the currently selected robot is affected. The robot currently selected by the MCP is shown by the state of the DEV LED (in the manual state LED group, see Figure 8-3 on page 145). The table below describes the conditions:

DEV LED state	Robot selected by pendant
OFF	1
ON	2
FLASHING	3 (and above)

The selected robot cycles from one robot to the next each time the DEV/F3 key is pressed. Be careful when recording positions with the MCP; the position recorded by HERE or TEACH commands depends on the robot that is currently selected by the monitor or program and not on the robot selected by the MCP. The following commands will allow you to teach the position of robot 2 regardless of which robot is selected by the MCP.

```
.SELECT ROBOT = 2       ;Choose robot to be accessed by Monitor
.TEACH p[1]             ;Record location(s) of robot 2
```

Robots With Fewer Than Six Joints

The MCP has six axis/joint selection buttons. In Cartesian modes (WORLD, TOOL), these correspond to all six possible Cartesian values: X, Y, Z, RX, RY, RZ. Not all mechanisms can move in all of these coordinates. For example, a 4-axis SCARA robot can move in only X, Y, Z, and RZ. Buttons that have no effect on your robot are ignored and in some cases cannot be selected.

Robots With More Than Six Joints

In JOINT mode, each of the six buttons is used to control a specific joint of the robot. If the robot has more than six joints, the F2/J7-J12 key can be used to access the 7th to 12th joints. Only the robot currently selected by the MCP is affected. The currently selected joint is shown by the state of the LED on the joint/axis key as described below. If you press the key for joint 1, and the LED is steady, you are controlling joint 1. If you press F2/J7-J12, then press the key for joint 1, the LED will flash, indicating that you are controlling joint 7.

Table 8-1. Robots With More Than 6 Axes

Joint/Axis LED state	Joint range
OFF	None
STEADY	1 to 6
FLASHING	7 to 12

The MCP cycles from one range to the other each time the F2/J7-J12 key is pressed.

9 Maintenance

9.1 Introduction

Table 9-1 gives a summary of the preventive maintenance procedures and guidelines on frequency.

Table 9-1. Inspection and Maintenance

Item	Period	Reference
Check ESTOP, enable and key switches, and barrier interlocks	6 months	See section 9.2.
Check robot mounting bolts	6 months	See section 9.3.
Lubricate Joint 3 (Z-axis) ball screw	3 months	See section 9.4.
Check air filter in PA-4 power chassis and MV Controller	1 month	See section 9.5.
Drain compressed air moisture trap on rear panel of robot (moisture trap included with optional solenoid kit)	As required	See page 105.

NOTE: The frequency of these procedures will depend on the particular system, its operating environment, and amount of usage. Use the times in Table 9-1 as guidelines and modify the schedule as needed.

WARNING: The procedures and replacement of parts mentioned in this section should be performed only by skilled or instructed persons, as defined in section 1.11 on page 37. The access covers on the robot are not interlocked – turn off disconnect power if covers have to be removed.

9.2 Checking of Safety Systems

Every Six Months

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

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

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

9.3 Checking Robot Mounting Bolts and Leveling

Check the tightness of the base mounting bolts every 6 months. Tighten to 85 N•m (50 ft-lb). Also check the tightness of all cover plate screws and all the captive screws of the cables.

9.4 Lubricate Joint 3 Ball Screw

Required Grease for the Adept Cobra Robot

Ball Screw/Spline Assembly Grease

LG-2 Lubricating Grease
Lithium Soap, Synthetic Hydrocarbon

Adept part number: 85139-00002

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

Manufacturer's Safety Data Sheets (MSDS)

The manufacturer's safety data sheets for the greases used in the Adept Cobra robots are available from the Adept FAXback system at the numbers listed in "How Can I Get Help?" on page 39.

Procedure

1. Turn off main power to the controller and power chassis.
2. Using a Phillips screwdriver, remove the outer link cover by removing four screws on a Cobra 600 (six on the Cobra 800) located on the top and sides of the cover. Carefully lift the cover up (see Figure 9-1).
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 9-2).
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.

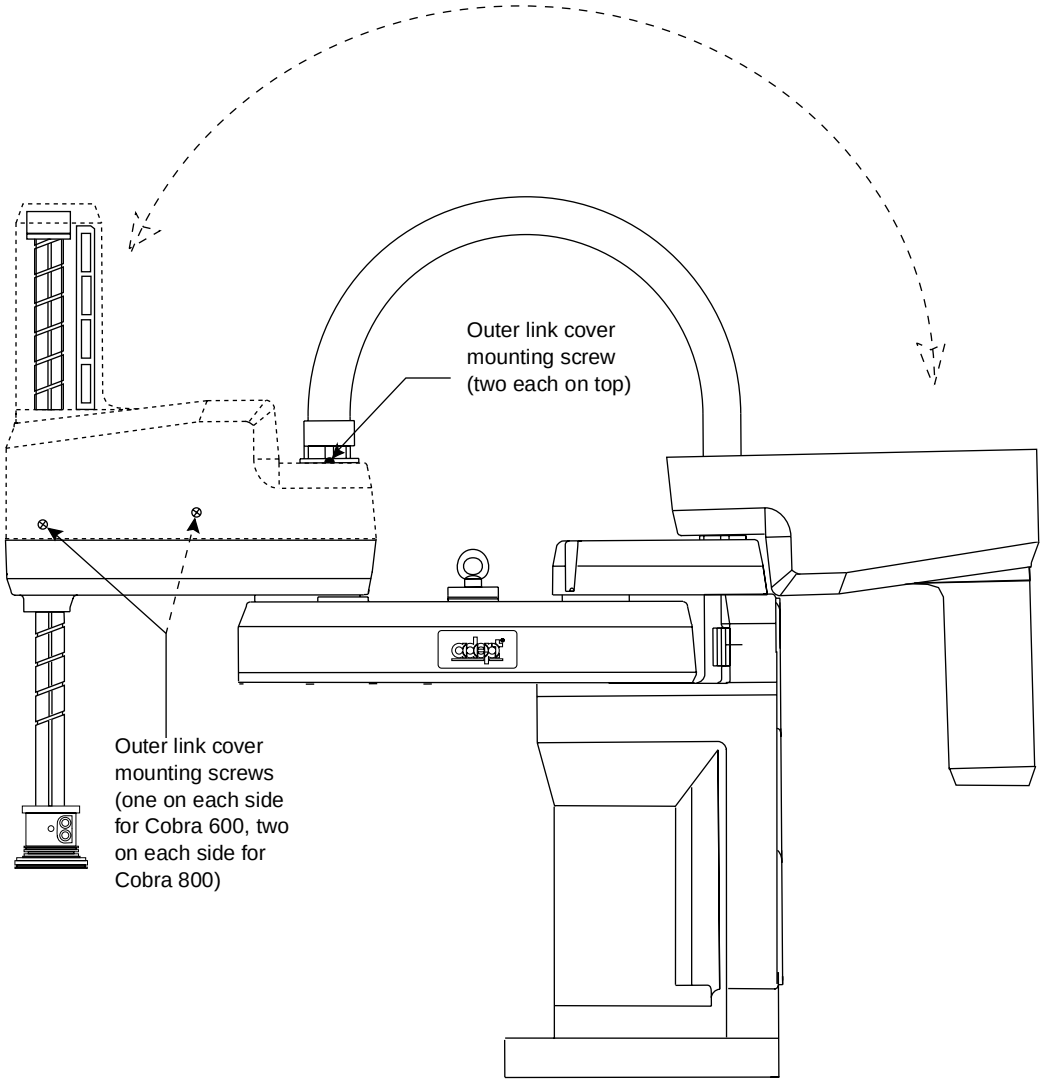


Figure 9-1. Outer Link Cover Removal

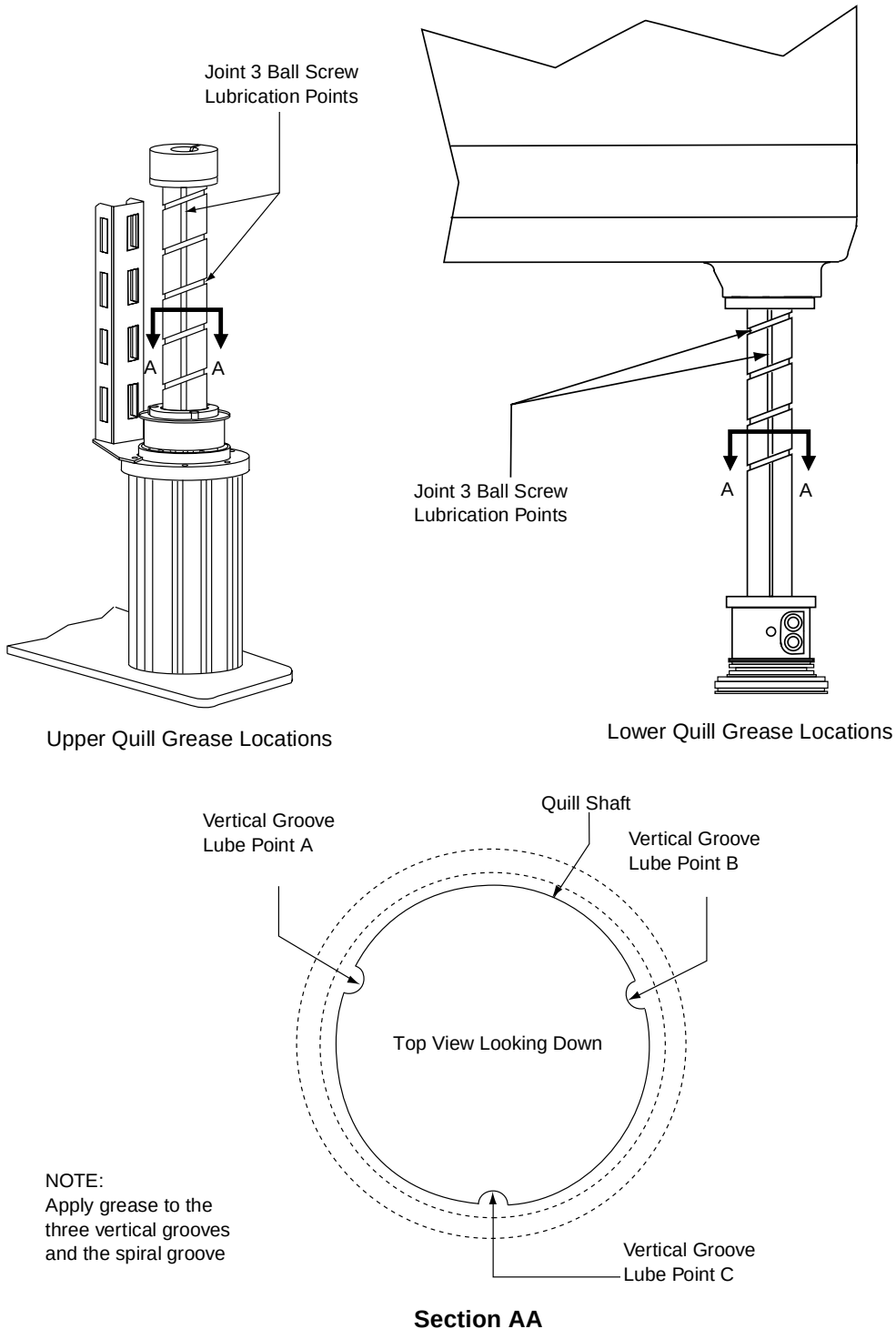


Figure 9-2. Lubrication of Joint 3 Ball Screw

9.5 Maintenance and Inspection of Air Filters

Adept PA-4 Power Chassis Fan Filter Inspection and Cleaning

The air filter located on the front of the chassis should be *inspected regularly and cleaned* at the first sign of dust or dirt buildup. The filter must be inspected and cleaned at least once per month. Regular cleaning will prolong the life of the filter. If the filter becomes clogged or unusable for any reason, order a new air filter. The PA-4 fan filter part number is 40330-11200.

WARNING: Dangerous voltages are present inside the power chassis. Turn off the power to the power chassis and protect it against an unauthorized return to service before opening the front grill to inspect the air filter. Failure to observe this warning could cause injury or damage to your equipment.

1. Turn off the power to the power chassis and protect it against an unauthorized return to service.
2. Open the front grill by loosening two screws and swinging the grill out.
3. Pull the air filter out and inspect for dust or dirt particles. If cleaning is required, use compressed air to clean the filter. (Follow all appropriate safety procedures regarding the use of compressed air.)
4. Replace the cleaned air filter and secure the grill.

Adept MV Controller Fan Filter Inspection and Cleaning

The air filter located on the front of the chassis should be inspected regularly and cleaned at the first sign of dust or dirt buildup. The filter must be inspected and cleaned at least once per month. Regular cleaning will prolong the life of the filter. If the filter becomes clogged or unusable for any reason, order a new air filter. The Adept MV controller fan filter part number is 40340-00030.

CAUTION: If the fan stops working or the filter becomes dirty, the controller could overheat and cause a thermal failure. This applies to all models of Adept MV controllers.

1. Turn off the controller.
2. Loosen the two screws on the fan filter cover to gain access to the filter.
3. Pull the air filter out and inspect for dust or dirt particles. If cleaning is required, use compressed air to clean the filter. (Follow all appropriate safety procedures regarding the use of compressed air.)
4. Replace the cleaned air filter and secure the filter holder.

9.6 Changing the Lamp on the CIP High Power Enable Switch

The system is equipped with circuitry to detect the potentially dangerous condition of a burned out CIP HIGH POWER push button/lamp. If this lamp is burned out, you cannot enable High Power until the lamp has been replaced. To replace the High Power indicator lamp:

1. Turn off the controller and disconnect system power.
2. Remove all cables from the back and side of the CIP.

WARNING: Make sure that the cables connected to JDIO1 through JDIO4 are properly labeled. The two input cables can be swapped and the two output cables can be swapped. This could result in a dangerous situation when you restart the controller.

3. Remove the CIP from its mounting location.
4. Remove the seven screws from the front of the CIP, including the MCP bypass plug retaining screw (see Figure 9-3).

