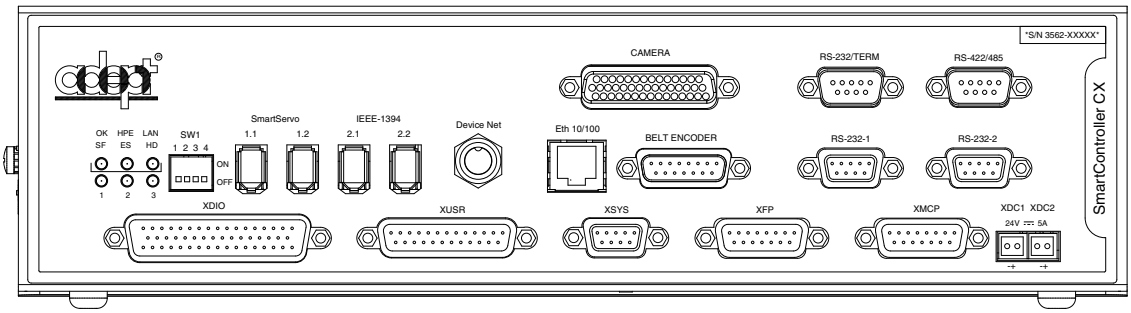
Adept SmartController

User's Guide

Covers the SmartController and sDIO Module



adept®

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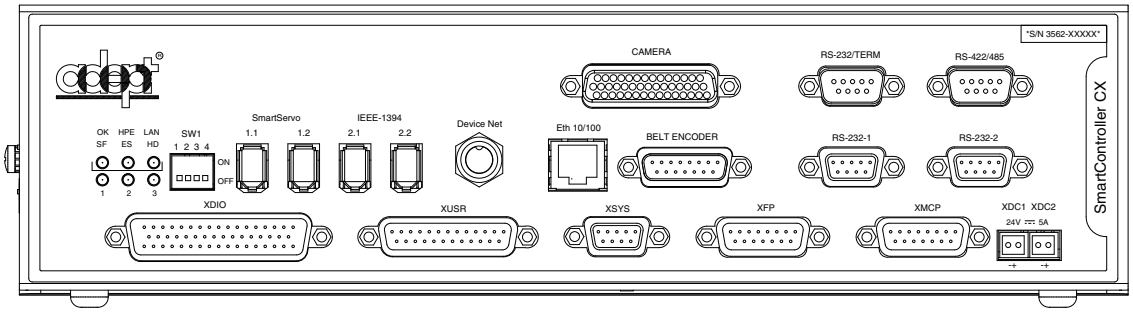

P/N: 00356-00100, Rev. K
August 2012

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Printed in the United States of America

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Product Description

The Adept SmartController is a member of Adept's family of high-performance distributed motion and vision controllers. The Adept SmartController is designed for use with Adept Python Linear Modules, Adept Cobra s-series robots, the Adept Viper line of six-axis robots, the Adept sMI6 Module for the SmartMotion product, Adept SmartServo kits, and Adept Quattros. All Adept SmartControllers offer known scalability and support for IEEE 1394-based digital I/O and general motion expansion modules.

Adept SmartController CX

The Adept SmartController CX is a high-performance motion controller, with support for a conveyor tracking option.

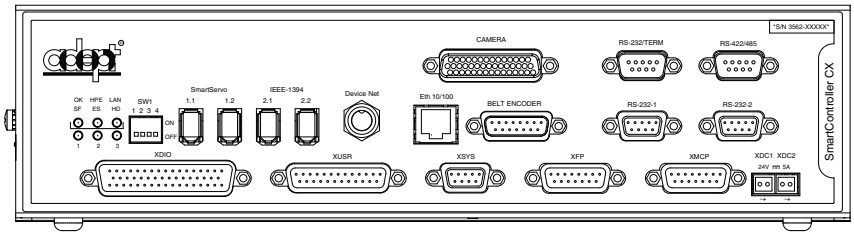


Figure 1-1. Adept SmartController CX

sDIO Expansion Module

The sDIO expansion module provides 32 optical-isolated digital inputs and 32 optical-isolated outputs and also includes an IEEE 1394 interface.

Customers can access I/O signals from the following points using these products:

- the XDIO connector on a SmartController
- the DeviceNet connector on a SmartController
- the DIO X1-X4 connectors on an sDIO

Optional Adept T2 Pendant

The optional Adept T2 pendant provides a user interface and teach pendant in an ergonomic and rugged package. The pendant is designed for right- or left-handed use. All gripping and holding positions enable comfortable and fatigue-free operation.

The safety features include:

- Emergency-stop switch (dual channel circuit)
- Two 3-position enable switches (dual channel circuits)

See the *Adept T2 Pendant User's Guide*, shipped with each pendant, for complete information on the product.

Figure 1-2. Adept T2 Pendant

1.2 Dangers, Warnings, Cautions, and Notes in Manual

There are six levels of special alert notation used in Adept manuals. 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: Notes provide supplementary information, emphasizes a point or procedure, or gives a tip for easier operation.

1.3 Safety Precautions

DANGER: Adept robots can cause serious injury or death, or damage to themselves and other equipment, if the following safety precautions are not observed:

- All personnel who install, operate, teach, program, or maintain the system must read this guide, read the *Adept Robot Safety Guide*, and complete a training course for their responsibilities in regard to the robot.
- All personnel who design the robot system must read this guide, read the *Adept Robot Safety Guide*, and must comply with all local and national safety regulations for the location in which the robot is installed.
- The robot system must not be used for purposes other than described in the robot user's guide. Contact Adept if you are not sure of the suitability for your application.
- The user is responsible for providing safety barriers around the robot to prevent anyone from accidentally coming into contact with the robot when it is in motion.
- Power to the robot and its power supply must be locked out and tagged out before any maintenance is performed.

