Omron Adept Python Modules

User's Guide

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1.1 Product Description

Adept Python Modules

The Adept Python Linear Modules product line consists of precision ball-screw driven modules that function as single-axis mechanisms, and can also be combined into numerous two-, three-, and four-axis configurations. Each linear module is available in different lengths (see **Table 1-1**) and motor mounting configurations. The Theta module adds a rotational axis to a Python system, providing additional handling options. You can find drawings for the multiple axis configurations in **Chapter 5**.

Most module configurations are shipped fully assembled, so the user only needs to connect the controller and any peripherals. This manual describes the different module and system types, and covers the basic steps of installing a typical system. Refer to **Table 1-2 on page 22** for a list of manuals that provide additional information on your Adept system.

Table 1-1. Adept Python Modules

Module Type	Width	Height	Available Lengths
L18	185 mm	93 mm	300 to 2000 mm
L12	125 mm	83 mm	200 to 1500 mm
L08	85 mm	68 mm	100 to 800 mm
LT1	90 mm	65 mm	With User Flange = 240 mm Without Flange = 230 mm

MotionBlox-10 Servo Controller and Amplifier

Each module axis is controlled and powered by its own on-board servo controller and amplifier, called a MotionBlox-10 (MB-10). Each MB-10 is linked via the IEEE 1394 high-speed serial communication protocol to the Adept SmartController.

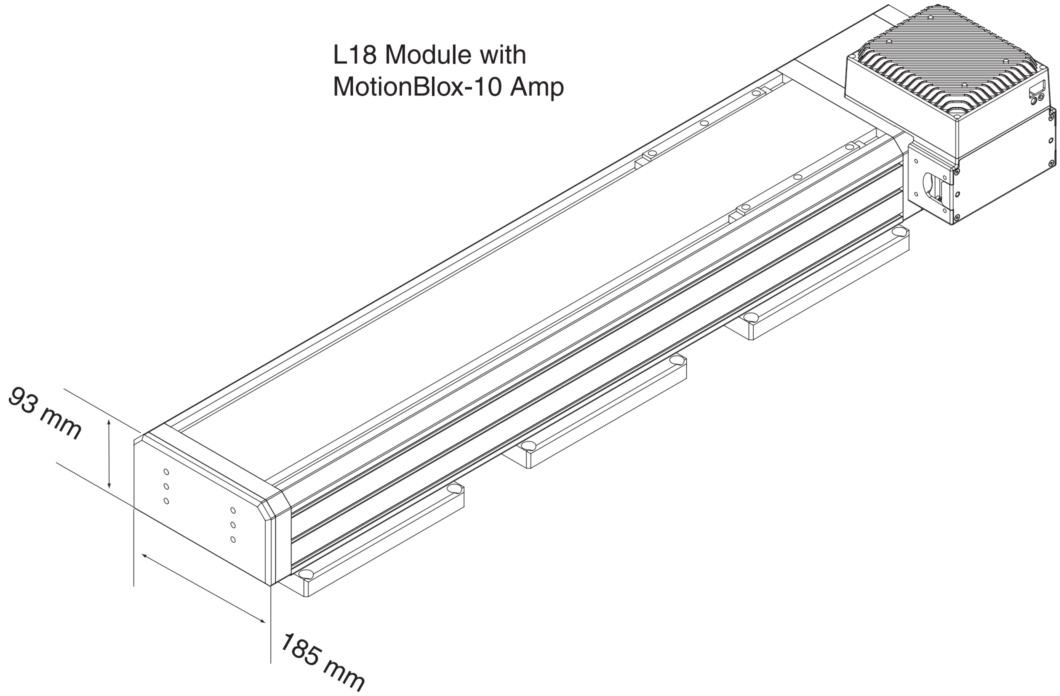


Figure 1-1. L18 Linear Module with MB-10 Amplifier

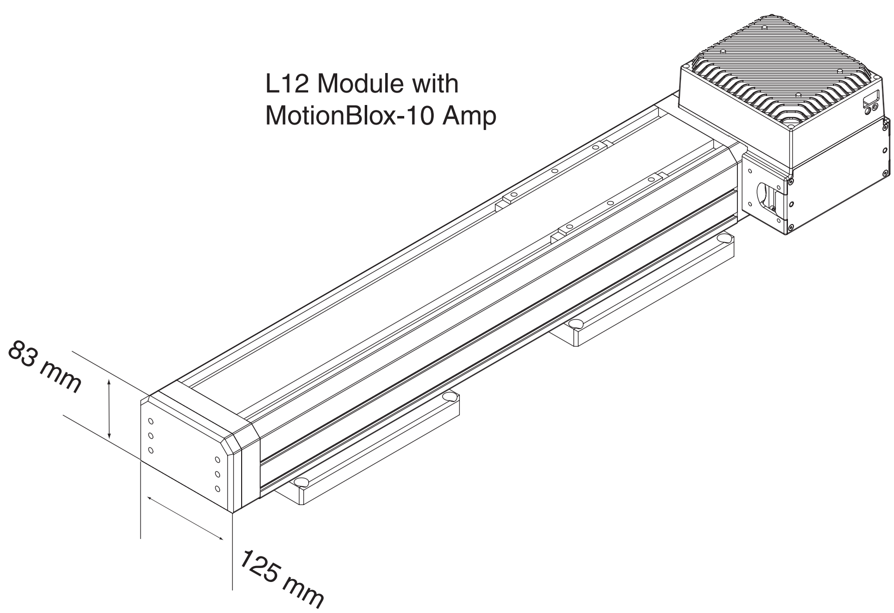


Figure 1-2. L12 Linear Module with MB-10 Amplifier

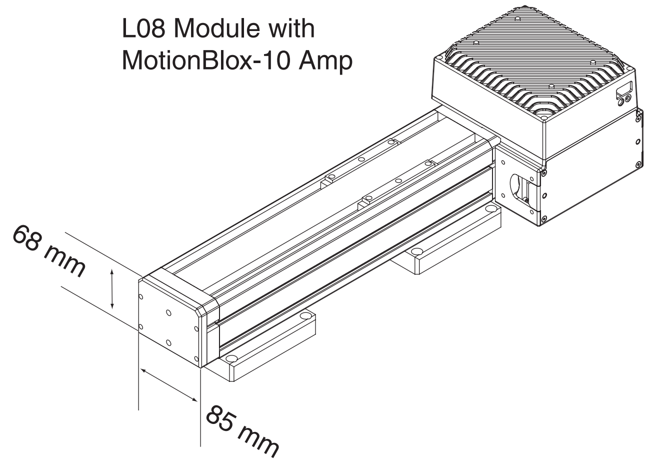


Figure 1-3. L08 Linear Module with MB-10 Amplifier

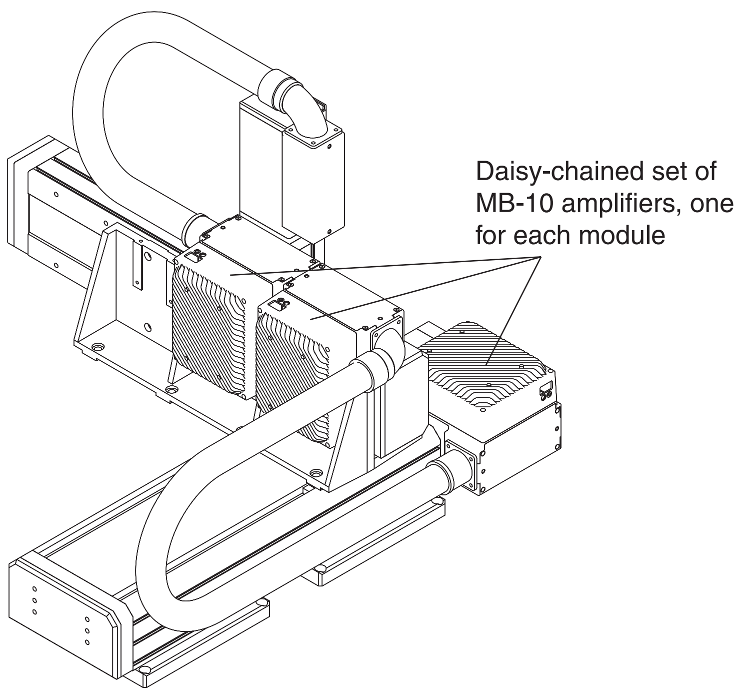


Figure 1-4. Three-Axis System with L18, L12, and L08 Modules

Special and Custom Orders

Special orders consist of any unique module or system configuration not outlined in this manual, or supported by the Adept 3D Modules configuration tool on our website. Custom orders consist of any order containing a custom module or module system. These orders may not be fully assembled at the factory.

Adept SmartController CX

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

- Adept Cobra s-series robots
- Adept Viper s-series robots
- Adept Python Modules
- Adept Servo Kit Systems
- Adept sMI6 (SmartMotion)
- Adept Quattro robots

The SmartController CX supports an integrated vision option and a conveyor tracking option. It offers scalability and support for IEEE 1394-based digital I/O and general motion expansion modules. The IEEE 1394 interface is the backbone of Adept SmartServo, Adept's distributed controls architecture supporting Adept products. The controller also includes Fast Ethernet and DeviceNet.

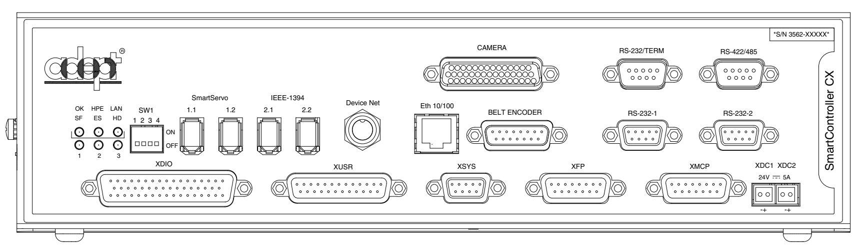


Figure 1-5. Adept SmartController CX

Power Distribution Unit (PDU3)

The Power Distribution Unit (PDU3) is a safety device that provides Category-3 E-Stop functionality, per EN 954. The PDU3 also provides surge protection, power filtering, and DC power for the MB-10 and optional IO Blox devices.

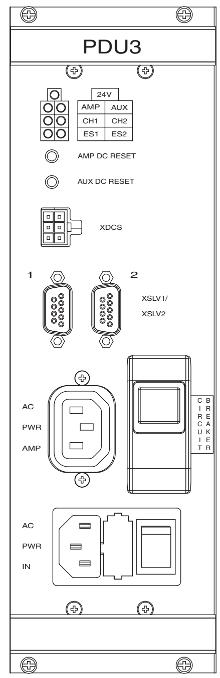


Figure 1-6. PDU3

1.2 Overview of Typical System Installation

This section provides an overview of the installation process for a typical Adept Python modules system using an Adept SmartController.

Installing Adept Python Modules

1. Unpack your system and verify that you have everything required.
2. Install the modules onto your work surface (see **Chapter 6** for information).
3. Connect these cables:
   a. IEEE 1394 cable from MB-10 #1 to SmartController
   b. Switched AC power cable from MB-10 #1 to PDU3
   c. 24 VDC cable from MB-10 #1 to PDU3
4. To install an optional IO Blox device, see the ***Adept IO Blox User's Guide***.

Installing the SmartController

NOTE: Refer to the ***Adept SmartController User's Guide*** for detailed instructions on installing the controller.

1. Mount the controller chassis in the workcell. There are several different mounting choices. See **page 117**.
2. Connect 24 VDC power to the SmartController.
3. Connect a ground wire to the SmartController.

Installing Peripherals and Options

1. Install the PDU3 in the workcell. See **Section 8.2 on page 122**.
2. Connect AC power to the PDU3. See **Section 8.3 on page 123**.
3. Mount the Adept Front Panel.

   It must be outside of the workcell. See the ***Adept SmartController User's Guide*** for information on using the Front Panel.
4. Connect the Front Panel to the SmartController. See **Section 7.4 on page 119**.
5. Connect the optional T2 pendant to the SmartController. See **Section 7.5 on page 119**.
6. Install the User Interface. See **Section 7.6 on page 120**. There are two choices:
   - AdeptWindows PC software, running on the user-supplied PC
   - Optional Adept DeskTop software, running on the user-supplied PC

7. Refer to the Operation chapter in the ***Adept SmartController User's Guide*** for information on installing customer-supplied equipment and safety circuits, including:
   - Emergency Stop circuits
   - Remote Manual Mode control
   - Remote High Power control
   - Connecting user-supplied serial and digital I/O equipment

Turning On the System

1. Refer to **Chapter 10** to perform system installation verification.
2. After the installation has been verified for all safety regulations, turn on DC power to the controller and AC power to the PDU.
3. See **Section 10.4 on page 145** for the software configuration process.

1.3 Manufacturer's Declaration

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

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

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

1.4 How Can I Get Help?

Refer to the ***How to Get Help Resource Guide*** (Adept P/N 00961-00700) for details on getting assistance with your Adept software and hardware.

Additionally, you can access information sources on Adept's corporate website:

http://www.adept.com

1.5 Related Manuals

This manual covers the installation of a SmartContoller-based Adept Python Modules system. There are additional manuals that cover programming the system, reconfiguring installed components, and adding other optional components. See **Table 1-2**. These manuals are available on the Adept Document Library on CD-ROM provided with each system.

Table 1-2. Related Manuals

Manual Title	Description
Adept SmartController User's Guide	Contains complete information on the installation and operation of the Adept SmartController and the optional sDIO products.
Adept T2 Pendant User's Guide	Describes the T2 Pendant product.
Adept IO Blox User's Guide	Describes the IO Blox product.
AdeptWindows Installation Guide and AdeptWindows Online Help	Describes complex network installations, installation and use of NFS server software, the AdeptWindows Offline Editor, and the AdeptWindows DDE software.
Instructions for Adept Utility Programs	Describes the utility programs used for advanced system configurations, system upgrades, file copying, and other system configuration procedures.
V+ Operating System User's Guide	Describes the V+ operating system, including disk file operations, monitor commands, and monitor command programs.
V+ Language User's Guide	Describes the V+ language and programming of an Adept control system.

Adept Document Library

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

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

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

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

Safety 2

2.1 Dangers, Warnings, Cautions, and Notes

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

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

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

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

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

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

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

2.2 Intended Use of the Modules

The installation and use of Adept products must comply with all safety instructions and warnings in this manual. Installation and use must also comply with all applicable local and national requirements and safety standards (see **Section 2.7 on page 31**).

Adept Python Modules are intended for use in parts assembly and material handling for a variety of payloads, depending on the specific configuration.

WARNING: For safety reasons, it is prohibited to make certain modifications to Adept robots (see **Section 2.5 on page 30**).

The SmartController is a component subassembly of a complete industrial automation system. The SmartController must be installed inside a suitable enclosure. The SmartController and modules 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 washed down or subject to extremes of heat or humidity.

Non-intended use of an Adept Python Modules system 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 the documentation

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

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

2.3 Risk Assessment

Without special safeguards in its control system, Adept Python Modules could inflict serious injury on an Operator working within its work envelope. Safety standards in many countries require appropriate safety equipment to be installed as part of the system. **Table 2-1** 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 2-1. 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 in the following sections.

Exposure

When High 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 **Section 2.11 on page 33**), who must wear safety equipment (see **Section 2.12 on page 33**) and carry the T2 pendant. Therefore, exposure of personnel to hazards related to the robot is limited (seldom and/or short exposure time).

Severity of Injury

Provided that skilled personnel who enter the modules 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

Due to the module's size and speed capability, 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 T2 pendant when inside the work envelope, as the T2 pendant provides both E-Stop and Enabling switch functions.

For *normal* operation, AUTO mode, user-supplied interlocked guarding must be installed to prevent any person entering the workcell while High Power is on.

DANGER: The Adept-supplied system components provide Category 3 Emergency Stop functionality and Category 1 protection during TeachMode operation, 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 system in the event of personnel attempting to enter the workcell when High Power is enabled, except for Teaching in Manual mode. Failure to install suitable guarding could result in injury or death.

The E-stop CIRCUIT is "category 3" as defined by EN 954 (dual channel: redundant, diverse, and control-reliable).

Activating the E-stop system causes a Category 0, Uncontrolled stop, as defined by NFPA79.

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

The Risk Assessment for *teaching* this product depends on the application. In many applications, the programmer will need to enter the robot workcell while High 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 High Power is on. Examples of alternative methods of programming include:

1. Programming from outside the safety barrier.
2. Programming with High Power off (using the brake release button when required).
3. Copying a program from another (master) robot.
4. Off-line or CAD programming.

Control System Behavior Category

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

In situations with low exposure consideration factors, European Standard EN 1050 specifies use of a Category 1 Control System per EN 954. EN 954 defines a Category 1 Control System as one that employs Category B components designed to withstand environmental influences, such as voltage, current, temperature, EMI, and well-tried safety principles. The standard SmartController control system described in this user's guide 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 maximum current limit provided to the motor by the amplifier have 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 SmartController Control System meets or exceeds the requirements imposed by the EN 954 specified Category 1 level of safety.

2.4 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, EN 954-1, and EN 60204-1, especially section 13.

Maximum Thrust

Adept Python Modules 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 2-2 and Table 2-3).

Table 2-2. Maximum Thrust (at slider)[a]

Module Type	Lead type, mm/rev	Maximum thrust [N], Instantaneous
L18 and L12	10	2280
	20	1140
L08	10	850
	20	430

[a] See module product specifications for maximum rated thrust that can be applied repeatedly in an application. The values listed in the table above are for safety considerations.

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 2.7 on page 31**).

The safe distance to the robot depends on the height of the safety fence. The height and the distance of the safety fence from the robot must ensure that personnel cannot reach the danger zone of the robot (see **Section 2.7 on page 31**).

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

Impact and Trapping Points

The modules 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. System 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 Python Modules in a **runaway** situation are listed in **Table 2-3**. Any tooling, fixtures, end-effectors, etc., mounted to the module must be attached by sufficient means to resist being expelled from the module. Additionally, any payload must be held by the end-effector in a manner that prevents the payload from being expelled accidentally.

Table 2-3. Maximum Linear Modules Joint Velocities in Runaway Situations[a]

Module Type	Lead type, mm/rev	Max linear speed (mm/s)
L18	10	979
	20	1940
L12	10	979
	20	1940
L08	10	1170
	20	2340

[a] These velocities can occur only in a runaway or mechanical failure situation. These are *not* 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 $E = 1/2mv^2$.

Additional Safety Information

The standards and regulations listed in this manual contain additional guidelines for robot system installation, safeguarding, maintenance, testing, start-up, and operator training. Table 2-4 on page 29 lists some sources for the various standards.

Table 2-4. Sources for International Standards and Directives

SEMI International Standards 3081 Zanker Road San Jose, CA 95134 USA Phone: 1.408.943.6900 Fax: 1.408.428.9600 http://www.semi.org/	American National Standards Institute (ANSI) 11 West 42nd Street, 13th Floor New York, NY 10036 USA Phone 212-642-4900 Fax 212-398-0023 http://www.ansi.org
BSI Group (British Standards) 389 Chiswick High Road London W4 4AL United Kingdom Phone +44 (0)20 8996 9000 Fax +44 (0)20 8996 7400 http://www.bsi-global.com	Document Center, Inc. 1504 Industrial Way, Unit 9 Belmont, CA 94002 USA Phone 415-591-7600 Fax 415-591-7617 http://www.document-center.com
DIN, Deutsches Institut für Normung e.V. German Institute for Standardization Burggrafenstrasse 6 10787 Berlin Germany Phone.: +49 30 2601-0 Fax: +49 30 2601-1231 http://www.din.de http://www2.beuth.de/ (publishing)	Global Engineering Documents 15 Inverness Way East Englewood, CO 80112 USA Phone 800-854-7179 Fax 303-397-2740 http://global.ihs.com
IEC, International Electrotechnical Commission Rue de Varembe 3 PO Box 131 CH-1211 Geneva 20 Switzerland Phone 41 22 919-0211 Fax 41 22 919-0300 http://www.iec.ch	Robotic Industries Association (RIA) 900 Victors Way PO Box 3724 Ann Arbor, MI 48106 USA Phone 313-994-6088 Fax 313-994-3338 http://www.robotics.org

Table 2-4. Sources for International Standards and Directives (Continued)

Underwriters Laboratories Inc. 333 Pfingsten Road Northbrook, IL 60062-2096 USA Phone: +1-847-272-8800 Fax: +1-847-272-8129 http://www.ul.com/info/		

2.5 Equipment 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 modifications will not cause problems, but may affect performance:

- Attaching tooling, utility boxes, solenoid packs, vacuum pumps, screwdrivers, cameras, lighting, etc., to a module.
- Attaching hoses, pneumatic lines, or cables to a module. These should be designed so they do not restrict robot motion or cause robot motion errors. T-slots and threaded holes are provided on each module for the purpose of mounting user equipment. T-slots accept a standard M4 square nut (DIN 562).

Unacceptable Modifications

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

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 module harnesses or module-to-controller cables.
- Modifying any module access covers or drive system components.
- Modifying, including drilling or cutting, any module extrusion.
- Modifying any module or MB-10 electrical component or printed-circuit board.
- Routing additional hoses, air lines, or wires through the module.
- Modifications that compromise EMC performance, including shielding.

2.6 Transport

Always use adequate equipment to transport and lift Adept products.

WARNING: Never stand under the module while it is lifted or transported.

Encoder Battery Life

The servo motors in Adept Python modules with MB-10 amplifiers have a serial absolute encoder. Each module is calibrated before shipment. An external encoder backup battery is shipped with each module, and is located inside the motor cover. The battery allows the encoder to retain the calibration data for 10 years of use in this application. The MB-10 amplifier has its own internal battery, which is also rated for 10 years. The encoder does not receive any power from the MB-10 amplifier's battery. Therefore, leaving the encoder connected to the MB-10 during transport or power-off periods will not drain the MB-10 battery. Likewise, disconnecting the module from the MB-10 will not affect the absolute encoder.

CAUTION: Do not disconnect the encoder backup battery from the motor encoder cable. Doing so may cause loss of encoder multi-turn data and the user will be required to recalibrate the system. See Section 11.4 on page 156 for the procedure to replace the encoder battery.

2.7 Safety Requirements for Additional Equipment

Additional equipment used with modules (grippers, conveyor belts, etc.) must not reduce the workcell safeguards.

All emergency stop switches must always be accessible.

If the system is to be used in an EU or EEA member country, all components in the system 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, EN 954-1, and EN 60204. For safety fences, see EN 294.

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

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

In Canada, applicable standards include CAN/CSA Z434.

2.8 Sound Emissions

The sound emission level of a module system depends on the commanded speed and payload. The maximum value is 85 dB, when measured at 1 meter. (This is at maximum AUTO-mode speed.)

CAUTION: Acoustic emission from this system may be up to 85 dB (A) under worst-case conditions. Typical values will be lower, depending on payload, speed, acceleration, and mounting. Appropriate safety measures should be taken, such as ear protection and display of a warning sign.

2.9 Thermal Hazard

WARNING: Thermal Hazard!
You can burn yourself. Do not touch the MB-10 cooling fins shortly after the system has been running at high ambient temperatures (40°C/104°F) or at fast cycle times (over 60 cycles per minute). The MB-10 skin/surface temperature can reach 85°C (185°F).

2.10 Working Areas

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

In Manual mode, operators with additional safety equipment (see **Section 2.12 on page 33**) are allowed to work in the workcell. For safety reasons the operator should, whenever possible, stay outside of the 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 2.11** for the specifications.

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

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

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

All personnel must observe 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:

- Has received the manual
- Has read the manual
- Understands the manual
- Will work in the manner specified by the manual

For vertically oriented modules, always lower the payload to the bottom hardstop before attempting any repair or upgrade activity.

2.12 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.

2.13 Protection Against Unauthorized Operation

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

2.14 Safety Aspects While Performing Maintenance

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

WARNING: During maintenance and repair, the power to the SmartController and PDU3 must be turned off. Unauthorized third parties must be prevented from turning on power through the use of lockout measures.

2.15 Risks That Cannot Be Avoided

The Adept Python Modules 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 a device or an E-Stop system

2.16 Risks Due to Incorrect Installation or Operation

Certain risks will be present if installation or operation is not performed properly.

- 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 an interlock so that an operator can enter a workcell with High Power ON
- Ejection of a work piece (see **“Hazards From Expelling a Part or Attached Tooling” on page 28**)

Take precautions to ensure that these situations do not occur.

2.17 What to Do in an Emergency Situation

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

Python Linear Module Descriptions 3

3.1 Adept Python Linear Modules

Use the Adept 3D Linear Modules Builder section of the Adept website (www.adept.com) to select, configure, and request a quote for your linear modules. The website and this chapter provide detailed information about Adept Python linear modules. See **Chapter 4** for information about the Adept Python Theta modules.

Single-Axis and Multiple-Axis Configurations

You can order an Adept Python linear module system consisting of a single module, MB-10 amplifier, and a SmartController CX. Or, multiple modules can be assembled into a multi-axis system. For systems with an extended-reach Y-axis, or extended payloads, a gantry support module is also available.

3.2 Linear Module Options

The following are configurable for each linear module:

- L-Series module type - L18, L12, and L08
- Stroke lengths - 100 and 200 mm increments standard
- Ball screw lead - 5, 10, and 20 mm leads standard
- Fail-safe brakes
- Motor mount orientation - in-line, side-, or bottom--mounted
- Harness exit configuration - left or right side
- Module preparation (assembly) - standard or cleanroom

L-Series Module Types

Three Python L-Series linear module types are available: L18, L12, and L08. All three module types have similar construction features:

- Rigid aluminum extruded-frame bodies for high stiffness with precision-machined straightness tolerances
- Dual linear square rails with four preloaded bearings per carriage to maximize carriage stiffness and assure high moment load capacities
- Precision ground screw, low backlash ball screw drivetrain (rolled screws used on certain module configurations)
- Maintenance-free operation - all bearing components are lubricated for life
- High-performance AC servo motors with 8 kHz servo update rate and optimized current loop tuning in amplifier
- Serial absolute encoders with 65,536 counts/rev minimum resolution; no homing required
- Zero-backlash, high-stiffness shaft couplings
- Extruded covers with integral belt seals to keep dust out and provide IP-20 ingress protection
- Mounting options including bolt and dowel pin patterns on underside and extruded T-slots for toe clamp mounting

All external dimension and weight specifications for each module type can be found on the module specification drawings located on the Adept website. The load ratings for each module type scale with the frame size and ball screw lead.

Payloads and Moments

For cantilevered or simply-supported applications, the stiffness of the module's main body extrusion is an important parameter to determine overall system and tool tip stiffness. The Python modules main body moment of inertia and polar moment of inertia values, listed in the following table, can be used to calculate approximate system tool tip stiffness.

Table 3-1. Main Body Extrusion Moment of Inertia

Module Type	IXX (Pitch)	IYY (Yaw)	Polar (Roll)	Units
L18	8.74E+5	2.37E+7	3.31E+7	mm^4
L12	5.47E+5	5.64E+6	6.95E+6	mm^4
L08	3.20E+5	1.56E+6	2.20E+6	mm^4

Python linear modules employ high quality linear rails manufactured by IKO corporation. The following load rating values and maximum transportable moments apply to the carriage bearing life. These values are typically motor and/or ball screw dependent.

Table 3-2. Carriage Bearing Static and Dynamic Load Ratings

Module Type	C[a] (N)	Co[b] (N)	To[c] (N·m)	Tx[d] (N·m)	Ty[e] (N·m)
L18	25200	28800	362	1690	1690
L12	11600	13400	112	556	556
L08	2370	4030	18.7	98.3	82.5

[a] Basic Dynamic load rating (50 km)
[b] Basic Static load rating
[c] Static Roll Moment rating
[d] Static Pitch Moment rating
[e] Static Yaw Moment rating

Rated payload specifications for Python modules are provided as a general guideline for users. At these payloads, the user can expect to achieve good performance for the 15,000 km life of the modules, assuming typical cycle and dwell times are used.

Dynamic payload capacities for Python modules are limited by available motor torque and duty cycle restrictions. These values change based on the ball screw lead selection and the mounting orientation (horizontal or vertical). Adept specifies sustained cycle performance for Python modules at SPEED 100 and ACCEL 100 at 100% duty cycle using a MotionBlox-10 amplifier (unless otherwise specified). These values are measured without any dwell time or breaks between moves. This performance is limited by a heat sensor in the motor or amplifier.

Python modules are capable of carrying much higher payloads than the values listed in the following table. However, the speed or acceleration must be reduced and/or breaks inserted to avoid envelope errors or duty cycle limits.

In a vertical application, one of the limiting factors for payload capacity is regeneration energy produced by the motor. Because of this, Adept recommends that vertical axes be restricted to a stroke length of 400 mm or less.

Table 3-3. Carriage Maximum Payload and Transportable Moments

		Horizontal Mount				Vertical Mount				Side Mount			
			Moments				Moments				Moments		
Mod. Type	Pitch (mm)	Max Pay-load (kg)	Roll (N·m)	Pitch (N·m)	Yaw (N·m)	Max Pay-load (kg)	Roll (N·m)	Pitch (N·m)	Yaw (N·m)	Max Pay-load (kg)	Roll (N·m)	Pitch (N·m)	Yaw (N·m)
L18	10	80	400	450	325	40	n/a	420	430	80	330	270	450
	20	30	330	500	530	20	n/a	300	320	30	250	400	500
L12	10	40	130	160	105	30	n/a	120	140	40	100	80	140
	20	20	100	160	160	15	n/a	90	100	20	80	130	160
L08	10	10	16	25	13	8	n/a	16	18	10	10	8	20
	20	5	12	25	19	5	n/a	10	11	5	10	16	25

NOTE: Maximum payloads require decreased duty cycle for continuous operation. Please contact Adept sales for more information.

NOTE: These values apply at 15,000 km of travel which is equivalent to 25 million 300 mm pick and place cycles. For 10,000 km of travel, multiply all values by 1.14. For 5,000 km of travel, multiply all values by 1.44. These values are calculated in a traditional manner and assume constant velocity, they do not take moments caused by acceleration into account.

The motors used in Python modules are high-quality AC servo motors manufactured by Yaskawa corporation. These motors employ serial absolute encoders. The motor model numbers, size, maximum torque values, and encoder resolution are provided here for reference.

Table 3-4. Motors Used in Python Linear Modules

Module Type	Motor Type	Motor Size (Watts)	Peak Torque (N-m)	Encoder Resolution (Cnts/Rev)
L18	Sigma-II	400 W	3.82	65,536
L12	Sigma-II	400 W	3.82	65,536
L08	Sigma-III	150 W	1.43	131,072

Stroke Length

Stroke lengths are available in 100 and 200 mm increments, depending on module type.

Table 3-5. Linear Module Available Standard Stroke Lengths

Module Type	Available Lengths
L18	300 to 2000 mm
L12	200 to 1500 mm
L08	100 to 800 mm

NOTE: Check the Adept website for actual standard-length increments. Module systems with stroke lengths greater than 1200 mm may not be shipped fully assembled.

Accuracy

Module axial positional accuracy, straightness, and flatness depend on the stroke length of the module. The following table lists the specified values for fully-constrained modules in a thermally-controlled environment. Cantilevered mounting conditions (such as a typical Y-axis) will cause these values to degrade.

Table 3-6. Python Module Accuracy

Stroke Length (mm)	Positional Accuracy (µm)	Straightness and Flatness (µm)
100	25	10
200	25	15
300	30	20
400	35	25
500	40	30
600	45	35
800	55	45
1000	65	55
1200	75	65
1400	85	75
1500	90	80
1600	95	85

Ball Screw Lead

The available ball screw lead options are 5, 10, and 20 mm per revolution. Repeatability, thrust, payload, speed, resolution, and other specifications vary by the selected lead option.

All Python modules up to 1600 mm in stroke length employ precision ground ball screws manufactured by Kuroda corporation. 15 mm diameter screws are used in all modules up to and including lengths of 1000 mm. Modules over 1000 mm use 20 mm diameter screws. 1800 and 2000 mm L18 modules use 20 mm diameter rolled ball screws, which have reduced lead accuracy.

Speed

The maximum speeds of Python linear modules are determined by ball bearing recirculation limits established by the ball screw manufacturer up to certain lengths, then decrease due to ball screw shaft rotation dynamics. Therefore, the maximum speed settings are constant up to 800 mm stroke lengths but are reduced as lengths increase.

1800 and 2000 mm modules are only available in side- and bottom-mount configurations. 40 mm lead ball screws are coupled with 2:1 timing belt ratios for a net lead of 20 mm. L18 modules with 10 mm net ball screw leads are available as customs in lengths of 1400 to 2000 mm. The following table lists the SPEED 100 speeds for each module stroke length.

Table 3-7. Linear module SPEED 100 speed (mm/s)[a]

	Lead Pitch (mm/rev)		
Length [mm]	5	10	20
100	330	660	1330
200	330	660	1330
300	330	660	1330
400	330	660	1330
500	330	660	1330
600	330	660	1330
800	330	660	1330
1000	n/a	440	880
1200	n/a	320	635
1400	n/a	n/a	635
1500	n/a	n/a	590
1600	n/a	n/a	515
1800	n/a	n/a	500
2000	n/a	n/a	500

a. Adept users are able to command speeds up to SPEED 110, so the effective maximum speeds are 10% higher than those listed above.

Acceleration

The maximum acceleration rate achievable for Python modules varies with ball screw lead pitch, stroke length, module type, and payload. As payload and/or ball screw inertia increase, the available torque to inertia ratio will decrease, limiting the maximum acceleration rate. The ACCEL 100 values for Python are conservatively set in SPEC, so they are achievable for all rated payload and screw combinations (see **Table 3-8**). The user is able to command higher acceleration values up to Accel 110 by modifying the Max Accel value in SPEC. For short axes with light payloads, maximum acceleration rates 50% higher than these values may be possible.

Table 3-8. Linear Module ACCEL 100 Acceleration Rate (mm/s^2)

Ball Screw Lead (mm)	ACCEL 100 Rate (mm/sec^2)
5	4,000
10	8,000
20	16,000

Resolution and Repeatability

The linear resolution of Python modules is a function of the encoder resolution and the ball screw lead. Therefore, the values vary with module and ball screw type. See the following table for details.

Table 3-9. Linear Module Resolution

Module type	Encoder resolution (counts/rev)	Linear resolution (counts/mm)			Linear resolution (μm/count)		
		Screw Lead			Screw Lead		
		5 mm	10 mm	20 mm	5 mm	10 mm	20 mm
L18/L12	65536	n/a	6553.6	3276.8	n/a	0.153	0.305
L08	131072	26214.4	13107.2	6553.6	0.0381	0.0763	0.153

NOTE: The minimum incremental step size may be greater than the linear resolution due to mechanical and/or servo limitations. Adept has demonstrated consistent sub-micron incremental step performance on standard modules under various payloads. Typically a Python module motor will null to a single count, and the high stiffness and low friction in the drive train of in-line modules will enable discrete step increments per the previous table. However, Adept does not guarantee this performance due to other variables that could have adverse effects.

Linear module repeatability is a function of linear resolution, servo performance, ball screw linear clearances, friction, payload, etc. Unidirectional and bidirectional repeatability values as measured per ISO 232 for Python modules are specified in the following table.

Table 3-10. Linear Module Repeatability

	In-Line Motors	Wrap-Around Motors
Ground Screws:		
Unidirectional	±6 µm	±15 µm
Bidirectional	±8 µm	±20 µm
Rolled Screws:		
Unidirectional	n/a	±20 µm
Bidirectional	n/a	±50 µm

Thrust

Python linear modules are capable of generating significant intermittent axial thrust forces for applications such as insertion. As long as the thrust force is applied slowly (i.e. non-impacting) and the resultant pitch moments are within the Carriage Maximum Transportable Moments specified in table Table 3-3 on page 40, the modules can successfully perform millions of repeated operations. The maximum non-impact thrust force capabilities are dependent upon the ball screw lead. See the following table for details.

Table 3-11. Maximum Non-impact Axial Thrust Force

Module	5 mm Pitch	10 mm Pitch	20 mm Pitch
L18	n/a	200 kg	100 kg
L12	n/a	200 kg	100 kg
L08	140 kg	70 kg	35 kg

NOTE: Continuous thrust values are approximately 30% of the values listed above, limited by the motor duty cycle limitations.

Brakes

Python linear modules can be configured with or without payload-holding brakes. The brakes used on L18 and L12 modules are ball screw shaft-mounted brakes and are located at the end of the module, opposite the motor. L08 modules use motor-mounted brakes.

Brakes are required for all modules on which the payload will be moving vertically. The brakes are designed to hold the maximum-rated payload when High Power to the MB-10 amplifier is removed. Brakes are not engaged during normal servo operation. They are not required to assist in deceleration or nulling at a programmed location. When ordering linear modules via the Adept website, configurations with vertical axes default to include a brake.

Brakes increase the length of each module, as shown in the following drawings.