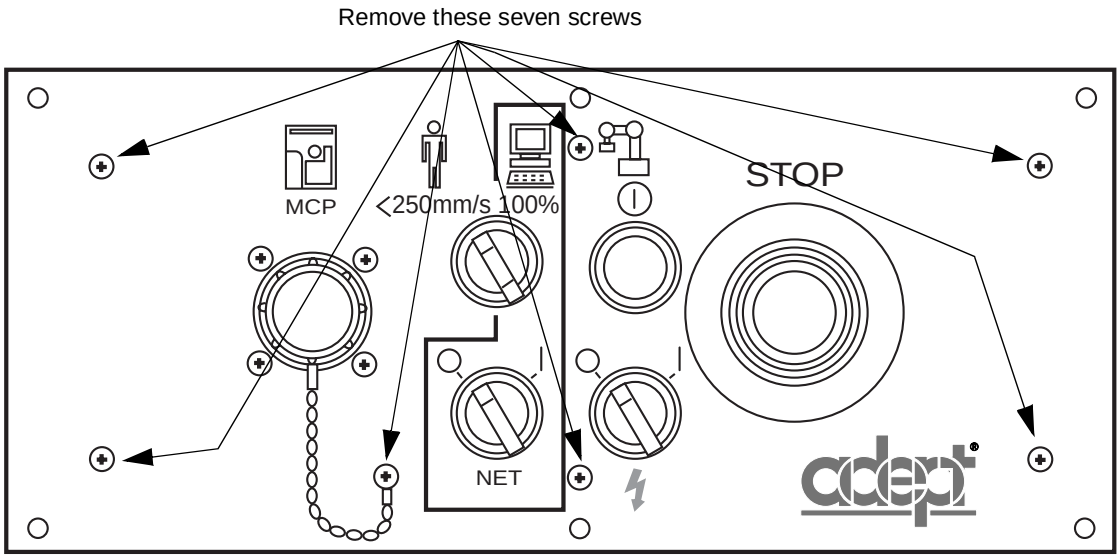


Figure 9-3. CIP Front Panel Screws

5. Carefully pull the front panel away from the body of the CIP. You will encounter considerable resistance as there are several plug-type connectors that you need to disconnect as you pull the front panel away from the body of the CIP. Pull the front panel as straight away as possible.
6. Locate the lamp body on the back side of the front panel. Turn the lamp body approximately 20 degrees (in either direction) and then pull the lamp body straight back.
7. Ensure that the lamp body is now free. Remove the old lamp and insert a new lamp (part number 27400-29006).

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 9-4).

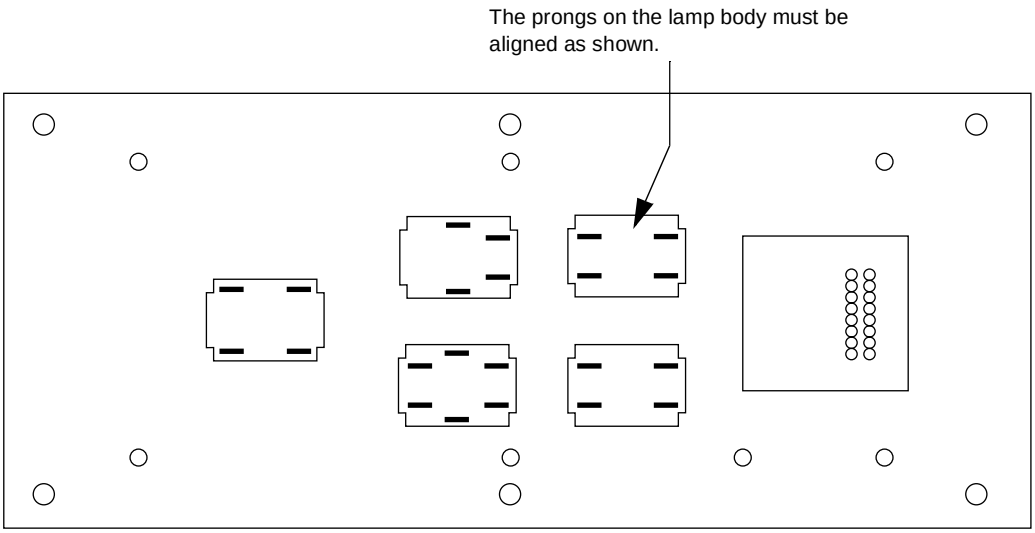


Figure 9-4. Lamp Body Contact Alignment

9. Push the CIP front panel into the CIP body, taking care to align all of the plug-type connectors.
10. Replace the six front panel screws and the MCP bypass plug retainer screw.
11. Reinstall the CIP in its mounting.
12. Reconnect the CIP cables. Ensure that the JDIO1 through JDIO4 cables are correctly reinstalled.

9.7 Controller Fuse Information

The two fuses (F1 and F2) at the power entry board on the front panel are for the incoming AC power lines. See Table 9-2 for ratings.

WARNING: Only skilled or instructed personnel should attempt to change any fuses. Always replace blown fuses with new fuses of the same type and rating.

To remove the fuse holder:

1. Turn off AC power to the controller and disconnect the power cord from the AC power source.
2. Remove the AC power cord from the socket on the power entry board.
3. To remove the fuse holder, insert a small flat-blade screwdriver into the slot between the fuse holder and the power cord socket, then lift up to release the fuse holder; see Figure 9-5. Spare fuses are stored in the sliding compartments.

4. To reinstall the fuse holder, insert it in place, then press down firmly until the entire holder snaps into position.

Table 9-2. Adept MV Controller Fuse Ratings

Fuse	Rating	Type
F1 – AC Line fuse at Power Entry board	5 AT/250 V	IEC 127-style 5 x 20 mm
F2 – AC Line fuse at Power Entry board	5 AT/250 V	IEC 127-style 5 x 20 mm

NOTE: The "T" suffix indicates the fuse response time; a 5 AT fuse rating specifies a 5 amp "slow blow" type.

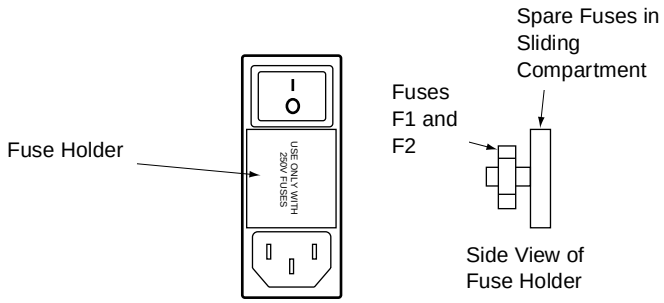


Figure 9-5. Adept MV Controller Fuse Holder

9.8 PA-4 Power Chassis Circuit Breaker and Fuse Information

NOTE: The SSER, LVON, HPON, and ILMT labels on the lower right corner of the front of the power chassis are for diagnostic LEDs that can be viewed behind the front grill. These LEDs are for Adept Field Service use only.

Chassis Circuit Breaker

The power chassis circuit breaker is rated at 15A, and is located on the lower-left front of the chassis, on the power entry module. It also functions as an on/off switch to isolate the chassis.

CAUTION: If the circuit breaker trips due to current overload, it indicates an internal fault. Do not reset the circuit breaker yourself: Contact Adept Customer Service (see section 1.18 on page 39 for details on contacting Adept).

Chassis and Amplifier Module Fuses

Six chassis fuses are located inside the base of the power chassis on the power control board. These fuses are not user-replaceable. If you suspect that a chassis fuse may have blown, contact Customer Service.

In addition to the fuses in the power chassis, there are additional fuses located inside the power amplifier modules. The amplifier fuses are not user-replaceable. If you suspect that an amplifier fuse may have blown, contact Customer Service.

CAUTION: Failure of a chassis or an amplifier fuse indicates an internal circuit fault which must be corrected before the fuse is replaced. Do not attempt to replace the fuse yourself: Contact Adept Customer Service (see section 1.18 on page 39 for details on contacting Adept).

Removing and Installing Amplifier Modules

The Adept PA-4 power chassis is shipped from the factory with the amplifier modules installed in the chassis. Any unused slots are filled with blank covers. Normally, you will not need to remove the amplifier modules. If you do need to remove and reinstall a module, follow the instructions below. The four slots in the chassis are not interchangeable: Some slots have special control signals. The amplifier modules are factory-installed in the correct slots. Contact Adept Customer Service if you need to relocate any modules (see section 1.18 on page 39 for details on contacting Adept).

WARNING: Do not attempt to install or remove any amplifier modules without first turning off the power to the power chassis and all related external power supplies. Failure to observe this warning could cause injury or damage to your equipment.

Removing Amplifier Modules

1. Turn off the PA-4 power chassis and the Adept MV controller.
2. Note the location of any cables connected to the module, then disconnect them.
3. Loosen the captive screws at the top and bottom of the module.
4. Using both the top handle and bottom handle, pull the module straight out of the chassis. Remove the module from the chassis and store it in a safe place.

CAUTION: Do not expose the amplifier modules to electrostatic discharge (ESD) while you are handling or storing them. Adept recommends using an antistatic ground strap on your wrist when handling modules.

Installing Amplifier Modules

1. Turn off the PA-4 power chassis and the Adept MV controller.
2. If the slot has a blank panel installed, loosen the captive screws at the top and bottom of the panel and remove it.
3. Verify that the intended slot for the module is ready to accept the module.

4. Align the module with the card guide slots at the top and bottom of the card cage. Slide the module in slowly. Apply straight-forward pressure to the top and bottom handles until it is firmly seated in the rear power connector, and the face of the module is flush with the other modules.
5. Do not use excessive pressure or force to engage the connector. If the board does not properly connect with the rear power connector, remove the module and inspect the connector and guide slots for possible damage or obstructions.
6. Tighten the captive screws at the top and bottom of the module.

WARNING: There is an interlock circuit that prevents enabling power if the amp module screws are not tightened securely. This also applies to any blank panel cover(s). There are dangerous voltages present inside the power chassis. Do not attempt to operate without blank panel cover(s) installed in any unused slots.

9.9 Spare Parts List: MV-5/MV-10

Part numbers and specifications are subject to change. Contact Adept Customer Service for ordering information for items in Table 9-3, or for items not listed (see section 1.18 on page 39).

Table 9-3. Controller Spare Parts List From Adept

Description	Adept Part Number	Quantity	General Comments
Fan Filter	40340-00030	1	
Front Panel Bypass plug	10330-01040	1	Users can build their own; see the *Adept MV Controller User's Guide* for details
E-Stop test plug, for JSIO port on CIP	10330-01075	1	
High Power lamp on CIP	27400-29006	1	

Table 9-4. Controller Spare Parts List From Third Parties[a]

Description	Specification	Quantity	General Comments
Fuse F1	5 AT/250V, 5x20mm, IEC 127 style	1	AC line fuse at power entry board.
Fuse F2	5 AT/250V, 5x20mm, IEC 127 style	1	AC line fuse at power entry board.

[a] These items are not available from Adept.

9.10 Spare Parts List: PA-4 Amplifier Chassis

Part numbers and specifications are subject to change. Contact Adept Customer Service for ordering information for items in Table 9-5.

Table 9-5. PA-4 Spare Parts List

Description	Adept Part Number	Quantity	General Comments
Fan Filter	40330-11200	1	

9.11 Spare Parts List: Cobra 600/800 Robot

Part numbers and specifications are subject to change. Contact Adept Customer Service for ordering information for items in Table 9-6, or for items not listed.

Table 9-6. Cobra 600/800 Robot Spare Parts List

Description	Adept Part Number	Quantity	General Comments
LG 2 Lubricating Grease	85139-00002	5.0 gram	Do Not Substitute