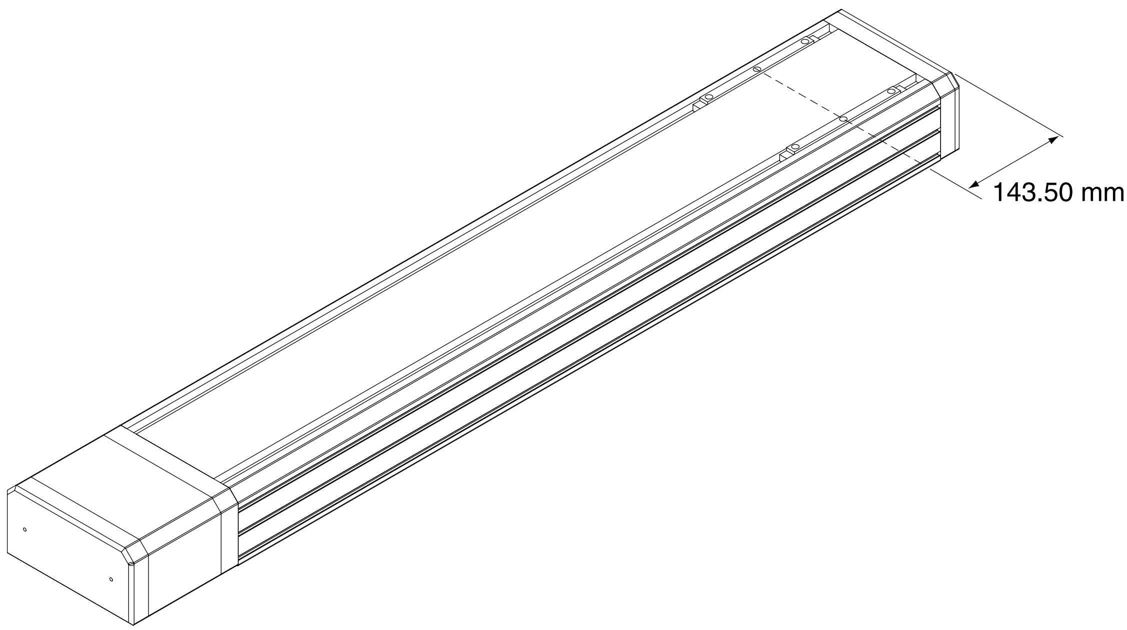


Figure 3-1. L18 Module without Brake, Shown at End of Stroke

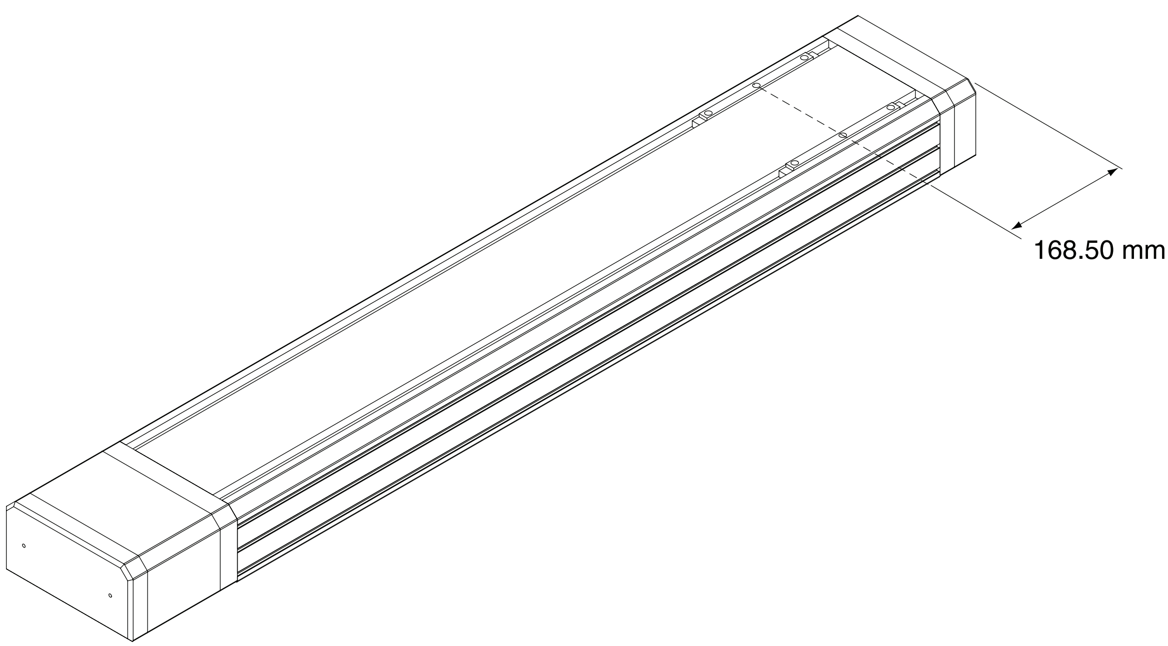


Figure 3-2. L18 Module with Brake, Shown at End of Stroke

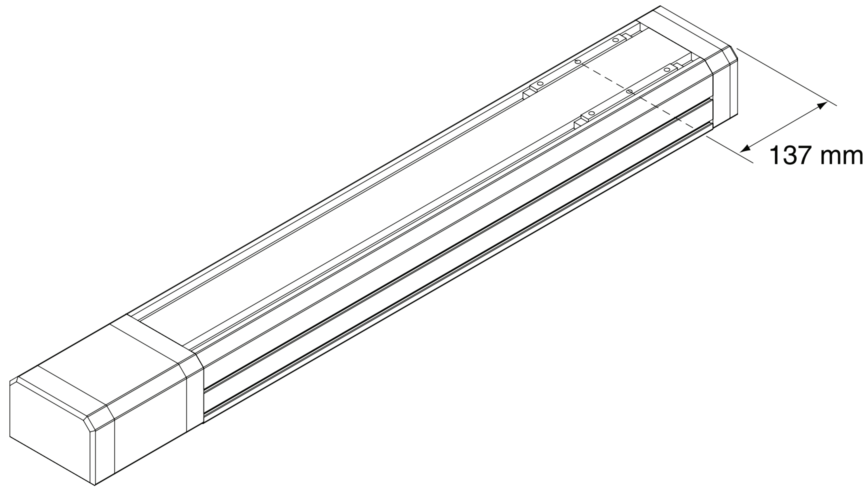


Figure 3-3. L12 Module without Brake, Shown at End of Stroke

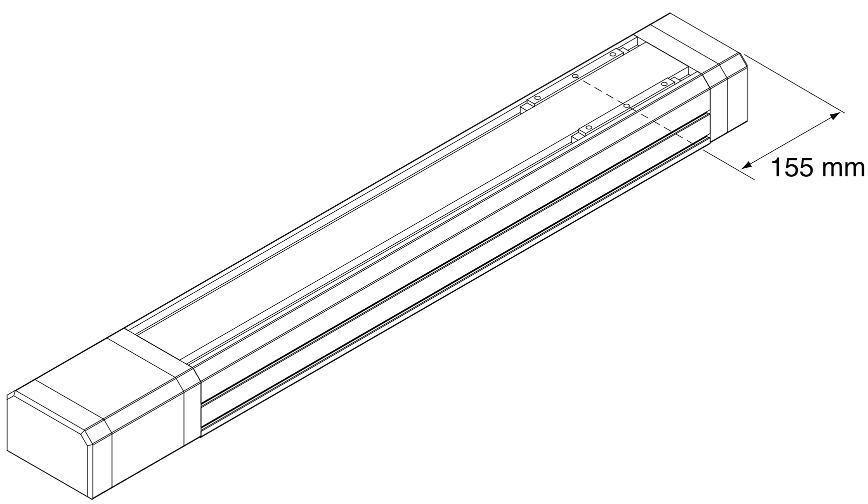
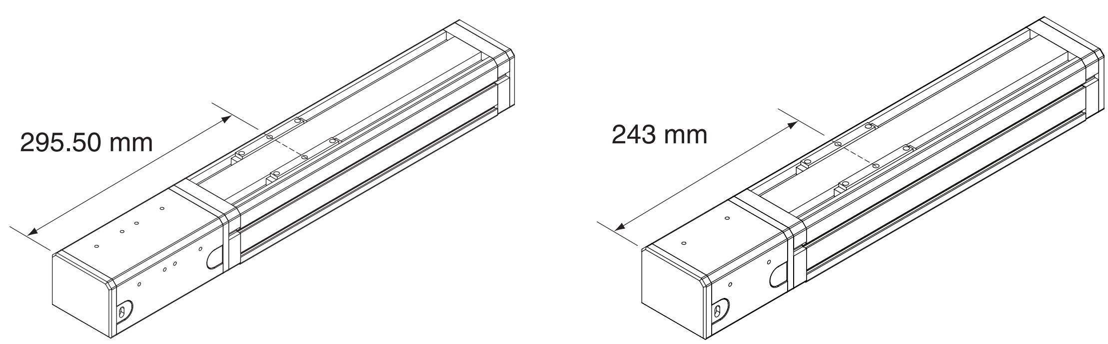


Figure 3-4. L12 Module with Brake, Shown at End of Stroke



Carriage shown at zero position in both drawings

Figure 3-5. L08 Module with Brake (Left) and without Brake (Right)

Motor Mount Configuration

The following motor mount configuration options are available:

- In-line motors
- Left-side motors
- Right-side motors
- Bottom-mount motors (L18 and L12 modules only)

In-line motor configurations provide the highest levels of accuracy and repeatability because the motor is directly coupled to the ball screw shaft. Side or bottom-mount configurations use a parallel timing belt drive and therefore are more compact in the axial direction.

> **NOTE:** The left- and right-hand orientations are observed when facing a module carriage with the motor end upward. See the following figure.

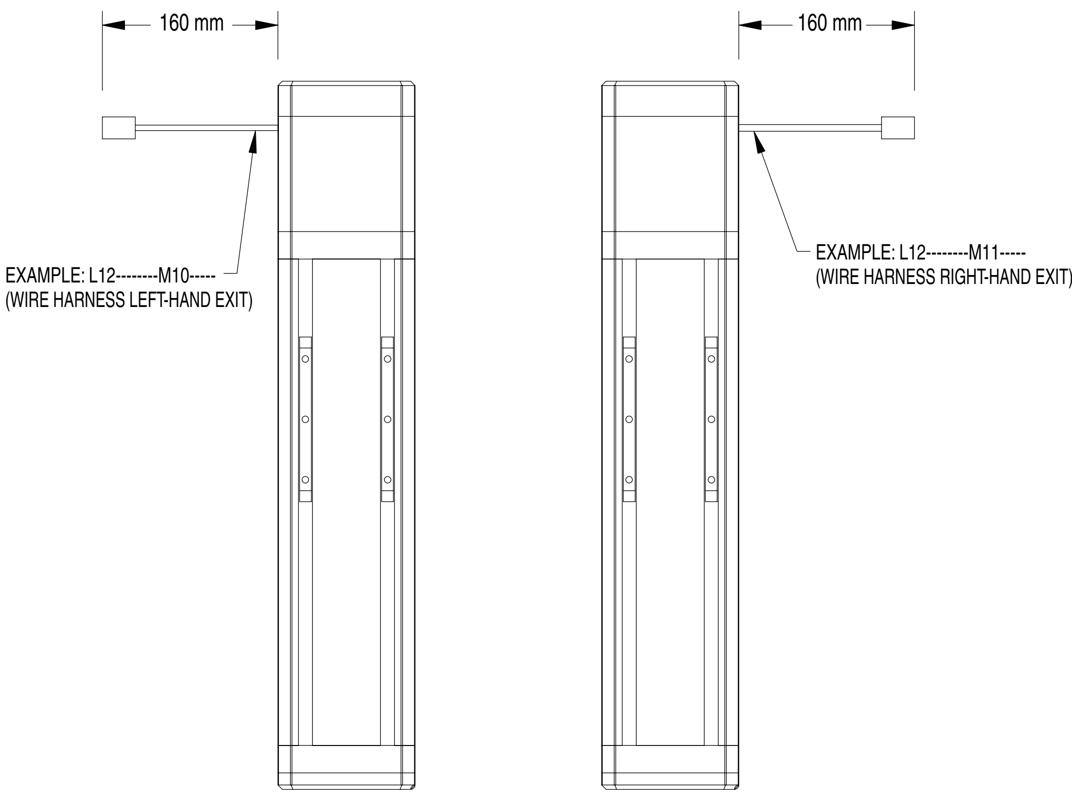


Figure 3-6. Left- and Right-Hand Orientation Example

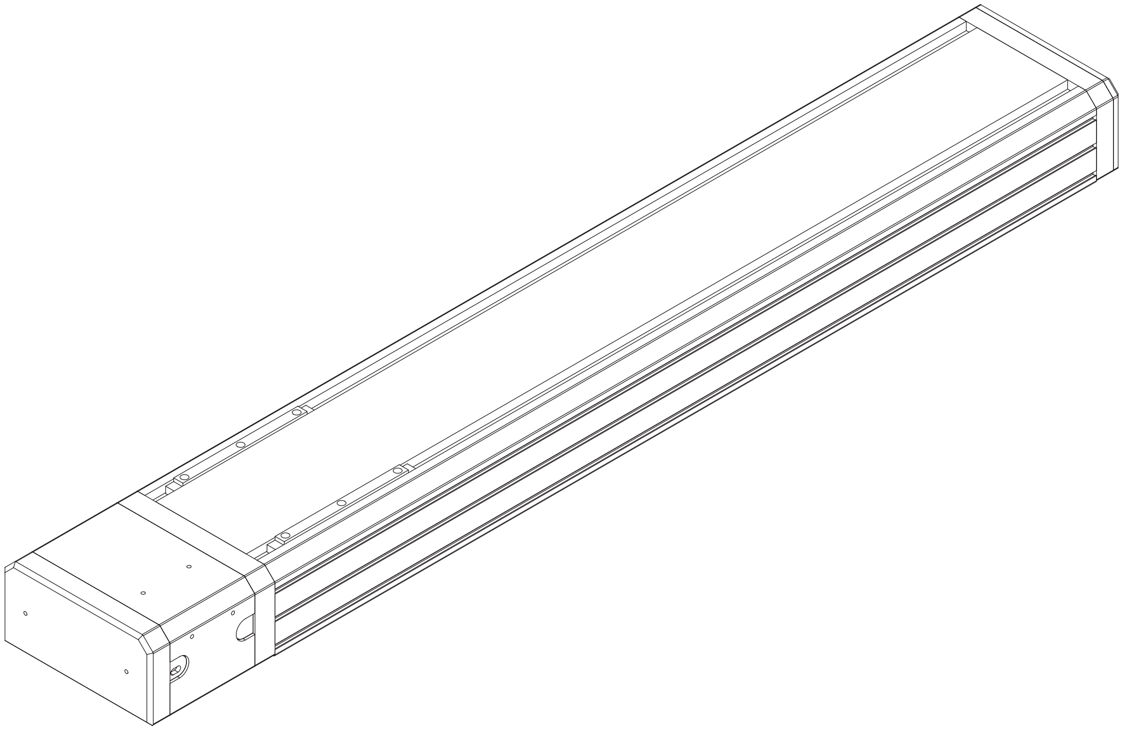


Figure 3-7. L18 Module with In-line Motor

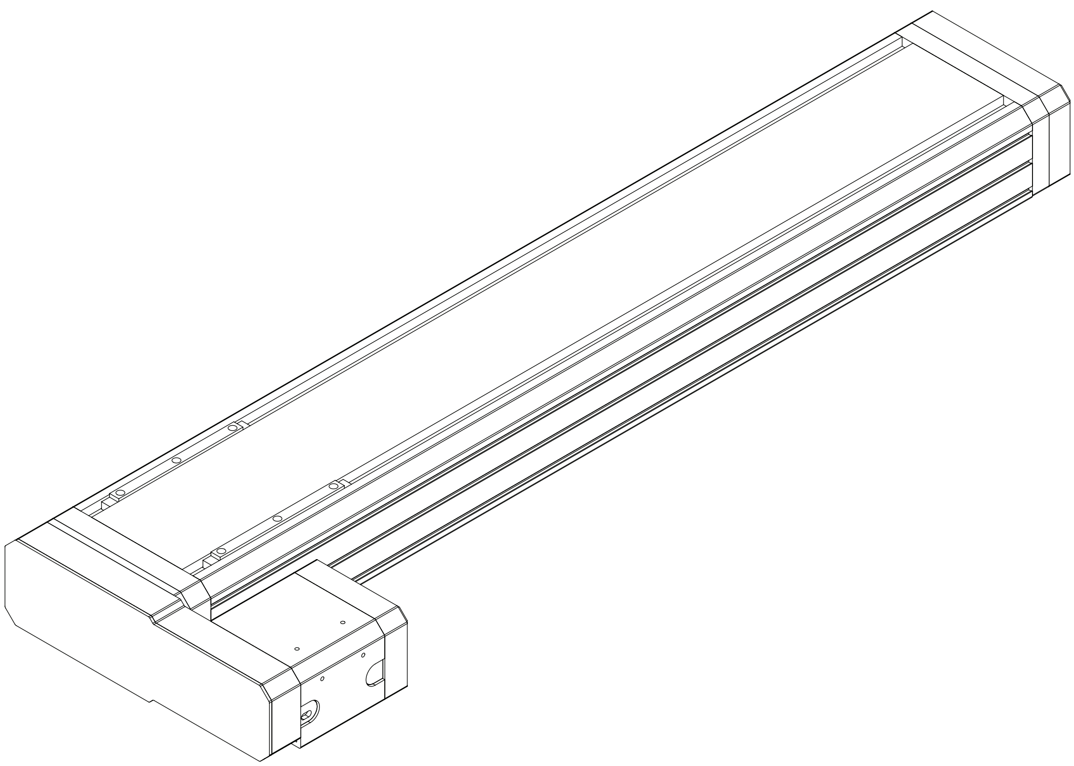


Figure 3-8. L18 Module with Left-Side Motor

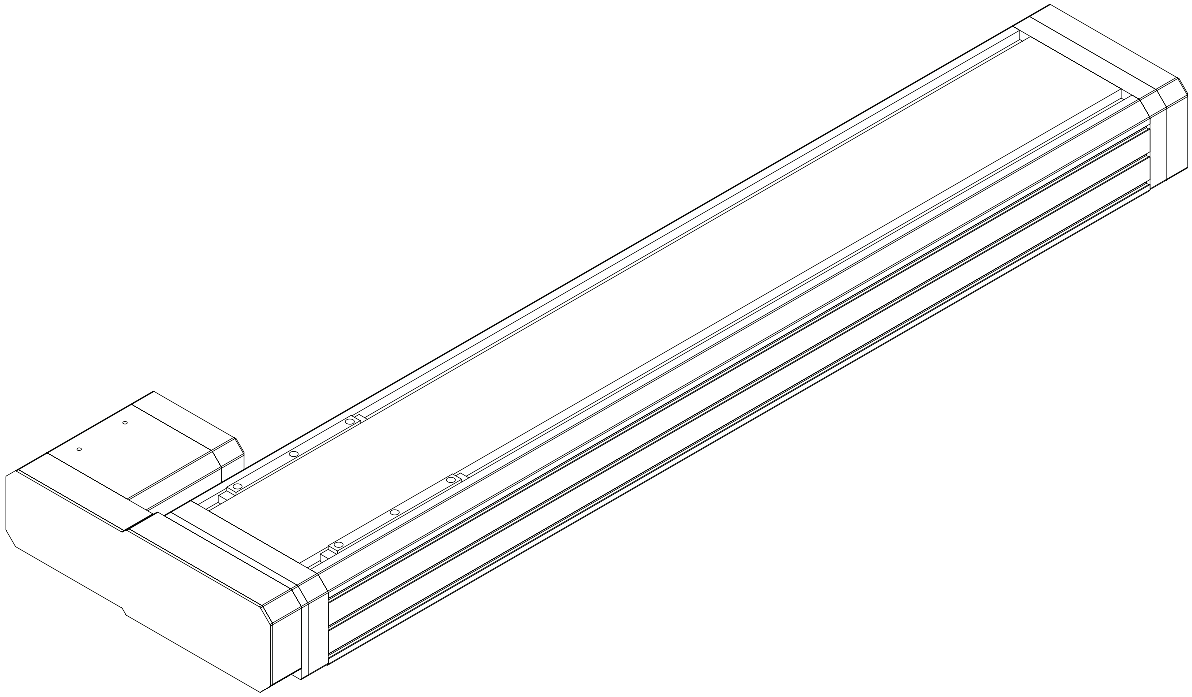


Figure 3-9. L18 Module with Right-Side Motor

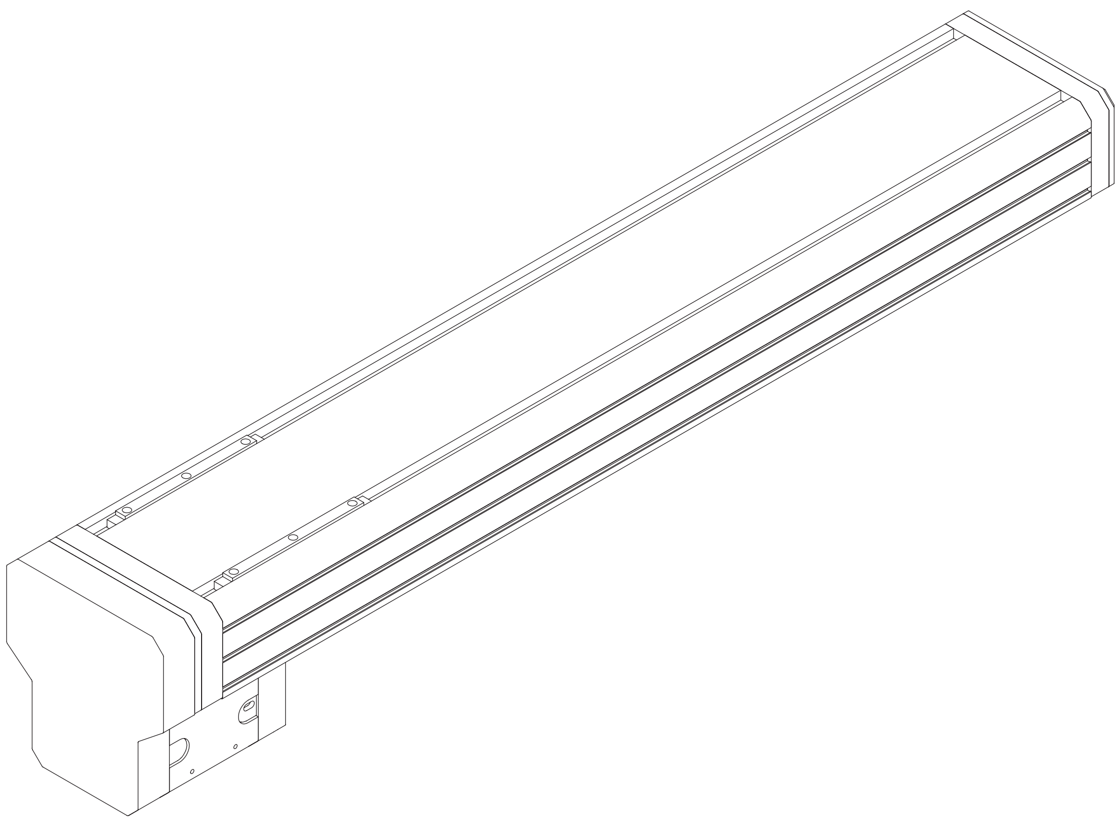


Figure 3-10. L18 Module with Bottom-Mount Motor

Harness Exit Configurations

Along with the motor mount configuration, the location where the wiring harness exits from the motor enclosure can be configured. On in-line motor modules, the wire harnesses can be configured to exit from the left or right side of the motor enclosure. For left- and right-side motor modules, the wire harness exits from the motor side of the module. The harness exit configurations are normally defined automatically as the module system is configured, to optimize the system wiring.

In addition to left and right exit configurations, the actual grommet location is also defined automatically. The harness exit locations and grommets can easily be reconfigured in the field if needed.

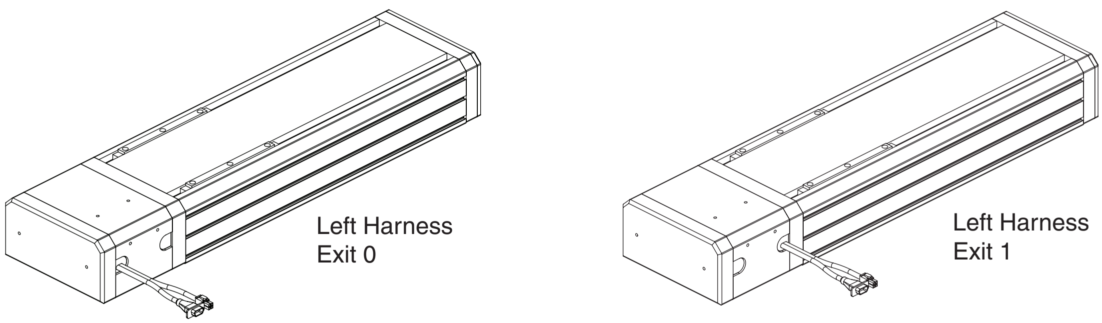


Figure 3-11. In-Line Motor, Left Harness Exit Locations

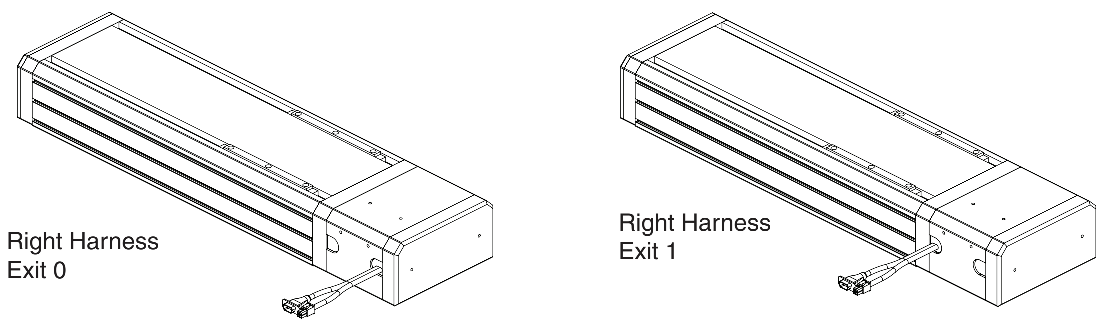


Figure 3-12. In-Line Motor, Right Harness Exit Locations

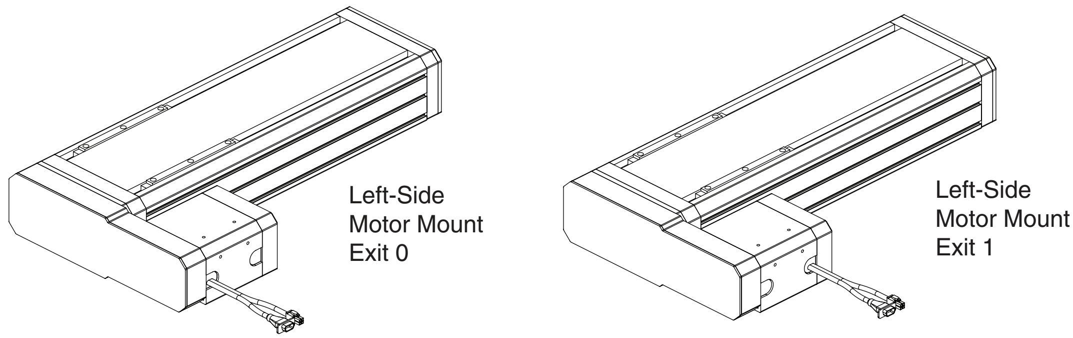


Figure 3-13. Left-Side Motor Mount, Harness Exit Locations

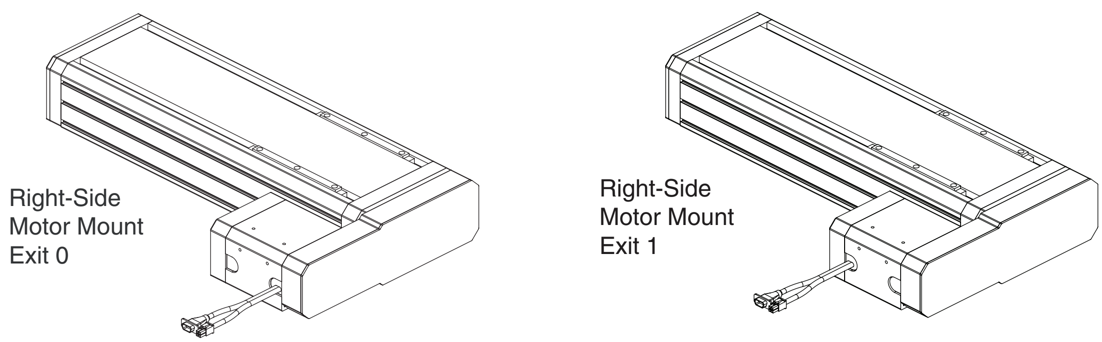


Figure 3-14. Right-Side Motor Mount, Harness Exit Locations

Module Preparation (Assembly)

Standard and cleanroom versions of all types of Python modules (including Theta modules) are available.

Standard and cleanroom modules all feature:

- Belt seals that provide IP-20 ingress protection

Standard modules feature:

- Hard, anodized aluminum with powder-coated surfaces
- Maximum speed: up to 1450 mm/sec (varies with ball screw)

Cleanroom Modules

Cleanroom versions are available for modules. These modules meet Class 10 Airborne Particulate Cleanliness Limits, as defined by Federal Standard 209E. Cleanroom modules provide two air (pneumatic) lines that can be connected to a vacuum source to help remove particles from within the module.

The specifications for cleanroom modules are as follows:

- Class rating of FED 209E Class 10 or ISO 14644 Class 4
- Module speed of up to 500 mm/s
- Vacuum flow rate of 60-90 L/min

The Cleanroom Air Kit includes a length of pneumatic tubing and some extra fittings for connecting the modules to the vacuum source.

Cleanroom modules feature:

- Belt seals made of polymer belt material
- A pair of 8 mm vacuum lines for each module

See **Section 6.4 on page 114** for cleanroom module installation instructions.

Module Descriptor Numbers

A descriptor number is associated with each Python linear module. This number fully defines its configuration and shows all the selected options for the module.

> **NOTE:** In addition to module descriptor numbers, a separate descriptor number is associated with each system configuration. See **"Module System Descriptor Numbers" on page 67** for information.

L18 Module Descriptor Number Example and Key

The following figure shows an example descriptor number for an L18 module.

L18	030	S10	B0	M10	0	P0	0	0

Figure 3-15. L18 Descriptor Number Example

The boxes are provided to show how the descriptor number consists of characters whose values and positions represent different configuration options. For example, "L18"in the first three positions indicates an L18 module is configured.

The following two figures provide a key that shows all the options these characters can represent. For layout purposes, the key is divided into two parts.

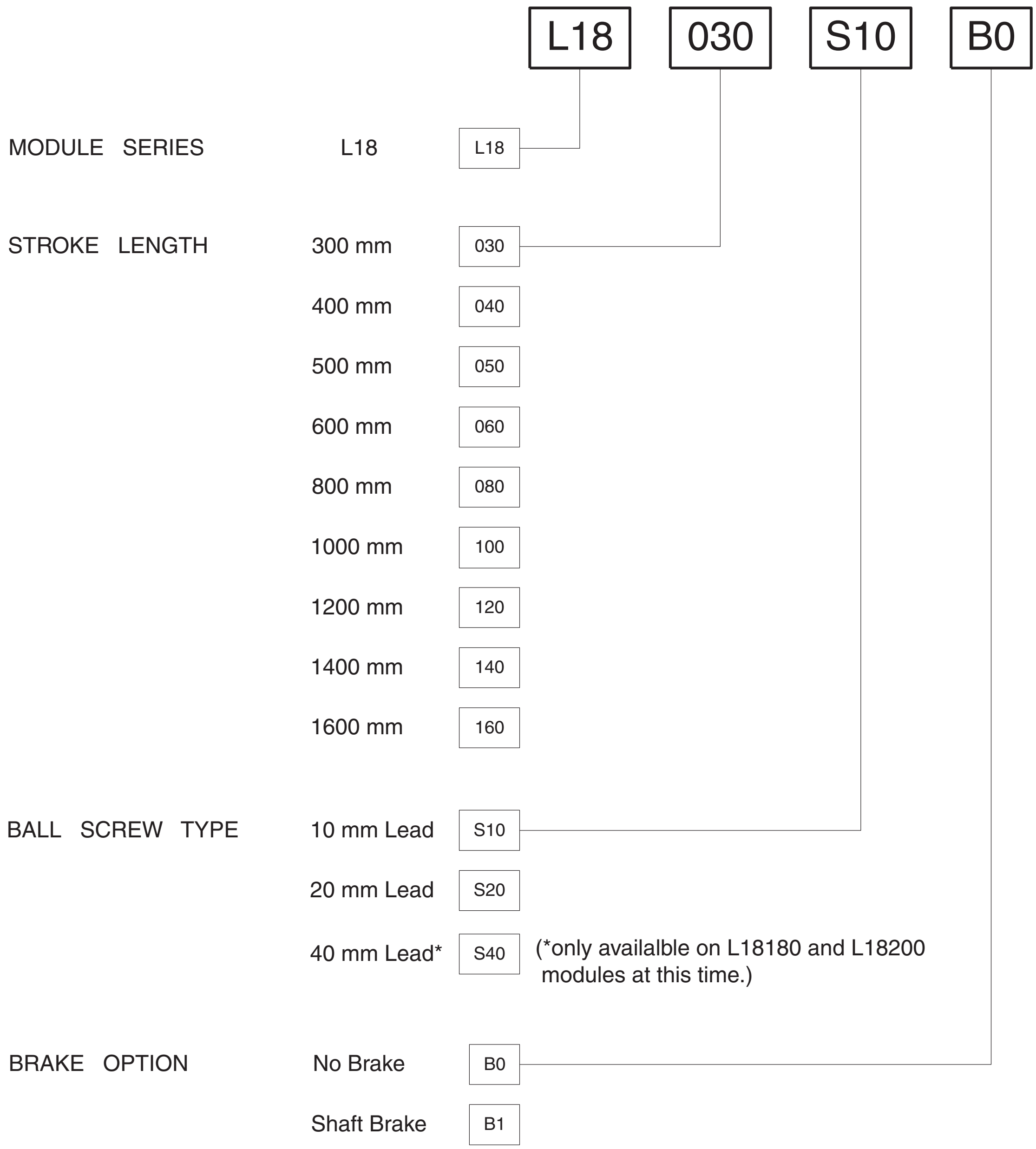


Figure 3-16. L18 Module Descriptor Key, Part 1 of 2

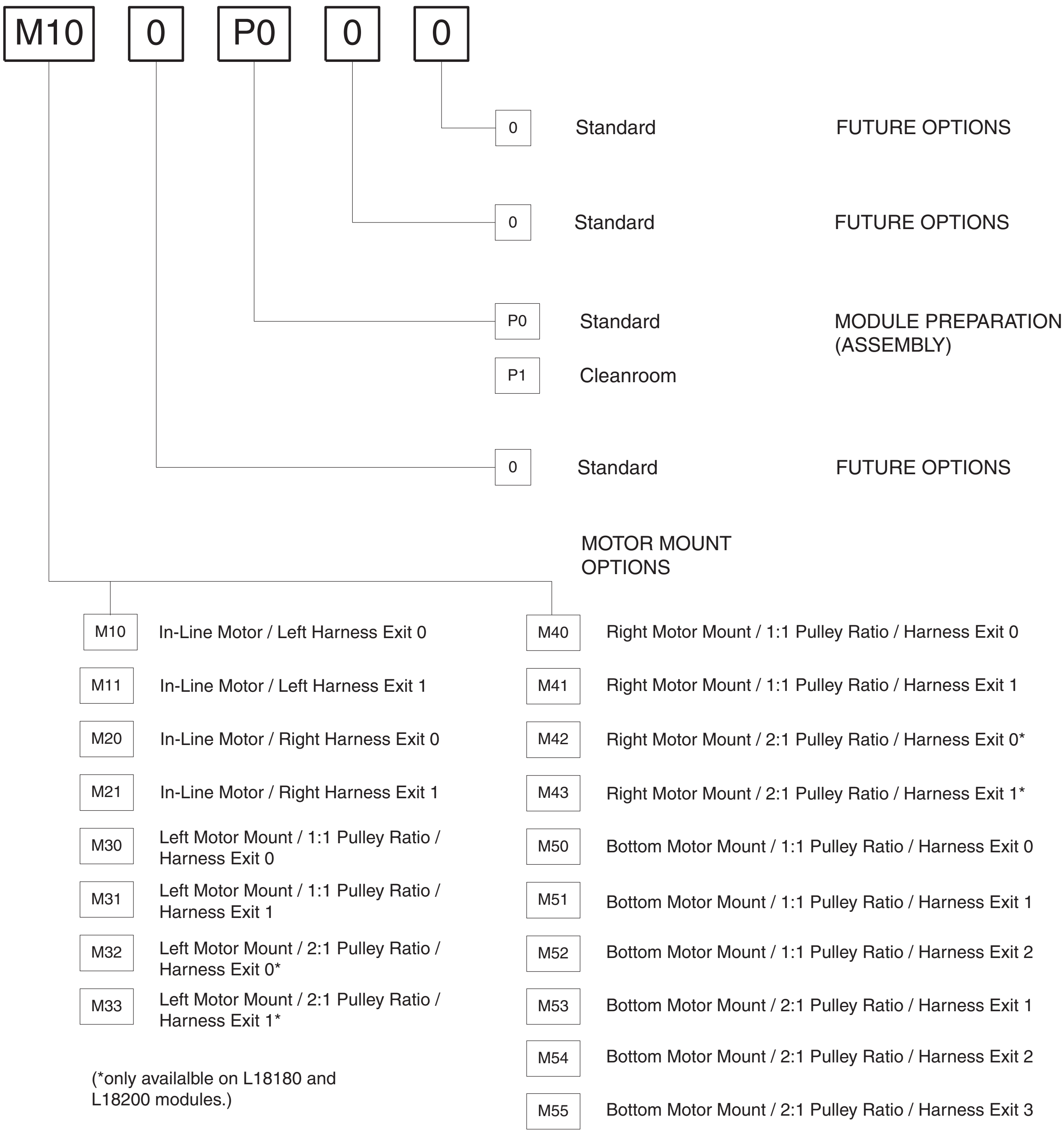


Figure 3-17. L18 Module Descriptor Key, Part 2 of 2

L12 Module Options and Descriptor Number Key

The next two figures provide a key that shows the options for L12 modules. For layout purposes, the key is divided into two parts.

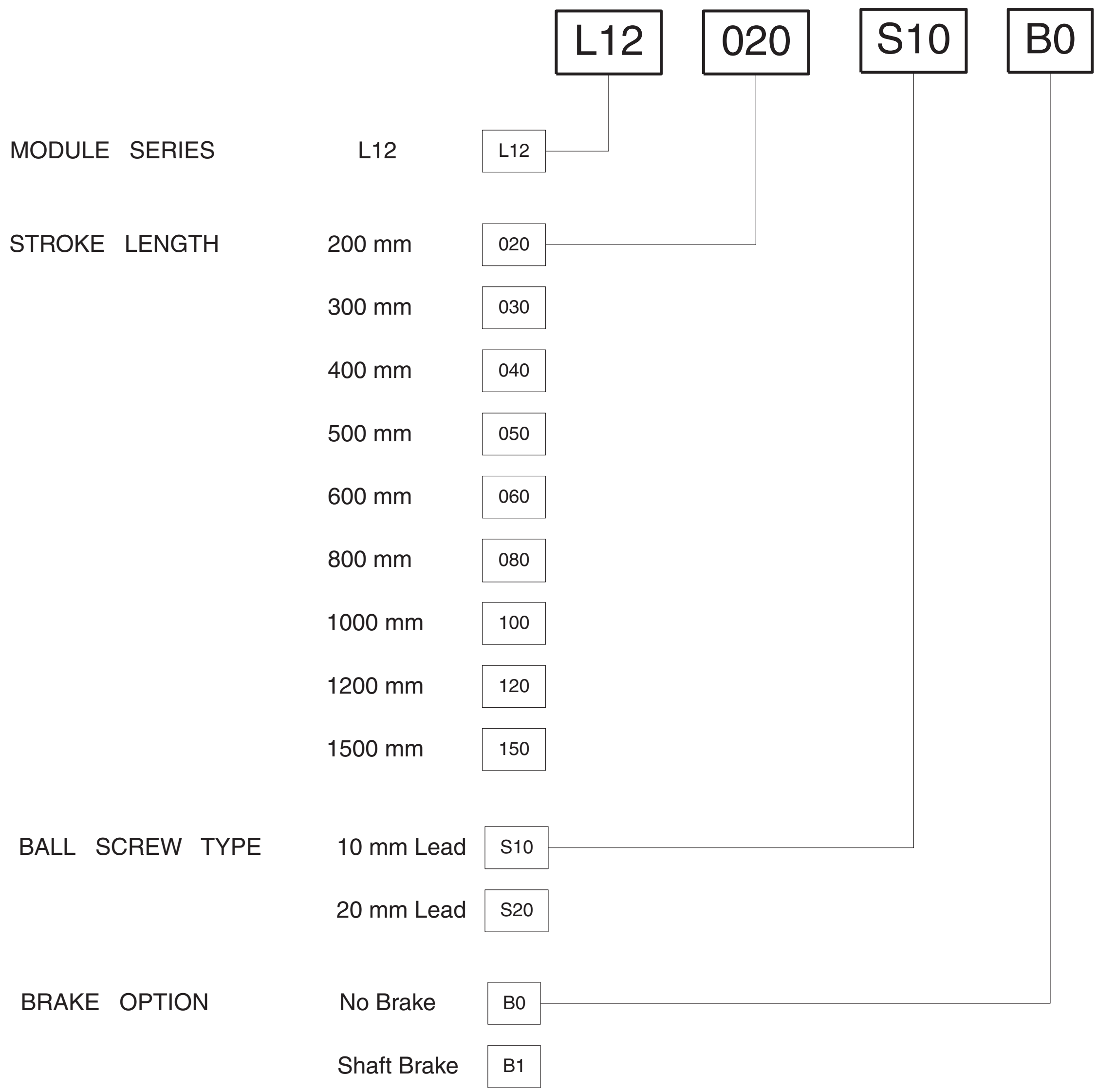


Figure 3-18. L12 Descriptor Number Key, Part 1 of 2

M10 0 P0 0 0

0	Standard	FUTURE OPTIONS
0	Standard	FUTURE OPTIONS
P0	Standard	MODULE PREPARATION (ASSEMBLY)
P1	Cleanroom	
0	Standard	FUTURE OPTIONS

MOTOR MOUNT OPTIONS

M10	In-Line Motor / Left Harness Exit 0
M11	In-Line Motor / Left Harness Exit 1
M20	In-Line Motor / Right Harness Exit 0
M21	In-Line Motor / Right Harness Exit 1
M30	Left Motor Mount / 1:1 Pulley Ratio / Harness Exit 0
M31	Left Motor Mount / 1:1 Pulley Ratio / Harness Exit 1
M32	Left Motor Mount / 2:1 Pulley Ratio / Harness Exit 0*
M33	Left Motor Mount / 2:1 Pulley Ratio / Harness Exit 1*
M40	Right Motor Mount / 1:1 Pulley Ratio / Harness Exit 0
M41	Right Motor Mount / 1:1 Pulley Ratio / Harness Exit 1
M42	Right Motor Mount / 2:1 Pulley Ratio / Harness Exit 0*
M43	Right Motor Mount / 2:1 Pulley Ratio / Harness Exit 1*
M50	Bottom Motor Mount / 1:1 Pulley Ratio / Harness Exit 0
M51	Bottom Motor Mount / 1:1 Pulley Ratio / Harness Exit 1
M52	Bottom Motor Mount / 1:1 Pulley Ratio / Harness Exit 2
M53	Bottom Motor Mount / 2:1 Pulley Ratio / Harness Exit 1
M54	Bottom Motor Mount / 2:1 Pulley Ratio / Harness Exit 2
M55	Bottom Motor Mount / 2:1 Pulley Ratio / Harness Exit 3

(*only availalble on L18180 and L18200 modules.)

Figure 3-19. L12 Descriptor Number Key, Part 2 of 2

L08 Module Options and Descriptor Number Key

The following charts show the module options unique to L08 modules (the ball screw type options are the same for all module types).

Figure 3-20. L08 Descriptor Number Key, Part 1 of 2

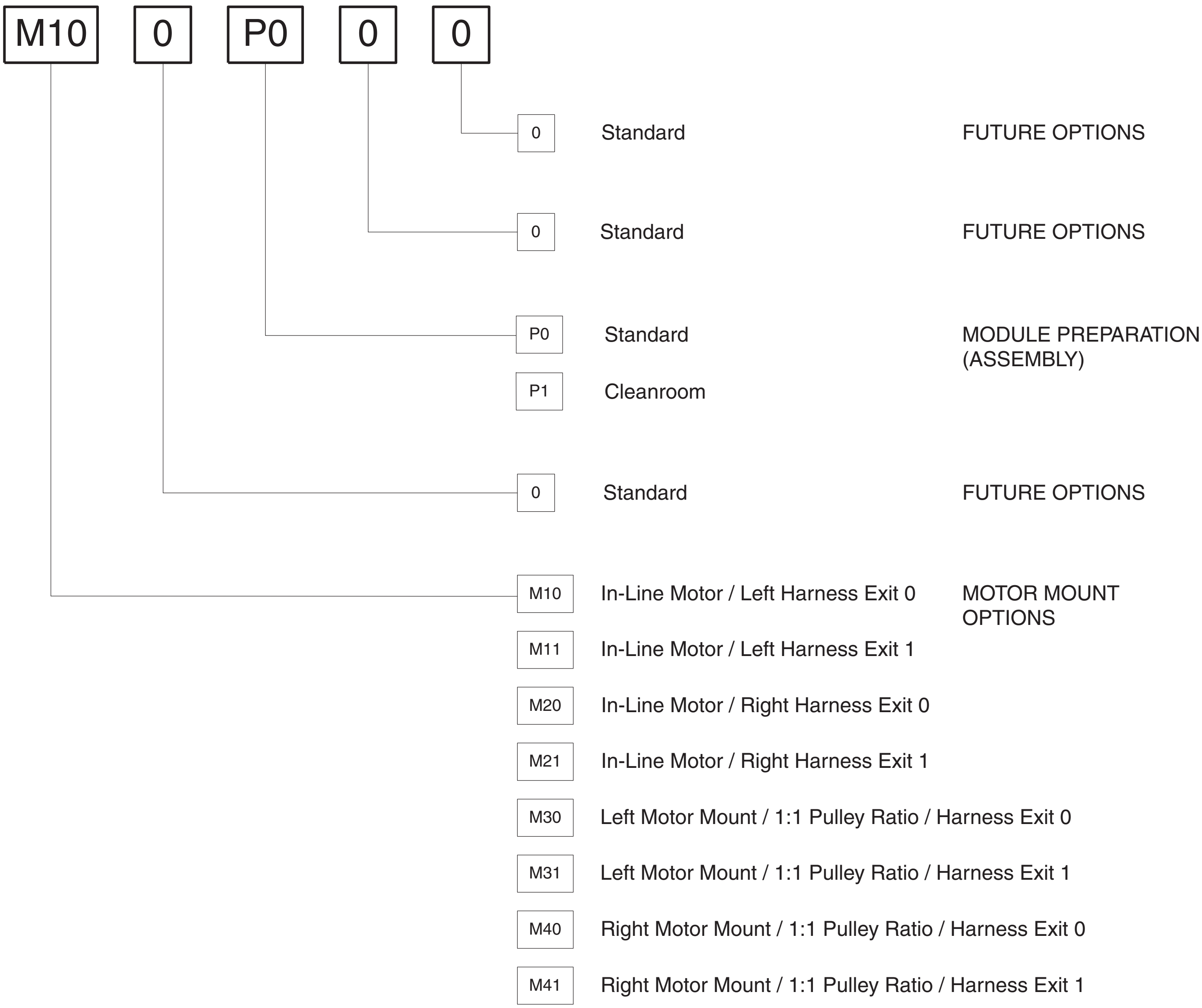


Figure 3-21. L08 Module Descriptor Key, Part 2 of 2

3.3 Gantry Support Modules

An L-Series gantry module is available to support Y-axis modules in multi-axis configurations. The gantry modules have a similar rigid aluminum extrusion frame with a single linear bearing support. These idler rails do not have motors or ball screws, but they are equipped with a single belt seal, similar to the standard linear modules. The purpose of the gantry module is to support the cantilevered end of a Y-axis to allow increased Y-axis stroke length, higher payloads, and improved system stiffness.

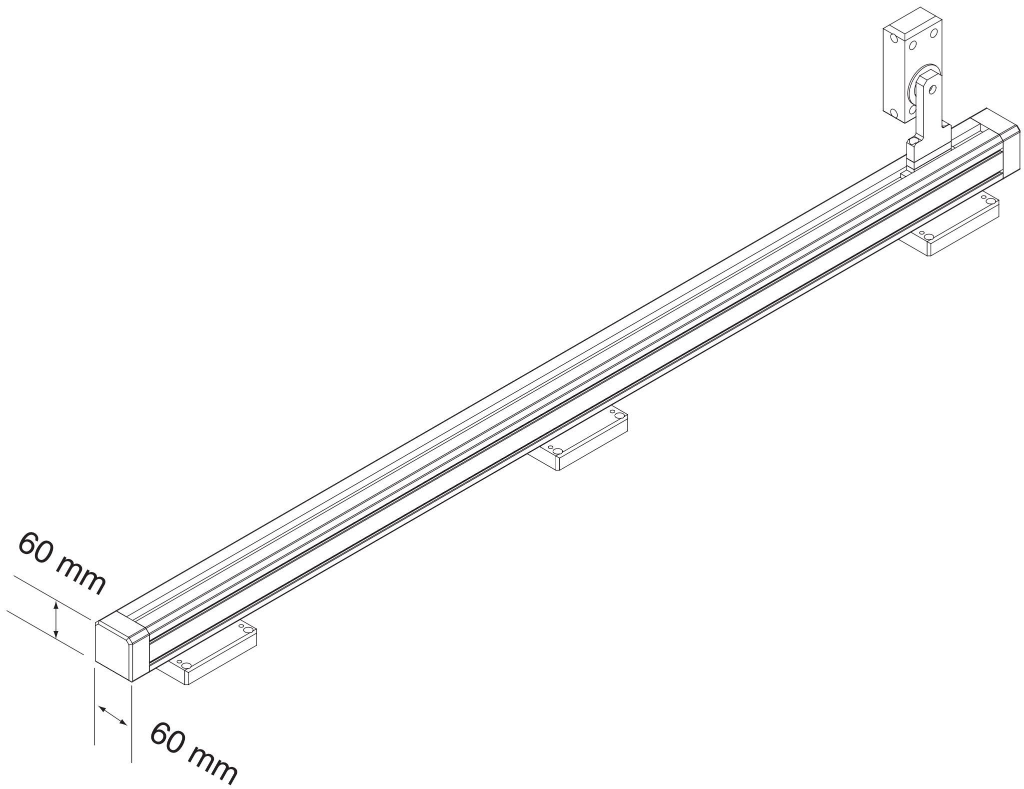


Figure 3-22. Gantry (LG6) Module

Gantry Support Module Descriptor Numbers

When a Python L-Series gantry support module is included in a system, a descriptor number is generated to describe the gantry, similar to the module descriptor numbers.

The following figure shows an example LG6 (gantry) descriptor number.

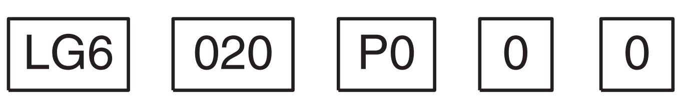


Figure 3-23. LG6 (Gantry) Descriptor Number Example

The boxes are provided to show how the descriptor number consists of characters whose values and positions represent different configuration options. For example, “020” indicates a 200 mm stroke length.

Figure 3-24 provides a key that shows all the options these characters can represent.

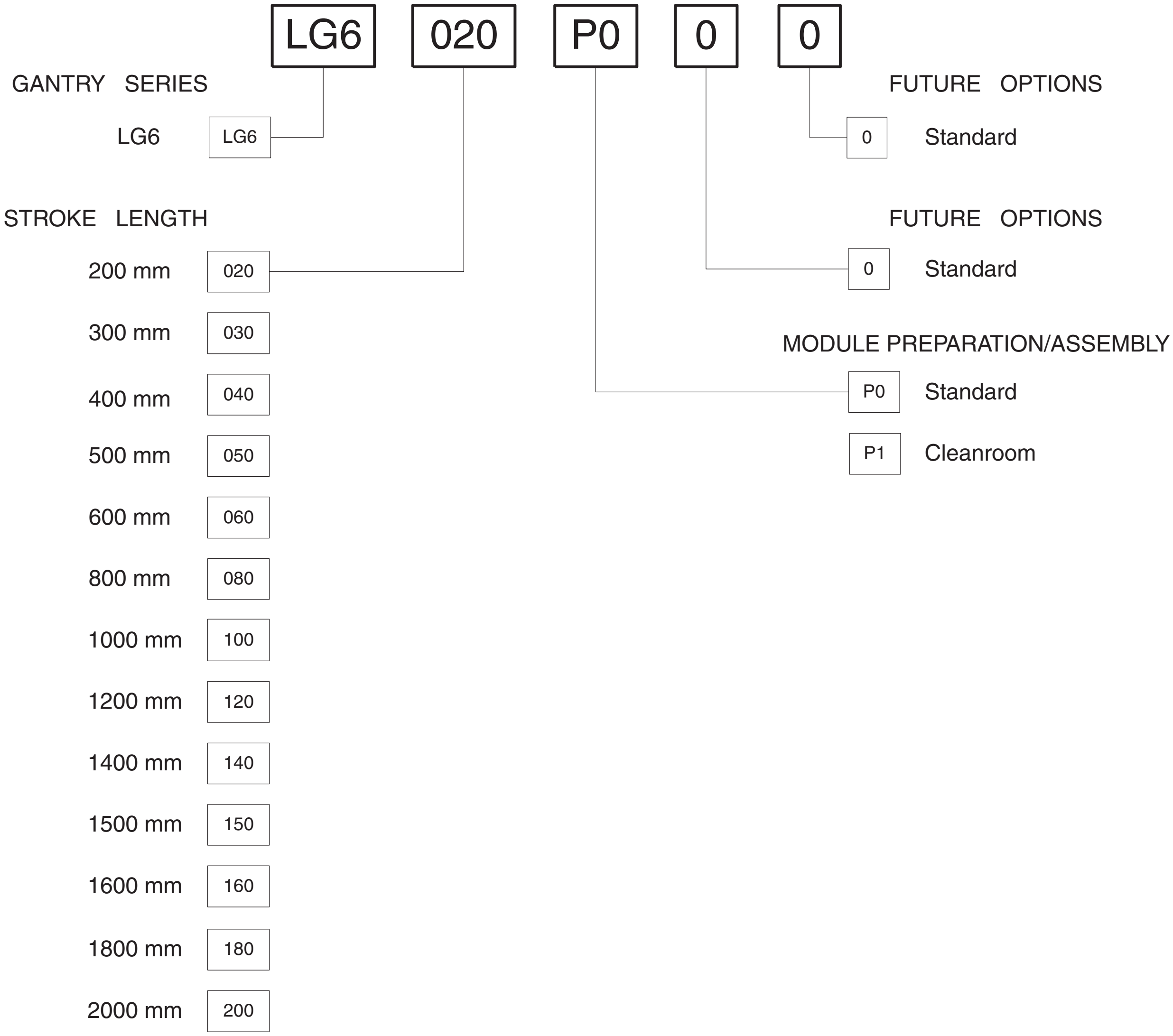


Figure 3-24. LG6 (Gantry) Descriptor Number Key

Python Theta Module Description 4

4.1 Adept Python Theta Modules

The LT1 Theta module adds a 4th axis to a Python system, providing additional handling options. Use the Adept 3D Linear Module Builder section of the Adept website (www.adept.com) to select, configure, and request a quote for your Theta modules. The website and this chapter provide detailed information about Adept Python Theta modules. See Chapter 3 for information about one-, two-, and three-axis linear modules.

Single-Axis and Multiple-Axis Configurations

You can order a single Adept Python Theta module system consisting of a single module, MB-10 amplifier, and a SmartController CX. Or, multiple modules can be assembled into a complete multi-axis system.

4.2 Theta Module Options

The following options are configurable for Theta modules:

- Module preparation (standard or ESD)
- Interface (flange or shaft)

L-Series Module Type

Currently, LT1 is the available Theta module type. See "Single-Axis Theta Modules" on page 75 for Theta module dimensions. LT1 Theta modules have the following construction features:

- Rigid aluminum body for high stiffness, with precision-machined tolerances for increased concentricity and repeatability
- Dual pre-loaded heavy duty radial ball bearings for maximized stiffness and increased load capacity
- High-precision Harmonic Drive component set for increased torque and repeatability
- Maintenance-free operation: bearing and drive components are lubricated for life
- High-performance AC servo motors with 8 kHz servo update rate and optimized current loop tuning in amplifier
- Serial absolute encoders with 65,536 counts/rev resolution, no homing required

- ±360 degrees of motion (continuous turn operation available)
- Mounting option on L08 module carriage or L08 module body

All external dimension and weight specifications for each module type can be found on the module specification drawings located on the Adept website.

The LT1 Theta module utilizes heavy duty radial ball bearings to support its output shaft. The basic load ratings for these bearings are given in the following table.

Table 4-1. Output Shaft Bearing Static and Dynamic Load Ratings

Module Type	C[a] (N)	Co[b] (N)
LT1	10,100	5850

[a] Basic Dynamic load rating
[b] Basic Static load rating

Table 4-2. Carriage Maximum Payload and Transportable Moments

Module Type	Payload (kg)	Payload Moment (kg-cm)	Load Inertia (kg-cm^2)
LT1	5.0 (max) / 2.0 (rated)	40.0 (max)	350 (max) / 150 (rated)

The motor used in the LT1 Theta module is a high-quality AC motor manufactured by Yaskawa corporation. These motors employ serial absolute encoders. The motor model numbers, size, maximum torque values, and encoder resolution are provided here for reference.

Table 4-3. Motors Used in Python LT1 Modules

Module Type	Motor Type	Motor Size (Watts)	Peak Torque (N-m)	Encoder Resolution (Cnts/Rev)
LT1	Sigma-II	50	0.48	65,536

Table 4-4. LT1 Module Acceleration, Speed, Torque, and Repeatability

Module Type	Acceleration (deg/sec)	Speed (deg/sec)	Torque (N-m)	Repeatability (deg)
LT1	8000 (max)	1000 (max) 400 (rated)	9.0 (max) 4.0 (rated)	±0.1

Gear Ratio

The LT1 Theta module uses a high-precision Harmonic Drive component set for the gear reduction in its drive mechanism. The gear ratio is 30:1.

Module Preparation (Assembly)

The LT1 Theta module comes standard with a painted motor cover. An optional ESD-resistant nickel-plated motor cover is available.

Cleanroom Modules

All Theta modules have cleanroom compliance as a standard feature. The Theta module meets Class 10 Airborne Particulate Cleanliness Limits, as defined by Federal Standard 209E. See **"Module Preparation (Assembly)" on page 51** for information on cleanroom versions of modules.

Interface

The LT1 Theta module comes standard with a 20 mm diameter output shaft. An optional user flange is also available. See **"Single-Axis Theta Modules" on page 75** for the mounting dimensions for the standard shaft and optional flange.

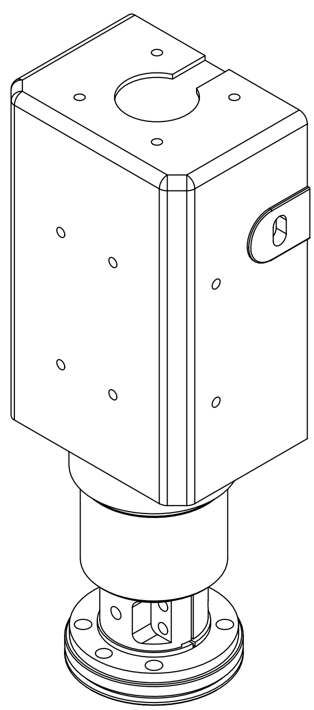


Figure 4-1. LT1 (Theta) Module with User Flange

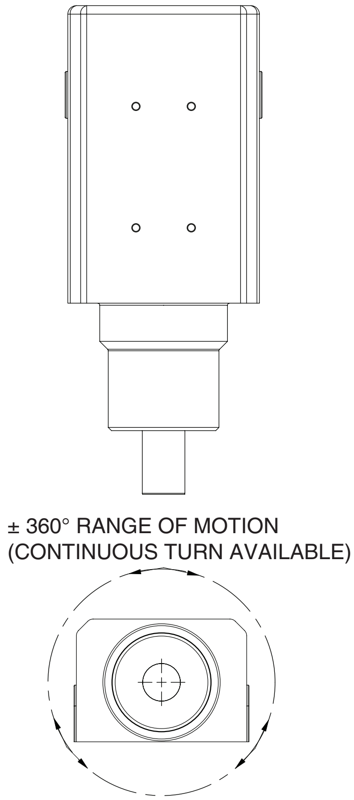


Figure 4-2. LT1 (Theta) Module with Standard Shaft/Range of Motion

Module Descriptor Numbers

A descriptor number is associated with each Python module. This number fully defines its configuration and shows all the selected options for the module.

> **NOTE:** In addition to module descriptor numbers, a separate descriptor number is associated with each system configuration. See **"Module System Descriptor Numbers" on page 67**.

LT1 Module Descriptor Number Example and Key

The following figure shows an example descriptor number for an L18 module.

LT1	G30	B0	P0	0	0

Figure 4-3. LT1 (Theta) Module Descriptor Number Example

The boxes are provided to show how the descriptor number consists of characters whose values and positions represent different configuration options. For example, "LT1"in the first three positions indicates a Theta (LT1) module is configured.

The following figure provides a key that shows all the options these characters can represent.

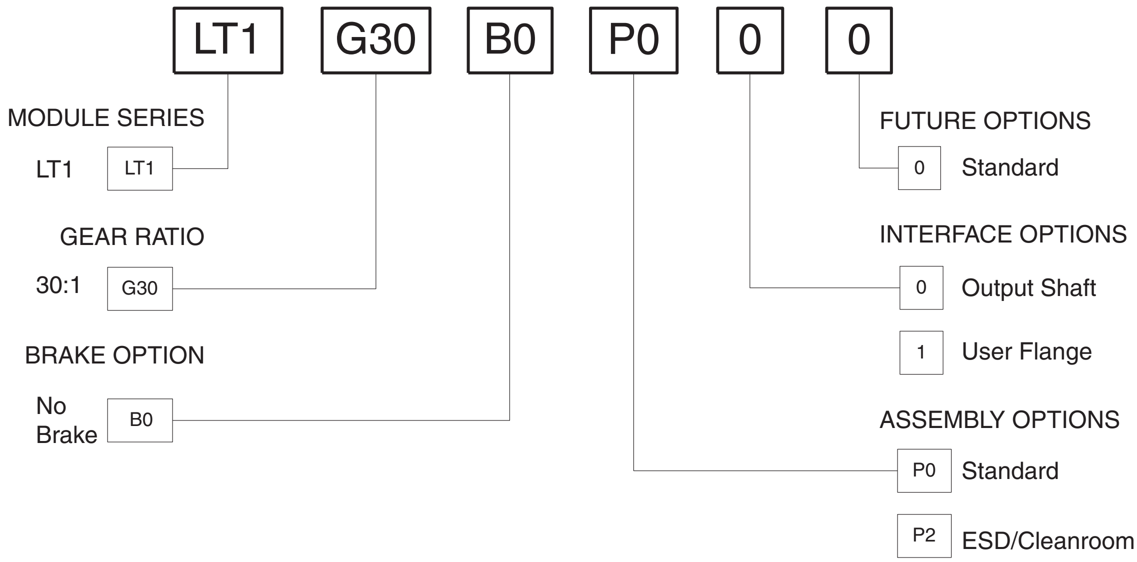


Figure 4-4. LT1 (Theta) Module Descriptor Key

Module System Descriptions 5

5.1 System Configuration Options

In addition to module options, several system configuration options are available. A system consists of one or more modules, one amplifier per module, combining brackets, interconnect harnesses, and optional mounting feet.The following system options are available:

- Control series
- System configuration
- Module types
- Orientation
- Mounting options
- Cable kits
- Gantry mounting kits
- IO Blox
- Cabling/plumbing option

5.2 Module System Descriptor Numbers

A module system descriptor number is associated with each system. This number is similar to the descriptor number used to specify each module: it specifies each selected system option and defines the assembly orientation of the system.

The module system descriptor number defines all of the system bill of material items, except for the individual modules and the controller bundle. For example, the descriptor number defines the number of MB-10 amplifiers, the type of combining bracket kits, and the lengths of the interconnect cable harnesses. The number also defines optional materials, such as gantry mount hardware, mounting feet/toe clamps, and IO Blox. Just as important, the module system descriptor number defines the assembly orientation for the modules, gantry, and IO Blox. Both the individual module and module system descriptor numbers are required to fully define a Python module system.

NOTE: In addition to module system descriptor numbers, a descriptor number is associated with each module. See **"Module Descriptor Numbers" on page 52** information.

Module System Descriptor Number Example and Key

The following figure shows an example module system descriptor number.

M	10	S	1	0	0	0	SS	13	A0	A0	A0	A0	0	X0	0

Figure 5-1. Module System Descriptor Number Example

The boxes are provided to show how the descriptor number consists of characters whose values and positions represent different configuration options. For example, "SS" indicates a Standard/Standard orientation.

The following two figures provide a key that shows all the options these characters can represent. For layout purposes, the key is divided into two parts.

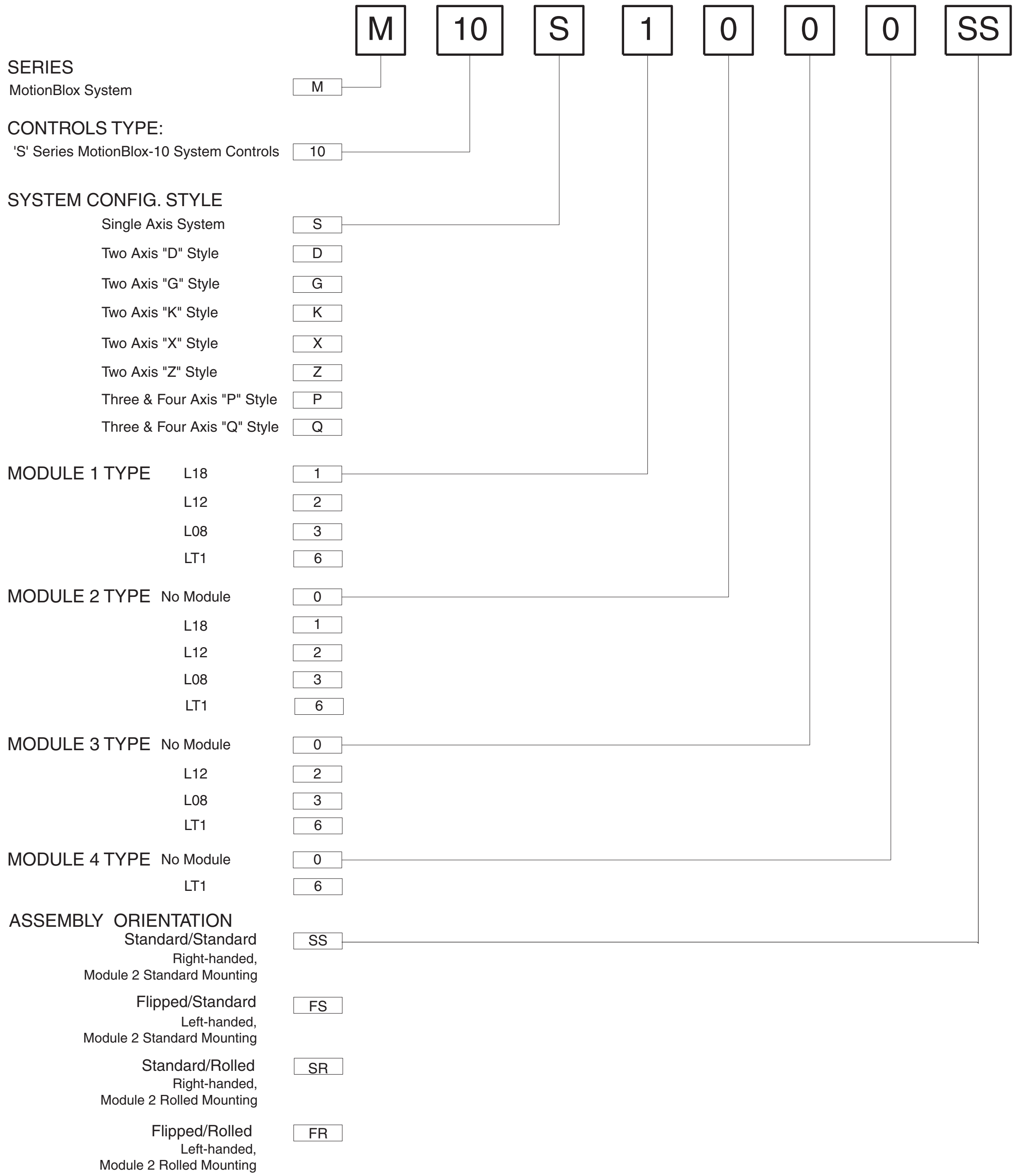


Figure 5-2. Module System Descriptor Number Key, Part 1 of 2

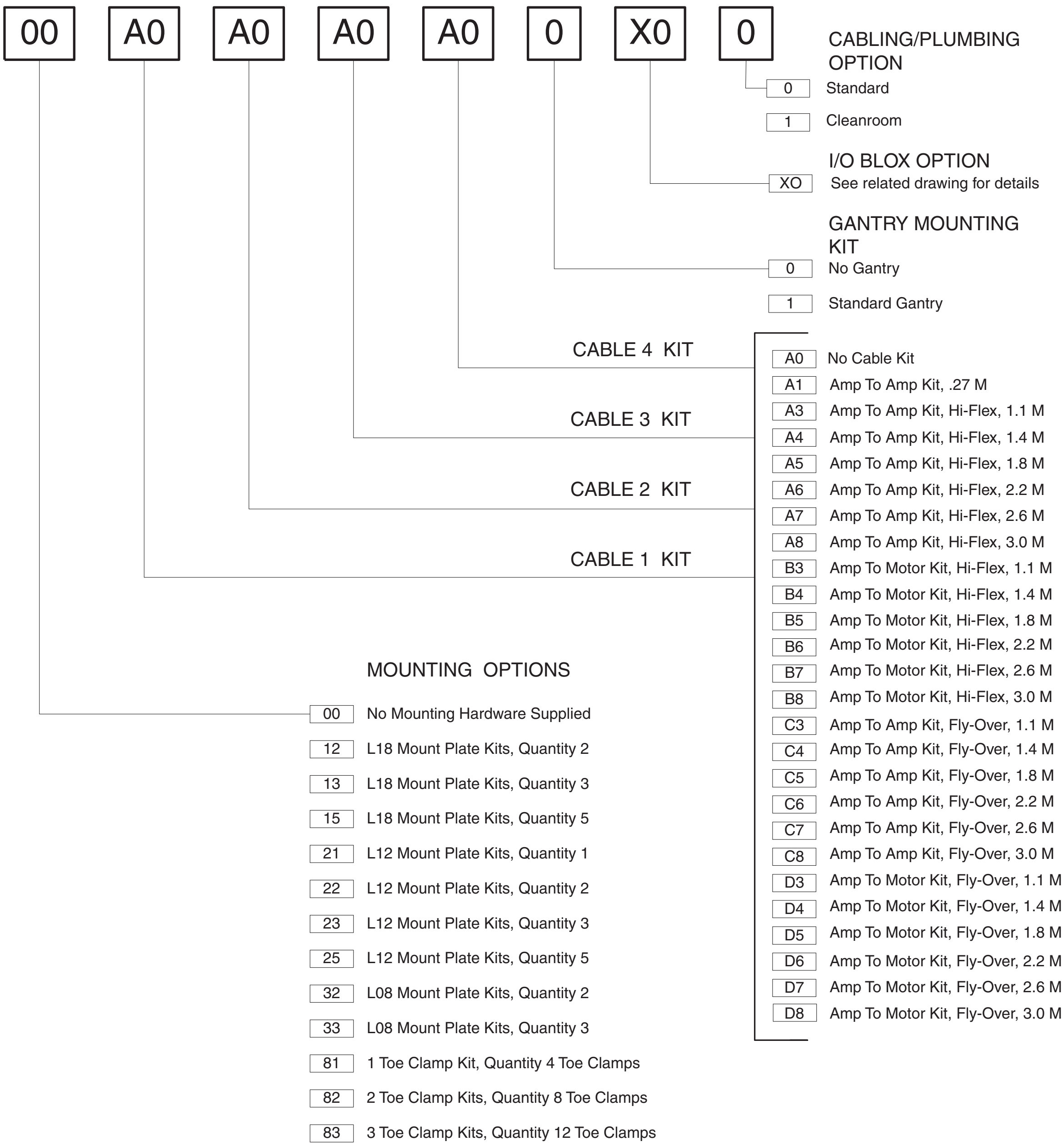


Figure 5-3. Module System Descriptor Number Key, Part 2 of 2

X0

IO BLOX OPTIONS

X0	No IO Blox Supplied
X1	1 IO Blox at 1st MB-10, mounted at T-bracket cover
X2	2 IO Blox at 1st MB-10, mounted at T-bracket cover & main body
X3	3 IO Blox at 1st MB-10, mounted at T-bracket cover & main body (2)
X4	4 IO Blox at 1st MB-10, mounted at T-bracket cover & main body (3)
X5	1 IO Blox at last MB-10, mounted at Y-axis T-bracket cover or Z-axis enclosure
X6	2 IO Blox at last MB-10, mounted at Y-axis T-bracket cover & main body or Z-axis enclosure & main body
X7	2 IO Blox (1 each at first and last MB-10, mounted at T-bracket cover or enclosure)
X8	4 IO Blox (2 each at first and last MB-10, mounted at T-bracket cover, enclosure, & main bodies)
X9	NOT USED

Figure 5-4. IO Blox Options in Module System Descriptor Number

Control Series

Currently, the only system control series available is the MotionBlox-10 ‘s’ series (CX controller required). Therefore, all module system descriptor numbers start with “M10.”

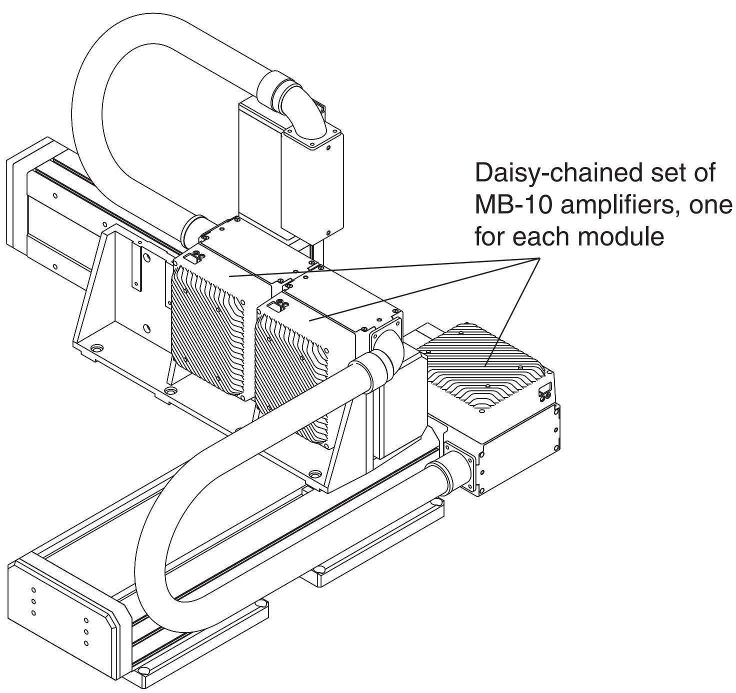


Figure 5-5. Three-Axis System with MB-10 Amplifiers Identified

5.3 System Configuration and Module Types

The following chart shows all the available configuration options and the descriptor characters used to indicate them.

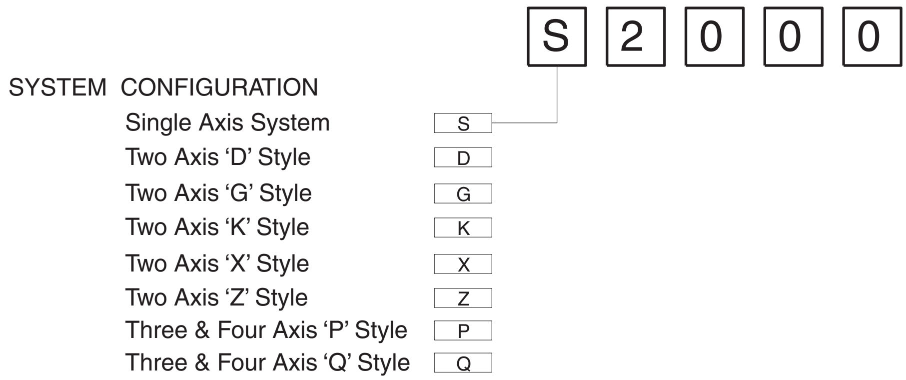


Figure 5-6. Configuration Options in Module System Descriptor Number

Module Types

Each Python module system configuration can be ordered with a variety of module types, depending on the payload and space requirements. For example, single-axis ('S' type) systems can be ordered with L18, L12, L08, or Theta modules.

The next 4 digits in the module system descriptor number define the type of module used for module 1, module 2, module 3, and module 4 (future) respectively. A '1' in any location denotes an L18 module, a '2' denotes an L12 module, '3' denotes an L08 module, and '6' denotes an LT1 (Theta) module ('0' denotes no module present).

Examples:

S2000 - a single-axis system comprising an L12 module as module 1.

P1230 - a three-axis 'P'-style system comprising an L18 as module 1, an L12 module as module 2, and an L08 module as module 3.

Single-Axis Configurations

Single-axis configurations combine a single module with an MB-10 amplifier. Any of the available module types can be configured in a single-axis configuration.

System Options

System options for linear modules include mounting feet or toe clamps (see **Section 5.5 on page 90**) and IO Blox modules (see **Section 5.8 on page 103**). Most module options can be configured with most system options. One exception is the requirement that brakes be configured on all vertically-oriented linear module axes.

Available in the following configurations:

- S1000
- S2000
- S3000

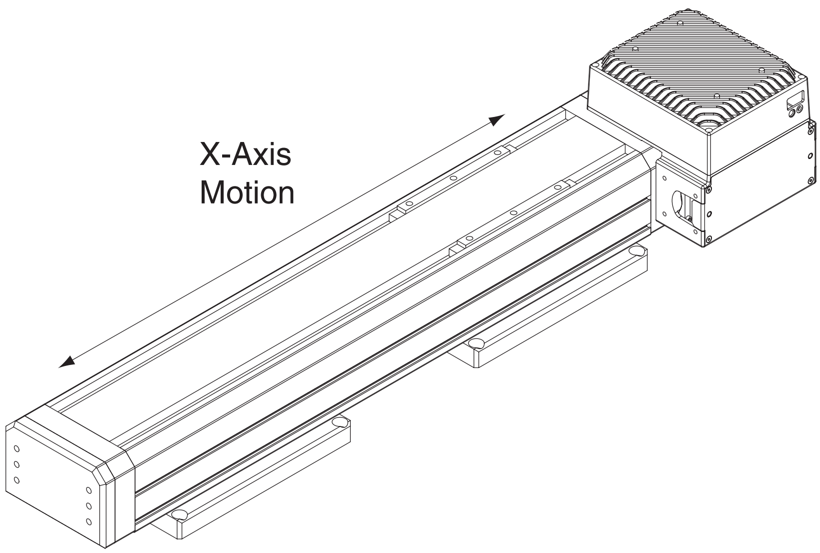


Figure 5-7. S2000 System with Mounting Feet

NOTE: The single-axis shown above is a "moving carriage" orientation, mounted horizontally. These module systems can also be mounted vertically or in "moving module" orientations, mounted either vertically or horizontally.

NOTE: In vertical mounting applications (see **Figure 5-8**), the linear module must be configured with a payload-holding brake. See **"Brakes" on page 44** for information on brakes.