Technical Specifications 10

10.1 Dimension Drawings

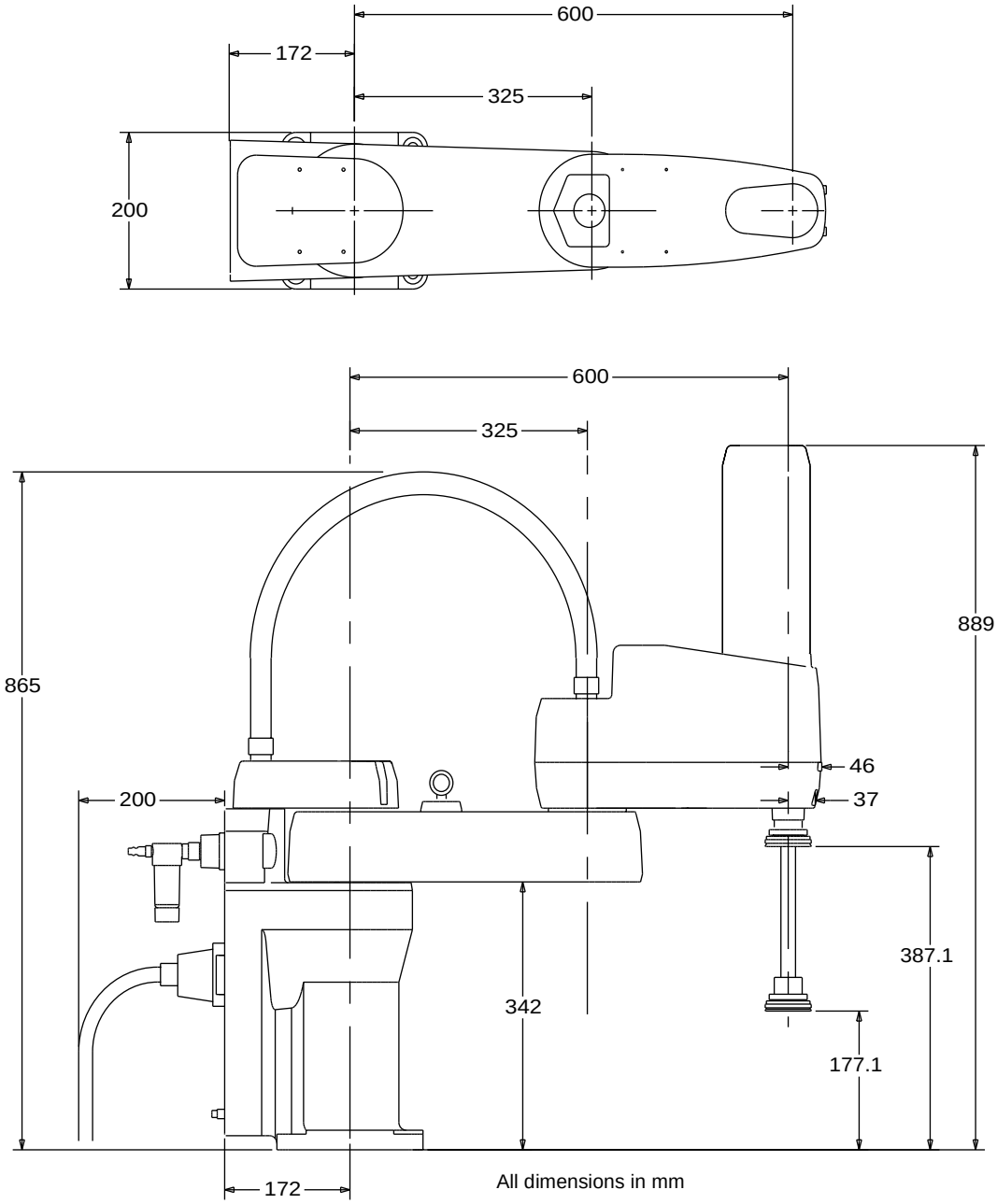


Figure 10-1. Adept Cobra 600 Robot Top and Side Dimensions

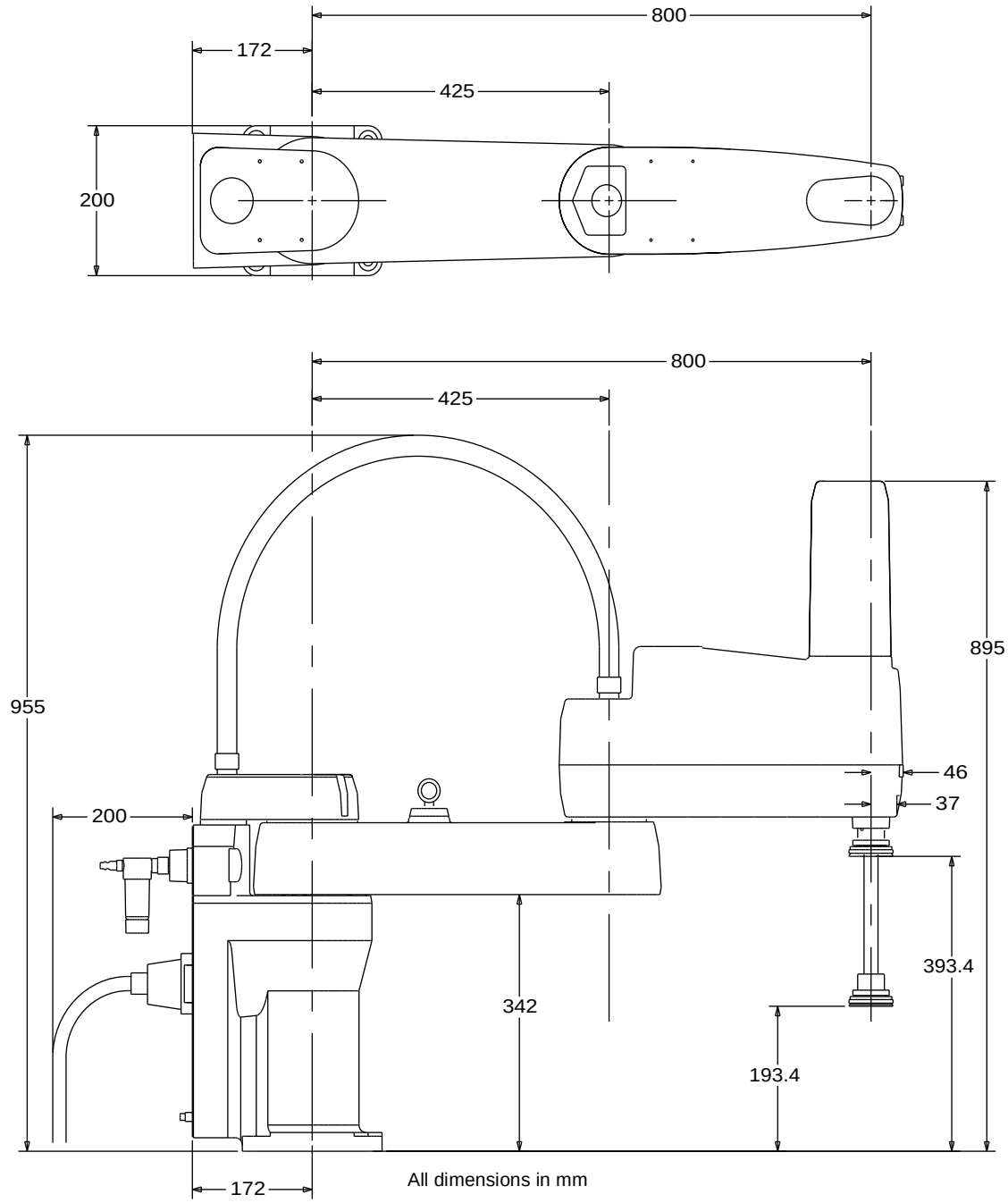


Figure 10-2. Adept Cobra 800 Robot Top and Side Dimensions

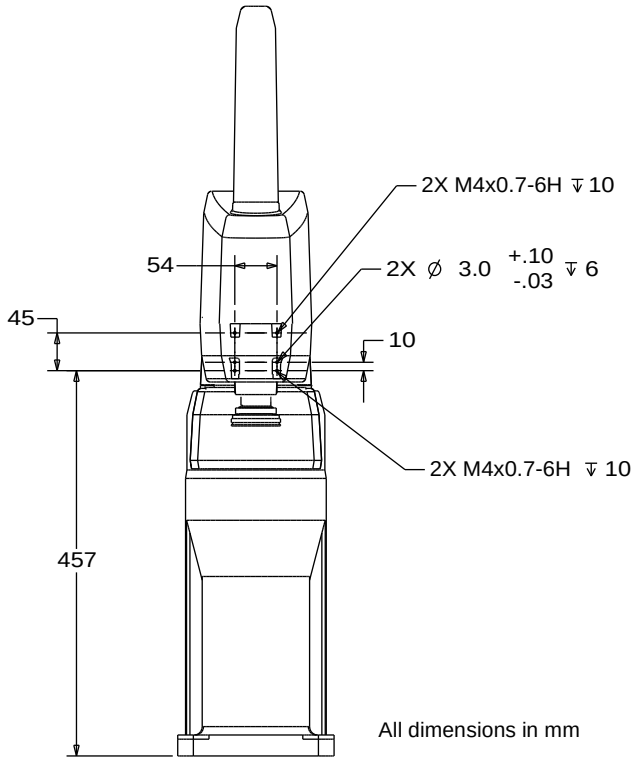


Figure 10-3. Dimensions of the Camera Bracket Mounting Pattern

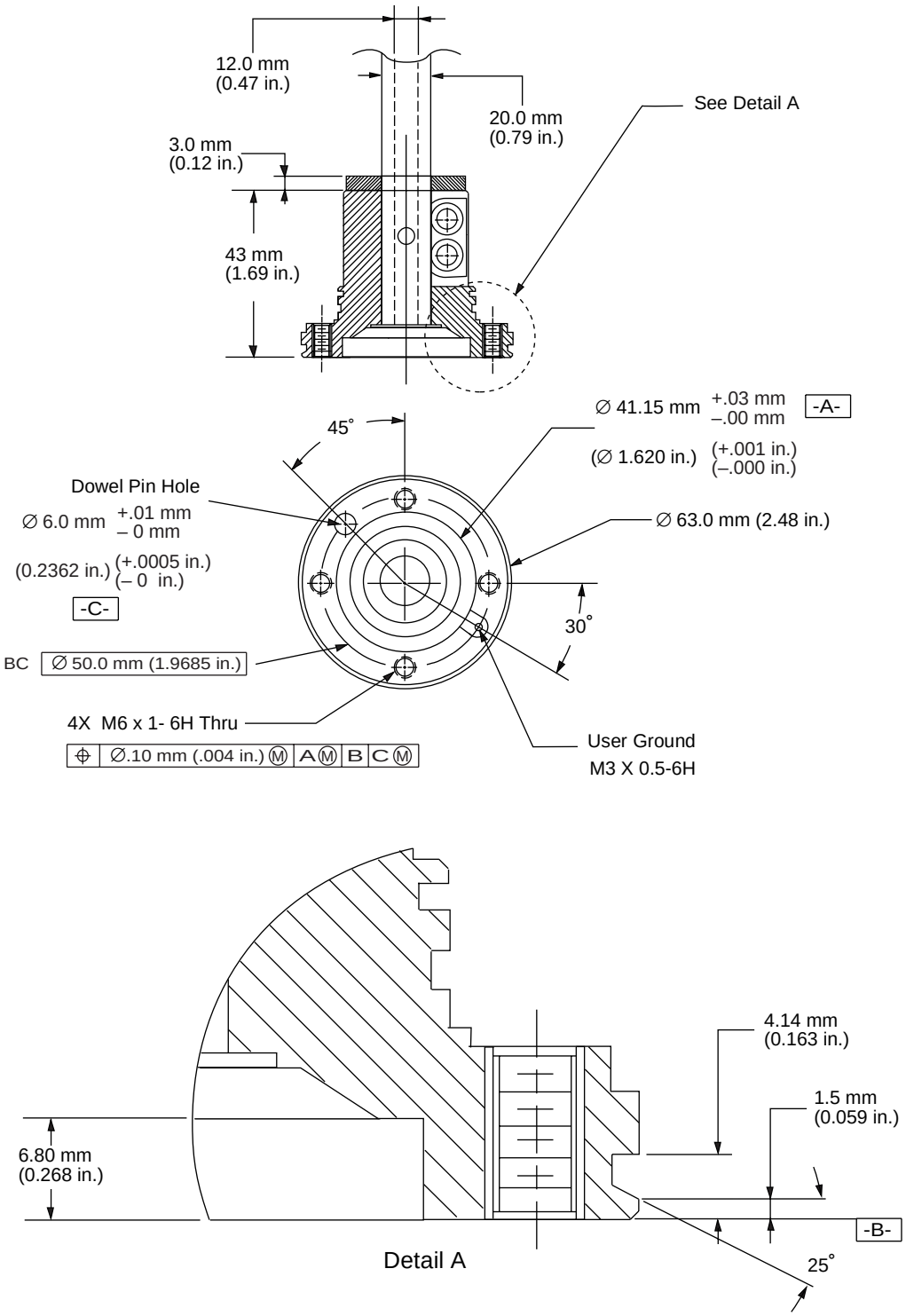


Figure 10-4. Tool Flange Dimensions for Adept Cobra Robots

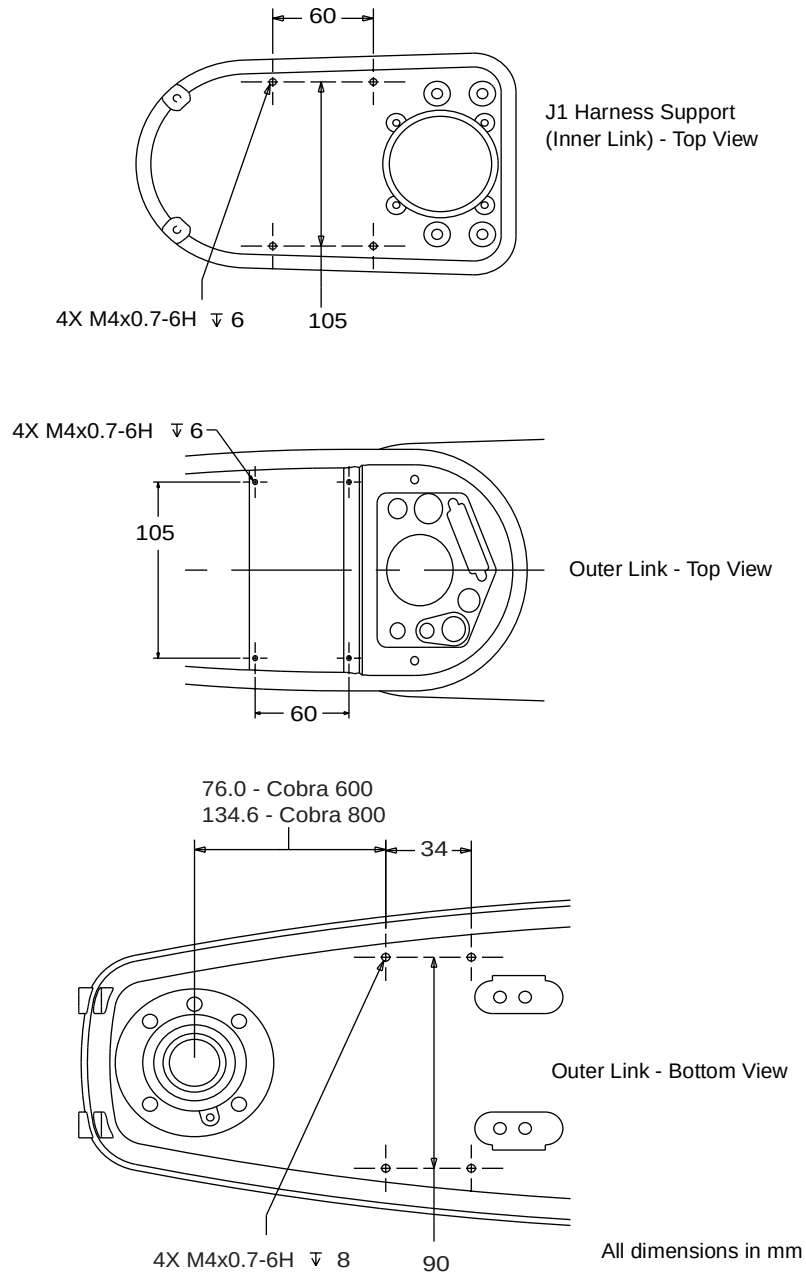


Figure 10-5. Locations for Mounting External Tooling on Robot Arm

Dimensions of the Adept MV-10 and Adept MV-5 Controllers

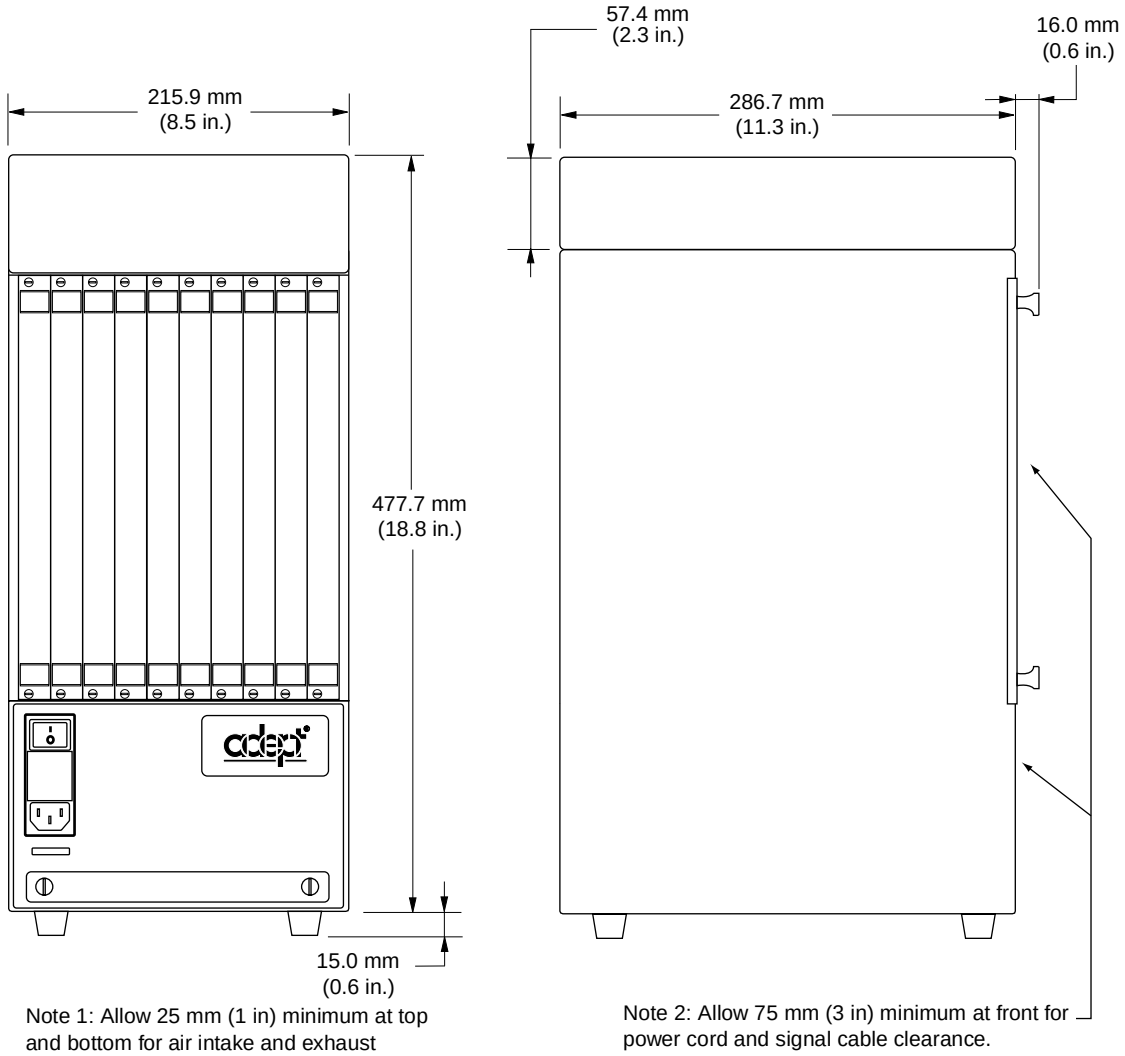


Figure 10-6. Adept MV-10 and Adept MV-5 Controller Dimensions

Dimensions of the Adept PA-4 Power Chassis and Compact Controller