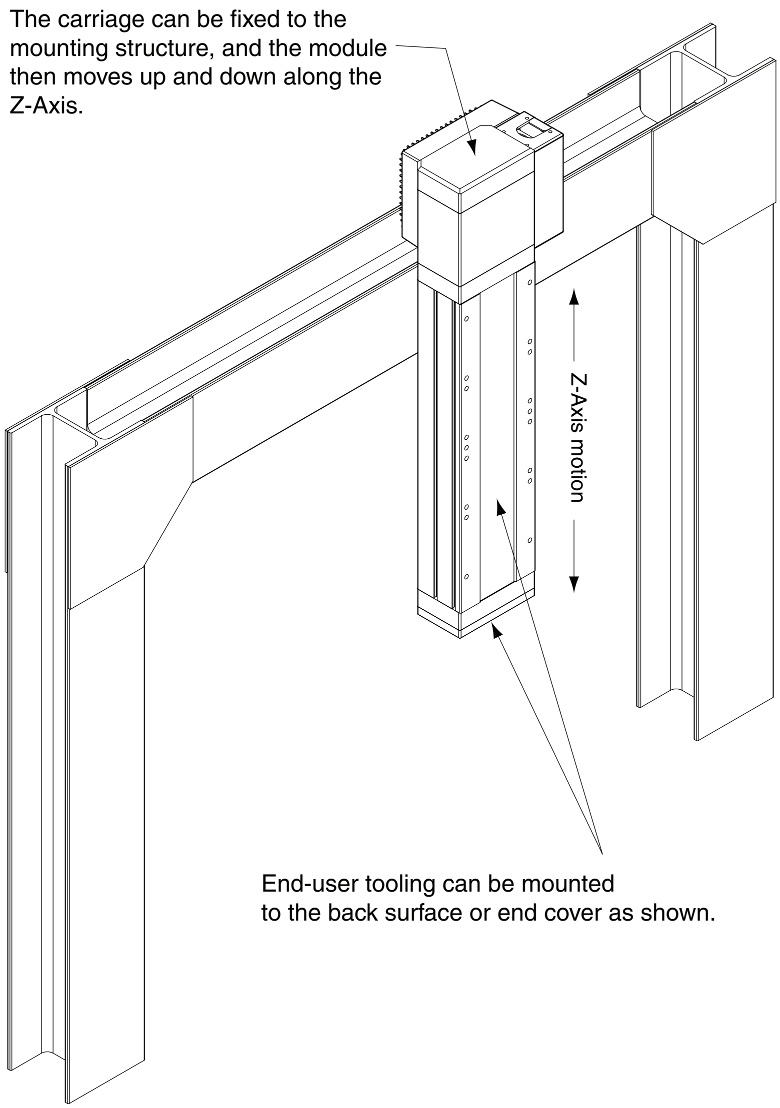


Figure 5-8. S2000 System (with Brake) Mounted Vertically

Single-Axis Theta Modules

The single-axis Theta module can be configured with a standard 20 mm diameter output shaft or an optional user flange. The following drawings show the module envelope and mounting hole dimensions for the Theta module. The output shaft and user flange dimensions are also shown.

Available in the following configurations:

- S6000

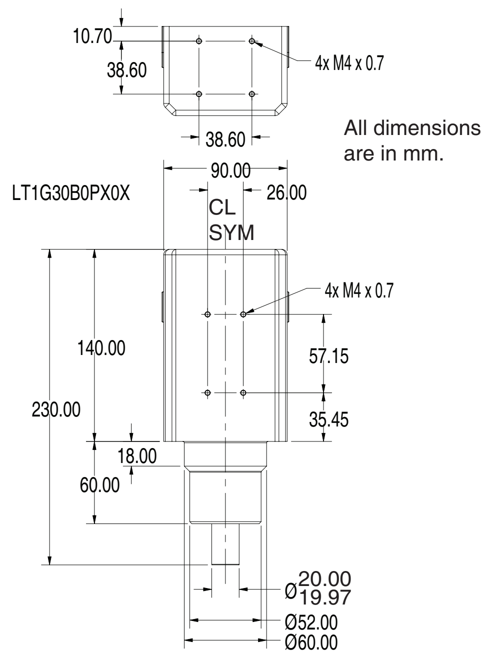


Figure 5-9. LT1 (Theta) Module Envelope/Mounting Hole Dimensions (Top View)

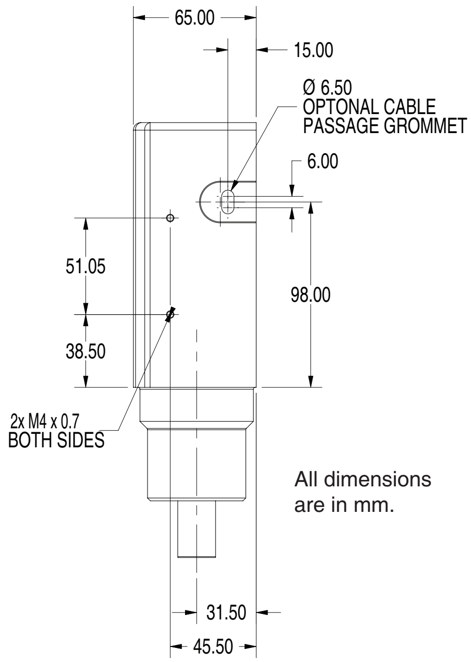


Figure 5-10. LT1 (Theta) Module Envelope/Mounting Hole Dimensions (Side View)

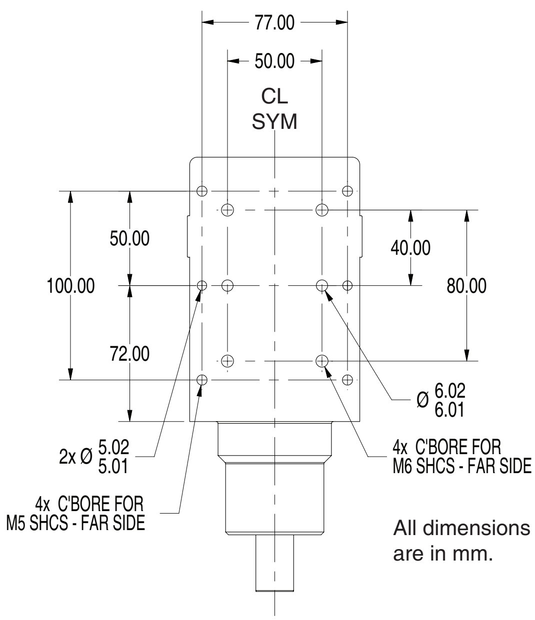


Figure 5-11. LT1 (Theta) Module Envelope/Mounting Hole Dimensions (Bottom View)

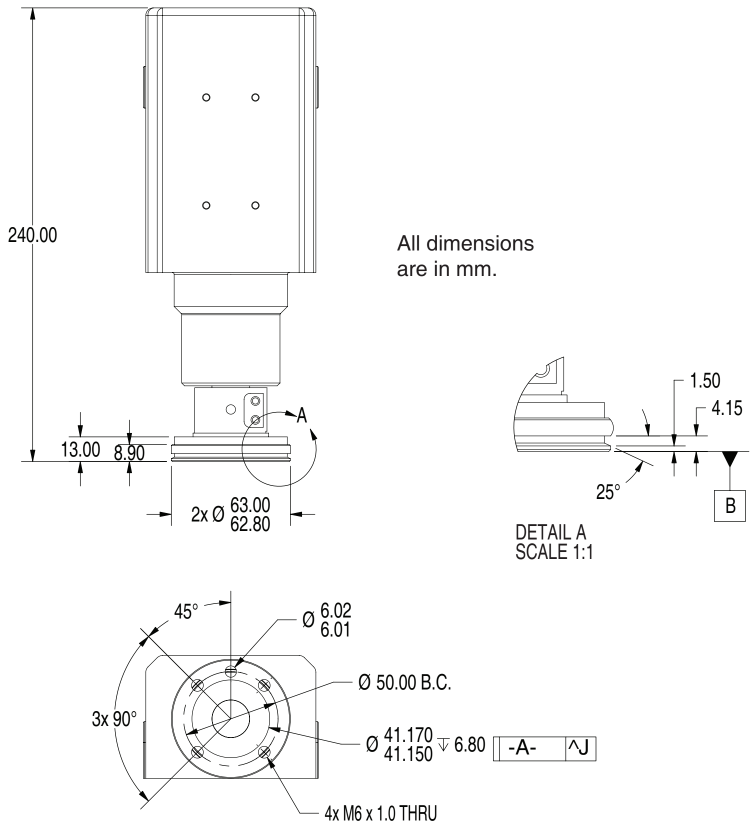


Figure 5-12. LT1 (Theta) Module User Flange Dimensions

Two-Axis Configuration Drawings

The drawings in this section show the available two-axis configurations.

D Configuration

In the D configuration, the second axis is mounted in a fixed position on the first-axis' slide, so that the second axis' slide is opposite the work surface and moves in a horizontal motion.

Available in the following configurations:

- D1200
- D2300

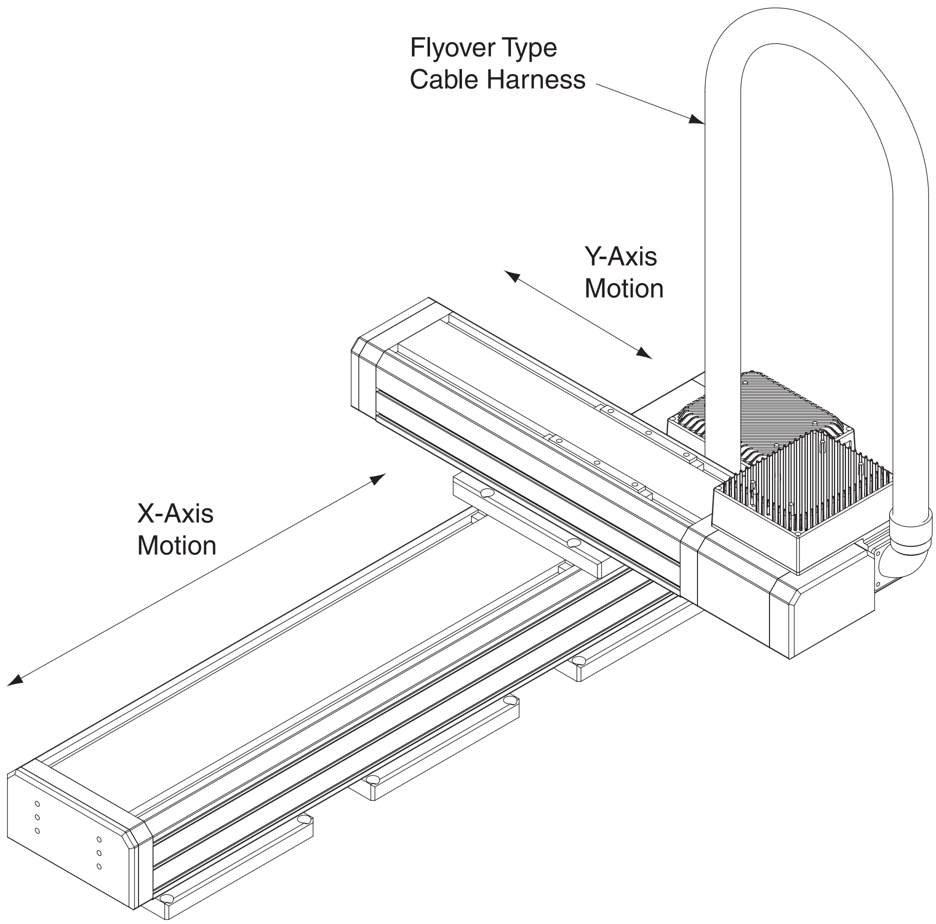


Figure 5-13. D1200 System with Optional Mounting Feet

G Configuration

In the G configuration, the second axis is rolled onto its side and mounted in a fixed position on the first-axis' slide, so that the second axis' slide is perpendicular to the work surface and moves in a horizontal motion.Available in the following configurations:

- G1100
- G1200
- G2300

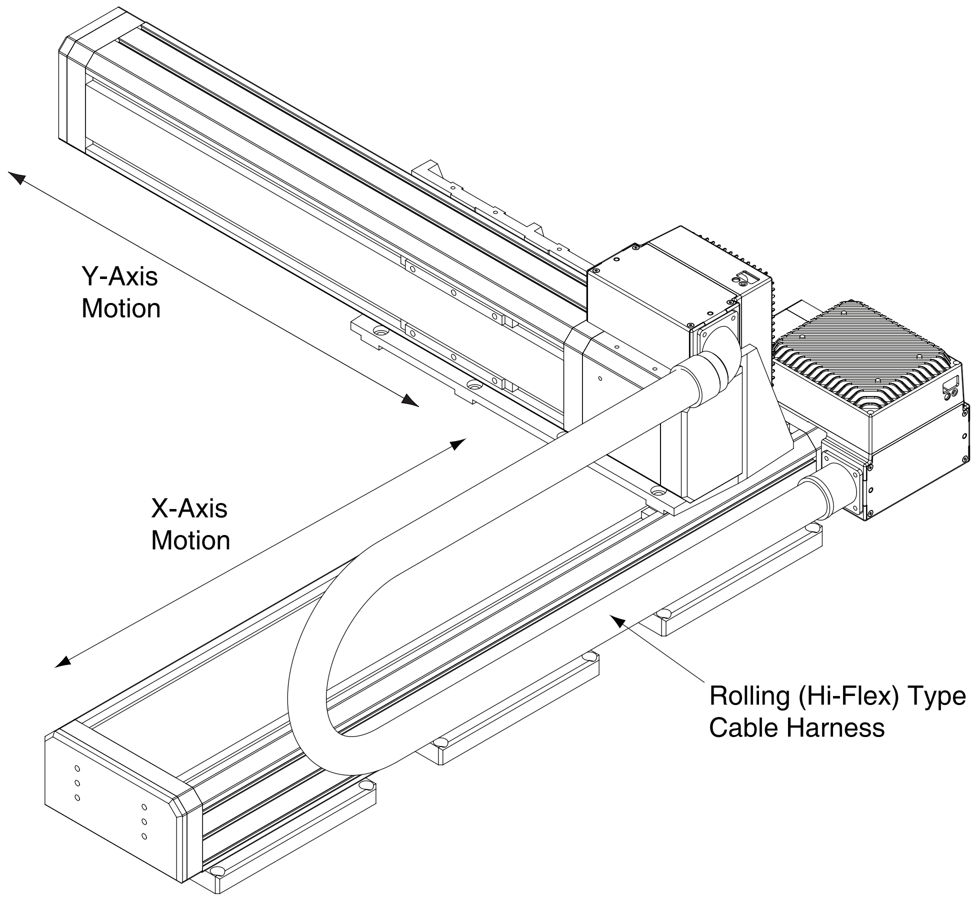


Figure 5-14. G1200 System with Optional Mounting Feet

K Configuration

In the K configuration, the first axis is parallel to the work surface and rotated 90 degrees so that the second axis is perpendicular to the work surface. The second axis' slide operates in a vertical 'Z' motion (perpendicular to the work surface).

Available in the following configurations:

- K1200
- K2300

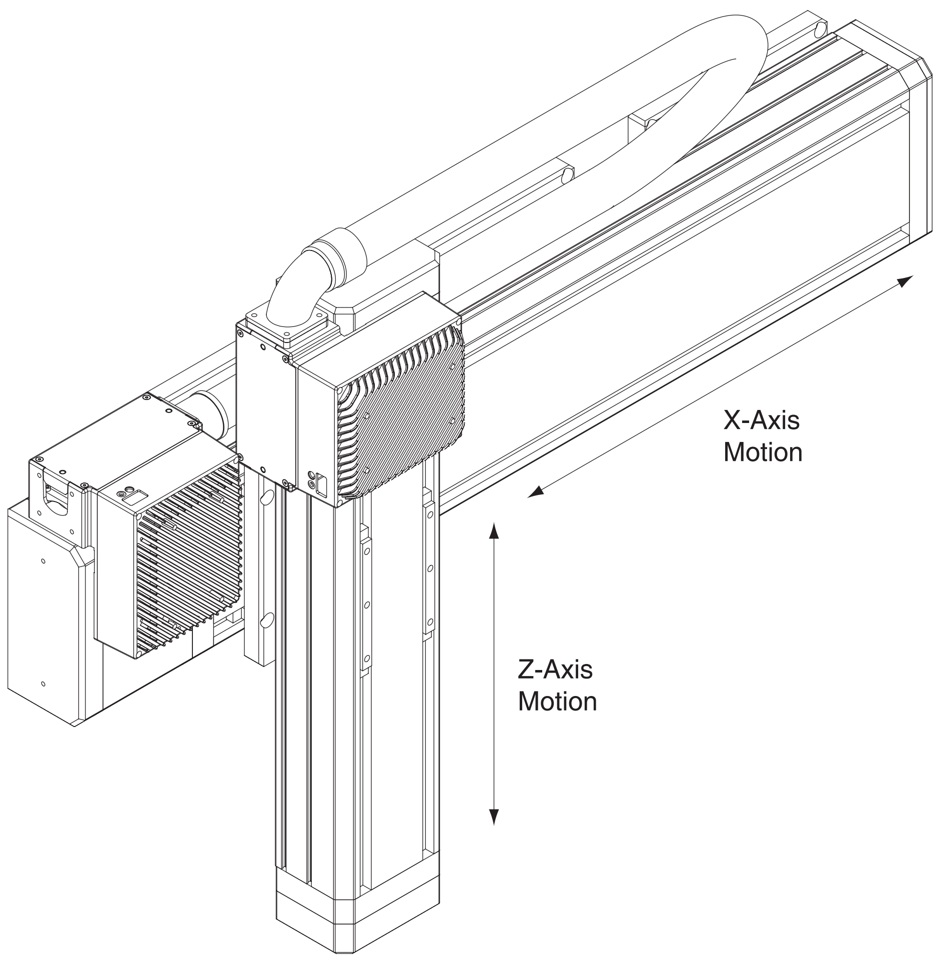


Figure 5-15. K1200 System

X Configuration

In the X configuration, the second axis' slide is mounted to the first axis' slide such that the entire second axis operates in a back-and-forth Y motion (parallel to the work surface).

Available in the following configuration:

- X1100

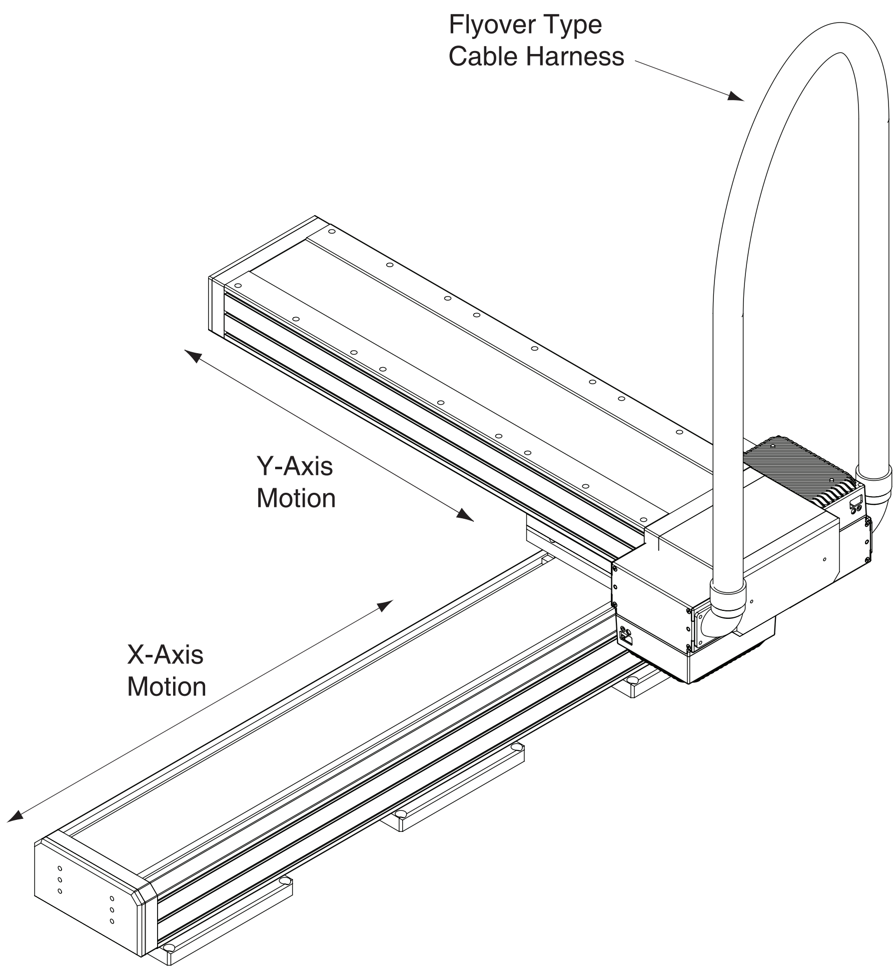


Figure 5-16. X1100 System with Optional Mounting Feet

Z Configurations

In the Z configuration, the first axis is parallel to the work surface and rotated 90 degrees so that the second axis is perpendicular to the work surface. The second axis' slide is attached to the first axis' slide such that the entire axis moves up and down in a vertical 'Z' motion (perpendicular to the work surface).

Available in the following configurations:

- Z1200
- Z2300

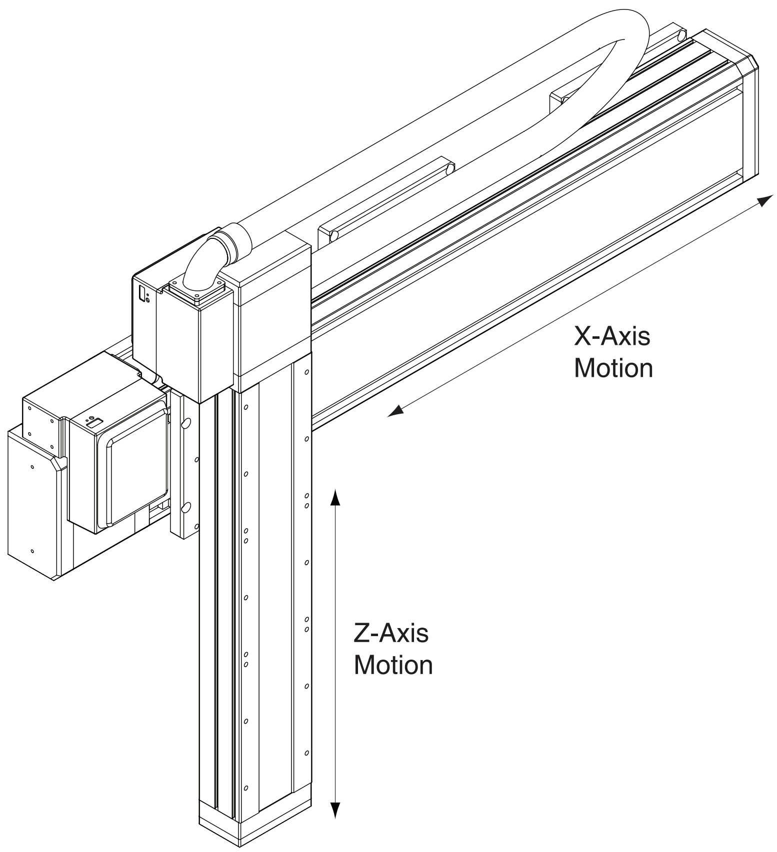


Figure 5-17. Z1200 System

Three-Axis Configuration Drawings

The following drawings show the available three-axis configurations.

P Configuration

In the P configuration, the second axis is rolled onto its side and mounted in a fixed position on the first-axis' slide, so that the second axis' slide is perpendicular to the work surface. The third (Z) axis is fixed to the second-axis' slide. The third (Z) axis' slide operates in an up-down 'Z' motion (perpendicular to the work surface).

> **NOTE:** In the P configuration, the tooling is mounted to the slide of the third axis.

Available in the following configurations:

- P1120
- P1230
- P2330

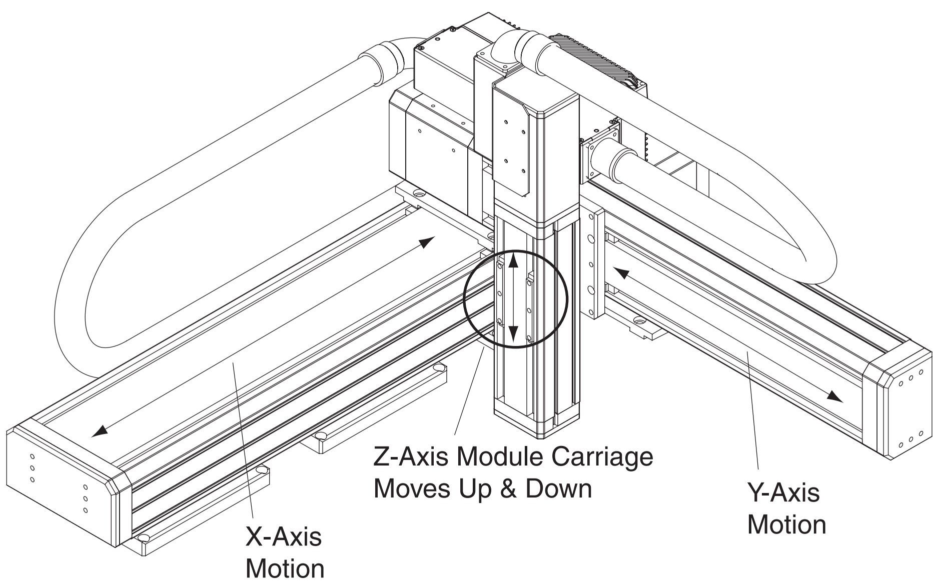


Figure 5-18. P Configuration (P1230 System)

Q Configuration

In this configuration, the second axis is rolled onto its side and mounted in a fixed position on the first-axis' slide, so that the second axis' slide is perpendicular to the work surface. The third (Z) axis' slide is mounted to the second-axis' slide so that the entire third axis operates in an up-down 'Z' motion (perpendicular to the work surface).

> **NOTE:** In the Q configuration, the tooling is mounted to the bottom end of the third axis.

Available in the following configurations:

- Q1120
- Q1230
- Q2330

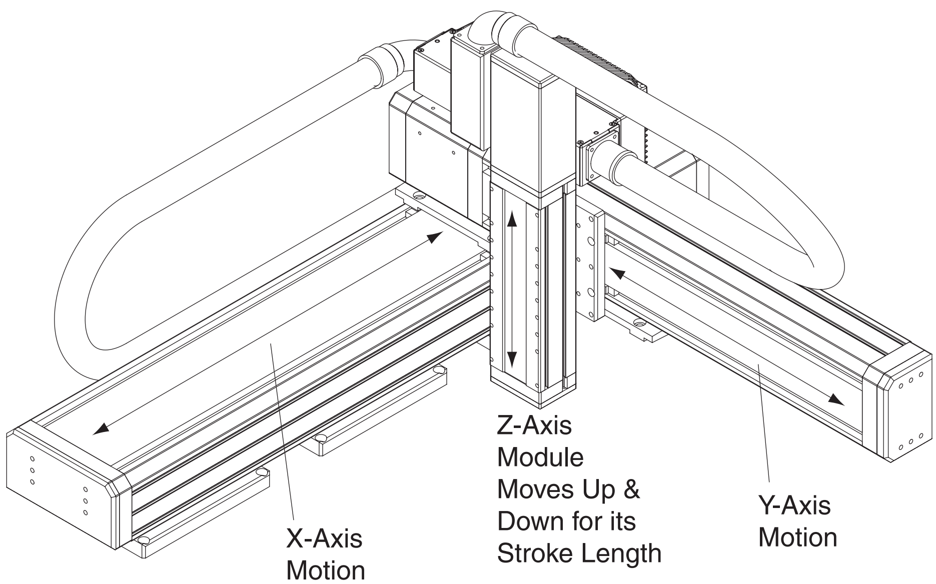


Figure 5-19. Q Configuration (Q1230 System)

Four-Axis Configuration Drawings

The following drawings show the available four-axis configurations.

P Configuration with Theta

In this configuration, the first, second, and third axes are configured as described in **“P Configuration” on page 83**. The Theta axis is mounted on the third axis carriage and operates in an up-down 'Z' motion, perpendicular to the work surface.

Available in the following configuration:

- P1236
- P2336

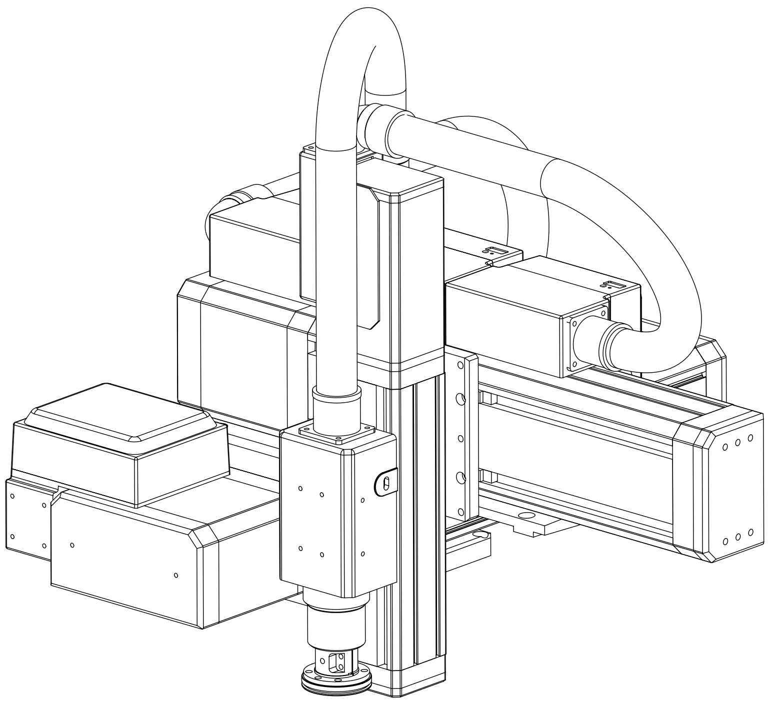


Figure 5-20. P Configuration with Theta

Q Configuration with Theta

In this configuration, the first, second, and third axes are configured as described in **"Q Configuration" on page 84**. The Theta axis is mounted in a fixed position on the third axis and operates in an up-down 'Z' motion, perpendicular to the work surface.

Available in the following configuration:

- Q1236
- Q2336

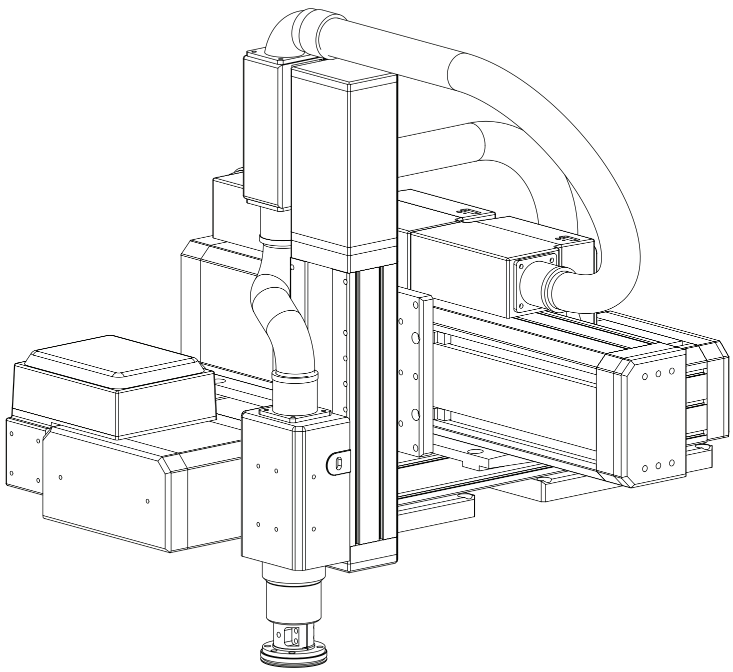


Figure 5-21. Q Configuration with Theta

5.4 System Orientation

The orientation options define the mounting positions of the amplifiers and interconnect harness tubes, as well as the alignment of the second module with respect to the first module.

- The first orientation option (Standard or Flipped) refers to the amplifier mounting orientation on module 1.
- The second orientation option (Standard or Rolled) refers to the orientation of module 2 (and module 3, if configured). The standard, or right-hand orientation, applies when viewing the module carriage with the motor end up (this naming convention is the same for multi-axis systems as for single-axis systems). See the following drawings for examples.

NOTE: Refer to the Python 3D Linear Modules section of the Adept website for more information on system orientation.

Single-Axis Orientations

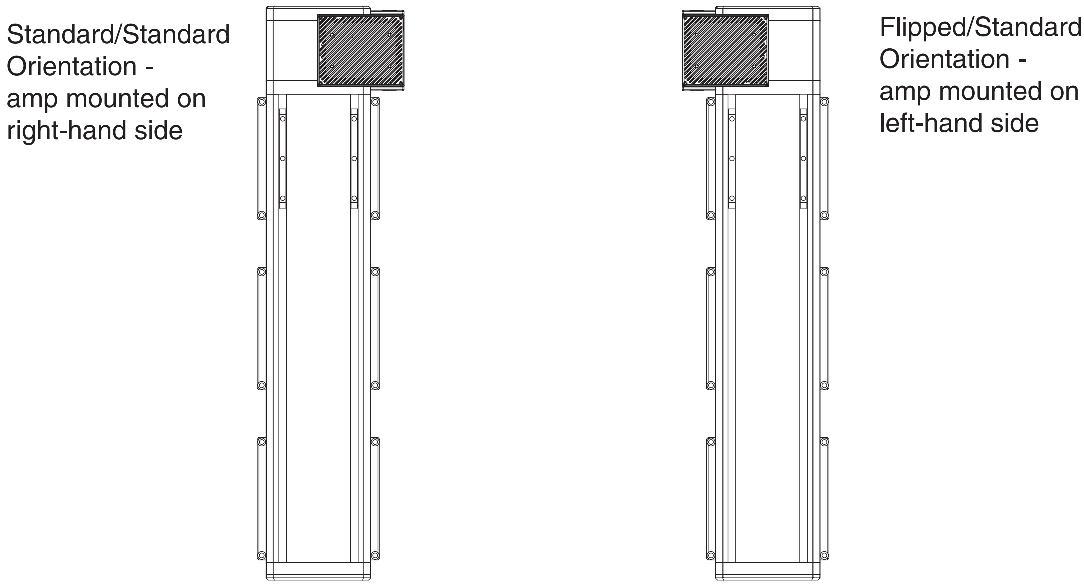


Figure 5-22. Single-Axis Orientation Example

Typical Two-Axis Orientations

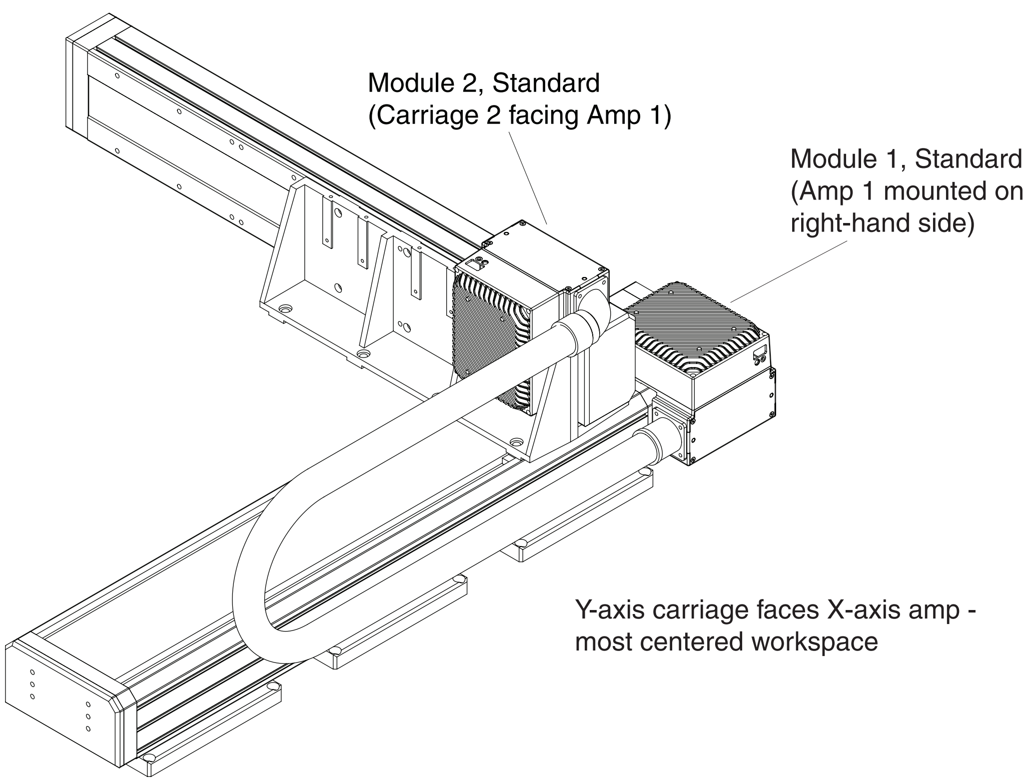


Figure 5-23. Standard/Standard Orientation

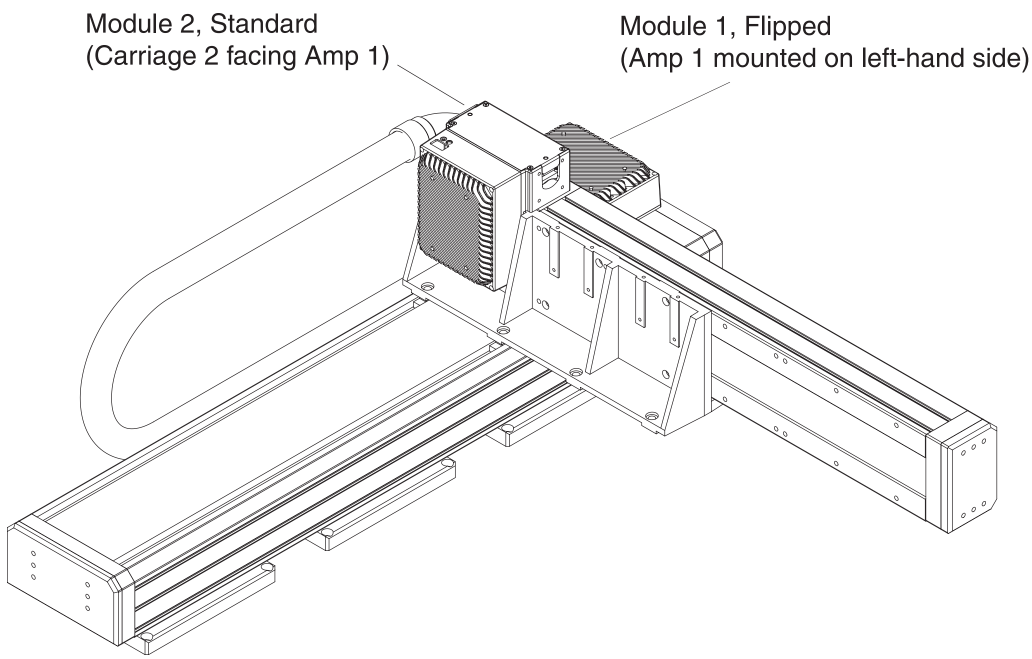


Figure 5-24. Flipped/Standard Orientation

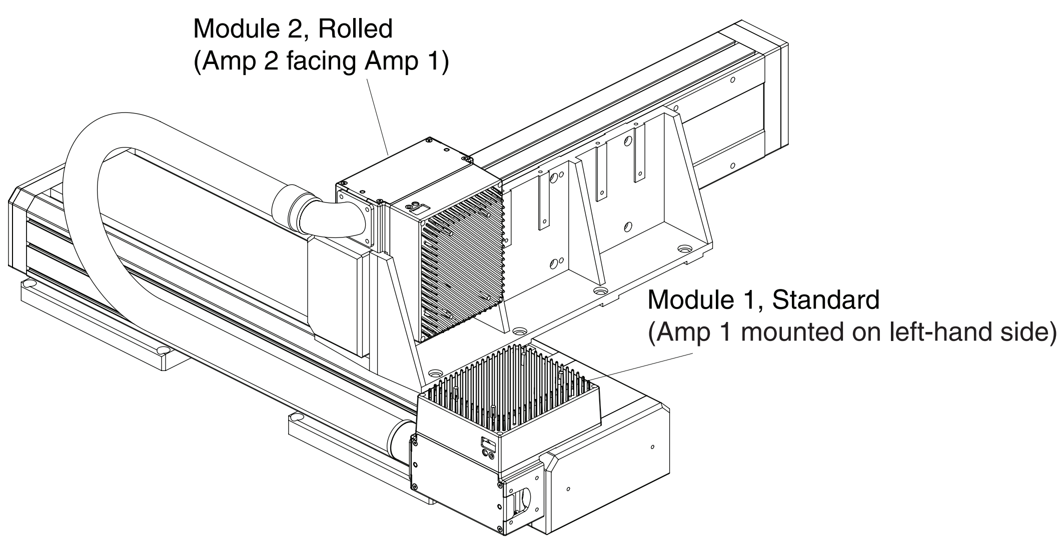


Figure 5-25. Standard/Rolled Orientation (Rear View)

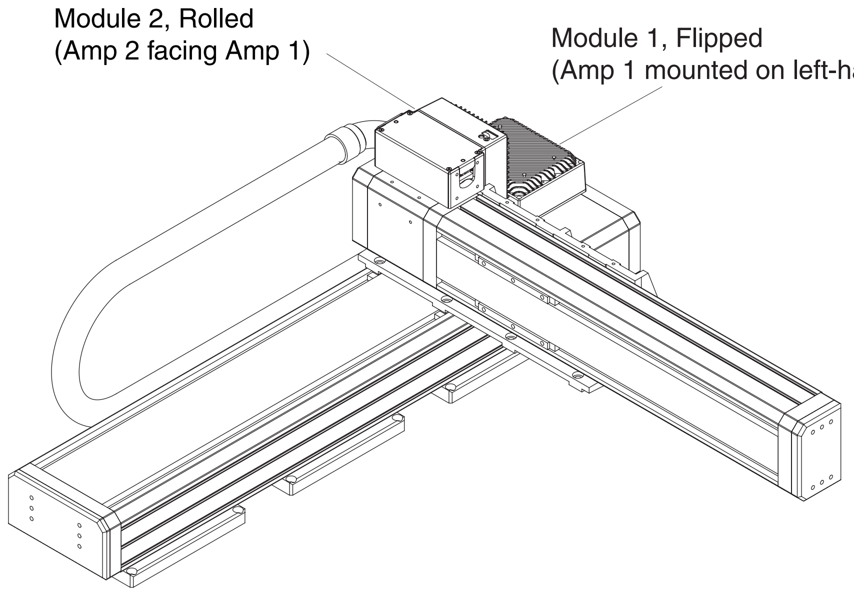


Figure 5-26. Flipped/Rolled Orientation

5.5 Mounting Options

When a Python module system is configured, mounting feet or toe clamps can be included. Mounting feet are aluminum plates that bolt to the underside of module 1 and allow the fully-assembled system to be bolted in place. Toe clamps are inserted into the T-slots on the sides of module 1 and secured to the mounting surface. Each toe clamp kit contains four toe clamps and two mounting screws per toe clamp. The type and number of mounting feet or toe clamps are automatically configured based on the selected stroke length for module 1.