Note: dimensions for the Adept Compact Controller are the same as the Adept PA-4 Power Chassis.

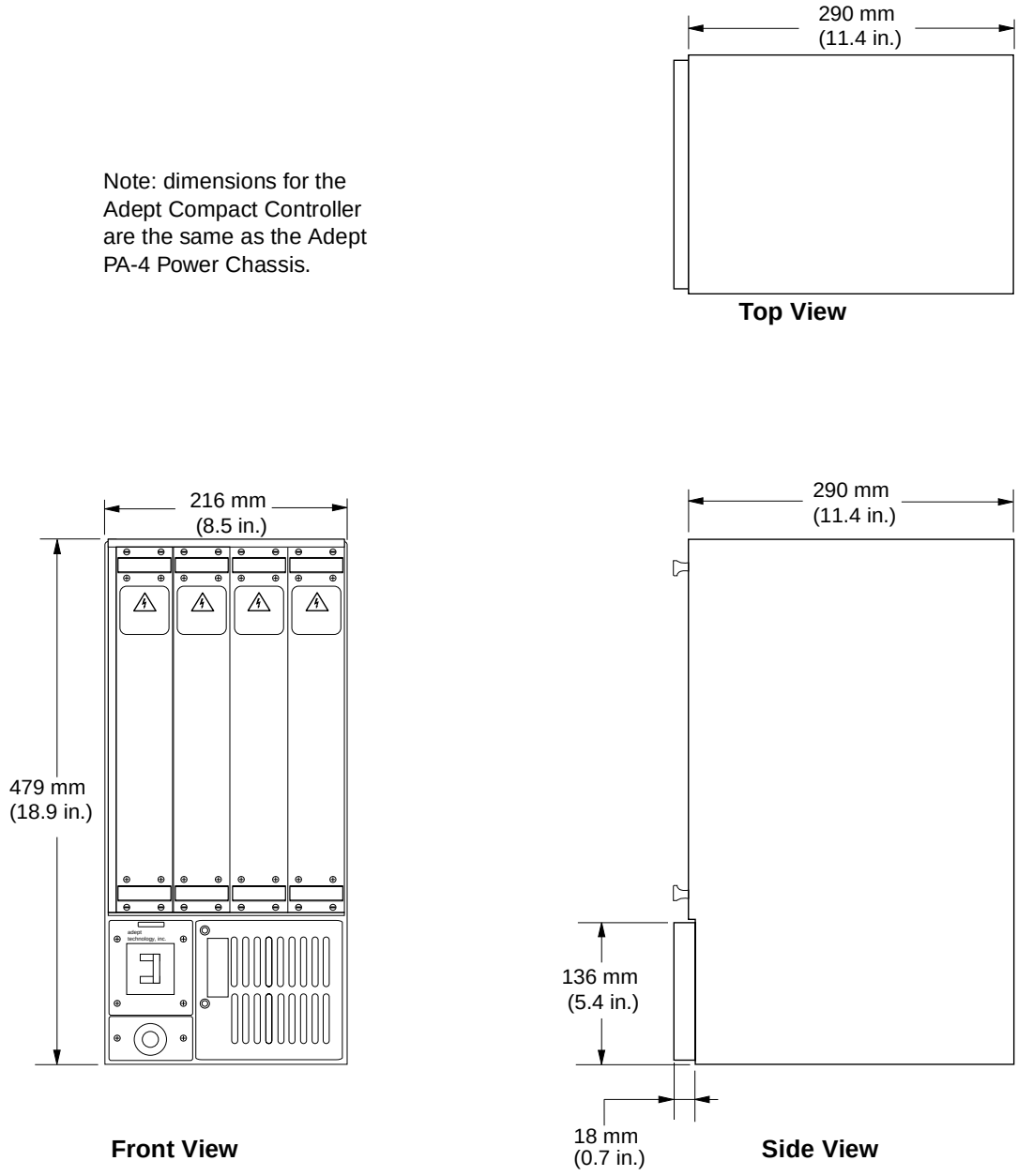


Figure 10-7. Adept PA-4 Power Chassis Dimensions

Dimensions of the Controller Interface Panel (CIP)

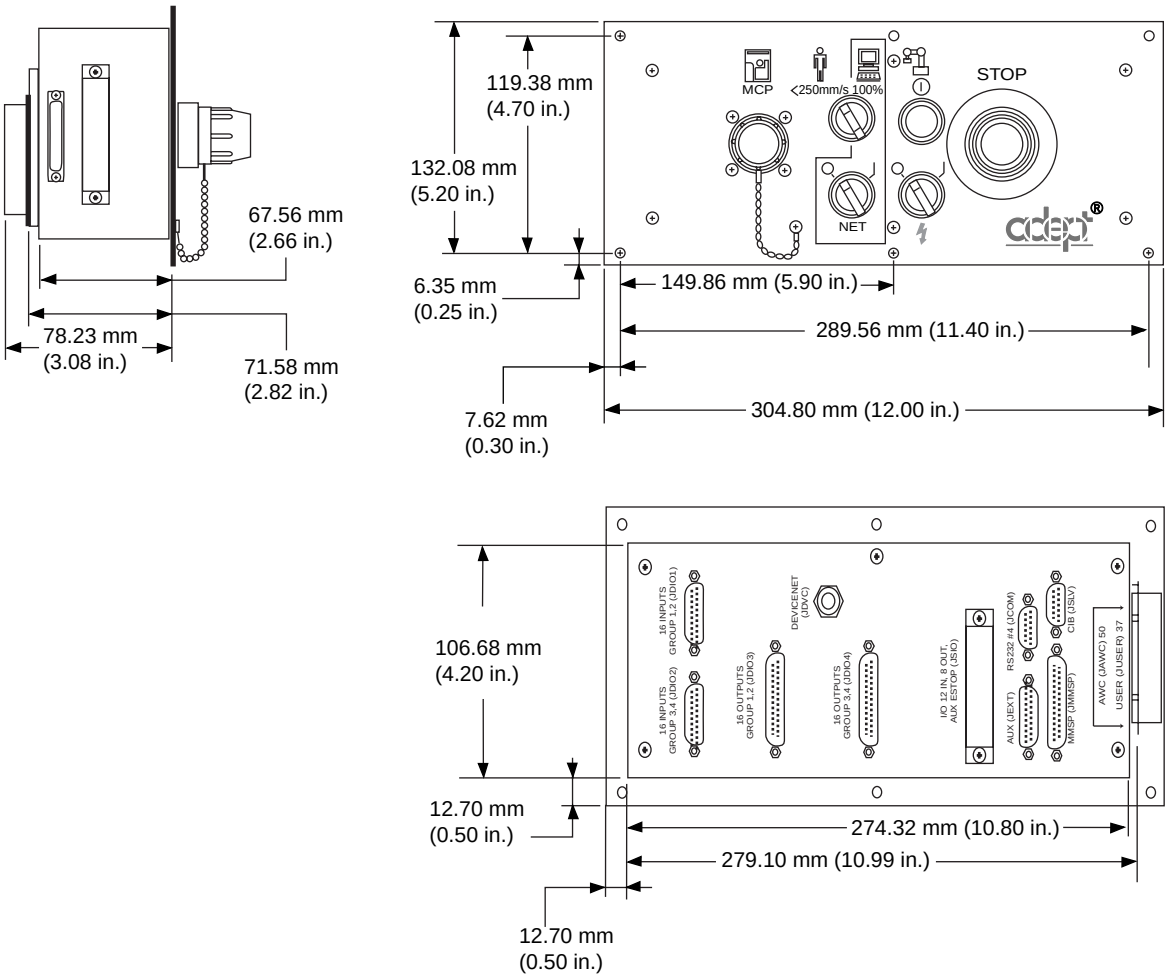
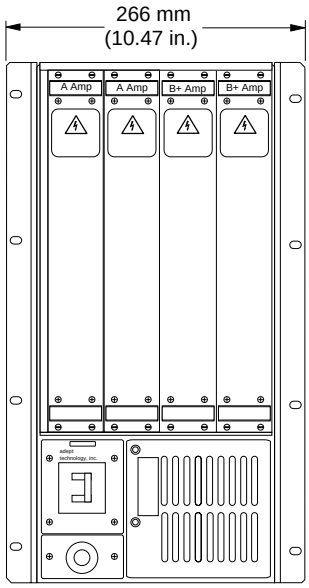
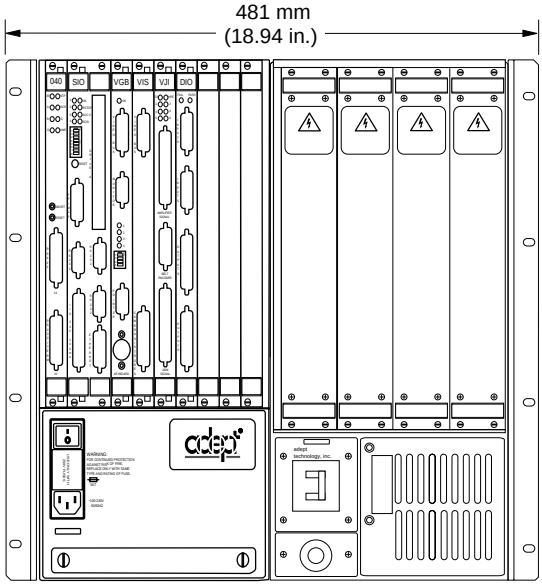


Figure 10-8. Adept Controller Interface Panel (CIP) Dimensions

Dimensions of the Controller and PA-4 Mounting Brackets



Power Chassis With Mounting Brackets Installed



Controller and Power Chassis With Mounting Brackets Installed

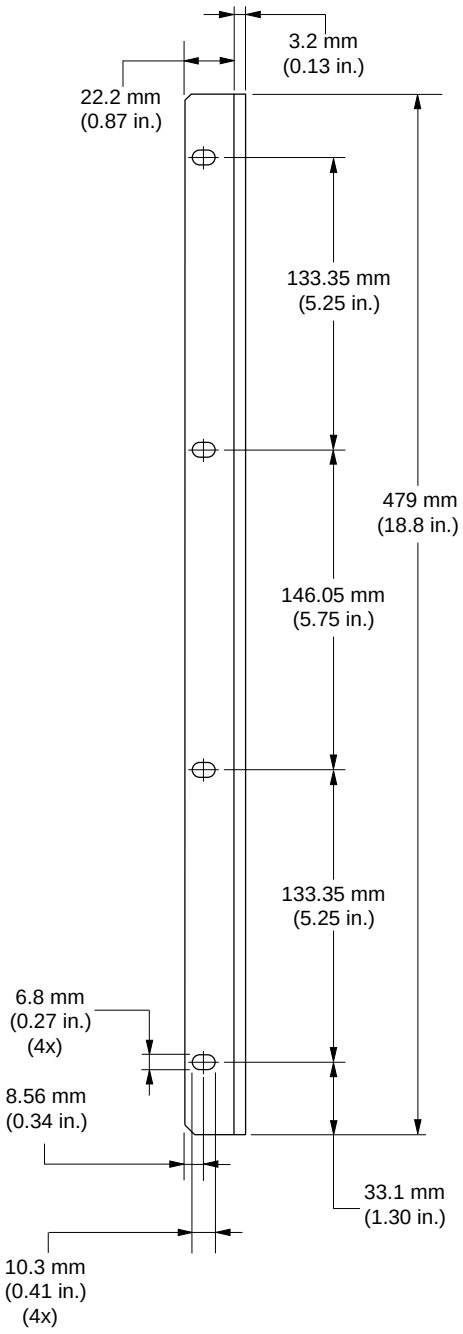


Figure 10-9. Controller and PA-4 Dimensions With Mounting Brackets Installed

Dimensions of the Manual Control Pendant (MCP)