The two digits following the system orientation characters define both mounting feet/toe clamps and the quantity of feet/toe clamps required. In the example from **Figure 5-1 on page 68**, “13” indicates an L18 module configured with three mounting feet. The following chart shows all the available mounting options and the descriptor numbers used to indicate them.

00

	MOUNTING OPTIONS
00	No Mounting Hardware Supplied
12	L18 Mount Feet Kits, Quantity 2
13	L18 Mount Feet Kits, Quantity 3
15	L18 Mount Feet Kits, Quantity 5
21	L12 Mount Feet Kits, Quantity 1
22	L12 Mount Feet Kits, Quantity 2
23	L12 Mount Feet Kits, Quantity 3
25	L12 Mount Feet Kits, Quantity 5
32	L08 Mount Feet Kits, Quantity 2
33	L08 Mount Feet Kits, Quantity 3
81	1 Toe Clamp Kit, Quantity 4 Toe Clamps
82	2 Toe Clamp Kits, Quantity 8 Toe Clamps
83	3 Toe Clamp Kits, Quantity 12 Toe Clamps

Figure 5-27. Mounting Options in Module System Descriptor Number

NOTE: If a gantry support module is included in the system, and if mounting feet or toe clamps are configured on module 1, the same number of gantry mounting feet/toe clamps are automatically included. If no mounting feet/toe clamps are specified on module 1, no mounting feet/toe clamps are configured on the gantry.

Mounting Feet Drawings

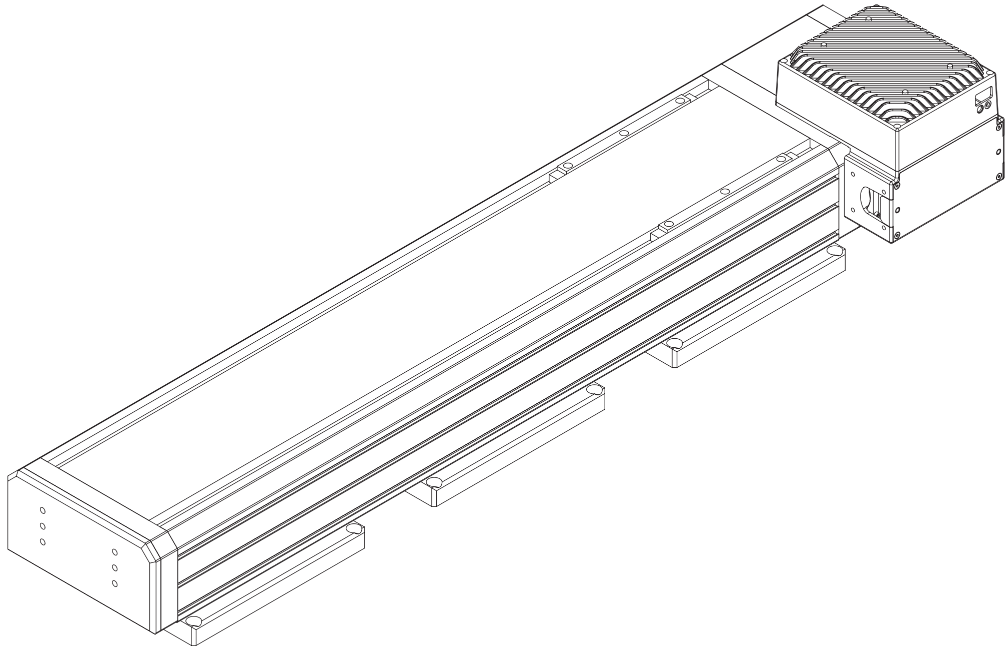


Figure 5-28. S1000SS13 - Single L18 System with Three Mounting Feet

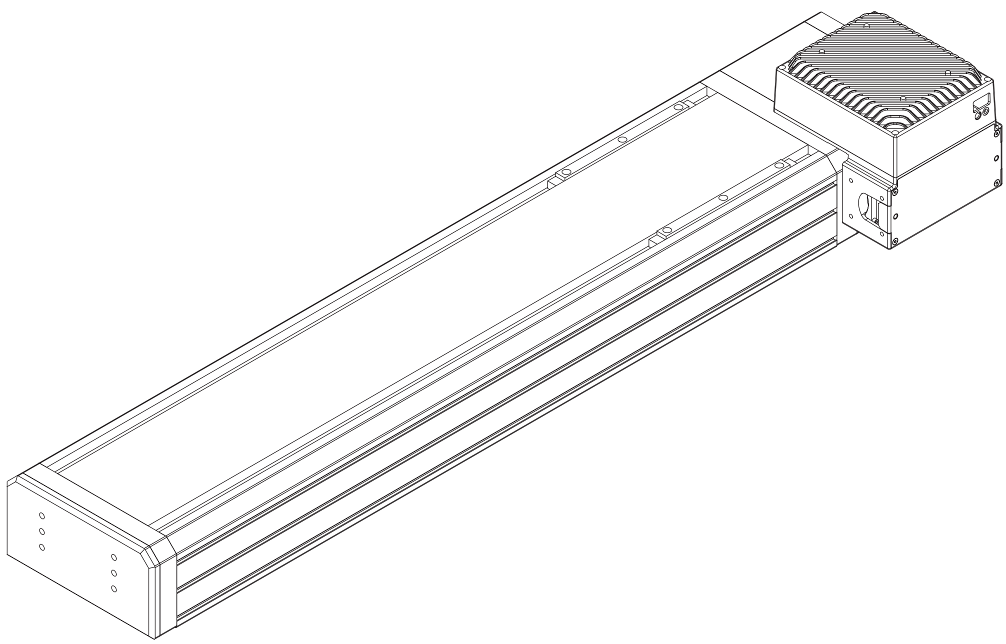


Figure 5-29. S1000SS00 - Single L18 System without Mounting Feet

Toe Clamp Drawings

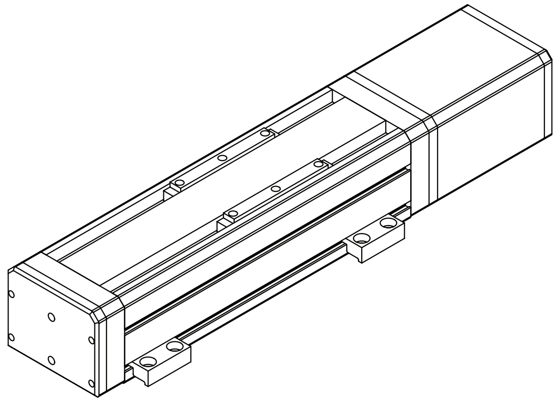


Figure 5-30. L08 Module with Toe Clamps

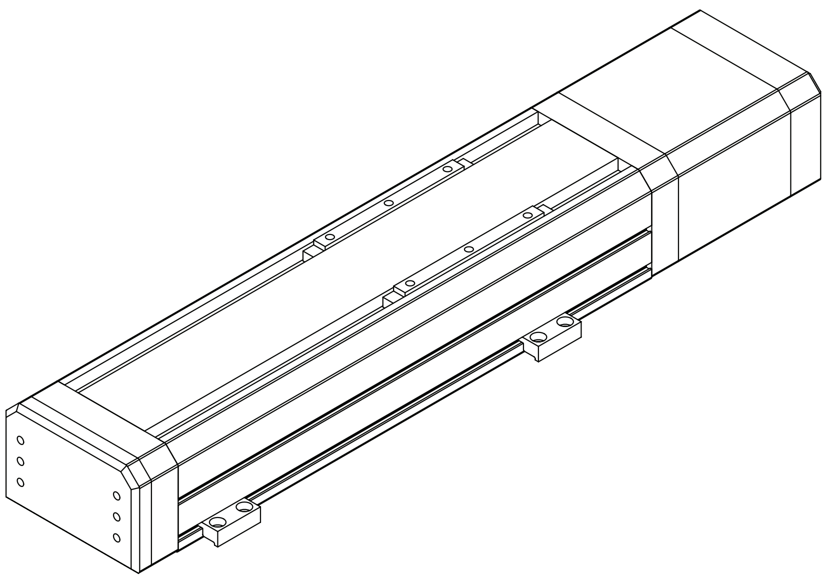


Figure 5-31. L12 Module with Toe Clamps

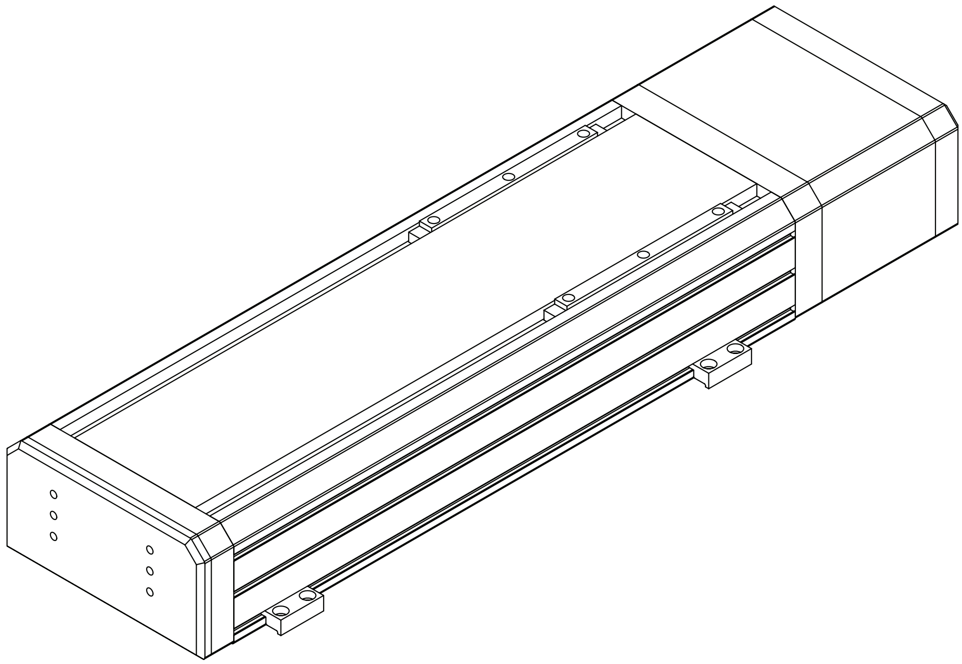


Figure 5-32. L18 Module with Toe Clamps

Mounting Feet Dimensions

Mounting feet are bolted to the underside of module 1 using the provided bolt patterns. The spacing of each mounting foot is determined by the length of the module. See the individual module specification drawings for that detail.

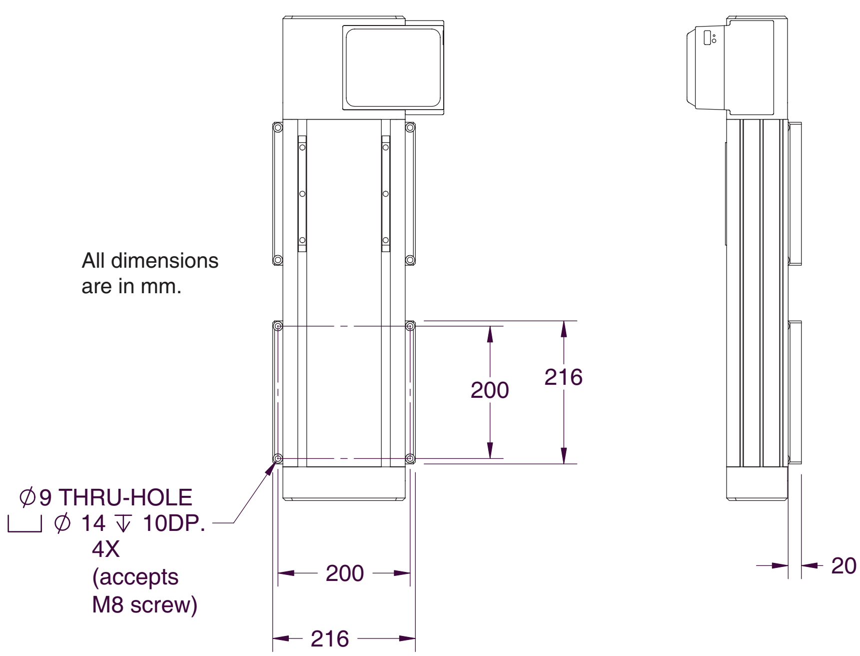


Figure 5-33. L18 Module with Mounting Feet Dimensions

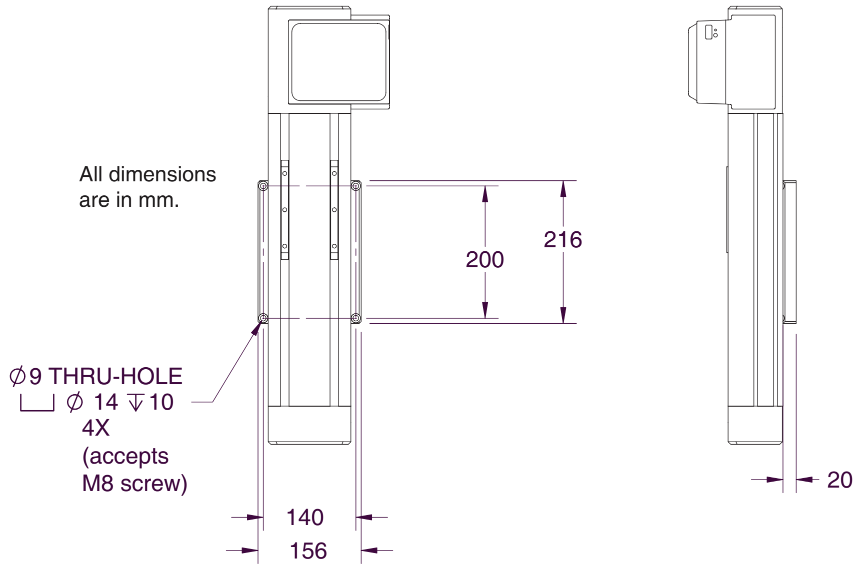


Figure 5-34. L12 Module with Mounting Feet Dimensions

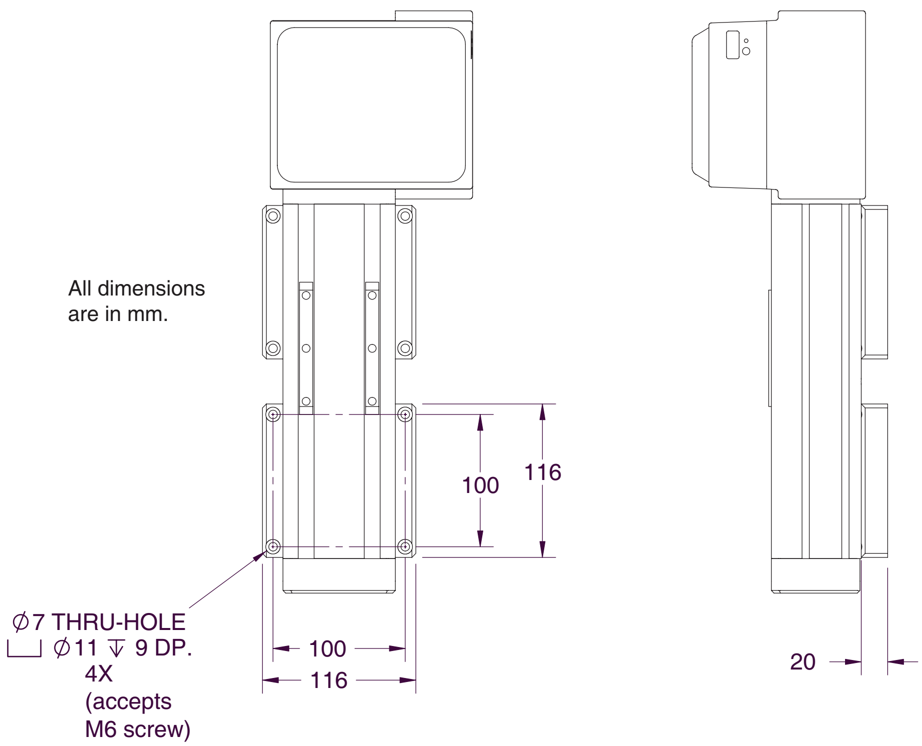


Figure 5-35. L08 Module with Mounting Feet Dimensions

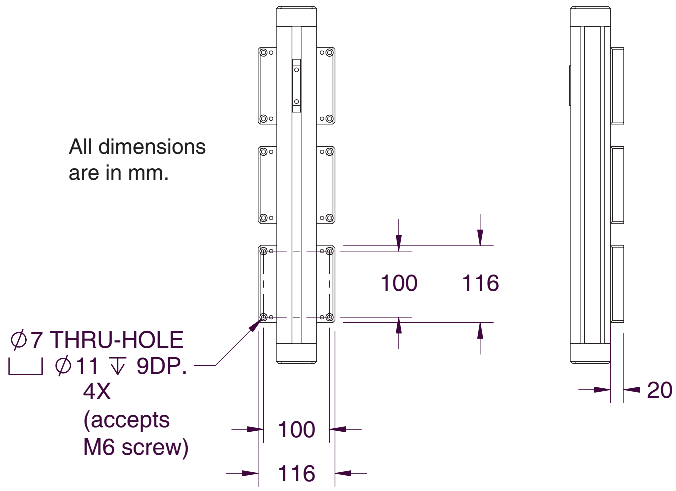


Figure 5-36. LG6 Module with Mounting Feet Dimensions

Toe Clamp Dimensions

Toe clamps are inserted into the T-slots on the sides of module 1 (see **"Toe Clamp Drawings" on page 92**) and then attached to a mounting surface using the provided two screws per toe clamp. See the following dimension drawings for the maximum spacing between toe clamps and other detailed dimension information.

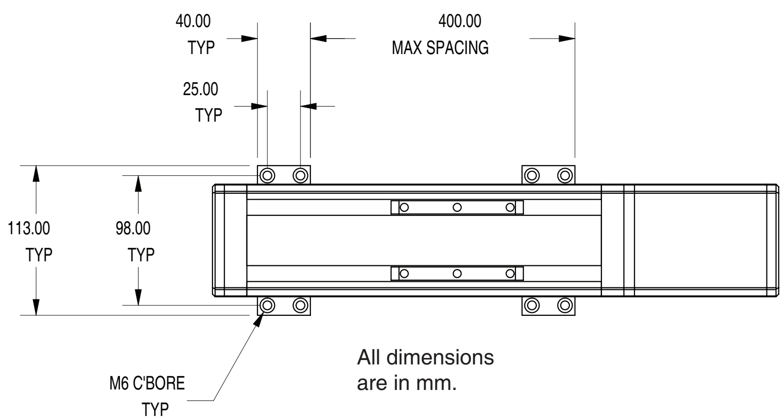


Figure 5-37. L08 Module with Toe Clamp Dimensions

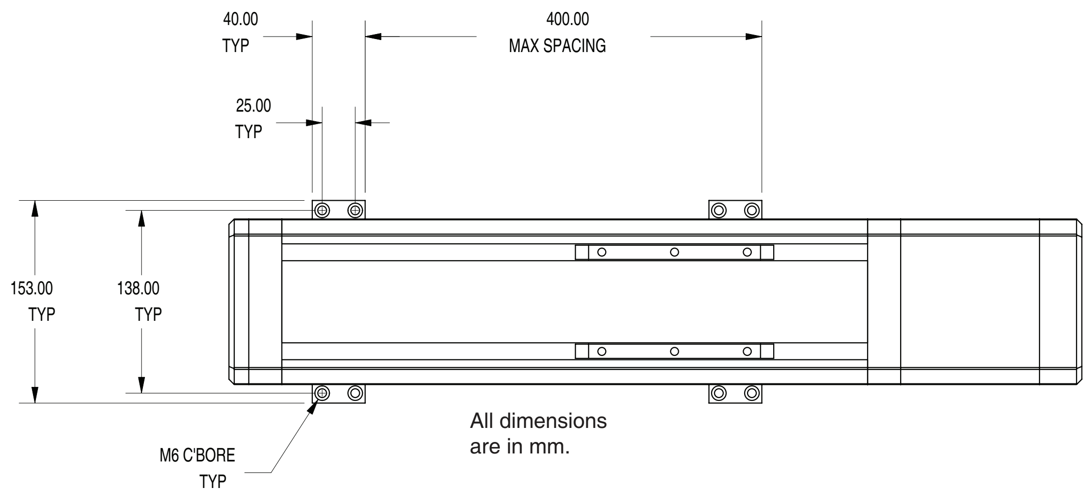


Figure 5-38. L12 Module with Toe Clamp Dimensions

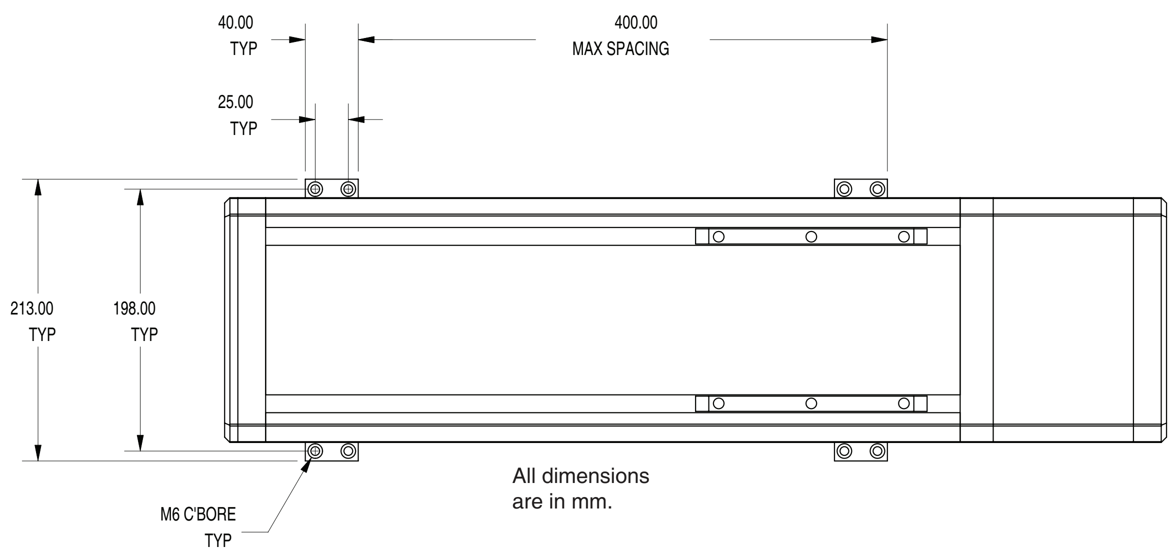


Figure 5-39. L18 Module with Toe Clamp Dimensions

5.6 Cable Kits

Currently all cable kits are automatically configured by Adept based on the module lengths and configuration of system ordered. The next eight alpha and numeric characters in the module system descriptor number (after the mounting options characters) define the type and length of cabling required to build the system. The first pair of characters define the cables leading to amplifier 1, the second pair of characters define the cables leading to amplifier or motor 2, and so on. In M10 systems (MotionBlox-10, CX controller required) the first set of characters always defaults to "A0" (no cable required). This is because the cables from the CX Controller and PDU3 are included in the CX controller bundle. (See **Chapter 7**.)

'A' style cable kits are hi-flex, MB-10 amp to MB-10 amp cable tube kits that include IEEE 1394 and AC and DC power cables.

'B' style cable kits are hi-flex MB-10 amp to motor cable tube kits that include motor, encoder, and brake (if required) cables. These kits are used on systems on which the amp is mounted remotely from the motor, such as module 3 on 'P' and 'Q' style systems.

'C' style and 'D' style cable kits are similar to 'A' and 'B' kits respectively, but are mounted in stiffer tubing for use in flyover-type applications, such as on 'D' and 'X' style systems.

The second digit in each pair determines the cable kit length required to assemble the system. Adept's goal is to optimize the cable length for each system to minimize cable overhang when the carriage travels to the end stroke. Therefore, each kit is available in 6 or 7 lengths.

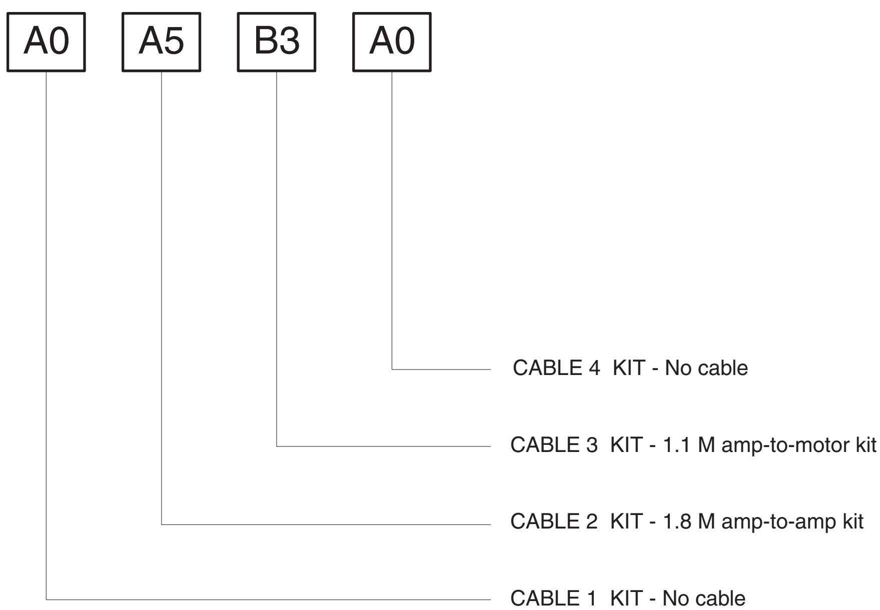


Figure 5-40. Cable Kit Descriptors for a Typical 3-Axis P or Q System

5.7 Gantry Mounting Kits

When ordering linear modules, an LG6 gantry support module is configured by default on systems with Y-axis modules over a certain length. For example, a gantry is automatically included on two-axis, G-style systems with a an L12 or L18 Y-axis module (module 2) 800 mm or longer.

> **NOTE:** Systems with carriage-mounted Y-axis modules, such as X-Style, cannot be configured with a gantry.

The following figure shows a gantry module with 3 support feet and Y-axis interconnect hardware.

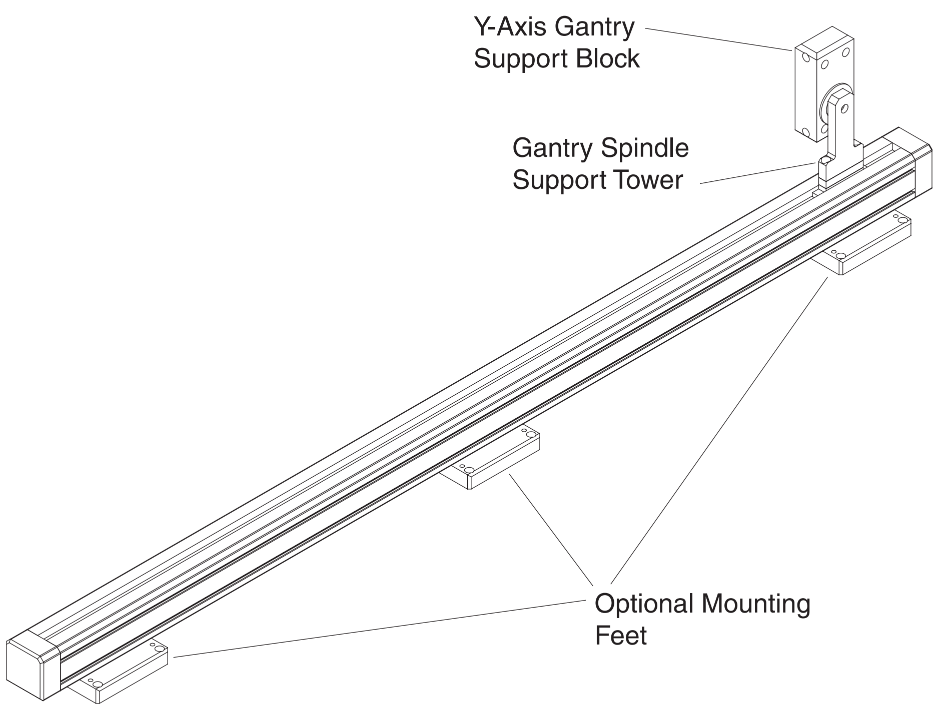


Figure 5-41. Gantry (LG6) Module Shown with Gantry Mounting Kit

The gantry is automatically configured to have the same stroke length as module 1. A similar quantity of gantry support module mounting feet/toe clamps are included if mounting feet/toe clamps are configured on module 1. If no mounting feet/toe clamps are configured on module 1, no mounting feet/toe clamps are configured on the gantry.

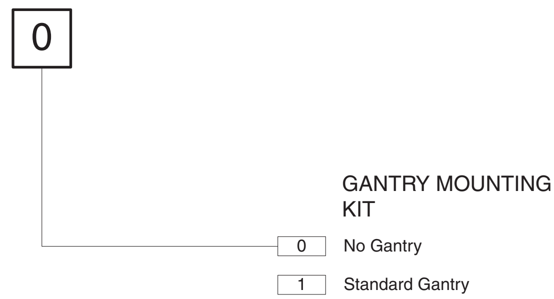


Figure 5-42. Gantry Key Details

If a gantry support module is specified, the standard option bit 1 defines the proper Y-axis interconnect hardware required. These hardware kits vary slightly depending on whether the Y-axis is an L18, L12, or an L08 module. The Y-axis gantry support block is sized appropriately for each module, and the gantry spindle support tower is sized such that the gantry module and the X-axis module always mount at the same elevation.

Each gantry interconnect hardware kit can be mounted to the Y-axis in one of two ways: end-mounted or side-mounted. See **Figure 5-43**. Side mounting allows for the most compact system footprint, but the gantry module or its mounting plates may interfere with full Y-axis travel, depending on Z-axis and/or end-effector configuration. For that reason, end mounting is the standard orientation.

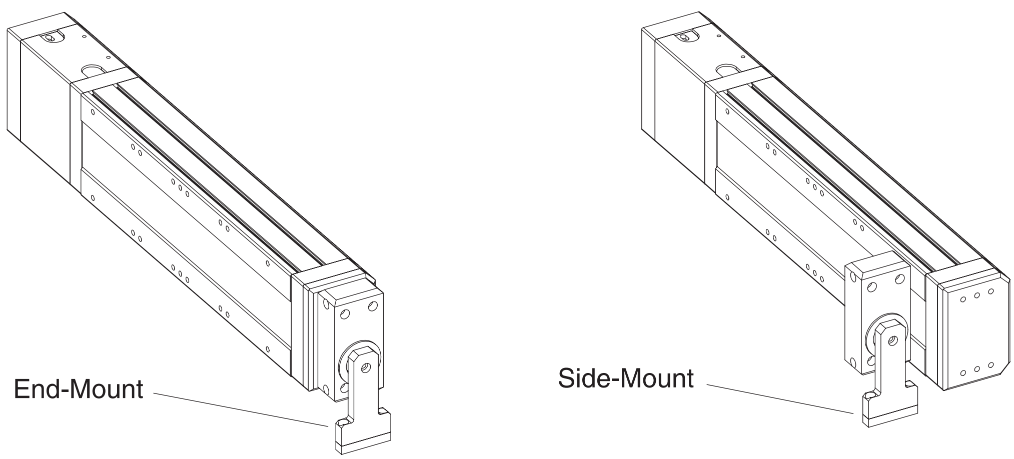


Figure 5-43. L12 Gantry Mounting Methods, End and Side

Gantry Support Module Installation

Parallel Alignment Specifications

The gantry support block contains a spherical bearing and a lip seal. It is factory-lubricated with cleanroom grease. Both the bearing and spindle interface surface are lubricated. This design allows the gantry to operate with up to 0.5 mm of mis-alignment with respect to the primary axis. The bearing will self-align and the gantry spindle will slide axially within the bearing's inner race.

> **NOTE:** The life of the LG6 gantry support module and the gantry support assembly may be reduced if the parallelism specification (see **Figure 5-44**) or nominal gap tolerances (see **Figure 5-45**) are exceeded. You must measure the gap throughout the entire X-axis stroke to verify compliance.