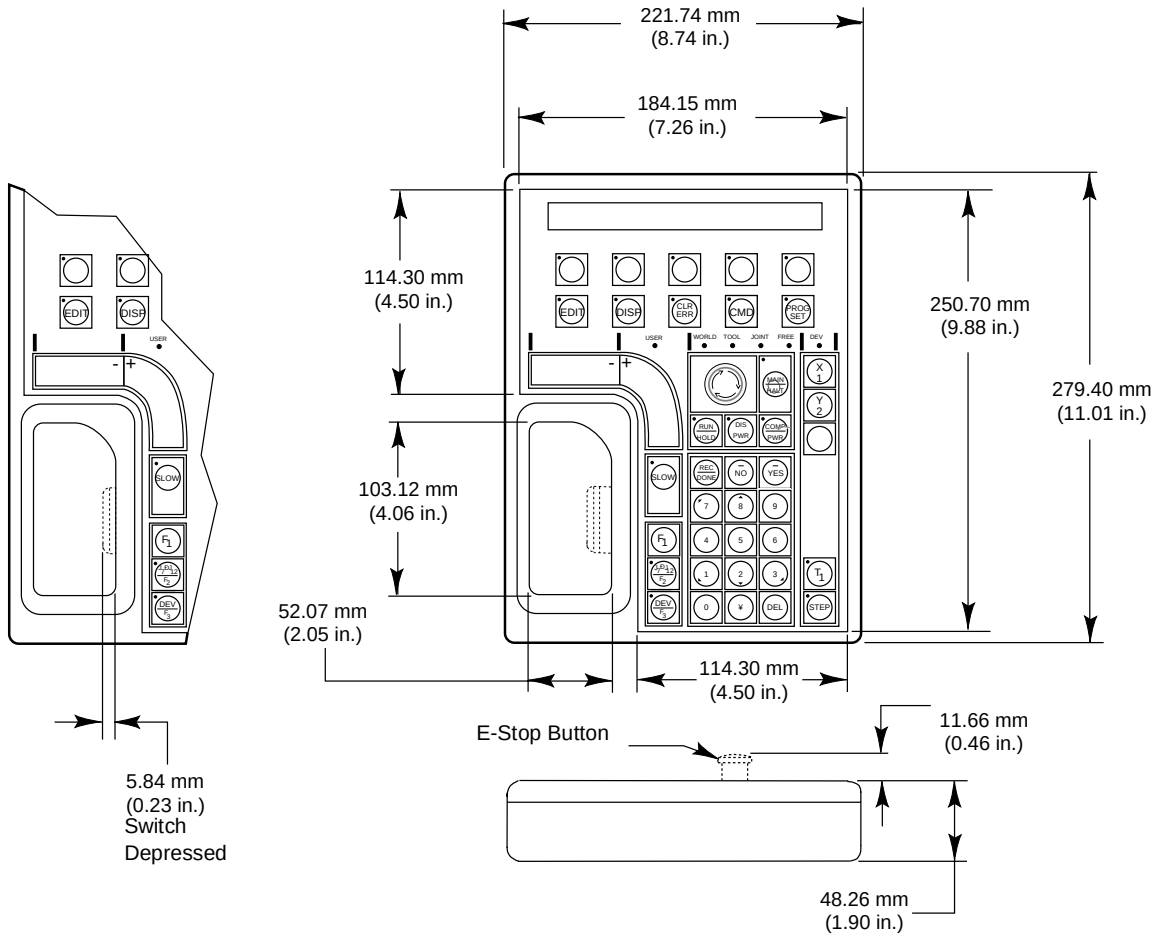


Figure 10-10. Manual Control Pendant (MCP) Dimensions

Dimensions of the MCP Cradle

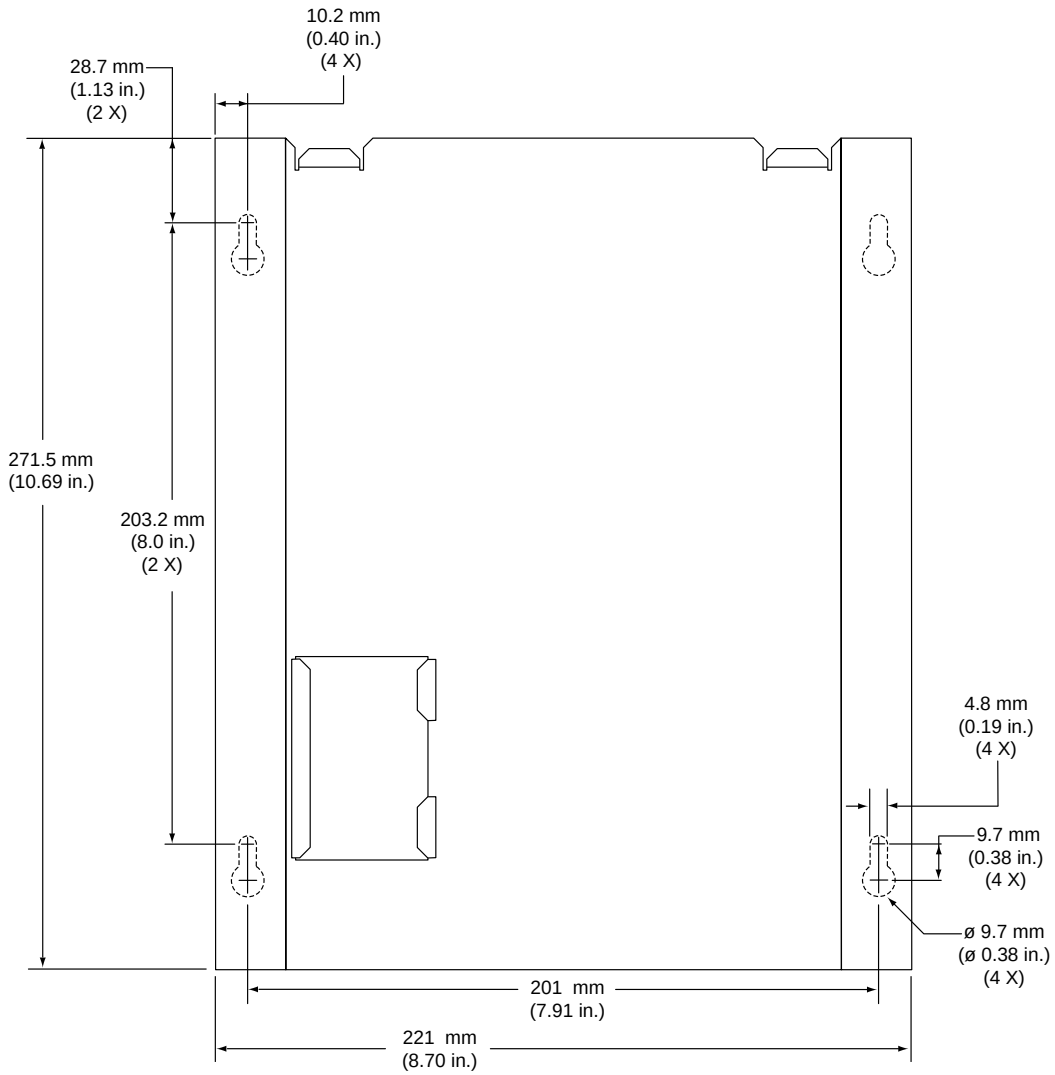


Figure 10-11. MCP Cradle Dimensions

10.2 Joint Motions

Adept Cobra 600 Robot Working Envelope

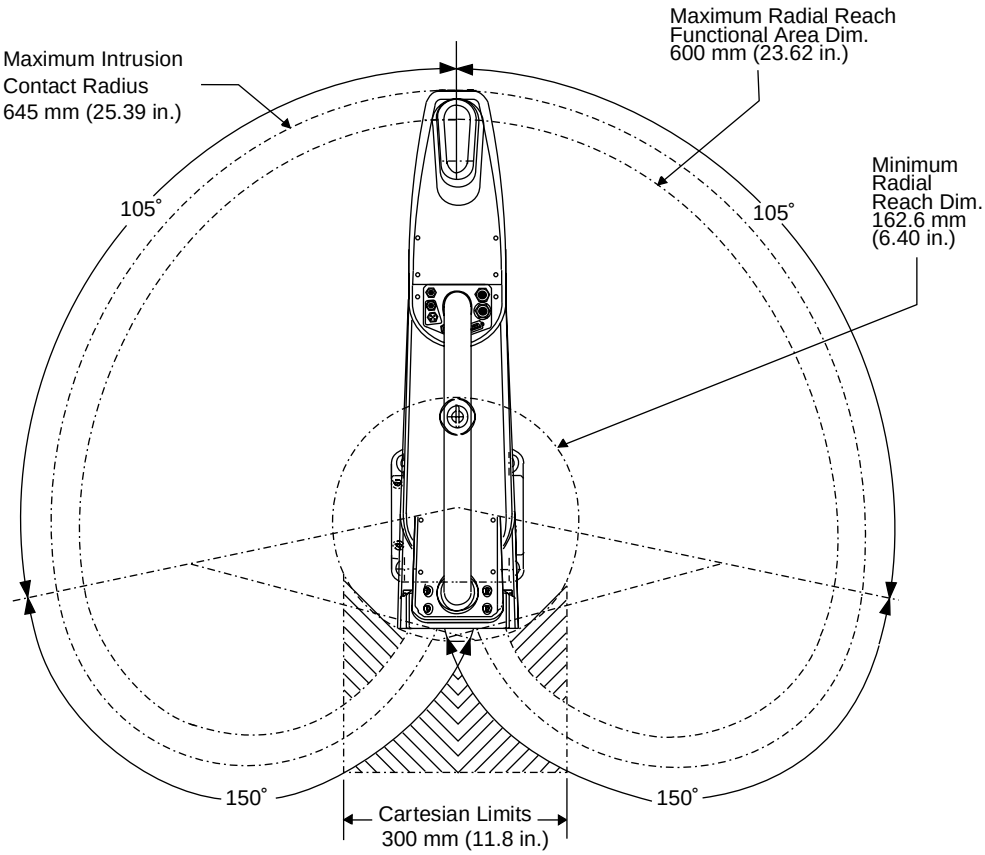


Figure 10-12. Adept Cobra 600 Robot Working Envelope

Adept Cobra 800 Working Envelope

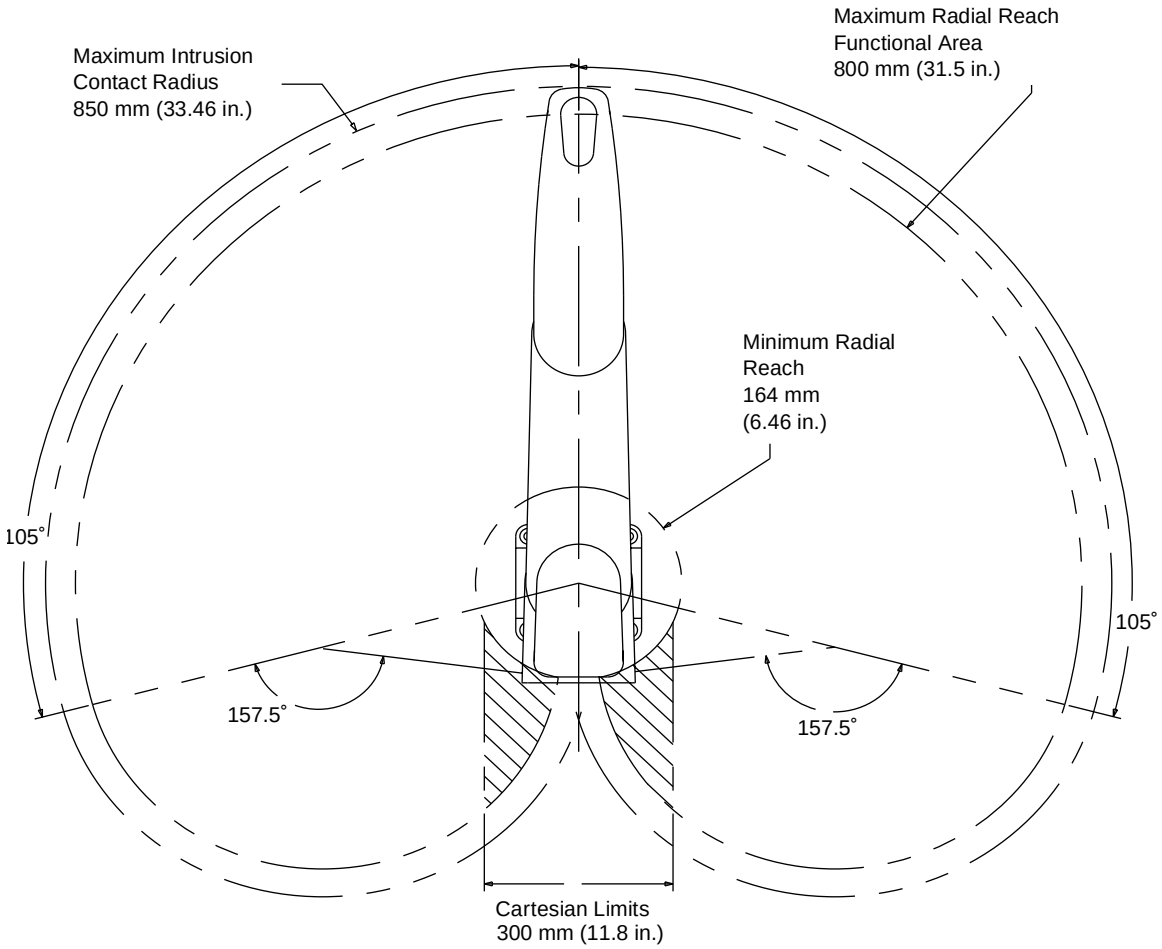


Figure 10-13. Adept Cobra 800 Robot Working Envelope

Joint 1

Joint 1, also referred to as the shoulder, provides rotation of the inner link. Joint 1 motion is limited to ±105° (see Figure 10-14).

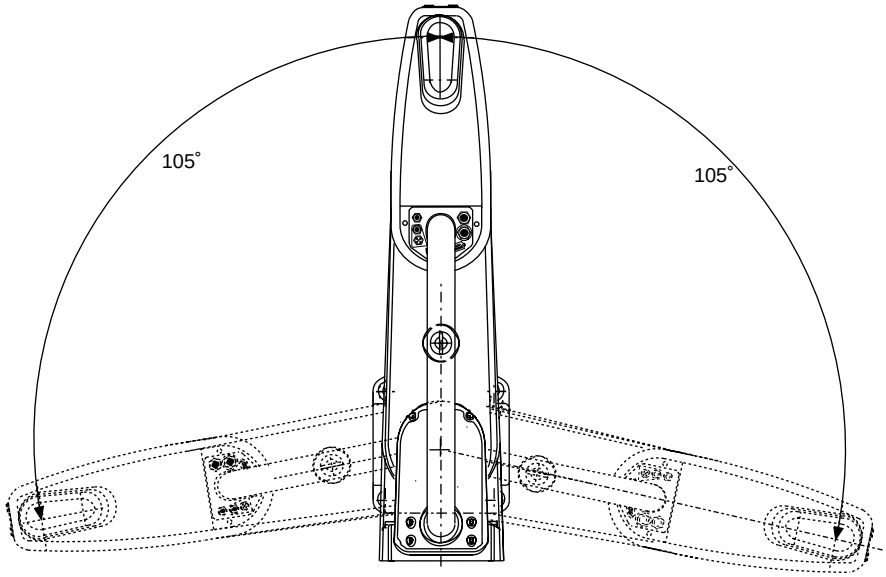


Figure 10-14. Joint 1 Motion

Joint 2

Joint 2, also referred to as the elbow, provides rotation of the outer link. Joint 2 motion is limited to ±150° in the Cobra 600, and ±157.5° in the Cobra 800. Joint 2's motion is similar to an elbow capable of acting in both left-hand and right-hand configurations (see Figure 10-15 on page 191).

When you teach a robot location, the robot elbow (when viewed from the back of the robot) will be pointing either to the left or right. These arm orientations are referred to as "Lefty" and "Righty." In Figure 10-15 on page 191, the dotted outline is in a lefty configuration and the solid outline is in a righty configuration. Under program control, the robot will always move to the next location in its current configuration (lefty or righty) unless the location is a "precision point" or the LEFTY or RIGHTY program instruction is used.

Cartesian Limits

There is a 300 mm-wide software-limited exclusion zone at the rear of the Adept Cobra robots (see Figure 10-12 on page 188 and Figure 10-13 on page 189).

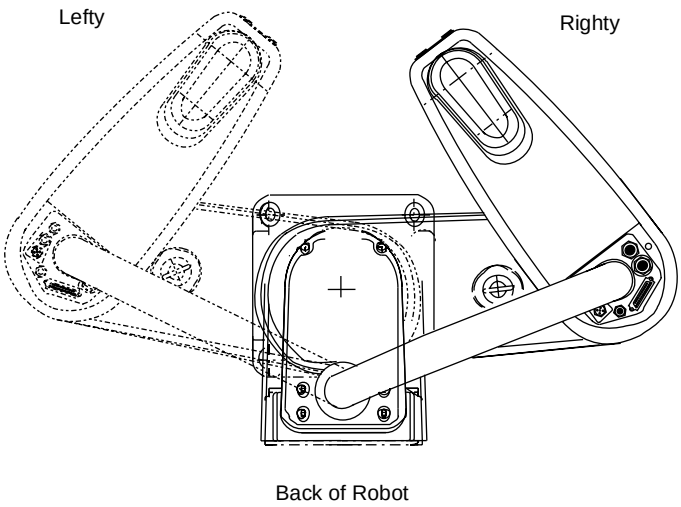


Figure 10-15. Joint 2 Motion and LEFTY/RIGHTY Configurations

Joint 3

Joint 3 provides vertical translation of the quill. Joint 3 drives the quill up and down with a maximum stroke of 210 mm (8.26 in.) for the Cobra 600 and 200 mm (7.87 in.) (see Figure 10-16).

Joint 4

Joint 4, also referred to as the wrist, provides for rotation of the quill. Joint 4 does not have hardstops, but software limits its motion to ±360° (see Figure 10-16).

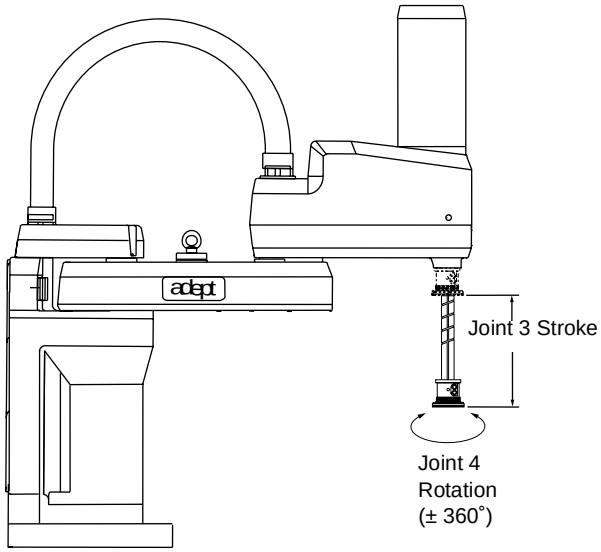


Figure 10-16. Joint 3 and Joint 4 Motions

10.3 Adept Cobra Robot Specifications

All specifications subject to change without notice.

Table 10-1. Adept Cobra Robot Specifications

Description	Cobra 600	Cobra 800
Reach		
Maximum radial	600 mm (23.6 in.)	800 mm (31.5 in.)
Minimum radial	163 mm (6.4 in.)	164 mm (6.4 in.)
Vertical clearance (bottom of base to end of quill) • with maximum joint 3 retraction • with maximum joint 3 extension	 387 mm (15.2 in.) 177 mm (6.9 in.)	 393.4 mm (15.49 in.) 193.4 mm (7.61 in.)
Vertical Stroke		
Joint 3 (Z direction)	210 mm (8.26 in.)	200 mm (7.87 in.)
Joint Rotation		
Joint 1	± 105°	± 105°
Joint 2	± 150°	± 157.5°
Joint 4	± 360°	± 360°
Payload (including end-effector and arm-mounted tooling)		
Rated	2.0 kg (4.4 lb)	2.0 kg (4.4 lb)
During operation (maximum)	5.5 kg (12.1 lb)	5.5 kg (12.1 lb)
External Payload on Outer Link Cover		
Maximum Payload	1.0 kg (2.2 lb)	1.0 kg (2.2 lb)
Inertia Load - about Joint 4 axis		
Rated	250 kg cm^2 (83 lb-in^2)	250 kg cm^2 (83 lb-in^2)
Maximum	450 kg cm^2 (150 lb-in^2)	450 kg cm^2 (150 lb-in^2)
Force		
Joint 3 downward force (nonimpact) without payload	25.0 kg (55.0 lb)	25.0 kg (55.0 lb)
Joint 3 sideways push force	See Table 10-2 on page 194.	
Burst Cycle Time		
0 Payload	0.47 seconds	0.52 seconds
2.0 kg (4.4 lb) Payload (Rated)	0.55 seconds	0.59 seconds
5.5 kg (12.1 lb) Payload (Maximum)	0.63 seconds	0.72 seconds
Sustained Cycle Time[a]		
0 Payload	0.56 seconds	0.59 seconds
2.0 kg (4.4 lb) Payload (Rated)	0.62 seconds	0.63 seconds
5.5 kg (12.1 lb) Payload (Maximum)	0.74 seconds	0.85 seconds

Table 10-1. Adept Cobra Robot Specifications (Continued)

Description	Cobra 600	Cobra 800
Resolution		
Joint 1	0.00045° per encoder count	0.00045° per encoder count
Joint 2	0.00072° per encoder count	0.00072° per encoder count
Joint 3 (vertical Z)	0.0015 mm per encoder count	0.0015 mm per encoder count
Joint 4 (tool rotation)	0.03125° per encoder count	0.03125° per encoder count
Repeatability (at constant temperature)		
X,Y plane	± 0.02 mm (±0.0008 in.)	± 0.02 mm (±0.0008 in.)
Joint 3 (vertical Z)	± 0.01 mm (± 0.0004 in.)	± 0.01 mm (± 0.0004 in.)
Joint 4 (rotational)	± 0.03°	± 0.03°
Maximum Joint Speed (with 2 kg [4.4 lb] payload)		
Joint 1	360°/sec	360°/sec
Joint 2	672°/sec	672°/sec
Joint 3	1100 mm/sec (43.3 in./sec)	1100 mm/sec (43.3 in./sec)
Joint 4	1200°/sec	1200°/sec
Weight		
Robot without options	approximately 34 kg (75 lb)	approximately 35 kg (77 lb)
Power chassis, with two amplifier modules	approximately 14.5 kg (32 lb)	approximately 14.5 kg (32 lb)
MV-10 controller, with AWC, SIO, VGB	approximately 14.5 kg (32 lb)	approximately 14.5 kg (32 lb)

[a] The robot tool performs continuous path, straight-line motions 25 mm (1 in.) up, 305 mm (12-in.) over, 25 mm (1 in.) down, and back along the same path. COARSE is enabled and BREAKs are used at each end location. Not achievable over all paths.

Table 10-2. Joint 3 Sideways Push Force

Joint 3 Extension (mm)[a]	Push Force (kg) Cobra 600	Push Force (kg) Cobra 800
0	28	28
25	23	23
50	19	19
75	17	17
100	15	15
125	13	13
150	12	12
175	11	11
200	10	10
225	9	9
250	9	9
275	8	8
300	8	8

[a] Joint 3 extension values include an extra 100 mm to account for user-supplied end-effectors.

Table 10-3. Softstop and Hardstop Specifications

Joint	Cobra 600		Cobra 800	
	Softstop	Hardstop – Approximate	Softstop	Hardstop – Approximate
Joint 1	± 105°	± 110°	± 105°	± 110°
Joint 2	± 150°	± 153°	± 157.5°	± 159°
Joint 3	0 to 210 mm (0 to 8.3 in.)	– 6 to 216 mm (– 0.2 to 8.5 in.)	0 to 200 mm (0 to 7.9 in.)	– 8 to 208 mm (– 0.4 to 8.3 in.)
Joint 4	± 360°	None	± 360°	None
Robot Base Cartesian Limit	± 150 mm (± 5.9 in.)	Not Applicable	± 150 mm (± 5.9 in.)	Not Applicable
Joint 3 zero position to mounting surface	387.1 mm (15.24 in.)	Not Applicable	393.4 mm (15.49 in.)	Not Applicable

10.4 Adept PA-4 Power Chassis Specifications

The following power consumption information is provided to allow customers to install adequate electrical wiring and power sources for worst case (short duration) demands of the Adept PA-4 power chassis. The typical values are for calculating air conditioning requirements.

Table 10-4. Power Consumption for PA-4 Power Chassis

Line Voltage		Typical	Worst Case
380-415 VAC, 50/60Hz, 3 phase[a]	Current (RMS)	8.5 amps/phase	20 amps/phase
	Watts	1.65 kW	3 kW
200-240 VAC, 50/60Hz, 3 phase	Current (RMS)	7.2 amps/phase	17 amps/phase
	Watts	1.65 kW	3 kW

[a] In the 380-415 VAC configuration, the Adept system draws current for a short duration during the positive peak voltage only.

EMC Test Information

Information on EMC testing of the Adept control system can be obtained from the FAXBack numbers listed in “How Can I Get Help?” on page 39.

Adept Cobra Robot Factory-Installed Options

A

A.1 Cobra 600/800 Clean Room Option

Introduction

The Adept Cobra Class 10 Clean Room Option is a modification to the standard Cobra 600 and 800 robots that certifies the robot to meet the Class 10 Airborne Particulate Cleanliness Limits as defined by Federal Standard 209E. This option is a factory-installed configuration.

Changes to the robot include the addition of a bellows assembly mounted at the joint 3 quill, fully sealed access covers, and a two-stage vacuum system to evacuate the arm. This vacuum system incorporates a compressed air vacuum generator mounted in the base of the robot to provide a high vacuum in the outer link and bellows area. An additional high flow rate vacuum source is required at the back panel to evacuate in the inner link and base.

Specifications

Table A-1. Adept Cobra Clean Room Robot Specifications

Airborne Particulate Cleanliness	Meets Class 10 Limits, Federal Standard 209E Certified by Dryden Engineering Co., Fremont, CA
Robot Performance Specification	Identical to Table 10-1 on page 192
Ambient Temperature Specification	5 - 35 degrees Celsius (41 - 95 degrees Fahrenheit) Reference Table 2-1 on page 42.

Requirements

Table A-2. Adept Cobra Clean Room Robot Requirements

Vacuum source	0.80 m^3/min (28 ft^3/min) minimum volumetric flow rate
	6 mm of water (0.2 inches of water) differential pressure measured between the robot and the vacuum source
	1-1/4 inch NPT male thread pipe fitting at the rear bulkhead panel
Compressed air source	Clean, dry, oil-free compressed air
	1.1 - 1.5 bar (16 - 22 psi)
	21 liters/minute (0.75 SCFM) flow rate
	Flow regulator not supplied
Quill inside diameter	The inside diameter of the quill must be plugged by the user's end-effector in order for sufficient vacuum to develop in the outer link.

Exclusions and Incompatibilities

Table A-3. Internally Mounted Hand Valves

Installation considerations	The internal air line normally used to supply the internally mounted hand valves (Adept Option Kit P/N 40560-12000) is instead used to provide vacuum to the bellows/outer link. One of the passive 6 mm user air lines would need to be used instead.
Performance considerations	The air exhausting from the internally mounted hand valves (Adept Option Kit P/N 40560-12000) may be of sufficient quantity/ quality to cause the robot to exceed Class 10 Particulate Limits.
Recommendation	For these reasons, Adept recommends mounting hand valves externally. A 1.0 m (40-in.) harness is provided with the Option Kit for this purpose.

Maintenance

Draining Moisture From the Compressed Air Filter

The air filter on the compressed air inlet, located on the back of the robot, has a moisture trap that should be emptied periodically, depending on the quality of the air supply and the frequency of use. The trap is emptied with the air supply connected. To empty the trap, use a rag to push up on the bottom of the air filter. The compressed air filter Adept part number is 42045-84020.

If you have to empty water from the filter housing frequently, check the water content in your compressed air supply and consider using an air dryer. Moisture inside the robot can cause damage to mechanical, electrical, and pneumatic components.

Bellows

Check the bellows, Adept P/N 40560-40340, periodically for cracks, wear, or damage. Replace bellows, if necessary. Refer to section 6.2 on page 97 for the user flange removal procedure.

Lubrication

The upper and lower quill requires lubrication in the same manner as the standard Cobra robot (see section 9.4 on page 166).

Dual Adept Cobra Robots B

B.1 Introduction

All of the information in this instruction handbook is applicable to the Dual Adept Cobra robot configuration. This appendix describes some additional considerations when working with this product.