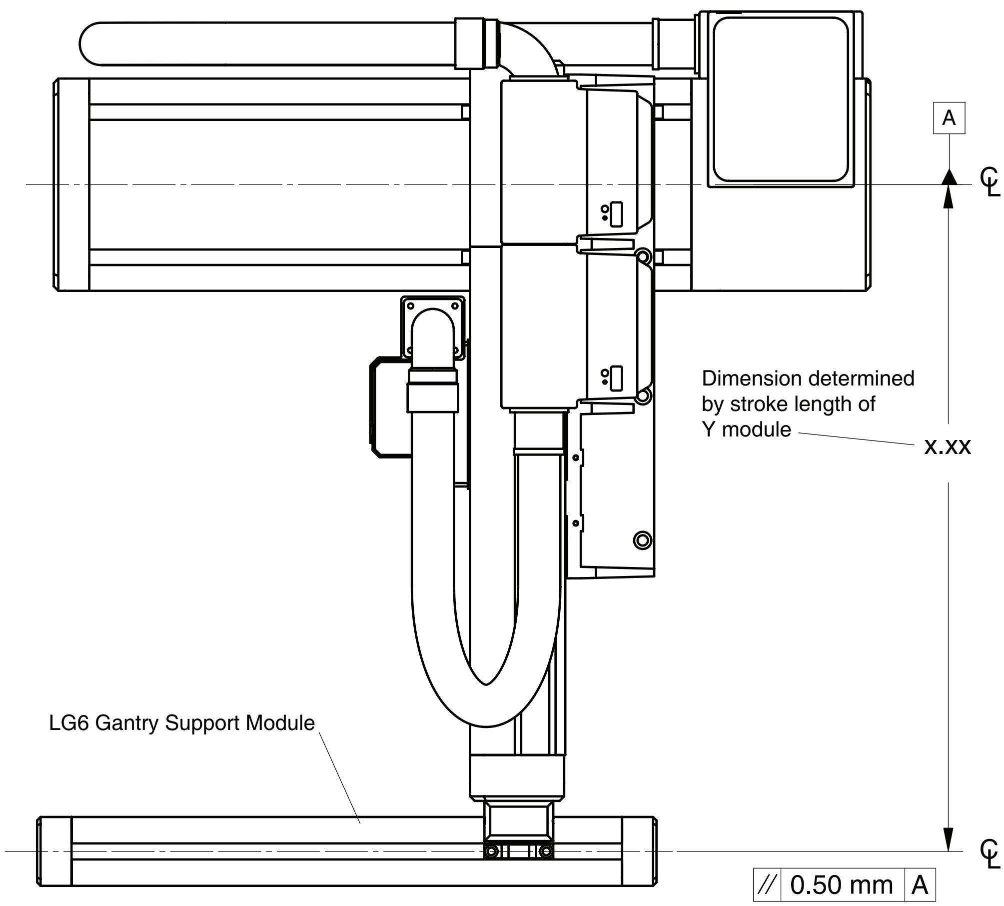


Figure 5-44. Gantry Installation: Parallel Alignment Specs

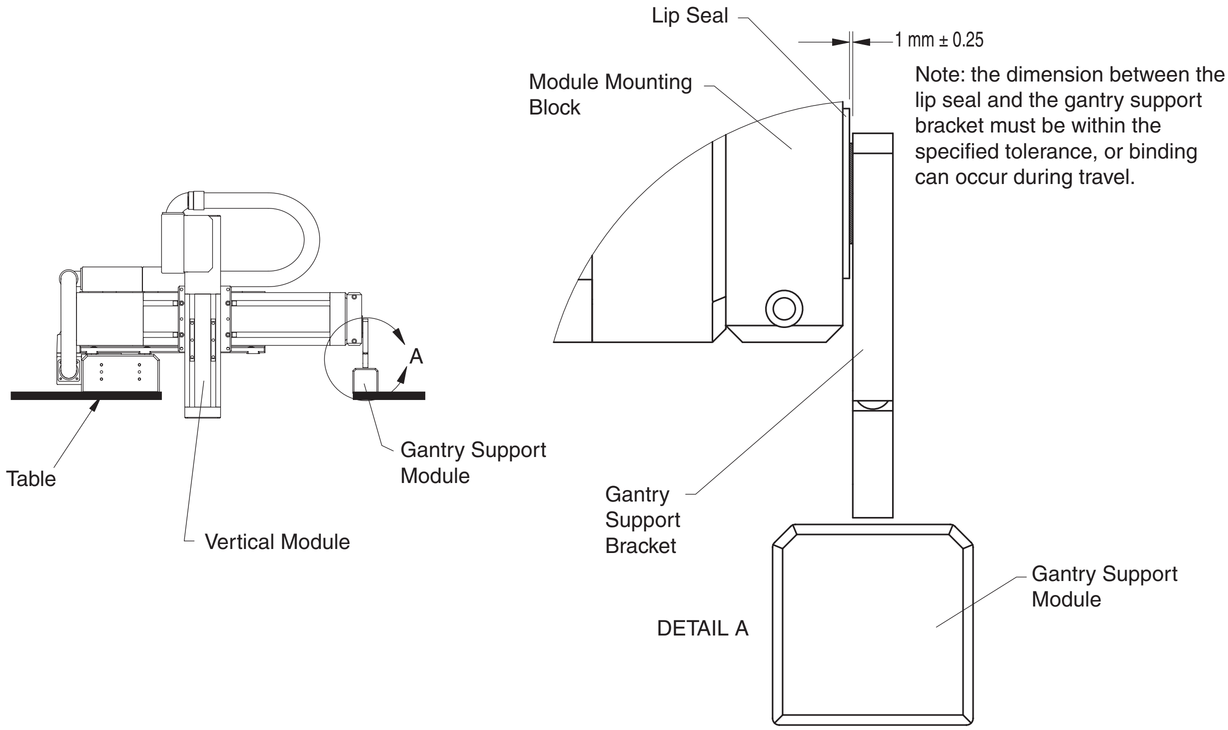


Figure 5-45. Gantry Installation: Lip Seal to Support Bracket Gap Dimensions

Gantry Over-Travel Specifications

The LG6 gantry support module is designed with approximately 45 mm more travel than the X-axis module. This provides flexibility in axial mounting locations. The X-axis module hardstops should always limit the module system travel, not the gantry support module. See Figure 5-46.

> **NOTE:** You must verify that the gantry support over-travel requirements are within specification. If not, the life of the module system could be greatly reduced.

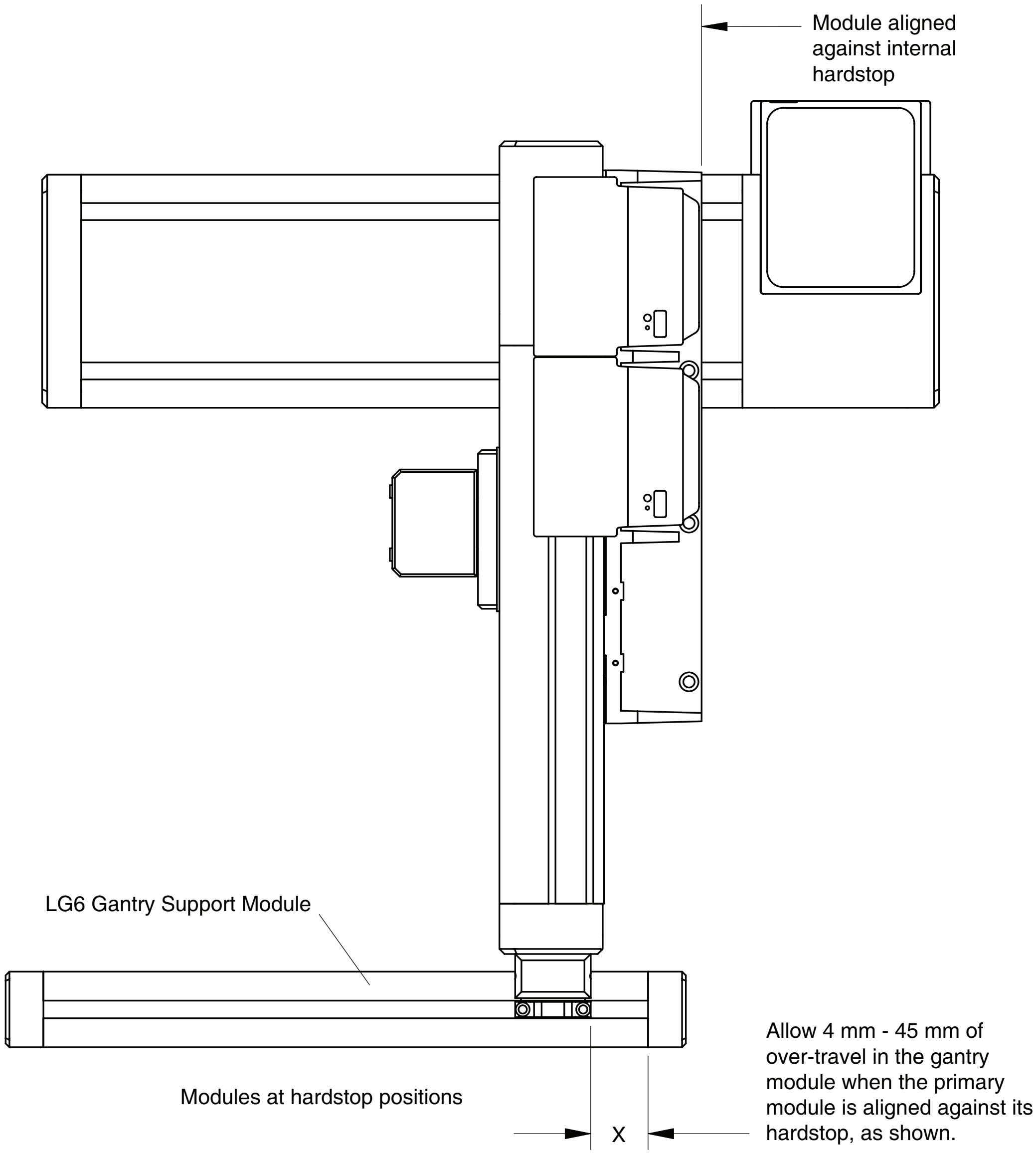


Figure 5-46. Gantry Over-Travel Specifications

5.8 IO Blox

The Adept IO Blox device is designed for adding digital input and output capability to Adept products, including Adept Python modules. The IO Blox offers 8 inputs and 8 outputs, all optically isolated. You can connect up to four IO Blox devices to the first and last MB-10 amp in the system.

IO Blox modules can be mounted onto Adept Python Modules systems in the following ways:

- Onto the MB-10 T-bracket cover (see **Figure 5-48 on page 104**)
- Onto the end cap of an L18 module (see **Figure 5-49 on page 105**)
- Onto a module T-slot (see **Figure 5-50 on page 105**)
- Onto a Z-axis harness enclosure (see **Figure 5-52 on page 107**)

IO Blox can also be mounted on a DIN rail. See the following illustrations for examples of IO Blox devices mechanical mounting. See the ***Adept IO Blox User's Guide*** for IO Blox installation details.

The following IO Blox device configurations are available:

- One IO Blox mounted on the first MB-10 amp T-bracket cover
- Two IO Blox devices: one on the first MB-10 amp T-bracket cover, one on the module body
- Three IO Blox devices: one on the first MB-10 amp T-bracket cover, two on the module body
- Four IO Blox devices: one on the first MB-10 amp T-bracket cover, three on the module body
- One IO Blox on the Y-axis module MB-10 amp T-bracket cover or the Z-axis harness enclosure
- Two IO Blox devices: one on the Y-axis module MB-10 amp T-bracket cover and one on the module body, or one on the Z-axis harness enclosure and one on the module body
- Two IO Blox devices: one on the first MB-10 amp T-bracket cover, one on the Z-axis harness enclosure
- Four IO Blox devices: two on the first and last MB-10 amps, on the T-bracket cover, the Z-axis harness enclosure, and the module body

X0

IO BLOX OPTIONS

X0	No IO Blox Supplied
X1	1 IO Blox at 1st MB-10, mounted at T-bracket cover
X2	2 IO Blox at 1st MB-10, mounted at T-bracket cover & main body
X3	3 IO Blox at 1st MB-10, mounted at T-bracket cover & main body (2)
X4	4 IO Blox at 1st MB-10, mounted at T-bracket cover & main body (3)
X5	1 IO Blox at last MB-10, mounted at Y-axis T-bracket cover or Z-axis enclosure
X6	2 IO Blox at last MB-10, mounted at Y-axis T-bracket cover & main body or Z-axis enclosure & main body
X7	2 IO Blox (1 each at first and last MB-10, mounted at T-bracket cover or enclosure)
X8	4 IO Blox (2 each at first and last MB-10, mounted at T-bracket cover, enclosure, & main bodies)
X9	NOT USED

Figure 5-47. IO Blox Options in Module System Descriptor Number

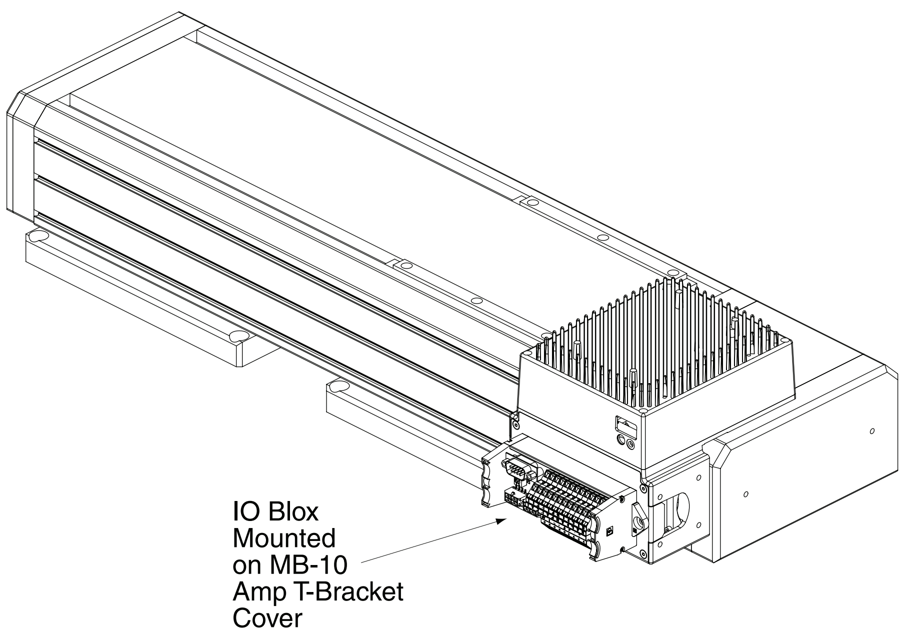


Figure 5-48. Mounting onto an MB-10 Amp

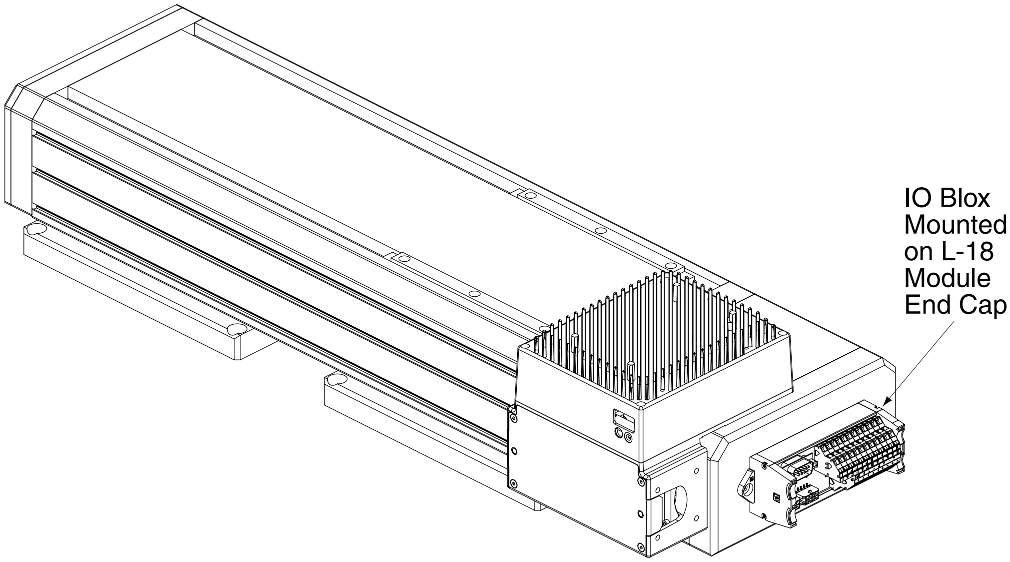


Figure 5-49. Mounting onto an L18 Module

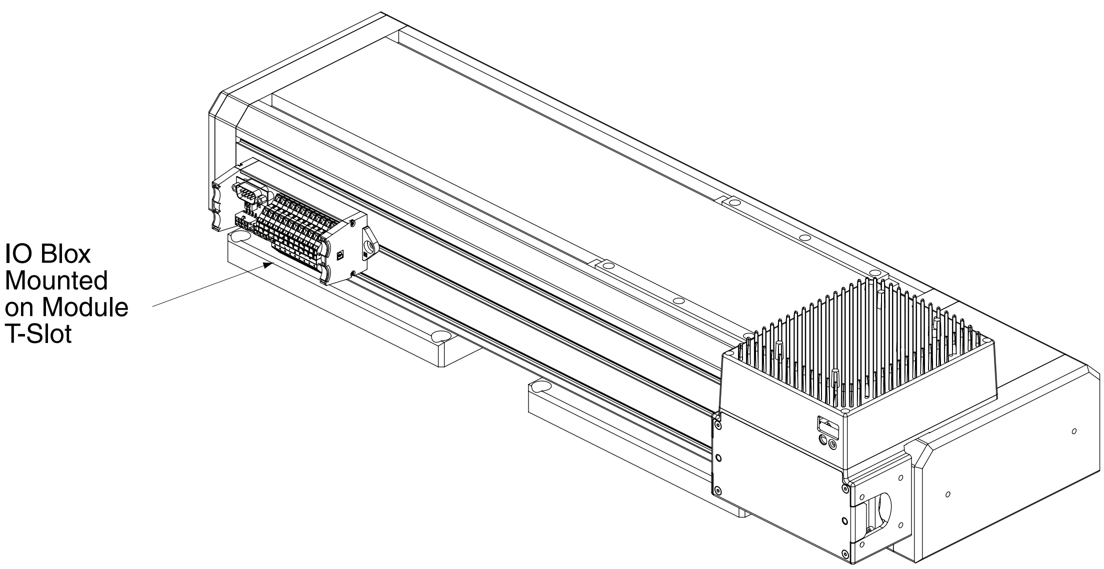


Figure 5-50. Mounting onto a Module T-Slot

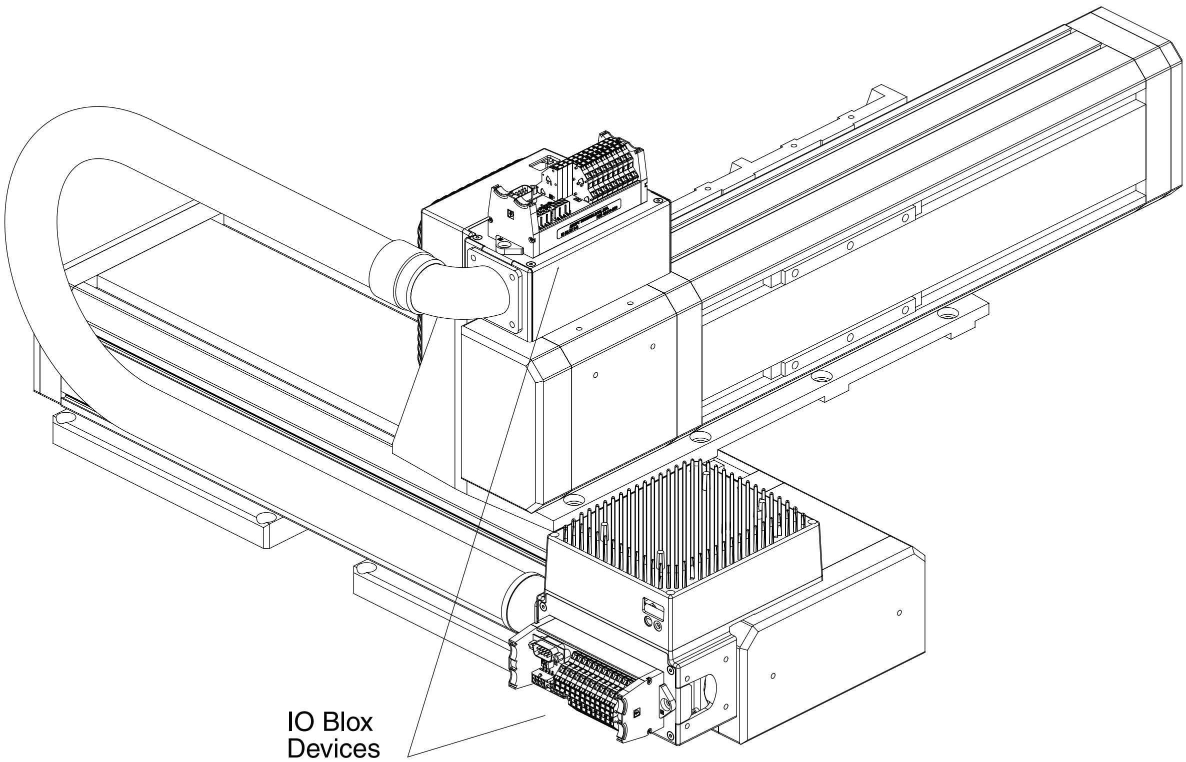


Figure 5-51. Mounting onto a Two-Axis System

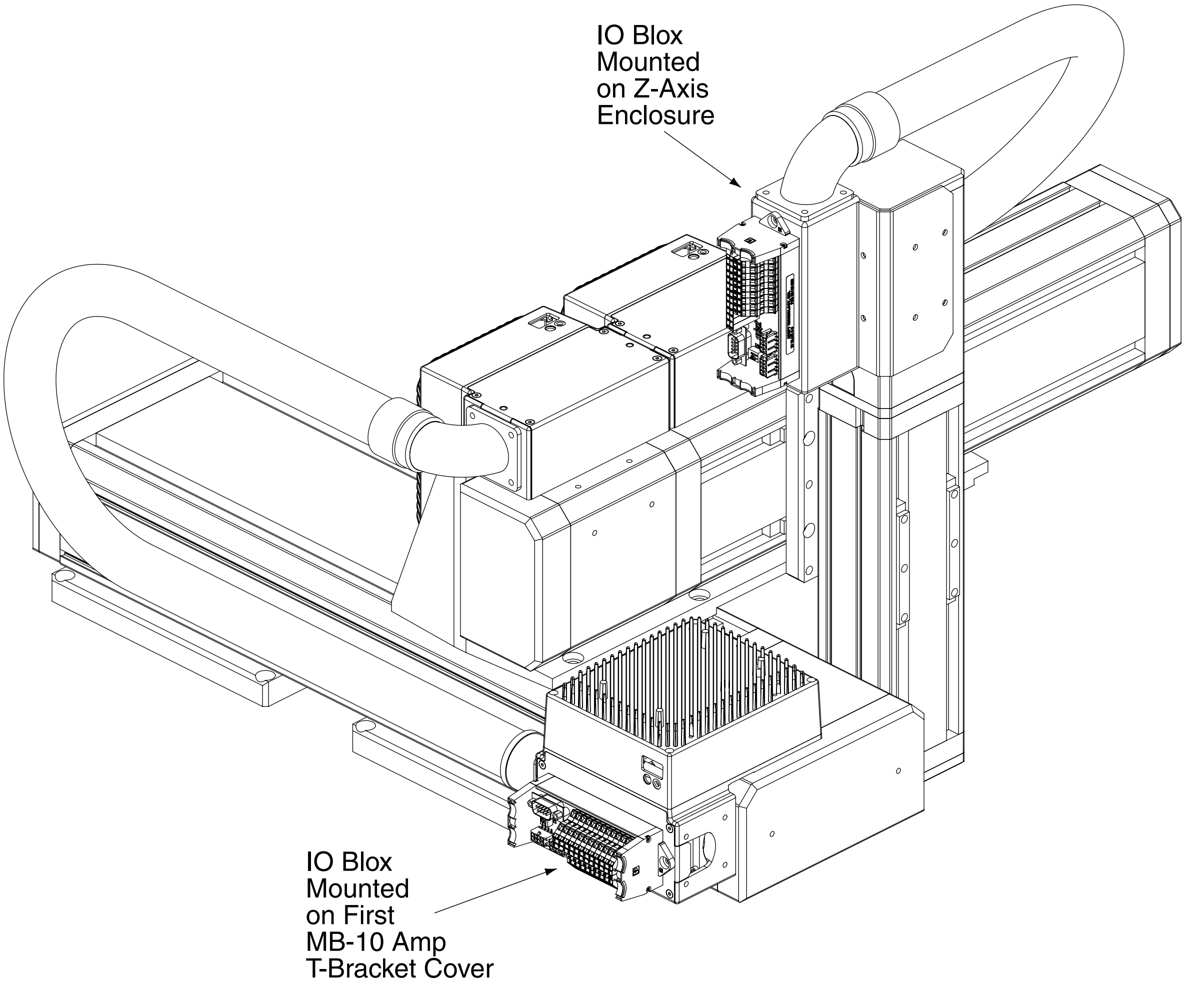


Figure 5-52. Mounting onto a Three-Axis System

5.9 Cabling/Plumbing

The Cleanroom Air Kit includes a length of pneumatic tubing and some extra fittings for connecting the modules to the vacuum source. See **"Module Preparation (Assembly)" on page 51** for details about cleanroom modules. See **Section 6.4 on page 114** for cleanroom system installation instructions.

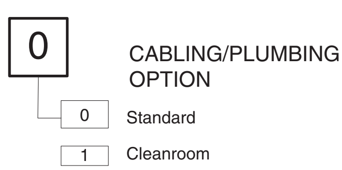


Figure 5-53. Cabling/Plumbing Options in Module System Descriptor Number

Module Installation 6

6.1 Lifting and Transporting Modules

Always use adequate equipment to lift and transport Adept Python modules. The modules can be very heavy, especially when configured as multiple-axis systems. See the following figure for one possible method using a mechanical hoist and slings.

Figure 6-1. Recommended Lifting Technique for Python System

6.2 Mounting Requirements

The mounting structure at the installation site must comply with all local codes. The mounting plate surface should be level. Due to the very high forces transmitted by the module system, it *must* be mounted to an extremely rigid structure. Any mounting structure vibration or flexing will seriously degrade performance.

Adept recommends using a welded and gusseted table structure with steel legs. Optionally, you can install steel risers on the mounting plate and then mount the system on top of the risers. If another type of mounting structure is used, it must adequately resist vibration and flexure.

Mounting Plate

The mounting plate should conform to the following recommended specifications:

- Material: carbon steel
- Thickness (min.): 25 mm
- Mounting surface flatness: ± 0.5 mm
- Mounting surface level: ± 0.25 degrees

6.3 Installing a Python Module System

The installation process varies depending on the number of axes in the system This section covers the details of three-axis system. If you have one or two-axis system, some of the initial steps can be skipped.

Most three- and four-axis module systems are shipped pre-assembled, with the third axis removed and packed in a separate section of the crate to ensure safe transport of the system. Typically, the third axis cables are left connected for shipping, requiring the user to remount that module on Axis 2. On four-axis systems, the fourth axis is mounted to the third axis. Both axes are removed together and mounted to the shipping pallet with all cabling intact. To install the modules, follow the procedure described in the next section.

General Installation Notes

Mating surfaces should be cleaned with IPA to remove debris, oil, etc.

All mounting screws must have thread engagement of at least 2 turns.

Loctite 242 (or equivalent) is recommended for all mounting screws.

Torque mounting screws to:

- M5 - 50 in-lb (5.6 N·m)
- M6 - 75 in-lb (8.5 N·m)
- M8 - 135 in-lb (15 N·m)

1. Remove the cover and the shroud from the packing crate and verify that all components on the packing list are present.

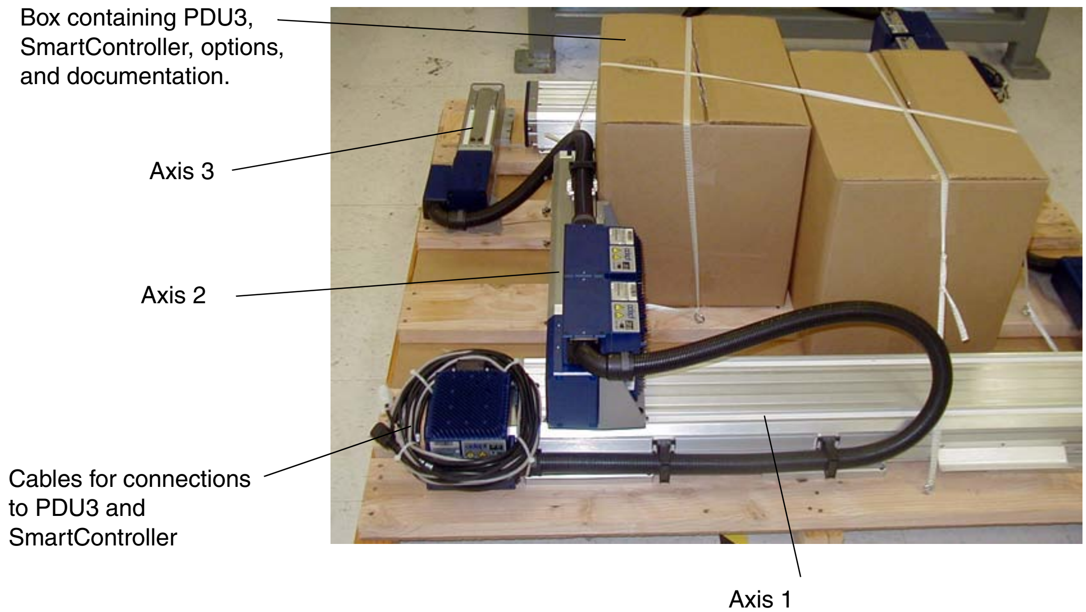


Figure 6-2. Typical Three-Axis System on Shipping Pallet with Contents Labelled

2. Remove the shipping screws that secure Axis 3 to the pallet. See **Figure 6-3**.

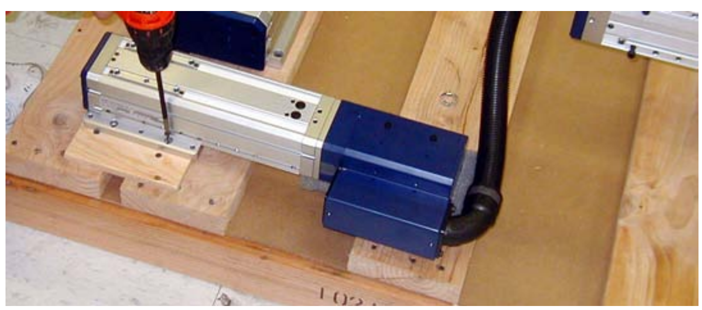


Figure 6-3. Removing Shipping Screws from Axis 3

3. Position Axis 3 at the mounting location on Axis 2, and secure with the supplied mounting bolts. See **Figure 6-4**.

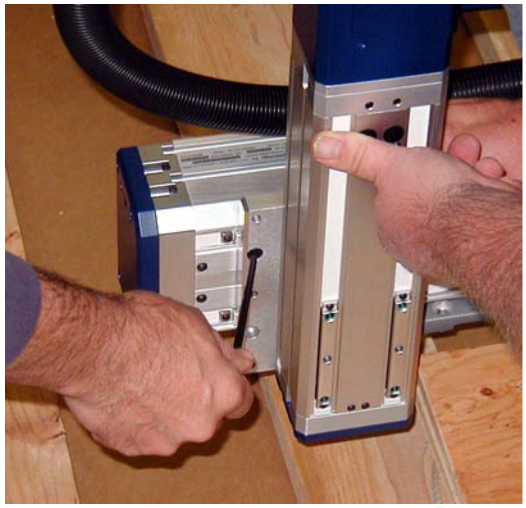


Figure 6-4. Installing Axis 3 on Axis 2

4. Remove the shipping screws from Axis 2. See **Figure 6-5**.

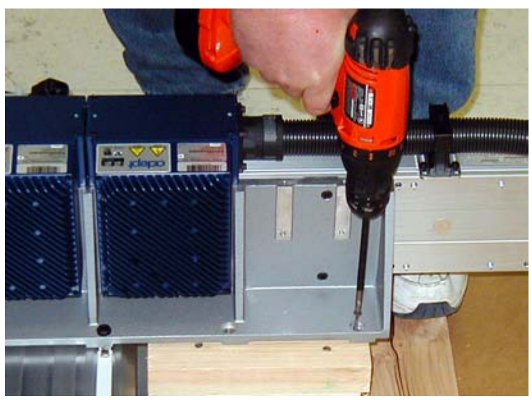


Figure 6-5. Removing Shipping Screws from Axis 2

5. Remove the shipping screws from Axis 1. See **Figure 6-6**.

Figure 6-6. Removing Shipping Screws from Axis 1

CAUTION: The center of gravity in the Y-Axis is dependent on the lengths and weights of the Y- and Z-Axes. The module system may tilt abruptly as the shipping screws are removed.

6. Verify that all shipping screws have been removed, and that the system is free to be lifted from the pallet.
7. Lift the system using a mechanical hoist or crane that is rated to handle the weight of the system. Arrange a series of slings around the axes that will safely support the system as it is being transported. See **Figure 6-7** for an example.

Figure 6-7. Lifting a Python System Using a Hoist and Slings

8. Transport the module assembly to the mounting location and lower it slowly and carefully into position.
9. Secure the system to the mounting platform, then go to the next chapter for details on connecting cables to the controller and other system components.

6.4 Cleanroom System Installation

The installation of modules in a cleanroom system is nearly identical to the installation of standard modules. On cleanroom systems, two 8-mm lines per module exit from the first module. The air lines must be connected to the house vacuum system, using the following guidelines.

Before installing the air lines, do the following for all types of systems:

- Follow the system-specific instructions in this manual for installing the Python system.
- Cut two sections of pneumatic tubing per cleanroom module to use for the air lines. Make sure the air lines are long enough to extend from the house vacuum source to the modules.

When installing the cleanroom modules, note the following.

- To maintain Class 10 cleanliness, make sure that the module speed does not exceed 500 mm/sec.
- Supply 30-45 liters/minute per air line (60-90 liters/minute per module) of air flow from the vacuum source at the point where the air lines enter the first module. Note that, due to air loss along the lengths of tubing, it might be necessary to supply more than 60 liters/minute from the vacuum source to achieve this level at the module entry point.

Connect air lines between the house vacuum source and the two air lines per module that exit from the first module.

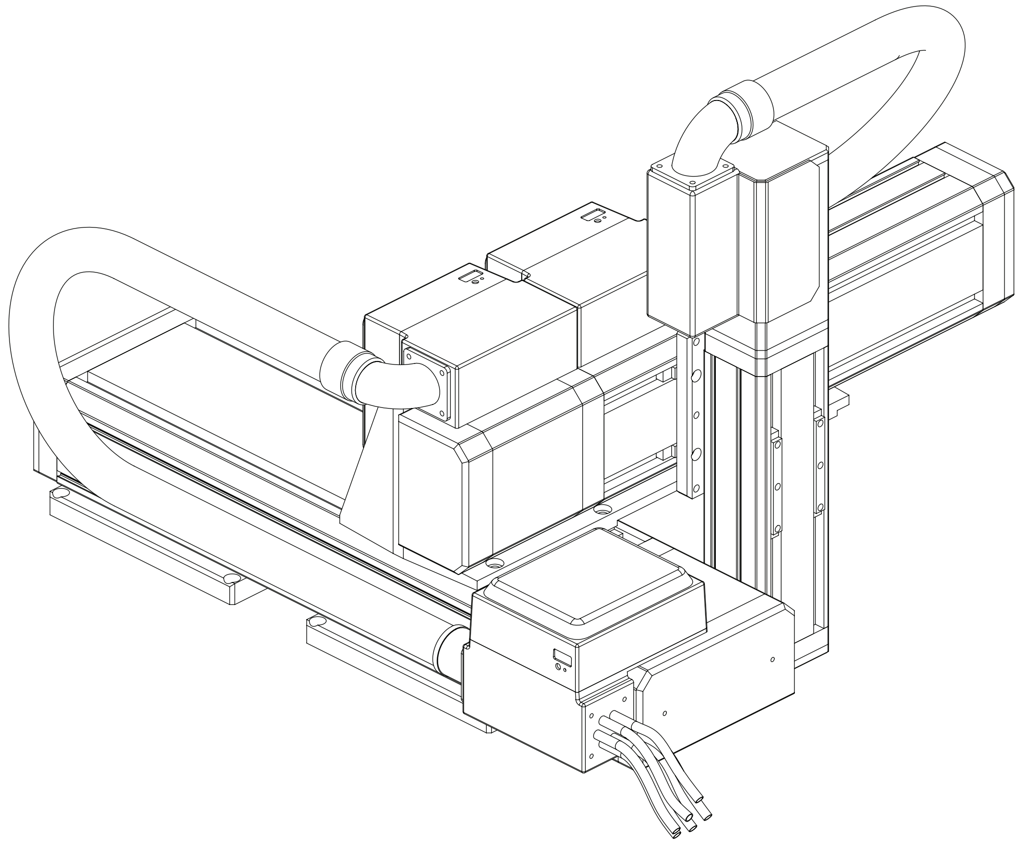


Figure 6-8. Example Cleanroom Module System

Controller System Installation 7

7.1 Installing the SmartController

The detailed instructions for installing the SmartController, including dimension drawings, are found in the *Adept SmartController User's Guide*. A summary of the main steps is provided here. Also refer to the system cable diagram in **Figure 7-1 on page 118** for an overview of the system components.

Space Around the Chassis

See Chapter 2 in the *Adept SmartController User's Guide*.

Mounting the Controller Chassis

The following mounting options are available for the SmartController:

- Rack
- Panel
- Table
- Stack

Brackets for panel-mounting the SmartController are supplied with the system. Brackets for rack- and table-mounting are available as options. See Chapter 2 in the *Adept SmartController User's Guide*. In addition, a SmartController, an sDIO module, and an sMI6 module can be stack mounted (one unit placed on top of another). These brackets are supplied with compatible Adept units.

Connect 24 VDC Power and Ground to the SmartController

See Chapter 2 in the *Adept SmartController User's Guide* for specifications on the user-supplied 24 VDC power source.

> **NOTE:** Attach the shield from the user-supplied 24 VDC cable to the right-hand side of the controller using a star washer and M3 x 6 mm screw. Select the threaded hole on the side of the controller that is closest to the 24 VDC connector (XDC1/XDC2). See **Figure 7-1 on page 118**.
>
> At the user-supplied 24 VDC power supply, attach the shield of the power cable to the frame ground of the power supply.

7.2 System Cable Diagram

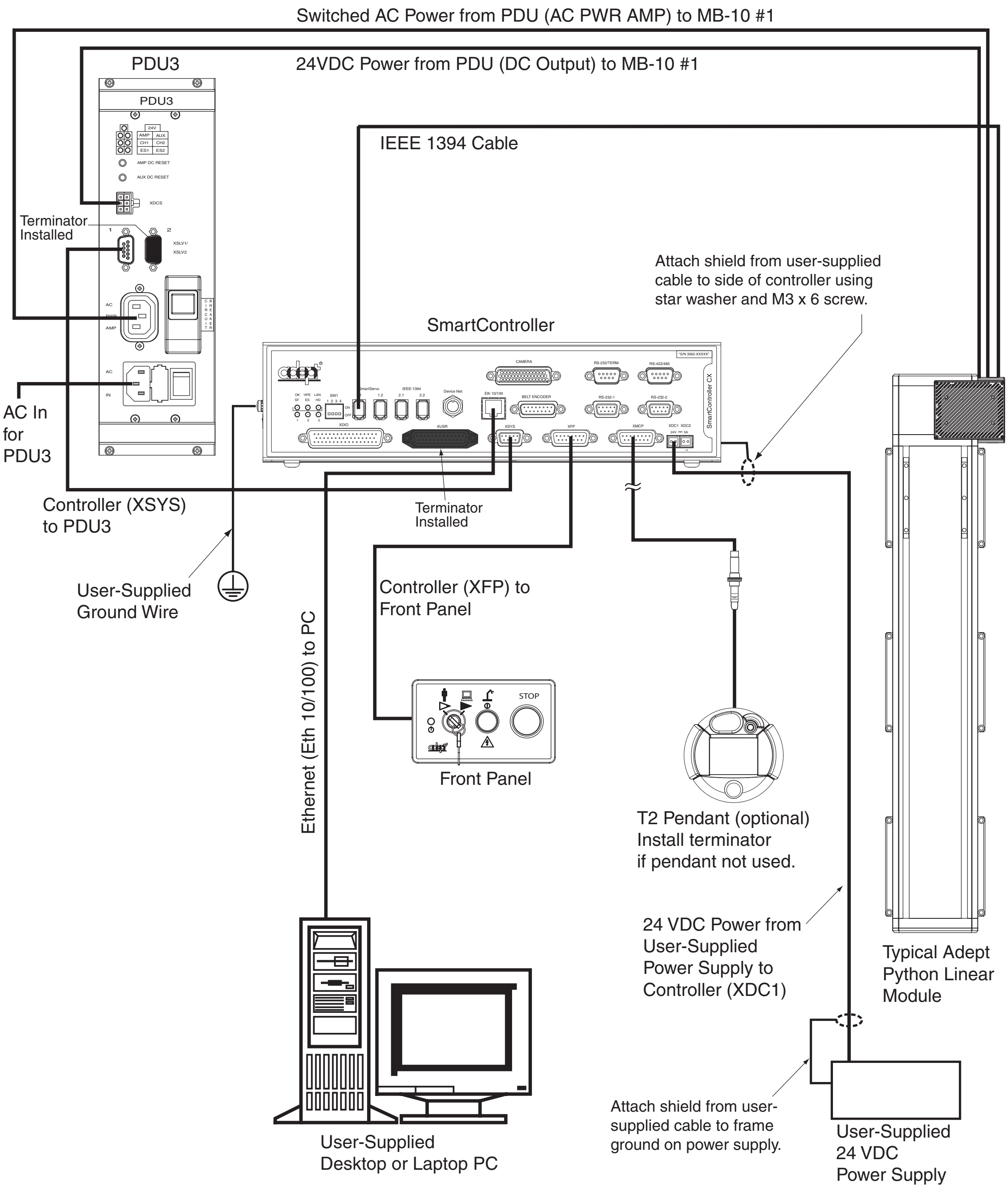


Figure 7-1. System Cable Diagram

7.3 Installing the PDU3

Refer to **Chapter 8** in this manual for information on installing and using the PDU3.

7.4 Installing the Adept Front Panel

The Adept Front Panel provides an Emergency Stop switch, a Manual/Auto mode switch, and a High Power enable switch. See **Figure 7-1 on page 118** for the system cable diagram. In order for the installation of the Front Panel to conform with RIA and European standards for power control functions, it must be mounted outside the Python modules or other robot workcell.

1. Locate the Front Panel cable. Connect one end to the XFP connector on the SmartController.
2. Connect the other end to the connector on the side of the Front Panel.

NOTE: If you do not use the Adept Front Panel, you must supply the E-Stop and High Power enable functionality to the system. See the ***Adept SmartController User's Guide*** for details.

7.5 Connecting the Optional T2 Pendant to the Controller

The T2 pendant is connected to the system at the XMCP connector on the SmartController. The controller does not have to be turned off to connect or disconnect the pendant. Note that if the pendant or the pendant bypass plug is removed, High Power will be turned off. The XMCP connector allows you to install a remote pendant connector. See the ***Adept SmartController User's Guide*** for details.

NOTE: The Adept T1 or MCP-4 pendant can also be used with a Python system.

WARNING: Before the pendant can be used in the workcell, turn the key switch on the Front Panel to MANUAL and remove the key. This will prevent program execution from being started from a keyboard or terminal.

1. Plug the pendant cable into the mating connector on the pendant Adapter cable.
2. Plug the pendant Adapter cable into the connector marked XMCP on the front of the SmartController.

NOTE: An optional wall bracket is available for storing the T2 pendant. See the ***Adept T2 Pendant User's Guide*** for more information.

7.6 Installing the User Interface

Using AdeptWindows PC Software

The Adept SmartController system is typically used with AdeptWindows software, which is a suite of application programs for the SmartController and a PC. AdeptWindows enables you to operate the controller via a graphical user interface running over an Ethernet connection. The procedure for installing AdeptWindows and setting up the user interface is described in the ***AdeptWindows Installation Guide***. Refer to this document for details on installing AdeptWindows and establishing an Ethernet connection to the controller.

> **NOTE:** The ***AdeptWindows Installation Guide*** also describes how to set up a serial connection between the PC and the controller. A serial connection can be used instead of an Ethernet connection to communicate with the controller.

After installing the AdeptWindows PC software, refer to the AdeptWindows on-line help for additional information on setting up the user interface.

Graphical Interface Using Adept DeskTop

Adept DeskTop 4.0 is a software package available as an option for SmartController-based systems. Adept DeskTop provides a powerful PC-based development environment for Adept systems with an extensive set of tools for programming, debugging, and testing. Adept DeskTop gives you the flexibility to customize the graphical user interface and user-access level for any given Adept robotic application

Some of the highlights of Adept DeskTop include an advanced Code Editor environment, a V+ Code Library, a Keyword Browser, a new File Manager Utility, and a Virtual Jog Pendant. Adept DeskTop also has an integrated, comprehensive online documentation system, with context-sensitive help.

For more information on Adept DeskTop, go to the Adept website and look in the PC software products area.

7.7 Installing Optional IO Blox Units

Adept IO Blox units can be installed in Python systems to enable additional input/output capacity. Each IO Blox unit can handle 8 inputs and 8 outputs. Up to 4 IO Blox units can be daisy-chained, for a total of 32 additional I/O lines. The IO Blox unit connects to an MB-10 amplifier in Python systems. See the ***Adept IO Blox User's Guide*** for complete installation and operation details.

Power Distribution Unit 8

8.1 Introduction to the PDU3

The Power Distribution Unit (PDU3) performs these functions in an Adept Python modules system:

- Supplies switched AC power to the MotionBlox-10 (MB-10) amps
- Provides AC power filtering and surge protection
- Supplies 24 VDC power to the MB-10 amps and optional IO Blox devices
- Provides CAT-3 E-Stop functionality

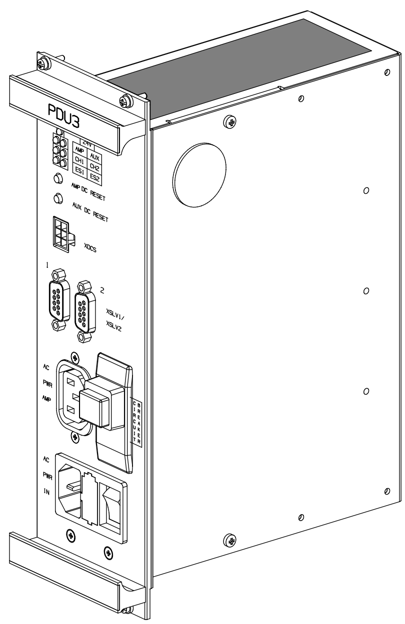


Figure 8-1. Adept PDU3

The PDU3 has been designed to power a typical Python modules system that contains up to four MB-10 amps, 1 motor brake, and up to 4 IO Blox devices. Both the AC and DC outputs of the PDU3 are fused to the limits specified in Table 8-2 on page 129. If your application requires additional Python modules, MB-10 Servo Kits, multiple large motors (>400 Watts), additional brakes, or other I/O requirements, please consult Adept Sales or Service for help in planning the correct configuration and capacity for a safe and effective system.

8.2 Installing the PDU3

See **Section 8.4 on page 124** for details about the connectors and indicators on the PDU3.

1. Mount the PDU3 in an appropriate location. Interface cables from the first MB-10 to the PDU3 are 4.5 meters, so the PDU3 must be within that distance. Mounting brackets are supplied with the PDU3 (see **Figure 8-5 on page 126**). For dimensions of the mounting brackets, see **Figure 8-7 on page 128**.

CAUTION: To allow for proper cooling, mount the PDU3 with 50 mm clearance at the top and bottom of the unit.

2. Connect the 24 VDC cable coming from the MB-10 to the XDCS connector on the PDU3.
3. Connect the AC power cable coming from the MB-10 to the AC PWR AMP connector on the PDU3.
4. Connect the XSLV1 connector on the PDU3 to the XSYS connector on the SmartController using the supplied 9-pin cable.

   NOTE: The unused XSLV connector must be terminated using the Adept-supplied terminating jumper.

5. Connect the user-supplied AC power source (200-240 VAC) to the AC PWR IN connector on the PDU3. See the AC power diagrams that follow. Also see **Table 8-2 on page 129** for AC power specifications.

   NOTE: The PDU3 is designed to operate with both MB-10 amps and the previous generation of Adept SmartAmps. Python module systems with the MB-10 require 200-240 VAC input. Any 110 VAC SmartAmp installations that are being upgraded to MB-10 must be upgraded to 200-240 VAC input.

8.3 Typical AC Power Connection Diagrams for PDU3

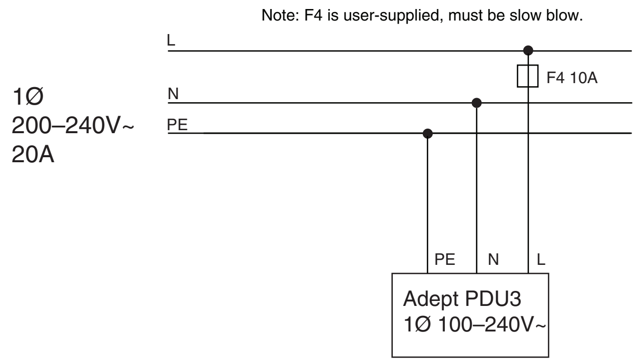


Figure 8-2. Typical Single-Phase 200-240 VAC Connection

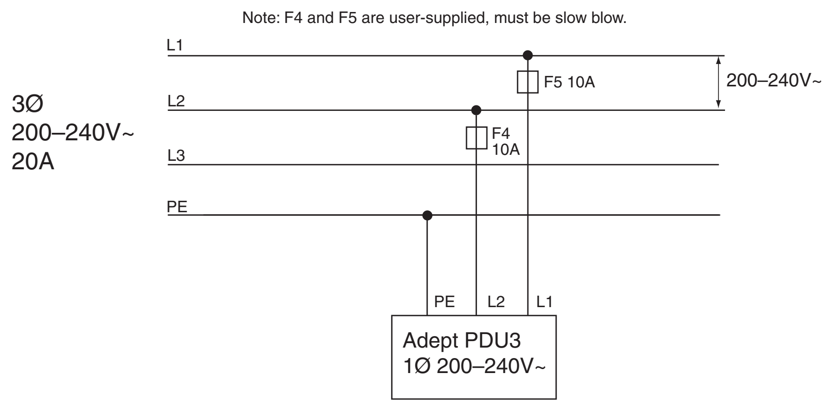


Figure 8-3. Typical Three-Phase 200-240 VAC Connection

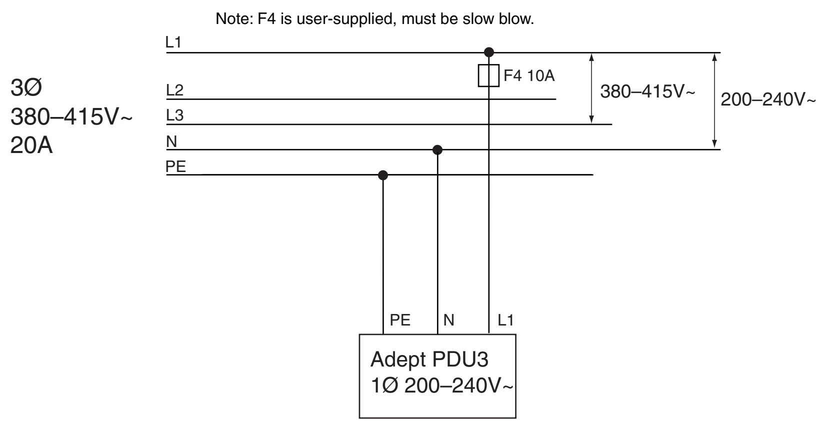
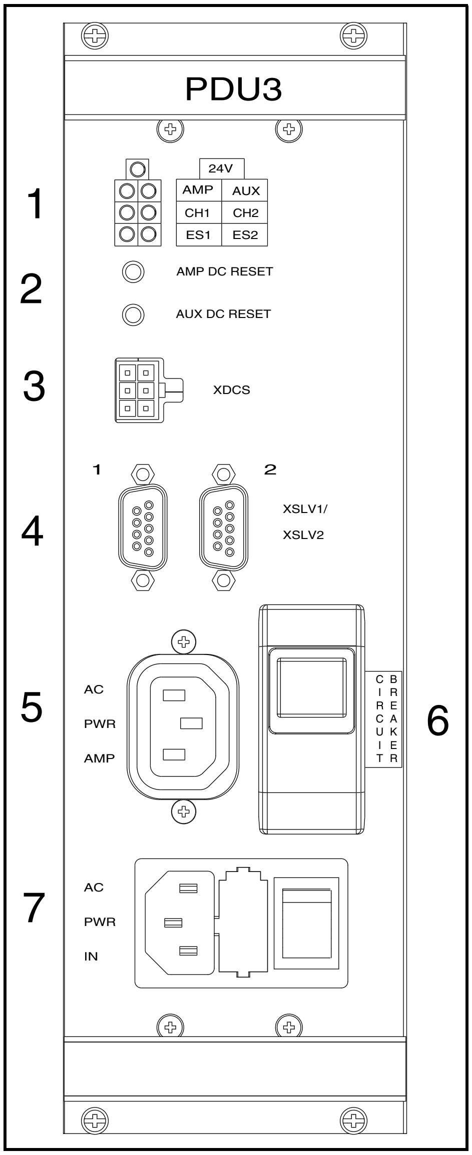


Figure 8-4. Typical Three-Phase 380-415 VAC Connection

8.4 PDU3 Connectors and Indicators



1. Status indicator LEDs:
   24 V - ON indicates 24 VDC power supply in the PDU3 is working
   AMP - ON indicates 24 VDC to MB-10 is operating
   AUX - ON indicates 24 VDC to AUX is operating
   CH1/2 - E-Stop channel 1 or 2 voltage within range
   ES1 - ON indicates E-Stop Relay 1 is on
   ES2 - ON indicates E-Stop Relay 2 is on
   Note: both relays must be on to enable AC power to MB-10 amps.

2. **AMP DC RESET** button - for resetting the internal circuit breaker on the 24 VDC supply to MB-10 amps

   AUX DC RESET button - for resetting the internal circuit breaker on the 24 VDC supply to AUX

   NOTE: Do not push reset buttons while the system is operating because it will cause 24 V power to cycle and will require restarting the system.

3. **XDCS** - connector for 24 VDC cable to MB-10 amps
   This cable provides:
   - 24 VDC to MB-10 amps
   - 24 VDC to Aux/IO Blox
   - Auto/Manual signals for Manual mode operation

4. **XSLV1/2** - (1) connection to host controller E-Stop
   (2) connection for terminator plug
   Note: XSLV1 and 2 are interchangeable. The terminator plug must be installed for the system to operate.

5. **AC PWR AMP** - connector for switched AC power cable to MB-10 amps.

6. **Circuit Breaker** - 6 Amp circuit breaker for switched AC power going to MB-10 amps. Press the button in to reset it if it has tripped.

7. **AC PWR IN** - connector, fuses, and On/Off switch for incoming AC power to PDU3.

   NOTE: 200-240 VAC required for Python systems.

8.5 PDU3 Fuses

Two fuses for the incoming AC power lines are located in the fuse compartment at the AC Power Inlet area, located between the power cable connector and the On/Off switch.

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.

Procedure to Remove Fuse Holder

1. Turn off AC power to the PDU3 and disconnect the power cord from the AC power source.
2. Remove the AC power cord from the socket on the AC Power Inlet area.
3. To remove the fuse holder, insert a small flat-blade screwdriver into the slots on the opposite sides of fuse holder, then press down and pull out the fuse holder.
4. To reinstall the fuse holder, insert it in place, then press down firmly until the entire holder snaps into position.

Table 8-1. PDU3 Fuse Ratings

Fuse	Quantity	Rating	Type
AC Line fuses at AC Power Inlet	2	8 Amp Time Lag	IEC 127-style 5 x 20 mm

8.6 PDU3 Mounting Brackets

The PDU3 can be mounted using the supplied mounting brackets, see the following figure. For dimensions of the mounting brackets. see **Figure 8-7 on page 128**.

CAUTION: Make sure the PDU3 is mounted so there is 50 mm clearance at the top and bottom of the unit to allow for proper cooling.

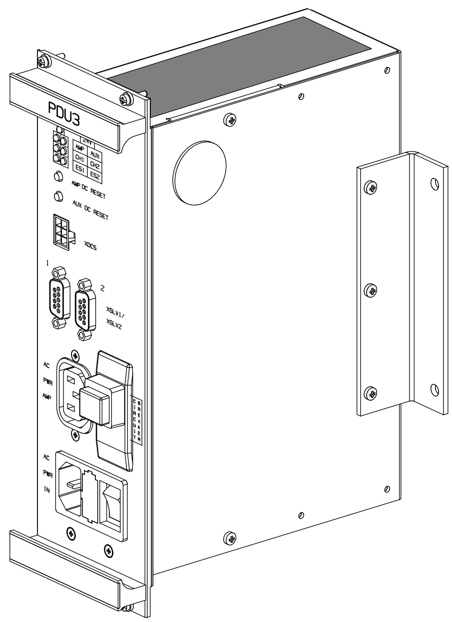


Figure 8-5. PDU3 with Mounting Brackets Installed

8.7 PDU3 Dimensions

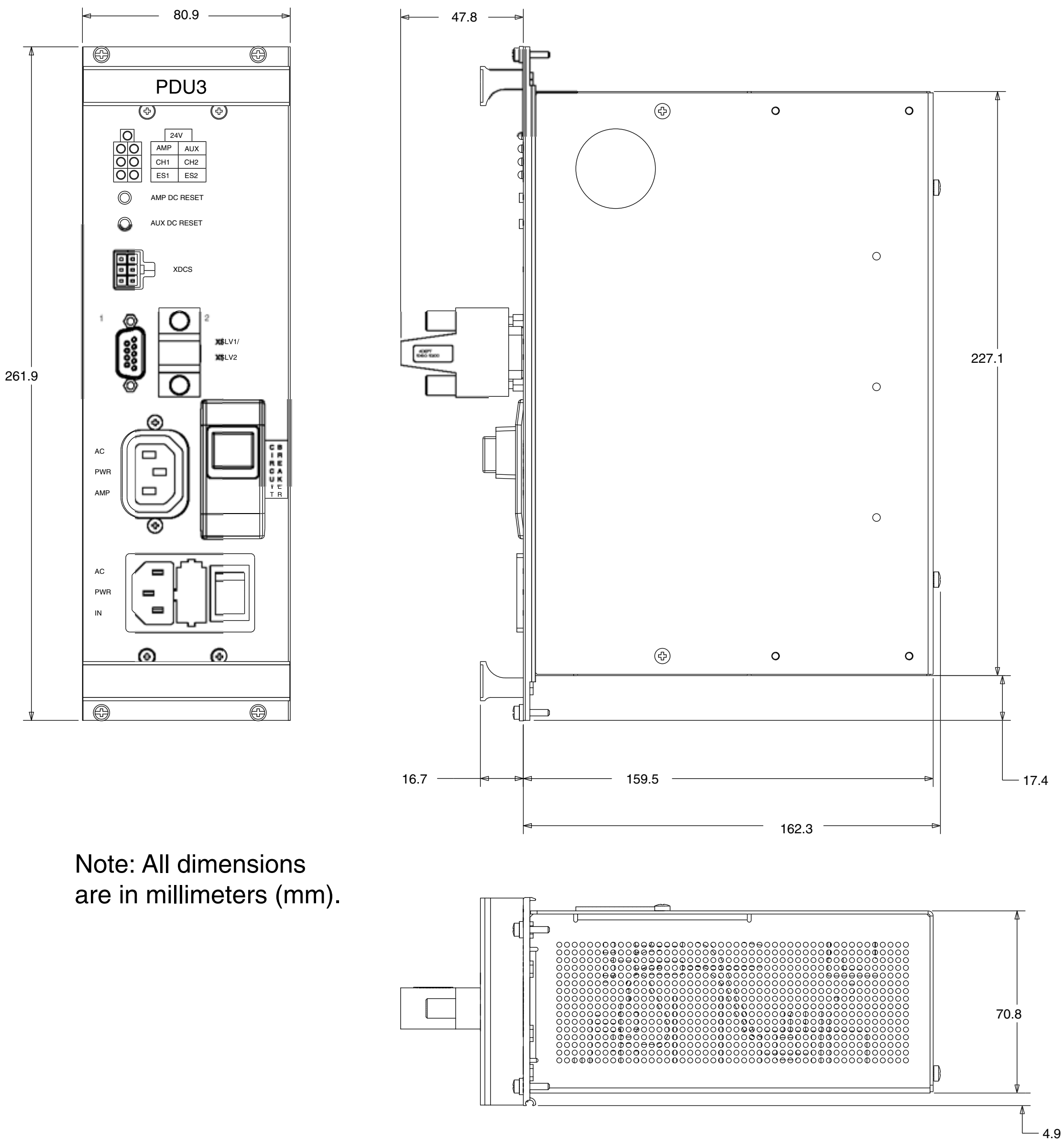


Figure 8-6. PDU3 Dimensions

8.8 PDU3 Mounting Bracket Dimensions

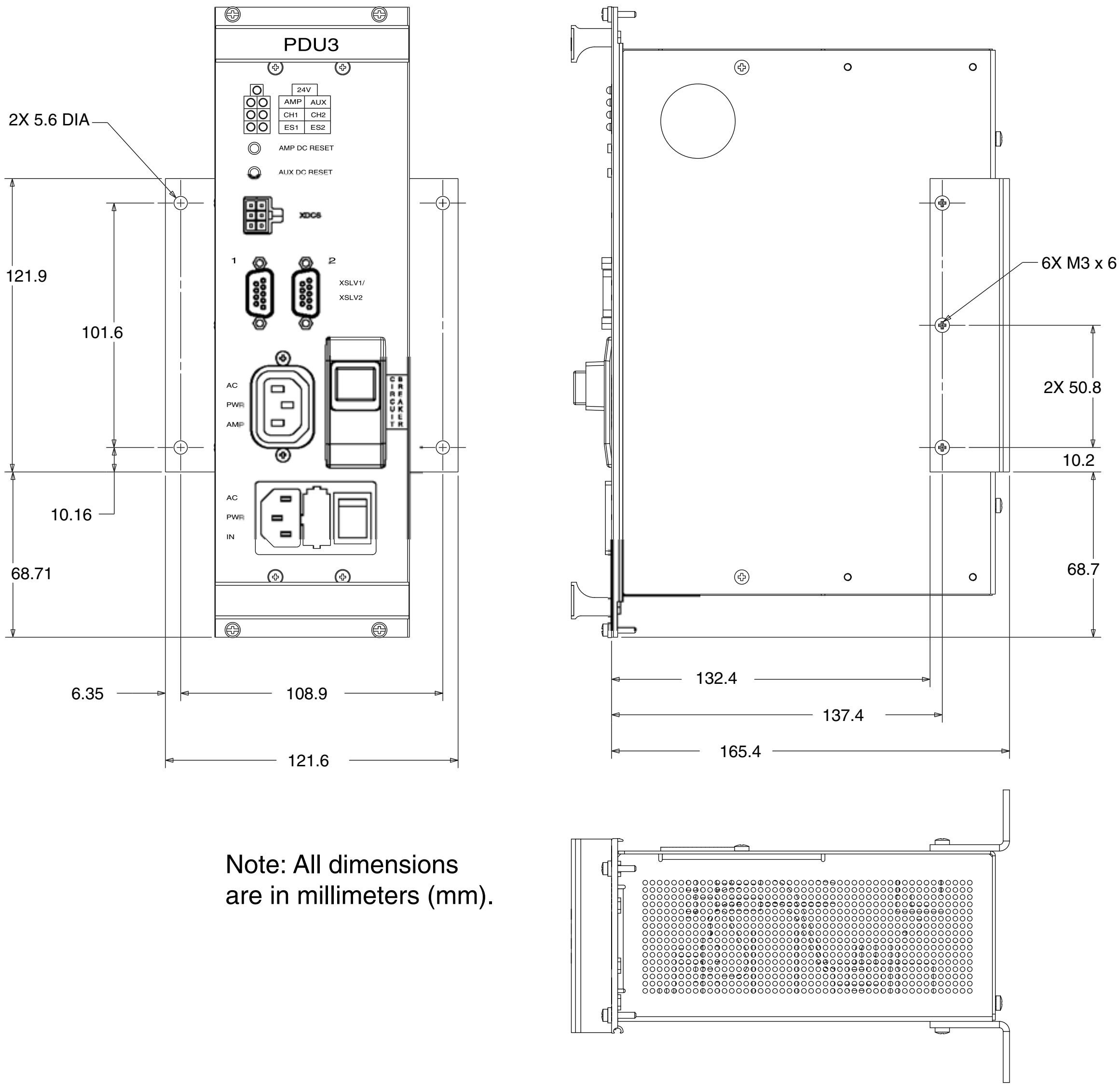


Figure 8-7. Mounting Bracket Dimensions

8.9 PDU3 Specifications

Table 8-2. PDU3 Specifications

Input Power Requirements	
Universal power input voltage	200-240 VAC (180-264 VAC max), single phase
Power input frequency	50-60 Hz (47 - 63 Hz max)
Power input current	8 Amps
Power Input connector (mating)	IEC 320 C13
Power Installation	Category II Overvoltage
Amplifier DC Output	
Output Voltage	24 VDC ±10%
Output Current	3 Amps maximum[a]
Hold up time	20 ms
AUX DC Output	
Output Voltage	24 VDC +10% -15%
Output Current	3 Amps maximum[a]
Hold up time	20 ms
Switched AC Output Section	
Maximum Continuous Output Current	6 Amps
Output Voltage	equal to input
Power Output Connector (mating)	IEC 320 C14
Environmental	
Ambient temperature	5° C to 40° C (41 to 104° F)
Humidity	5 to 90%, noncondensing
Pollution degree	2 (per IEC 1131-2/EN 61131-2)
Chassis protection class, unmounted	IP-20 (NEMA Type 1)
Weight	2.2 kg

[a] Note: maximum combined amplifier DC output current and Aux/IO Blox output current may not exceed 4 amps.

8.10 PDU3 E-Stop Circuit Diagram

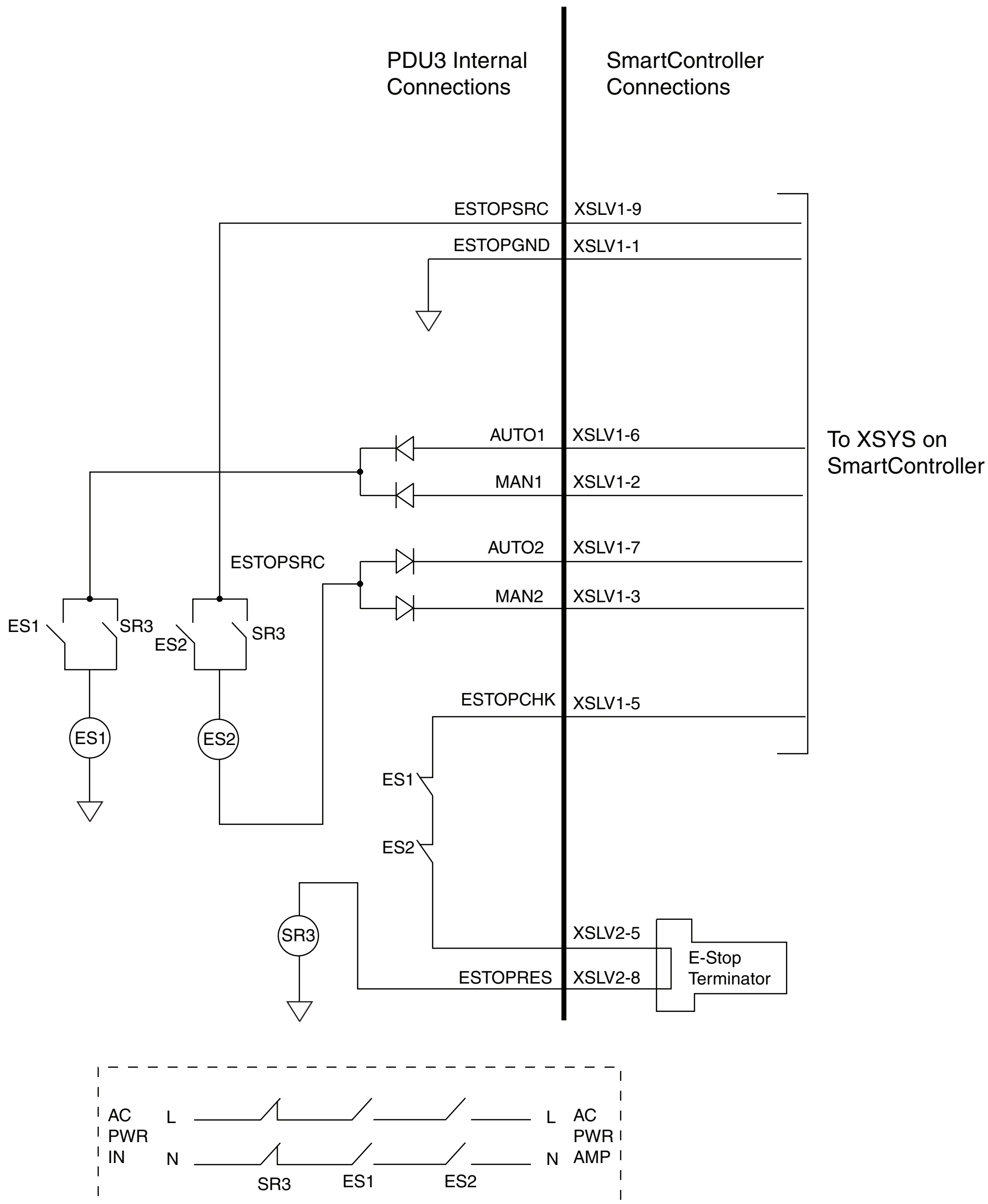
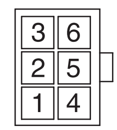


Figure 8-8. E-Stop Circuit Diagram for PDU3

8.11 PDU3 Connector Specifications

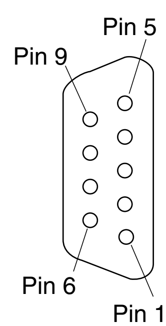
XDCS Connector

Table 8-3. XDCS Connector Pinout

Pin #	Description	Comment	Pin Location
1	GND	24 V supply ground	 XDCS Connector as viewed on PDU3
2	--	not used	
3	GND	24 V supply ground	
4	AMP_24 V	MB-10 +24 V	
5	SHIELD	Cable shield	
6	AUX_24 V	Auxiliary (IO Blox) +24 V	
Mating Connector: MOLEX #39-01-2065, 6-pin Mini-Fit Junior Receptacle Assembly MOLEX #39-00-0047, Contact Terminal, Mini-Fit Jr. Family MOLEX #15-04-0296, Strain Relief, Mini-Fit Family Jr.			

XSLV1/2 Connector

Table 8-4. XSLV1/2 Connector Pinout

Pin #	Description	Comment	Pin Location
1	ESTOPRTN	ESTOP System Ground	 XSLV1/2 Connector as viewed on PDU3
2	MAN1	ESTOP Manual Input Ch 1	
3	MAN2	ESTOP Manual Input Ch 2	
4	HIPWRDIS	High Power Disable	
5	ESTOPCHK	Normally Closed Check Contacts	
6	AUTO1	ESTOP Auto Input Ch 1	
7	AUTO2	ESTOP Auto Input Ch 2	
8	ESTOPRES	ESTOP System Reset	
9	ESTOPSRC	ESTOP System +24 V	
Mating Connector: AMP/Tyco #747904-2, 9-pin D-Sub AMP/Tyco #748676-1, D-Sub Cable Clamp			

Adept MB-10 Amps 9

9.1 Overview

The Adept MotionBlox-10 (MB-10) is a distributed servo controller and amplifier that mounts directly to each module axis. It is designed with a dedicated digital signal processor to communicate, coordinate, and execute servo commands. When linked to other MB-10 amps via IEEE 1394, it creates a Distributed Control Network for each module mechanism.

Figure 9-1. Adept MB-10 Amplifier

The main features of the MB-10 are:

- a distributed servo amplifier for the Adept SmartController
- RISC microprocessor for high-performance servo control
- multi-axis coordinated motion via Adept SmartServo (IEEE-1394)
- mounts directly to a module
- compatibility with AC servo motors from 50-750 Watts
- single-phase, 200-240 VAC, input power
- integrated regenerative energy dump resistor
- dual-digit alpha-numeric status display
- manual brake release button

9.2 MB-10 Operation

Status Panel

The status panel on the MB-10, shown in **Table 9-1**, displays alpha-numeric codes that indicate the operating status of the robot, including detailed fault codes. **Table 9-1** gives definitions of the fault codes. These codes provide details for quickly isolating problems during troubleshooting.

Table 9-1. Status Panel Codes on MB-10

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

[a] Note: The axis number (#) is counted on a per-node basis. Thus, the axis number for axis-specific status codes on MB-10 amps will generally display as axis 1.

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

Indicator LED

The Indicator LED on the MB-10 is a green/red bicolor LED that indicates specific conditions, depending on its status.

Table 9-2. MB-10 Indicator LED Conditions

LED Status	Condition
LED Off	24 VDC not present
LED green, blinking slow	24 VDC present, High Power disabled
LED green, blinking fast	24 VDC present, High Power enabled
LED blinking alternately green and red	To identify an axis during configuration
LED red, blinking fast	MB-10 fault, 24 VDC present
LED green or red, not blinking	MB-10 logic failure

Brake Release Button

The Brake Release button is the recessed push-button located below the Indicator LED.

- The brake release circuit requires 24 VDC at the MB-10 to function.
- Pressing the Brake Release button releases the brakes on any module equipped with brakes. This is typically a module mounted in a vertical orientation.
- Pressing the Brake Release button while the system is running causes a software E-Stop, disables High Power, and brings the mechanisms to an uncontrolled stop.
- Pressing the Brake Release button disables High Power, but does not disable PDU3 AC to the MB-10s. Both the ES1 and ES2 LEDs on the PDU3 remain on, if they were already on.

MB-10 Connectors

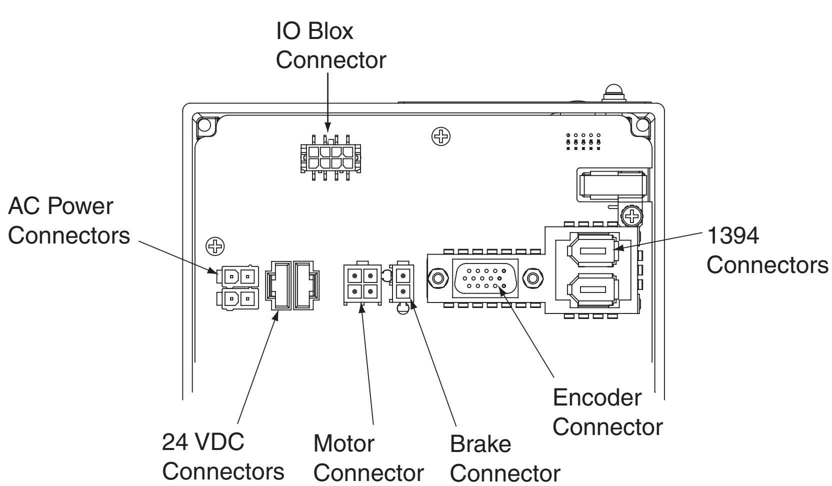


Figure 9-2. Connector Locations on MB-10 Amp

WARNING: Make sure you connect a ground cable to the ground lug (indicated by the black arrow in the following figure) on the MB-10.

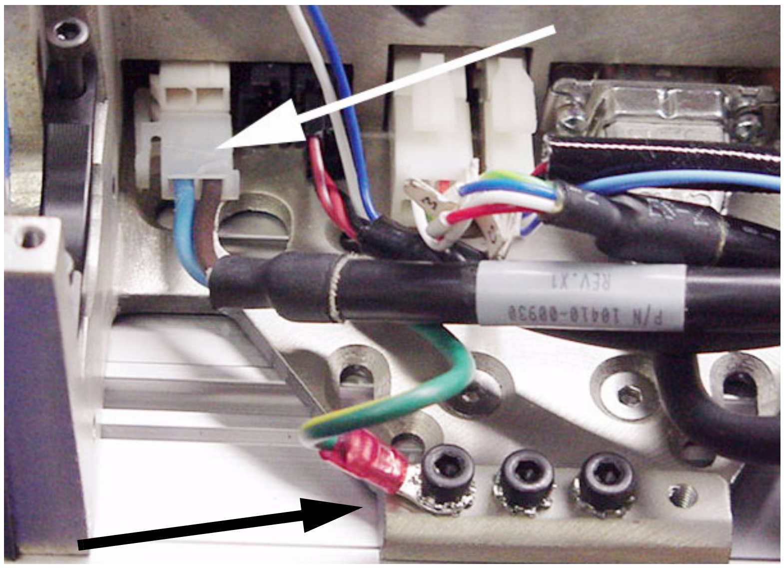


Figure 9-3. Attaching the AC Power and Ground Cables

IO Blox Connector

Adept IO Blox units can be used in Python module systems to provide I/O at a specific location. The IO Blox cable connects to the IO Blox connector on the MB-10. See the ***Adept IO Blox User's Guide*** for installation details.

EEPROM on MB-10 T-Bracket

The MB-10 is bolted to a mounting bracket called the MB-10 T-bracket. There is an EEPROM device installed on the T-bracket. This device stores system axis mapping information about the specific module that the MB-10 is mounted on. If an MB-10 has to be replaced, the EEPROM retains the module system data, and a new MB-10 can read that information.

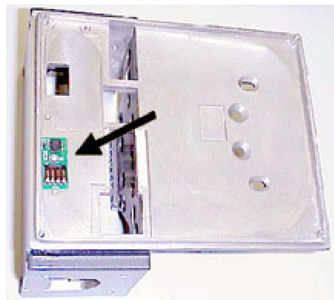


Figure 9-4. EEPROM Device on T-Bracket

9.3 MB-10 Firmware

The MB-10 firmware contains the real-time servo code that controls the motion of the module. If the firmware has to be updated, you can use the DC_UPDAT utility program. See the documentation that comes with the Update disk for information on using this utility, or contact Adept Customer Service.