Dual Adept Cobra Robot System Description

A Dual Adept Cobra robot system consists of the following components:

- Two standard Adept Cobra 600/800 robots, no modifications required
- An Adept MV-5 or MV-10 controller with two EJI modules installed
- One PA-4 power chassis with four amplifier modules
- Multiple Adept robots, License, and a V^+ Extensions License
- Two AWC Processors

B.2 Installation

The installation process for the system is the same as described in Chapter 3 and Chapter 4, except that there are two EJI modules in the Adept MV controller and four amplifier modules in a PA-4 power chassis.

VMEbus Address for VJI/EJI Module

If you purchased both Adept Cobra robots at the same time as part of a Dual Adept Cobra robot system, then the two EJI modules will be configured at the factory for the correct VMEbus address.

If you are upgrading or installing a second EJI as a replacement part, then you should check the EJI address setting to make sure it is configured correctly; it should be set as Servo Board 3 (see the EJI chapter in the *Adept MV Controller User's Guide* for the correct switch setting).

Adept PA-4 Power Chassis

Each Adept Cobra robot requires two C amplifier modules, resulting in a total of four amplifier modules per Dual Adept Cobra robot system (see Figure B-1 on page 202).

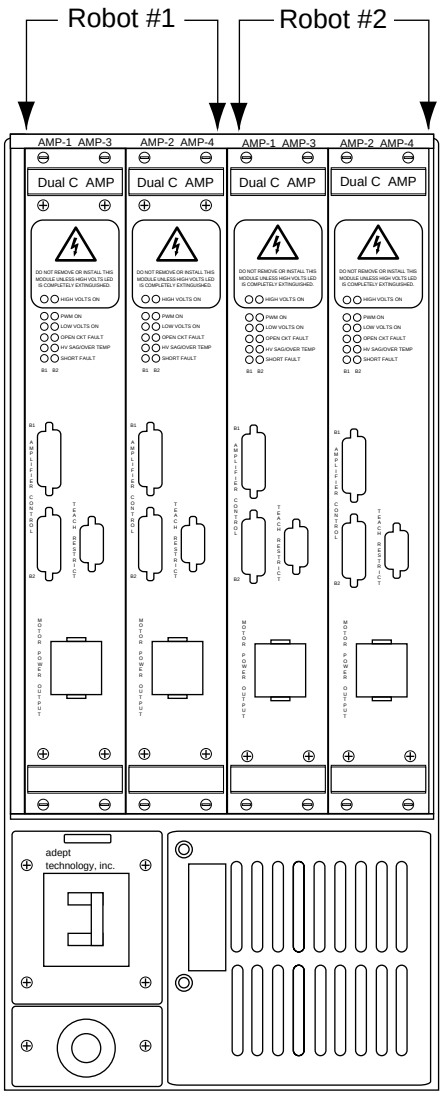


Figure B-1. Dual Robot System With Four Dual C Amplifier Modules

Cable Installation

The extra EJI module and two amplifier modules require additional cables that are shipped with the system. It is important to keep the cables organized and prevent cables from being interchanged by mistake. Table B-1 on page 203 shows a typical arrangement for cable assignments.

Table B-1. Robot-EJI-Amplifier Assignments in Dual Adept Cobra Robot System

Robot Number	EJI Module	Servo Board Dipswitch Setting on EJI	Amplifier Module
1	1 (Left)	1	1, 2
2	2 (Right)	3	3, 4

Make sure to clearly label or mark the cables so it will be obvious which robot they belong to, in case the cables have to be disconnected and reinstalled.

B.3 Operation With the Manual Control Pendant (MCP)

The optional MCP can be used to control either robot in a Dual Adept Cobra robot system. By default, the MCP controls robot 1. To switch to robot 2, press the DEV/F3 button on the MCP. The DEV LED turns on in this condition.

To switch back to robot 1, press the DEV/F3 button again. The DEV LED turns off.

See Chapter 8 for more information on using the MCP.

B.4 Programming Information

V+ Language Programming

By default, Task 0 is used to control robot 1. Task 1 is normally recommended for robot 2. Use the SELECT ROBOT=2 and ATTACH instructions in your program to select robot 2. See the *V+ Language User's Guide* and the *V+ Language Reference Guide* for more information on these instructions.

V+ Monitor Commands

By default, monitor commands such as HERE and WHERE apply to robot 1. Use the monitor command SELECT ROBOT=2 first when you need to display the location of robot 2.

> **NOTE:** The DISABLE POWER command shuts off high power to both robots in a Dual Adept Cobra robot system.

The CALIBRATE monitor command will calibrate both robots. Robot 1 will be calibrated first, then robot 2.

With single amp box dual system, you may disable only both robots. With two amp boxes, one for each robot, you may temporarily disable either robot and continue to use the other, by using the DISABLE ROBOT[ ] command. For example DISABLE ROBOT[2] will cause V^+ to ignore robot 2. If you issue this command before you use the CALIBRATE command, then only one robot will be calibrated. Robot 1 can be then used normally. To reenable robot 2, use the command ENABLE ROBOT[2].

B.5 Emergency Stop Circuit Shuts Off Both Robots

The Adept MV controller has many safety features, including the Emergency Stop circuit. These are designed to safely stop both robots simultaneously in the event of a problem. The Adept multirobot system is designed for multiple robots operating in the same workcell. Therefore, if one robot has a fault, the other robot will also be stopped. A brief message will be displayed, indicating the problem. The message will also state which joint(s) and which robot is affected. The most common system messages are described in the *V^+ Operating System User's Guide*. A full list of system messages with complete explanation and suggested user actions is in the *V^+ Language Reference Guide*.

Examples of faults that can be detected by the Adept control system are *Hard envelope error*, *Soft envelope error*, and *Motor stalled*. Any of these messages may mean that a robot has collided with an unexpected object in the workspace, therefore, both robots will be stopped.

The Emergency Stop signal will also stop both robots connected to the same controller. It is not possible to use the E-Stop signal to stop only one robot. The Emergency Stop switches on the Controller Interface Panel (CIP) and the Manual Control Pendant (MCP) shut off high power to both robots when the switch is pressed.

Troubleshooting C

C.1 Introduction

This chapter contains information about hardware failures, possible V+ error messages accompanying the failure, possible causes, and user actions that should correct the failure. These hardware failures are discussed in one of the following sections:

- Failures during system startup
- Failures accompanied by a V+ error message

NOTE: See the *V+ Language Reference Guide* for information on any V+ error message not described in this manual.

Troubleshooting V+ error messages without a monitor or terminal can be very difficult. When a failure occurs, a monitor should be installed on the system. If no monitor is available, the CIP keyswitch should be set to the "PENDANT" position after system startup. This will ensure that all possible V+ error messages are sent out to the Manual Control Pendant (MCP).

C.2 Failures During System Startup

When the controller power is turned on, the system powers up. The system startup firmware performs diagnostics, then the V+ operating system must be loaded from the disk. This loading process is called "booting" the system. If the operating system cannot be loaded, V+ will not run and an error message may be displayed by the system startup firmware.

If a load failure occurs on a system with no system terminal and the problem cannot be diagnosed, connect a terminal so that error messages can be seen on the screen.

If a failure occurs and no error message is displayed, diagnose the LED fault patterns on the system processor and SIO module.

V+ Operating System Will not Load

Possible Causes

1. There is no V+ operating system disk in the A: drive or the V+ operating system does not exist on the C: drive.
2. The disk in the A: drive does not contain the V+ operating system, has been corrupted, or is not compatible with this system's hardware configuration.
3. SIO or disk drive failure.

4. System processor failure or invalid configuration.
5. The disk drives are not receiving +5VDC (2-slot SIO).

User Actions

1. Place a V+ operating system disk in the A:drive or copy the operating system to the C: drive and try again.
2. Load the V+ operating system from a floppy disk that is known to be good.
3. Test the SIO module and disk drives; replace if necessary.
4. Test the system processor and replace if necessary.
5. Test the DC power supply and replace if necessary.

C.3 Failures Accompanied by a V+ Error Message

This section contains descriptions of some failures that occur after the SIO or AWC module successfully loads the V+ operating system and that are accompanied by a V+ error message. The errors described in this section are listed alphabetically. The V+ error code for each error is shown to the right.

Robot not calibrated (–605)

Explanation

An attempt has been made to execute a robot-control program when the robot is not calibrated. No motion is allowed until the robot is calibrated.

Possible Causes

1. The CALIBRATE program has not been executed.
2. Joint encoder failure.

User Actions

1. Issue a CALIBRATE command or have your monitor command program execute a CALIBRATE instruction.
2. Enable the DRY.RUN switch to allow program execution without using the robot.

External E-STOP (–608)

Explanation

A system panic line is open.

Possible Causes

1. The panic button on the Manual Control Pendant (MCP) or the CIP external front panel has been pressed.
2. The Remote E-Stop's (Remote Arm Power OFF) external panic circuit has been interrupted.

User Actions

1. Ensure that the panic buttons are reset (pulled out), then attempt to enable HIGH POWER to the robot.
2. Make sure the external panic circuit is wired correctly.
3. Swap out the SIO module and replace if necessary.

Obstacle collision detected (–901)

Explanation

A possible or actual collision has been detected between the robot and any statically defined obstacles. Obstacles may include fixed objects in the workcell, as well as structural elements of the robot, such as its base.

Possible Causes

1. For application programs, this error may indicate that either the planned end point of the motion will collide with an object or that a collision has been detected in the middle of a straight-line motion.

User Actions

1. Move the robot away from the obstacle and continue the motion, or modify the executing application program to avoid the obstacle and reexecute the program.

Soft envelope error (–1006)

Explanation

The indicated joint was not tracking its commanded position with sufficient accuracy.

Possible Causes

1. The robot's speed or acceleration is set too high.
2. The robot may have hit an object.
3. VJI or EJI module failure.

User Actions

1. Remove any obstacles in the robot's path.
2. Reduce the V^+ monitor speed or acceleration and/or program speed. Other parameters may also be adjusted to optimize robot speed while avoiding envelope errors. See the *V^+ Language Reference Guide* for more information concerning the SPEED and ACCEL keywords.
3. Put the robot in FREE mode and move the necessary joints to ensure there is no binding.
4. Test the encoder and replace if necessary.
5. Test the motor and replace if necessary.
6. Test the amplifier and replace if necessary.
7. Swap out the VJI or EJI module and replace if necessary.

8. If problem persists, contact Adept Customer Service. See "How Can I Get Help?" on page 39.

Encoder quadrature error Mtr n (–1008)

Explanation

The position encoder signal from the specified joint is sending information that is phased incorrectly.

The robot cannot move until a CALIBRATE monitor command is issued.

Possible Causes

1. Excessive electrical noise near encoder signal path. This includes noise near any of the following components:

- RSC
- Motor Encoder cables and connectors
- High resolution J4 Encoder and cable

2. Encoder failure.
3. VJI or EJI module failure. Arm signal cable connection failure.
4. Internal encoder harness failure.

User Actions

1. Make sure there is no noise on the encoder signal path. This may be caused by user-installed cables that do not follow installation procedures correctly.
2. Test the encoder and replace if necessary.
3. Swap out the VJI or EJI module.
4. Secure the arm signal cable connection.
5. Test the internal encoder harness and repair if necessary.
6. If problem persists, contact Adept Customer Service. See "How Can I Get Help?" on page 39.

Duty-cycle exceeded Mtr n (–1021)

Explanation

The indicated motor has been driven too fast for too long a period of time. The servo system has disabled Arm Power to protect the robot hardware.

User Actions

1. Reduce the V^+ monitor speed or acceleration and/or program speed. Other parameters may also be adjusted to optimize robot speed while avoiding envelope errors. See the *V^+ Language Reference Guide* for more information concerning the SPEED and ACCEL keywords.
2. Turn on Arm Power and repeat the motion that failed.

Hard envelope error (–1027)

Explanation

The indicated joint was not tracking its commanded position with sufficient accuracy.

Possible Causes

1. The robot's speed or acceleration is set too high.
2. The robot may have hit an object.
3. VJI or EJI module failure.

User Actions

1. Remove any obstacles in the robot's path. To ensure freedom of movement, put the robot in FREE mode and move the necessary joints to the fixed hardstops.
2. Reduce the V^+ monitor speed or acceleration and/or program speed. Other parameters may also be adjusted to optimize robot speed while avoiding envelope errors. See the *V^+ Language Reference Guide* for more information concerning the SPEED and ACCEL keywords.
3. Swap out the VJI or EJI module and replace if necessary.
4. If problem persists, contact Adept Customer Service. See "How Can I Get Help?" on page 39.

Calibration sensor failure Mtr n (–1106)

Explanation

During calibration, the calibration sensor for the indicated motor could not be read correctly. Either the robot is blocked from moving or a hardware error has occurred.

Possible Causes

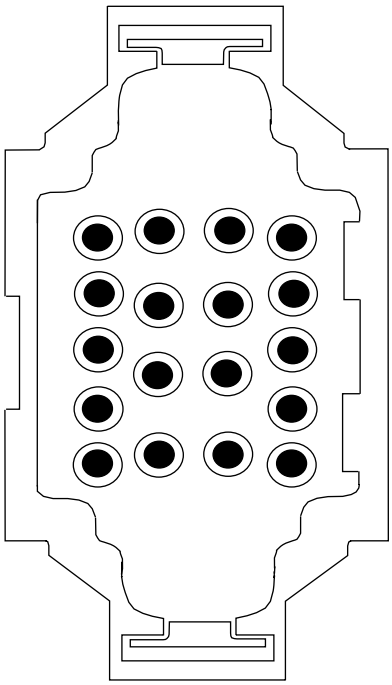
1. Stalled robot motor.
2. Calibration sensor failure.
3. Encoder failure.
4. Amplifier failure.
5. VJI/EJI module failure.

User Actions

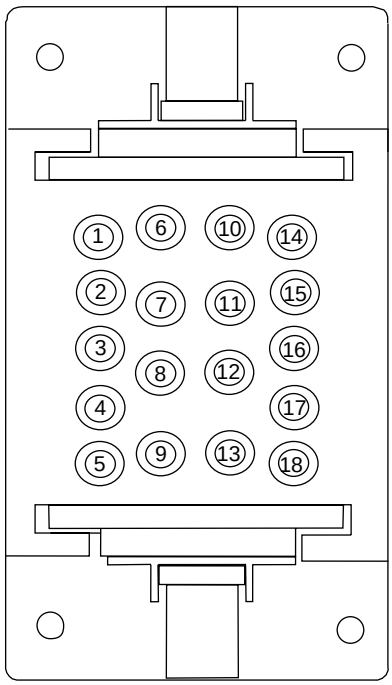
1. Remove any obstacles in the robot's path.
2. The J1 and J2 calibration sensors have LEDs that normally are OFF when the steel target is sensed and ON when the target is absent. Verify the proper operation of each sensor and replace if necessary.
3. Perform the CALIBRATE command or instruction after making sure that the robot is not blocked.
4. If problem persists, contact Adept Customer Service. See "How Can I Get Help?" on page 39.

C.4 Arm Power Cable Connector

Connector Pinout



Connector on Arm Power Cable (female)



Connector at Base of Robot (male)

See Table C-1 on page 211 for pin identification.

Figure C-1. Arm Power Cable Connector Pinout

Arm Power Cable Connector Pin Identification

Table C-1. Arm Power Cable Connector Pin Identification

Pin No.	Function
1	Jt 1 ground
2	Jt 1 A
3	Jt 1 B
4	Jt 1 C
5	NC
6	Jt 2 A
7	Jt 2 B
8	Jt 2 C
9	Jt 2 ground
10	Jt 3 ground
11	Jt 3 A
12	Jt 3 B
13	Jt 3 C
14	Jt 4 A
15	Jt 4 B
16	Jt 4 C
17	Jt 4 ground
18	NC

Adept Cobra Robot Configuration Utility D

D.1 Introduction

The Cobra 600/800 Robot Configuration Utility is designed to allow the user to adjust the calibration configuration and park (home) position of the Cobra robot. The calibration configuration includes the calibration sensor target locations and the order of the calibration of joints 1 and 2. The utility stores updated parameters to the Robot Signature Card (RSC).

> **NOTE:** The utility does not store or retrieve the original or factory default RSC parameters. Adept recommends using the RSC_RSTR utility to save the original RSC data to disk prior to executing the CFG_COBR utility.

> **NOTE:** During the target adjustment operation, Arm High Power will be cycled off and on. Do not turn off power to the Adept controller. Turning off controller power may result in loss of robot calibration and may require restoring the robot to its original calibration configuration.

D.2 Calibration Targets and Sensors

The joint 1 and joint 2 calibration targets are 180° steel sectors that mount to the inner link joint 1 and joint 2 axes. The calibration sensors are inductive proximity sensors mounted inside the joint 1 harness support bracket for joint 1 and externally on the outer link for joint 2. The targets are oriented so that only one edge is detected by the sensor throughout the entire range of joint motion. The factory default orientation places the target edge detection position approximately at joint 0° location.

The targets can be removed from the robot and modified. The sector angle can be reduced from 180° to as small as 30°. When the target is reinstalled, the nondetected target edge must be oriented in the same location, but the detected target edge can be oriented on either side of the joint 0° position. For example, if the target is modified to a 150° sector, the target can be reinstalled on the robot with a target edge position of +30° or –30°.

D.3 Restoring the Original Configuration

If you wish to restore the robot to its original calibration configuration, replace the sensor targets to their original locations, then use the RSC_RSTR utility provided with your robot to restore the original RSC data.

Compatibility Requirements

The CFG_COBR utility requires V+ 13.0 or later. The system on which CFG_COBR is being run must have calibration code for the appropriate boot version available, preferably on the hard drive. If booting from a floppy disk, issue a "calibrate 1" Monitor Command prior to removing the boot disk; then load and execute the CFG_COBR program.

Execution Walk-through

The text on the following pages is actual output generated during loading and execution of the CFG_COBR utility. The four main menu items are shown below:

- Change J1 sensor target edge location (see Figure D-1 on page 220)
- Change J2 sensor target edge location (see Figure D-2 on page 220)
- Change park position after calibration
- Change J1, J2 calibration order (currently J2, J1)

D.4 Change J1 Sensor Target Location

```
            ***   Adept Cobra Configuration Program, V13.0   ***
                Copyright (c) 1998 by Adept Technology, Inc.

                       V+ version and edit:   13.0C1

                              Robot: 560-111


                                  MAIN MENU

          0 => Exit
          1 => Change J1 sensor target location
          2 => Change J2 sensor target location
          3 => Change park position after calibration
          4 => Change J1, J2 calibration order (currently J2, J1)

          Enter selection: 1

Joint 1 will be moved to the + (CCW) or – (CW) hardstop as a reference.

Do you want to move to the + hardstop (Y/N)? y

Preparing to move to the + hardstop.
```

WARNING: Joint Motion cannot be stopped by the PANIC Monitor Command. You should have an E-Stop switch available.

The motion of Joint 1 must be unobstructed.

```
Do you want to abort (Y/N)? n

Home sensor ON

Returning to start position.

Modify the Joint 1 calibration target:
```

Remove the four large socket head screws on two small Phillips-head screws holding the J1 harness support bracket in place.

NOTE: Do **not** remove the sheet metal bracket to which the J1 sensor is mounted.

Rotate the inner link so that the screws in the J1 calibration target align with the access holes in the J1 sensor mount bracket. Remove the four Phillips-head screws holding the J1 calibration target to the inner link. Modify the target, as desired; then replace the screws.

```
Press ENTER to continue.

Verify that the motion of J1 is unobstructed. Press ENTER to continue.

Home sensor ON

Returning to start position.

Searching for target edge.

Is Joint 1 at the correct target edge? (Y/N)? y

Search entire joint range for extraneous target edges (Y/N)? y

Checking for joint interference.

Searching for extraneous target edges.
Found an edge
Found 1 sensor edge as expected. Press ENTER to continue.

Returning to start location.

Preparing to update the RSC. Do you want to abort (Y/N)? n

Recalibrate robot to verify change (Y/N)? y

Move arm straight out (Y/N)? y
```

D.5 Change J2 Sensor Target Location

```
***   Adept Cobra Configuration Program, V13.0   ***
    Copyright (c) 1998 by Adept Technology, Inc.

          V+ version and edit:   13.0C1

                 Robot: 560-111


                      MAIN MENU

       0 => Exit
       1 => Change J1 sensor target location
       2 => Change J2 sensor target location
       3 => Change park position after calibration
       4 => Change J1, J2 calibration order (currently J2, J1)

       Enter selection: 2

Joint 2 will be moved to the + (CCW) or – (CW) hardstop as a reference.

Do you want to move to the + hardstop (Y/N)? y

Preparing to move to the + hardstop.
```

WARNING: Joint Motion cannot be stopped by the PANIC Monitor Command. You should have an E-Stop switch available.

The motion of Joint 2 must be unobstructed.

```
Do you want to abort (Y/N)? n

Home sensor OFF

Returning to start position.

Modify the Joint 2 calibration target:
```

From underneath the inner link, remove the four small socket-head screws that hold the J2 calibration target in place.

Modify the target, as desired; then replace the screws.

```
*Robot power off*

Press ENTER to continue.

Verify that the motion of J2 is unobstructed. Press ENTER to continue.

Home sensor OFF

Returning to start position.
```

```
Searching for target edge.

Is Joint 2 at the correct target edge? (Y/N)? y

Search entire joint range for extraneous target edges (Y/N)? y

Checking for joint interference.

Searching for extraneous target edges.
Found an edge
Found 1 sensor edge as expected. Press ENTER to continue.

Returning to start location.

Preparing to update the RSC. Do you want to abort (Y/N)? n

Recalibrate robot to verify change (Y/N)? y

Move arm straight out (Y/N)? y
```

D.6 Change Park Position After Calibration

```
            ***   Adept Cobra Configuration Program, V13.0   ***
                Copyright (c) 1998 by Adept Technology, Inc.

                        V+ version and edit:   13.0C1

                               Robot: 560-111


                                  MAIN MENU

                    0 => Exit
                    1 => Change J1 sensor target location
                    2 => Change J2 sensor target location
                    3 => Change park position after calibration
                    4 => Change J1, J2 calibration order (currently J2, J1)

                    Enter selection: 3

                                PARK POSITION MENU

                    0 => Exit
                    1 => Teach park location
                    2 => Enter joint values for park location

                    Enter selection: 1

Place the robot in the desired park location. Press ENTER to continue.

Recalibrate robot to verify change (Y/N)? y


                                PARK POSITION MENU

                    0 => Exit
                    1 => Teach park location
                    2 => Enter joint values for park location

                    Enter selection: 2

Enter value for Joint 1 (hit RETURN to use current position 0)  45
Enter value for Joint 2 (hit RETURN to use current position 0) -45
Enter value for Joint 3 (hit RETURN to use current position 0)  10
Enter value for Joint 4 (hit RETURN to use current position 0)
Verification:

Joint 1 =  45
Joint 2 = -45
Joint 3 =  10
Joint 4 =   0

Do you want to change these values before proceeding (Y/N)? n
Recalibrate robot to verify change (Y/N)? y
```

D.7 Change J1, J2 Calibration Order

```
             ***   Adept Cobra Configuration Program, V13.0   ***
                 Copyright (c) 1998 by Adept Technology, Inc.

                        V+ version and edit:   13.0C1

                               Robot: 560-111


                                  MAIN MENU

            0 => Exit
            1 => Change J1 sensor target location
            2 => Change J2 sensor target location
            3 => Change park position after calibration
            4 => Change J1, J2 calibration order (currently J2, J1)

            Enter selection: 4

Recalibrate robot to verify change (Y/N)? y

             ***   Adept Cobra Configuration Program, V13.0   ***
                 Copyright (c) 1998 by Adept Technology, Inc.

                        V+ version and edit:   13.0C1

                               Robot: 560-111


                                  MAIN MENU

            0 => Exit
            1 => Change J1 sensor target location
            2 => Change J2 sensor target location
            3 => Change park position after calibration
            4 => Change J1, J2 calibration order (currently J2, J1)

            Enter selection: 0


                           ***   EXITING TEST PROGRAM   ***

Program completed
Program task 1 stopped at a.CFG_COBR, step 48
```

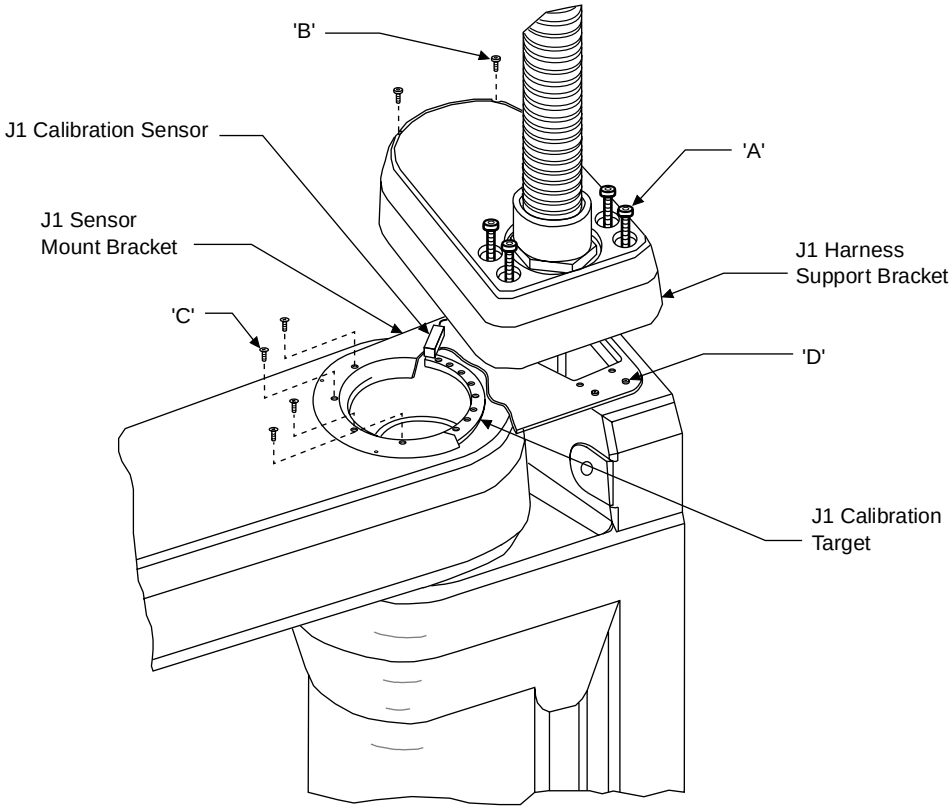


Figure D-1. J1 Calibration Target

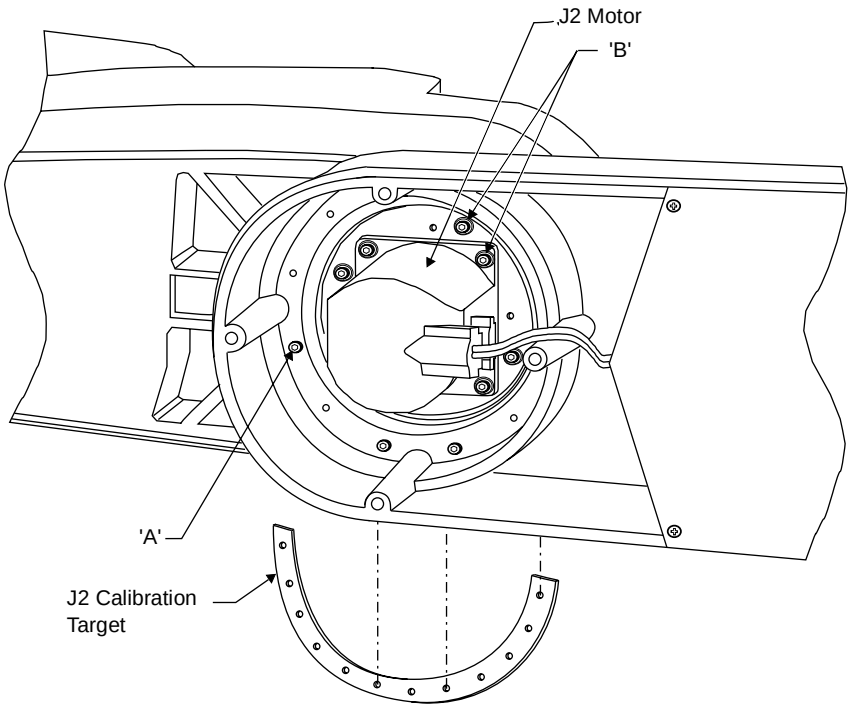


Figure D-2. J2 Calibration Target

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Adept User's Manual Comment Form

We have provided this form to allow you to make comments about this manual, to point out any mistakes you may find, or to offer suggestions about information you want to see added to the manual. We review and revise user's manuals on a regular basis, and any comments or feedback you send us will be given serious consideration. Thank you for your input.

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