9.4 MB-10 Specifications

Table 9-3. Adept MB-10 Specifications

Input Power Requirements	
AC input voltage (supplied by PDU3)	200-240 VAC, single-phase (180-264 VAC max.)
AC input frequency	50-60 Hz (47-63 Hz max.)
AC input current (continuous)	4 Amps
DC input voltage (supplied by PDU3)	24 V, ±10%
DC input current - MB-10 and motor only - MB-10, motor and brake - additional per IO Blox	1 Amp max. 400 mA, nominal at 24 V 675 mA, nominal at 24 V 25 mA, nominal at 24 V
Amplifier Output	
Bus Voltage	310 VDC (nominal)
PWM Frequency	16.5 kHz
Max Output Current (per phase)	10.5 A (rms), 15 A (peak)
Max Output Power (continuous)*	400 W
Max Output Power (momentary peak)*	2000 W
*Max output power may be limited in vertical movements on extreme payload deceleration conditions due to regenerative energy	
Brake Output	
Voltage	DC input voltage -1.0 V (@ 0.5 Amp)
Max current	0.5 Amp
Encoder Interface	
Serial	Yaskawa Sigma II/III
Quadrature	Yaskawa Sigma I
Communication	
Servo network communication standard	IEEE 1394a
Maximum data communication rate	400 Mb/s
Environmental	
Ambient temperature	5° to 40° C (41 to 104° F)
Humidity	5 to 90%, noncondensing
Maximum case temperature	85° C

Table 9-3. Adept MB-10 Specifications (Continued)

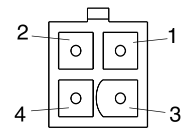
Dimensions	50 mm x 120 mm x 150 mm
Weight	1.5 kg

9.5 MB-10 Connector Specifications

Table 9-4. Motor Connector

Pin #	Description
1	PHASE U
2	PHASE V
3	PHASE W
4	FGND

Pin Location



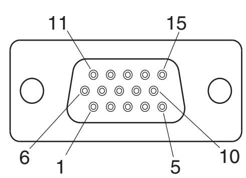
Motor Connector
as viewed on MB-10

Mating Connector:
AMP/Tyco #172167-1, 4-pin Mini-Universal Mate-N-Lock
AMP/Tyco #170362-2, Socket Contact, Mini-Univ. Mate-N-Lock

Table 9-5. Encoder Connector

Pin #	Description	Pin #	Description
1	PHASE A+	9	N/C
2	PHASE A-	10	PHASE Z2+
3	PHASE B+	11	PHASE Z2-
4	PHASE B-	12	SABS DATA+
5	PHASE Z+	13	RESET
6	PHASE Z-	14	SABS DATA-
7	GND	15	+3.6 V BAT
8	+5 V		

Pin Location



Encoder Connector
as viewed on MB-10

Mating Connector:
AMP/Tyco #748468-1, 15-pin HDP-22 Plug Kit
AMP/Tyco #748333-2, Pin Contact, Size 22DF, 22-28 AWG
AMP/Tyco #747579-8, Ferrule, Sizes 1-3

Table 9-6. Brake Connector

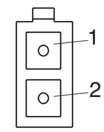
Pin #	Description	Pin Location
1	Brake_24 V	 Brake Connector as viewed on MB-10
2	Brake_GND	
Mating Connector: AMP/Tyco #172165-1, 2-pin Mini-Universal Mate-N-Lock AMP/Tyco #170362-2, Socket Contact, Mini-Univ. Mate-N-Lock		

Table 9-7. +24 V Connector (2 per MB-10)

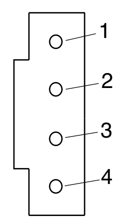
Pin #	Description	Pin Location
1	Not Used	 +24 V Connector as viewed on MB-10
2	Not Used	
3	GND	
4	+24 VDC	
Note: the two +24 V connectors on the MB-10 are interchangeable.		
Mating Connector: AMP/Tyco #104257-3, 4-pin AMPMODU Receptacle Housing AMP/Tyco #104480-9, Contact Pin, AMPMODU, 22-26 AWG		

Table 9-8. AC Connector (2 per MB-10)

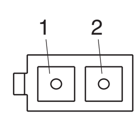
Pin #	Description	Pin Location
1	Hot (L1)	 AC Connector as viewed on MB-10
2	Neutral (L2)	
Ground Lug	Attach to ground point. See Figure 9-3 on page 136.	
Note: the two AC connectors on the MB-10 are interchangeable.		
Mating Connector: MOLEX #39-01-2025, 2-pin Mini-Fit Junior Receptacle Assembly MOLEX #39-00-0039, Contact Terminal, Mini-Fit Family		

Table 9-9. IEEE 1394 Connector (2 per MB-10)

Pin #	Description
1	VP
2	VG
3	TPB-
4	TPB+
5	TPA-
6	TPA+
7	Shield (FGND)
8	Shield (FGND)
Note: the two IEEE 1394 connectors on the MB-10 are interchangeable.	
Mating Connector: Use approved IEEE 1394 Cable	

System Operation 10

10.1 Introduction

This chapter takes you through the process of verifying the installation and turning on the system. These topics are covered:

- Verify system installation
- Turn on AC and DC Power
- Perform software configuration
- Enable High Power and test all E-Stops
- Perform run-time calibration

10.2 Verifying Installation

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

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

Mechanical Checks

- Verify that the modules are mounted level and that all fasteners are properly installed and tightened.
- Verify that the MB-10 amps are mounted securely for each axis in the system.
- Verify that any user-supplied 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.

- Manually move the slider on each axis in the system through the full range of motion to ensure there are no mechanical problems with the sliders or internal bearings. This also helps verify that all cable tubes are installed correctly and there is no binding or stress on any cables or connectors. If you have a module with a brake, you have to wait until you have 24 V power turned on to use the Brake Release button to move the module.

Power Checks

Verify that the SmartController and the PDU3 are correctly connected to their power supplies.

1. Make sure that power is shut off to both the SmartController and the PDU3.
2. Verify that 24 VDC power is connected to the SmartController.
3. Verify that 220 VAC single-phase power is connected to the PDU3.
4. Verify that all voltages and voltage frequencies are within range.

Cable Installation Checks

Make sure that all cables are correctly installed. Refer to **Figure 7-1 on page 118** for the system cable diagram.

1. Check all cable connections to the SmartController and make sure they are secure.
2. Check all connections on the PDU3 to make sure they are secure.
3. Check the cable connections at each MB-10 in the system to ensure integrity of signal connections, especially encoder feedback, and to ensure the integrity of the ground shields and other EMC measures.
4. Check the cable connection between the SmartController and the Front Panel. Verify that the plug is latched on both ends of the cable.
5. If you are using the AdeptWindows PC user interface, use a shielded Ethernet cable from the hub (or server) to the shielded RJ45 connector on the SmartController. 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.

User-Supplied Safety Equipment Checks

Verify that all user-supplied safety equipment and E-Stop circuits are installed correctly. See the ***Adept SmartController User’s Guide*** for information on these topics.

10.3 Turning On Power

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

DANGER: 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 system.

1. Verify that the black circuit breaker button on the PDU3 is pressed in.
2. Turn the AC power switch on the PDU3 to the ON position.
3. Turn on DC power to the Adept SmartController.
4. The SmartController will execute its boot sequence. When the boot sequence has completed, the OK/SF LED should be green. In addition, the status panel display on the MB-10 should read “OK”. If the OK/SF LED is red, the SmartController 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.
5. If the HPE/ES LED is continuously red, then at least one pair of E-Stop contacts is open. Check all E-stops.

For information on the Status LEDs, refer to the ***Adept SmartController User’s Guide***.

10.4 Software Configuration

NOTE: Most Adept Python modules systems are shipped with the software configuration already completed. In that case, you can proceed directly to **Section 10.5 on page 150**. The information in this section is provided for reference in case you have to perform the configuration process.

NOTE: Remember to save all specifications to the system disk when prompted at the end of the setup process.

Load and Run DC_SETUP.V2

This section goes through the MB-10 initialization. You identify and configure each axis in your system during this process. Type the following at the prompt.

```
load d:\util\dc_setup.v2

execute 1 a.dc_setup
```

1. The first screen in the Setup program looks similar to Figure 10-1. Select "Configure Modules/Servo Kits/Hybrid."

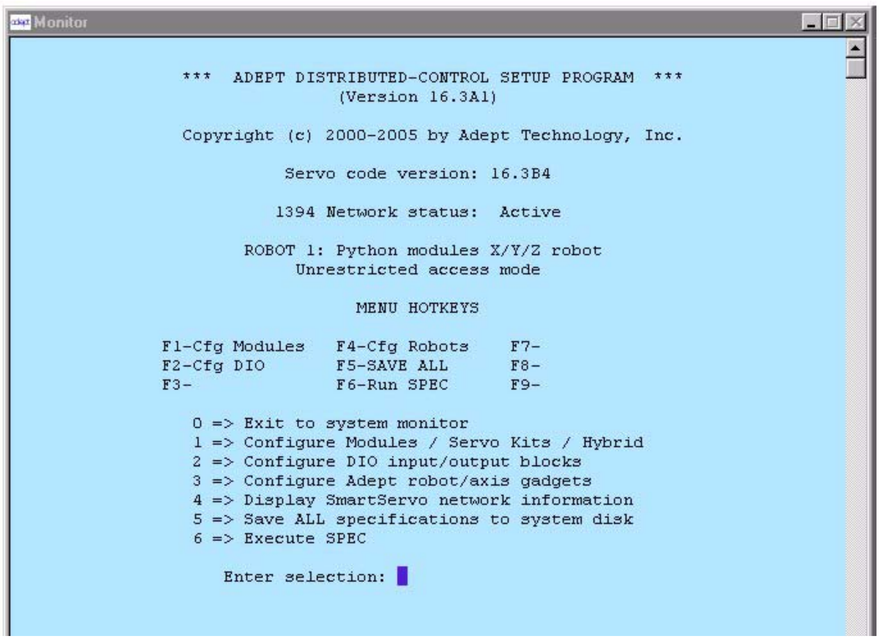


Figure 10-1. DC_SETUP Program Main Screen

2. In the next screen, select "Modules quick setup."

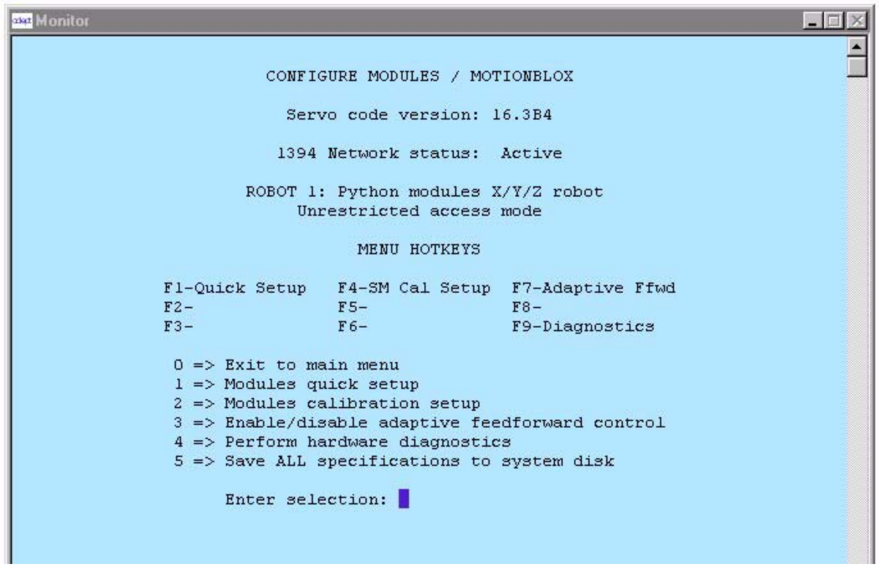


Figure 10-2. DC_SETUP Program Setup Screen

3. Follow the instructions on the screen as you proceed through the program until you reach the following screen.

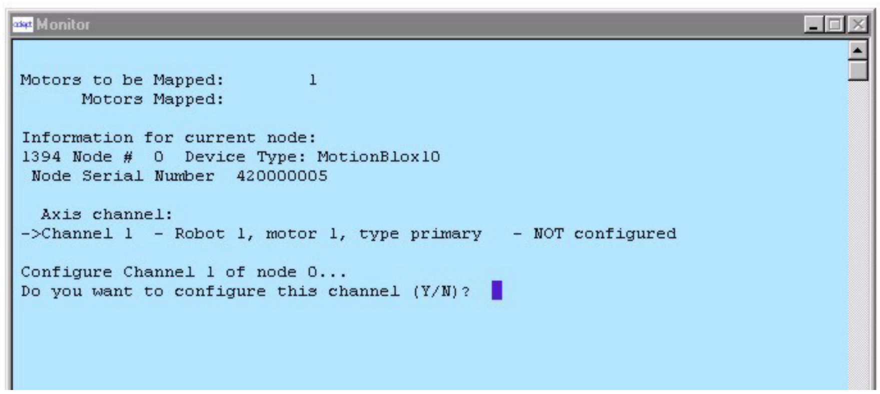


Figure 10-3. DC_SETUP Program Node to Robot/Motor Map Screen

4. Follow the on-screen prompts to assign each node (axis) on the 1394 network to the correct robot and motor number.

After loading the SPEC parameters based on the Python model number stored in the module, the program shows the information for all the configured Python modules, as shown in the following screen.

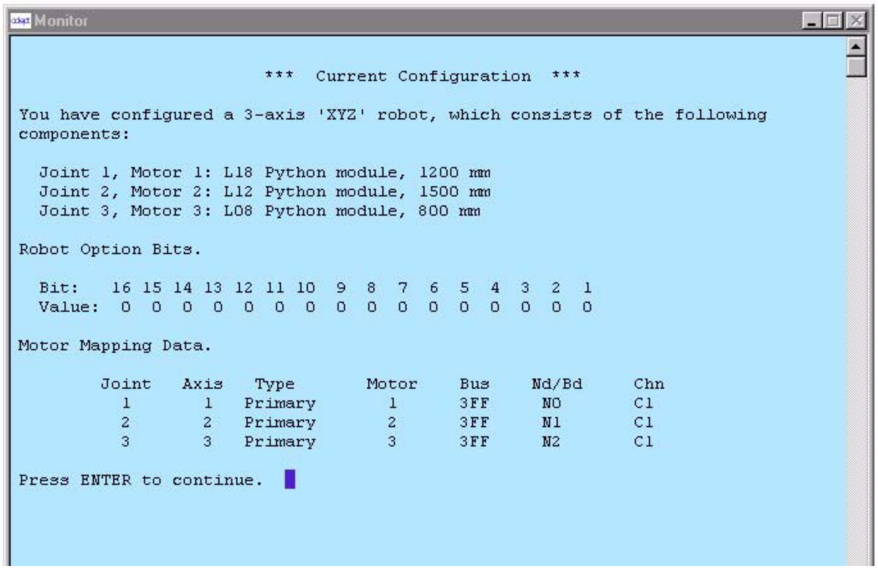


Figure 10-4. DC_SETUP Program Current Configuration Screen

After you run DC_SETUP to configure each axis, you might need to run DC_SETUP again if you:

- change your module configuration
- replace modules

You should not need to run DC_SETUP again if you replace the MotionBlox-10 amplifiers only.

Run Module Calibration Setup Program

The Linear Module Calibration Setup program starts automatically after the configuration program is complete. You can also select the program from the Setup screen shown in Figure 10-2 on page 147.

Figure 10-5 shows a typical screen as you begin the calibration process.

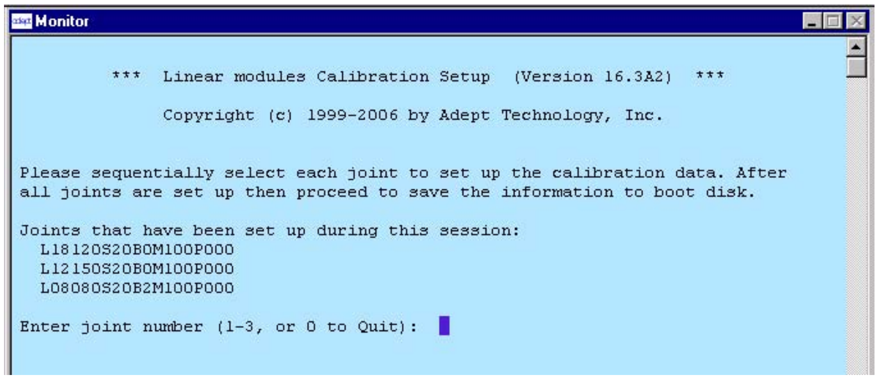


Figure 10-5. Calibration Setup Screen

CAUTION: The axes will move during calibration. Make sure the workcell is clear of any obstructions.

1. Follow the instructions on the screen as you proceed through the program.
2. During calibration, the program instructs the module to start moving towards the motor side until it finds the hard stop, backs off approximately 4 mm, and then sets the zero location for the absolute encoder. You can choose to move the zero location to the opposite end of the module if necessary. This will also change the orientation of positive motion.

   NOTE: Adaptive feed-forward compensation is enabled by default for Python modules; use the SPEC utility if you need to disable adaptive feed forward. See "Adaptive Feed-Forward Compensation" on page 150 for information.

3. Remember to save the new data to the system boot disk when prompted.
4. Exit DC_SETUP by selecting "Exit to system monitor."

You are now ready to start the system.

Adaptive Feed-Forward Compensation

The MB-10 amplifier has the ability to run an adaptive feed-forward compensator in addition to the PID controller. The advantage of this control algorithm is that there is no need to change the tuning of the acceleration and velocity feed-forward gains. Servo code determines the proper values of these feed-forward gains in real time based on estimations of inertia (payload), gravity, and viscous and coulomb friction. It takes about 5 to 6 motion cycles (acceleration-slew-deceleration) to find a good set of gains. The adaptive compensator is only in effect during motion; at steady state, the PID controller is doing all the compensation.

> **NOTE:** The adaptive feed-forward option is enabled by default and normally reduces (optimizes) cycle time. If you need to change the adaptive feed forward settings, use the SPEC.v2 program.

This option is recommended for repetitive motions or variable payload applications. There are situations that limit adaptive feed-forward performance. For example, when commanded trajectories are very short or random in nature, adaptive feed forward might take longer to find the correct gain values.

10.5 Enable High Power

The next step after performing software configuration is to enable High Power and test all E-Stops.

1. Verify that High Power can be enabled:

   a. Enter the following command at the monitor window:

   ```
   enable power
   ```

   Or press the Power On button on the pendant.

   b. When the High Power push button/light on the Front Panel begins flashing, press the push button. When you release the push button, the light should remain lit continuously, indicating that High Power has successfully been enabled.

   c. These events will happen next:

   On the SmartController, the HPE LED turns ON (green).

   On the PDU3, the ES1 and ES2 LEDs turn ON, if they were not already on.

   On each MB-10, the Status Panel display code changes to ON, and the Status LED starts blinking green quickly (approximately 2 Hz).

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

2. Verify that all E-Stop devices are functional (Front Panel, pendant, 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 Front Panel should go out and the red ES LED on the SmartController should be lit.

10.6 Run-Time Calibration

After High Power is enabled and all E-Stops have been checked, you must perform the run-time calibration on the system. Make sure the carriage on each module is at least 10 mm away from a hardstop, or an error may occur.

1. Enter the following command at the monitor window:

   `calibrate`

- The calibration process happens with very little noise, except possibly for a quiet high pitch humming.
- On modules equipped with brakes, brakes will release during calibration with a click.
- After calibration is complete, the system returns to the dot prompt. You are now ready to operate and program the system.

10.7 Turning Off Power

1. Stop any customer-supplied application programs that are running.
2. Enter the following command at the monitor window:

   `disable power`

3. Turn off the AC power switch on the PDU3 and turn off the DC power supply to the SmartController.

10.8 Operating and Programming an Adept Python Modules System

When the system has been calibrated, you should go to the ***Adept T2 Pendant User's Guide*** to learn how to move the system with the pendant.

Refer 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 additional programming information, refer to the following list of optional manuals:

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

NOTE: These manuals are located on the Adept Document Library CD-ROM that ships with each system.

Maintenance 11

11.1 Introduction

Table 11-1 gives a summary of the preventive maintenance procedures and guidelines on frequency.

Table 11-1. Inspection and Maintenance

Item	Period	Reference
Check E-Stop, enable and key switches, and barrier interlocks	6 months	See Section 11.2.
Check mounting bolts on all modules and brackets	6 months	
Clean the heat sink fins on all MB-10s	1 month	
Track the usage on the encoder battery and replace when required.	varies	See Section 11.4.
Track the usage on the MB-10 internal battery and replace when required.	varies	See Section 11.3.

NOTE: The frequency of these procedures will depend on the particular system, its operating environment, and amount of usage. Use the times in Table 11-1 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 2.11 on page 33.

11.2 Checking Safety Systems

Every Six Months

1. Test operation of:
   - E-Stop button on Front Panel
   - E-Stop button on optional pendant
   - Auto/Manual switch on Front Panel
   - Enabling switch on optional pendant (Manual mode only)

   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.

11.3 Replacing the MB-10 Internal Battery

The MB-10 amplifier is equipped with an internal, field-replaceable battery. The purpose of this battery is to power the MB-10’s real-time clock when the system is not powered up (that is, no 24 VDC supply is present).

If an encoder is plugged directly into the MB-10 amplifier (without the standard Adept supplied in-line battery cable), then the encoder will also draw power from this battery during conditions when the system is not externally powered.

Battery Replacement Time Periods

The life of the battery will vary greatly depending upon whether the system is powered up (with 24 VDC power) and whether the amplifier is directly powering an encoder. The following table lists the recommended replacement periods for various conditions.

Table 11-2. MB-10 Internal Battery Replacement Periods

MB-10 24 V Power Status	Encoder Load	Recommended Replacement Period
MB-10 powered more than half time	MB-10 only (No encoder OR ext. battery)	Not required[a] (10 years)
MB-10 not powered	MB-10 only (No encoder OR ext. battery)	Not required[a] (10 years)
MB-10 powered more than half time	MB-10 and encoder (No external battery)	3 years
MB-10 not powered	MB-10 and encoder (No external battery)	1.5 years

[a] If an external battery is used for encoder backup, the MB-10 will function normally even if the internal battery is exhausted. The only effect will be a loss of the time/date stamp used for the internal error-logging function.

Battery Replacement Procedure

This procedure covers replacing the MB-10's internal battery with a new replacement battery.

1. Obtain a replacement battery. Adept part number: 04805-000 (see **Figure 11-1**). Trim the leads to 2.5 ± 0.5 mm (0.10 ± 0.02 in.).

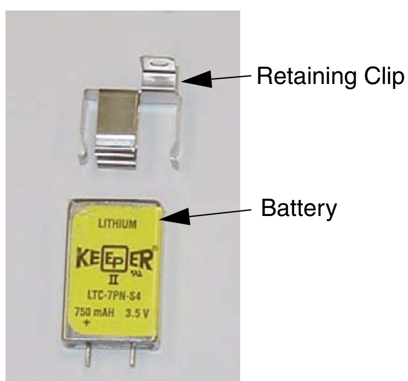


Figure 11-1. MB-10 Internal Battery and Retaining Clip

2. Turn off the 24 VDC power to the SmartController and turn off the AC power switch on the PDU3.
3. At the PDU3, unplug the AC cable between the MB-10 and the PDU3.
4. Remove the cover from the MB-10 T-bracket and unplug all the cables from the MB-10.
5. Remove the MB-10 amplifier from the T-bracket by loosening the four screws at the corners of the MB-10. Carefully lift the MB-10 away from the bracket and set it down on its heatsink fins, with the electronics facing upwards.

6. Locate the M3 screw, washer, and sheet metal retaining clip which retain the battery (see **Figure 11-2**). Remove the screw and washer.

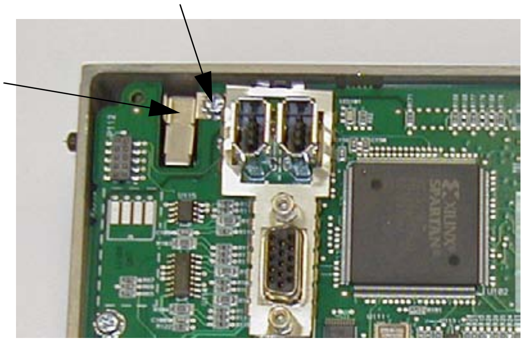


Figure 11-2. MB-10 Internal Battery Location

7. Remove the clip by pulling straight up on the small tab with small pliers.
8. Remove the battery by pulling straight up with pliers or a similar tool.
9. Insert the replacement battery. Make certain the positive lead (+) is inserted into the (+) marking on the circuit board. Be careful not to bend the leads on the battery as you insert it.
10. Replace the clip and secure it with the screw and washer.
11. Reinstall the MB-10 amplifier onto the T-bracket assembly and reconnect all cables. Turn on the AC and DC power to the system. See **Section 10.3 on page 145**.
12. The final step is to use the Calibration Set-up function in the DC_Setup program. See **Section 10.4 on page 145** for information on software configuration.

11.4 Replacing the Module Encoder Battery

The encoder multi-turn data and module specification data stored by the encoder in the module is protected by a backup battery. Each module is supplied from the factory with the battery attached to the encoder harness and located inside the module's motor cover. See **Figure 11-3**.

Figure 11-3. Encoder Battery

Battery Replacement Time Periods

If the module is kept in storage, or it is turned off (no 24 VDC supply) most of the time, then the battery life is shortened, and it must be replaced according to the specifications in **Table 11-3**.

If the module is turned on with 24 VDC supplied to its MB-10 amplifier more than half the time, then the battery life is increased and the replacement period is extended.

Table 11-3. Encoder Battery Replacement Periods

MB-10 24 V power status	Recommended Replacement Period
24 V power OFF most of the time.	8 years
24 V power ON more than half of the time.	12 years

Battery Replacement Procedures

The encoder batteries are easily accessible on most modules by removing the motor end cap. In these situations, the battery replacement can be performed without removing 24 VDC power and without having to recalibrate the system. On some modules it may be necessary to remove all power from the system, remove the MB-10 amplifier, motor endcap, and extruded motor cover, in order to gain access to the battery. Please follow the following procedures for either case.

1. Obtain a replacement encoder battery. Adept p/n 05142-000.

   NOTE: The photo in the procedure detailed in the following section shows an L18 module. The procedures for L12 or L08 modules are very similar; therefore, you can follow the steps provided here.

Battery Accessible via End Cap Removal

1. Leave power turned on to the PDU3, and push the E-Stop button on the Front Panel. In this procedure, you want to have the 24 VDC power supplied to the encoder, so you do not have to recalibrate the axis.
2. Remove the end cap from the module by removing four screws. See **Figure 11-4**.
3. Pull the external battery out from inside the module and disconnect it from the wiring harness.
4. Plug the new external battery into the wiring harness, and secure it inside the module.
5. Replace the end cap on the module.

The system should be ready to use, with no calibration required.

Figure 11-4. Replacement Cable Assembly Installed in Module

Battery Not Easily Accessible, MB-10 Removal Required

1. Turn off the 24 VDC power to the SmartController and turn off the AC power switch on the PDU3.
2. At the PDU3, unplug the AC cable between the MB-10 and the PDU3.
3. Remove the cover from the MB-10 mounting bracket and unplug all of the cables from the MB-10.
4. Remove the MB-10 from the MB-10 T-bracket by loosening the four screws at the corners of the MB-10. Lift the MB-10 straight up and off of the bracket.
5. Remove the MB-10 T-bracket from the module by unscrewing the two screws on the top and the two screws on the side.
6. Remove the end cap from the module by removing four screws.
7. Slide the encoder and motor cable bundle out from the end of the module, and unwrap the flexible grommet from the bundle. Note the location of the grommet and the amount of cable extension. This info. is useful for a step later in this procedure.
8. Disconnect the old battery and plug the replacement battery into the matching connector on the replacement encoder cable.
9. Coil the encoder cable assembly and tuck it into the open area of the module, under and next to the motor. Secure the battery to the inside of the module using the self-adhesive Velcro tape on the battery.
10. Wrap the flexible grommet around the encoder and motor cables at the same location as the original position, so that the cables extend a similar distance.
11. Slide the flexible grommet into the slot in the side of the module and push it all the way to the back of the slot.
12. Ensure that all cables are tucked inside the module and that none of them will be crimped when the end cap is replaced.
13. Install the end cap and secure it with four screws.
14. Install the T-bracket and reconnect all cables. Turn on DC and AC power to the system.

15. The final step is to use the Linear Module Calibration Setup function in the DC_Setup program to recalibrate the axis that had the new battery installed. See **Section 10.4 on page 145** for information on software configuration.

11.5 Python Module Maintenance

The ball screw, linear rail bearings, and ball bearings used in the Python linear modules are lubricated for life. The ball screw nut and linear rail bearings are fully sealed to retain the factory lubrication.

CAUTION: Adding additional grease or oil to the ball screw shaft on the linear rails could damage these seals and reduce the life of the module.

11.6 Additional Maintenance

Refer to the ***Adept SmartController User's Guide*** for information on changing the lamp for the Front Panel High Power Indicator.

11.7 MB-10 Decommissioning

Contact Adept Customer Service to determine when the MB-10 unit must be decommissioned, or removed from service. If it is determined that the MB-10 is no longer usable, then it must be disposed of according to all local and national regulations regarding electronic components.

Advanced System Configurations 12

12.1 Description

The installation drawing in **Figure 12-1 on page 162** shows the cable connections for a system with two 2-axis linear module robots running on one SmartController.

The installation drawing in **Figure 12-2 on page 163** shows the cable connections for a system with three 2-axis linear module robots and two PDUs running on one SmartController.

The installation drawing in **Figure 12-3 on page 164** shows the cable connections for a system with three 2-axis linear module robots, two PDUs, and a Cobra s600 with Vision, running on one SmartController.

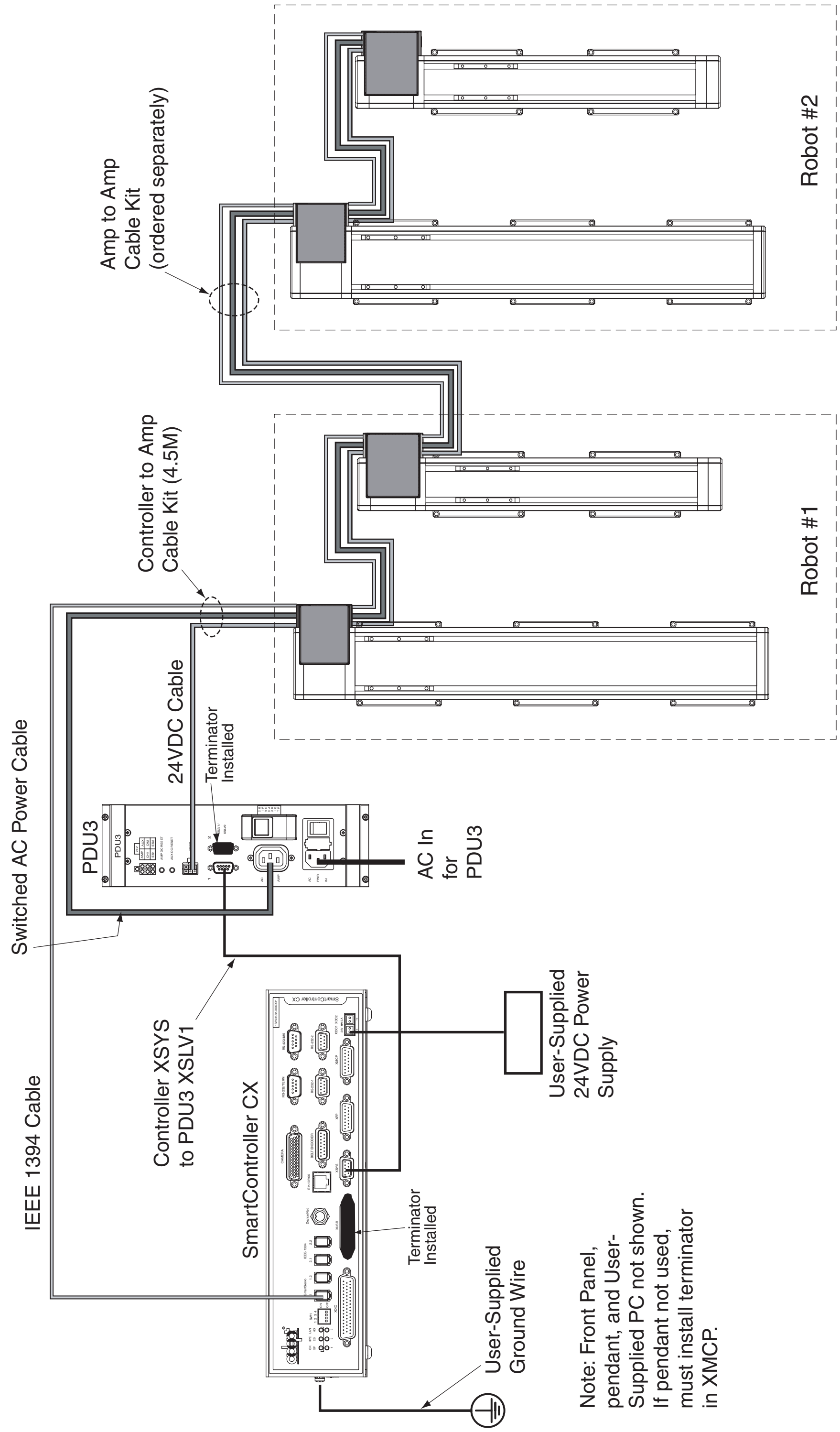


Figure 12-1. System Installation with Two Linear Module Robots Daisy-Chained

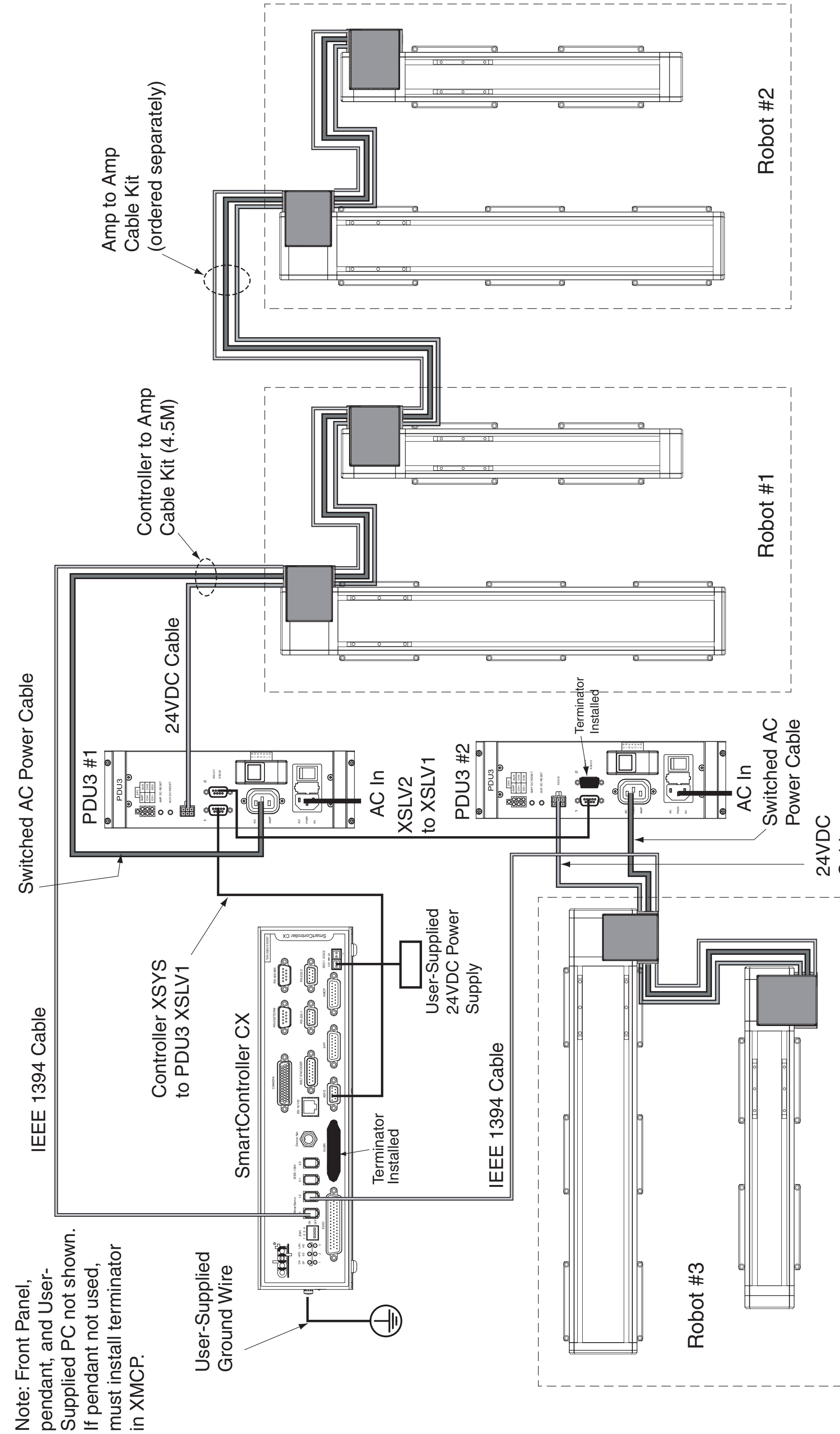


Figure 12-2. System Installation with Three Linear Module Robots and Two PDUs

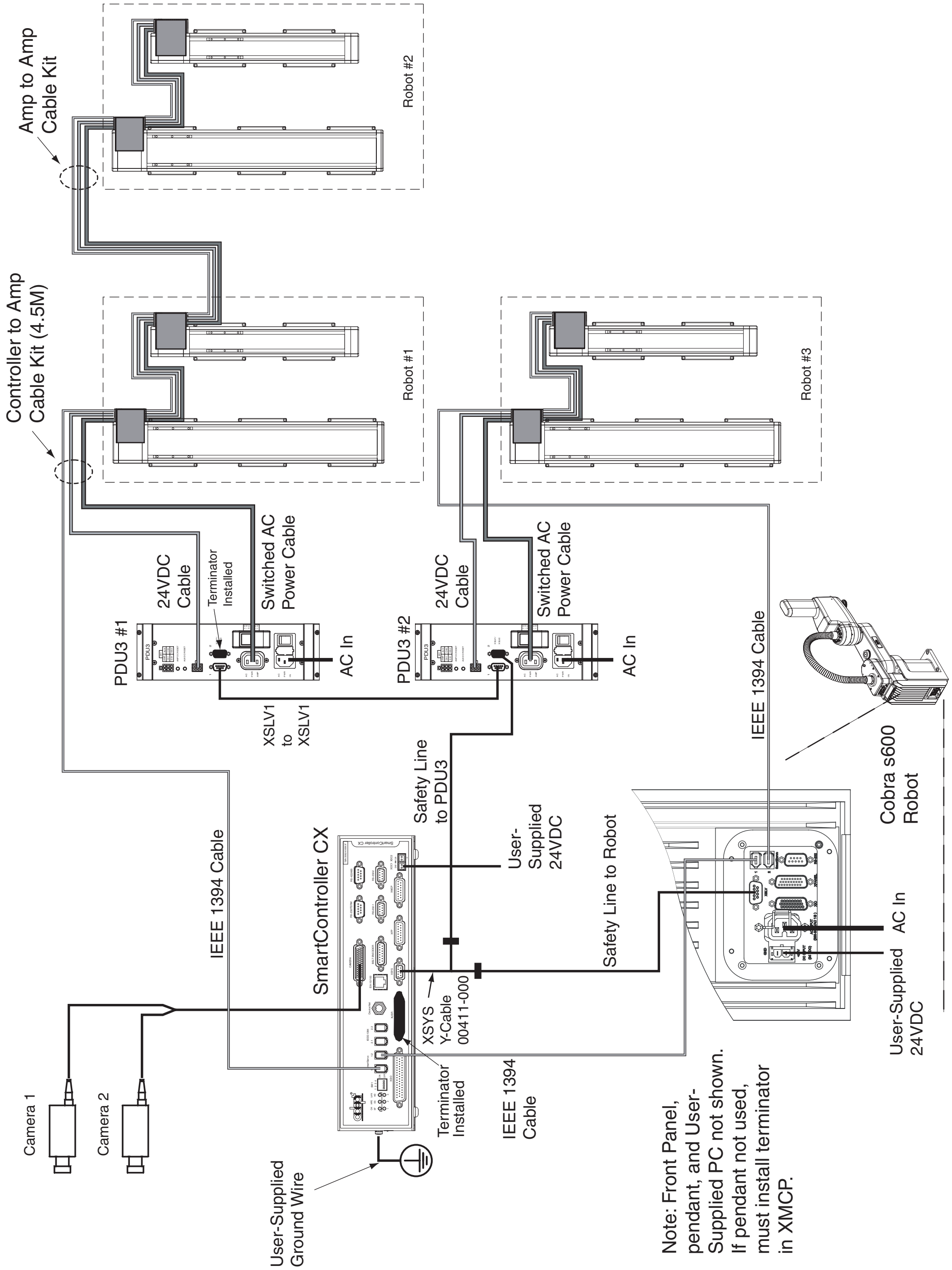


Figure 12-3. Three Linear Module Robots, Two PDUs, and a Cobra s600 with Vision

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Pub Number R278I-E-01

P/N:05850-000, Rev. E