1.4 What to Do in an Emergency Situation

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

1.5 Additional Safety Information

Adept provides other sources for more safety information:

Manufacturer's Declaration of Compliance (MDOC)

This lists all standards with which each robot complies. **See "Manufacturer's Declaration" on page 16.**

Adept Robot Safety Guide

The ***Adept Robot Safety Guide*** provides detailed information on safety for Adept robots. It also gives resources for more information on relevant standards.

It ships with each robot manual, and is also available from the Adept Document Library. **See "Adept Document Library" on page 18.**

Program Security

Programs and data stored in memory can be changed by trained personnel using the V+ commands and instructions documented in the V+ manuals. To prevent unauthorized alteration of programs, you should restrict access to the keyboard. This can be done by placing the keyboard in a locked cabinet. Alternatively, the V+ ATTACH and FSET instructions can be used in your programs to restrict access to the V+ command prompt.

1.6 Manufacturer's Declaration

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

http://www.adept.com/support/downloads/file-search

NOTE: The Download Center requires that you are logged in for access. If you are not logged in, you will be redirected to the Adept website Login page, and then automatically returned to the Download Center when you have completed the login process.

1. From the Download Types drop-down list, select Manufacturer Declarations.
2. From the Product drop-down list, select your Adept robot product category (such as Adept Cobra Robots, Adept Viper robots, etc.).
3. Click Begin Search.

   The list of available documents is shown in the Search Results area, which opens at the bottom of the page. You may need to scroll down to see it.
4. Use the Description column to locate the document for your Adept robot, and then click the corresponding Download ID number to access the Download Details page.
5. On the Download Details page, click Download to open or save the file.

1.7 How Can I Get Help?

For details on getting assistance with your Adept software or hardware, you can access the following information sources on the Adept corporate website:

- For Contact information:
  http://www.adept.com/contact/americas
- For Product Support information:
  http://www.adept.com/support/service-and-support/main
- For user discussions, support, and programming examples:
  http://www.adept.com/forum/
- For further information about Adept Technology, Inc.:
  http://www.adept.com

Related Manuals

This manual covers the installation and maintenance of an Adept SmartController system, including the sDIO. There are additional manuals that cover programming the system, reconfiguring installed components, and adding other optional components. The following manuals provide information on advanced configurations and system specifications.

Table 1-1. Related Manuals

Manual Title	Description
Adept Robot Safety Guide	Contains safety information for Adept robots.
Adept T2 Pendant User's Guide	Contains information on the installation and operation of the Adept T2 Pendant.
Adept ACE User's Guide	Describes the use of the Adept ACE software.
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

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

- Select **Support > Document Library** from the menu bar on the Adept website Home page.
- Type the following URL into your web browser:

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

To locate information on a specific topic, use the Document Library search engine on the ADL main page.

2 SmartController Installation

2.1 Controller Installation

This equipment must be shipped and stored in a temperature-controlled environment. See **Table 2-1**. It should be shipped and stored in the Adept-supplied packaging, which is designed to prevent damage from normal shock and vibration. You should protect the package from excess shock and vibration.

Table 2-1. Environmental Specifications

Ambient temperature	5° C to 40° C
Storage and shipment temperature	–25° C to +55° C
Humidity range	5 to 90%, non-condensing
Altitude	up to 2000 m (6500 feet)
Free space around controller (for proper cooling)	10 mm at back, 13 mm on sides
Chassis protection class	IP-20 (NEMA Type 1)

Before Unpacking

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

Upon Unpacking

Compare the actual items received (not just the packing slip) with your equipment purchase order, and verify that all items are present and that the shipment is correct. Inspect each item for external damage as it is removed from its container. Contact Adept immediately if any damage is evident. **See "How Can I Get Help?" on page 17.**

Retain all containers and packaging materials. These items may be needed in the future to settle a damage claim.

Perform the following steps to unpack the Adept SmartController and Front Panel, optional Adept sDIO Expansion Module, and optional pendant. Refer to the following sections for information on mounting the equipment.

1. Remove the Adept SmartController and any optional sDIO from their boxes. Place them near the robot, or mount them in a rack. See **"Mounting the SmartController"**.
2. Remove the Front Panel from its box and set it on a flat surface near the Adept SmartController.
3. Remove the optional pendant from its box and place it on a flat surface near the Front Panel.

Repacking for Relocation

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

Space Around the Chassis

When the SmartController and/or sDIO is installed, you must allow 10 mm at the back of the unit and 13 mm on the sides of the unit for proper air cooling. To facilitate installation, make sure that the factory-installed CompactFlash Memory Card is in place within the SmartController prior to mounting it. This is important if you plan to mount it in a way that restricts access to the side of the unit, and thus to the CompactFlash Memory compartment (see the **"CompactFlash Memory Card" section on page 24** for information).

Mounting the SmartController

The following mounting options are available for the SmartController:

- Rack
- Panel
- Table
- Stack

  The SmartController and compatible Adept units can be mounted with one unit placed on top of another.

See **page 65** for information on mounting the sDIO.

> **NOTE:** To maintain compliance with standards in European installations, the mounting of the controller and all terminations at the controller must be performed in accordance with those standards.

Rack-Mounting the SmartController

To rack-mount the SmartController in a standard 19-inch equipment rack, install the optional mounting brackets on the side of the controller, as shown in **Figure 2-1**. These brackets must be ordered separately. They do not come with the SmartController.

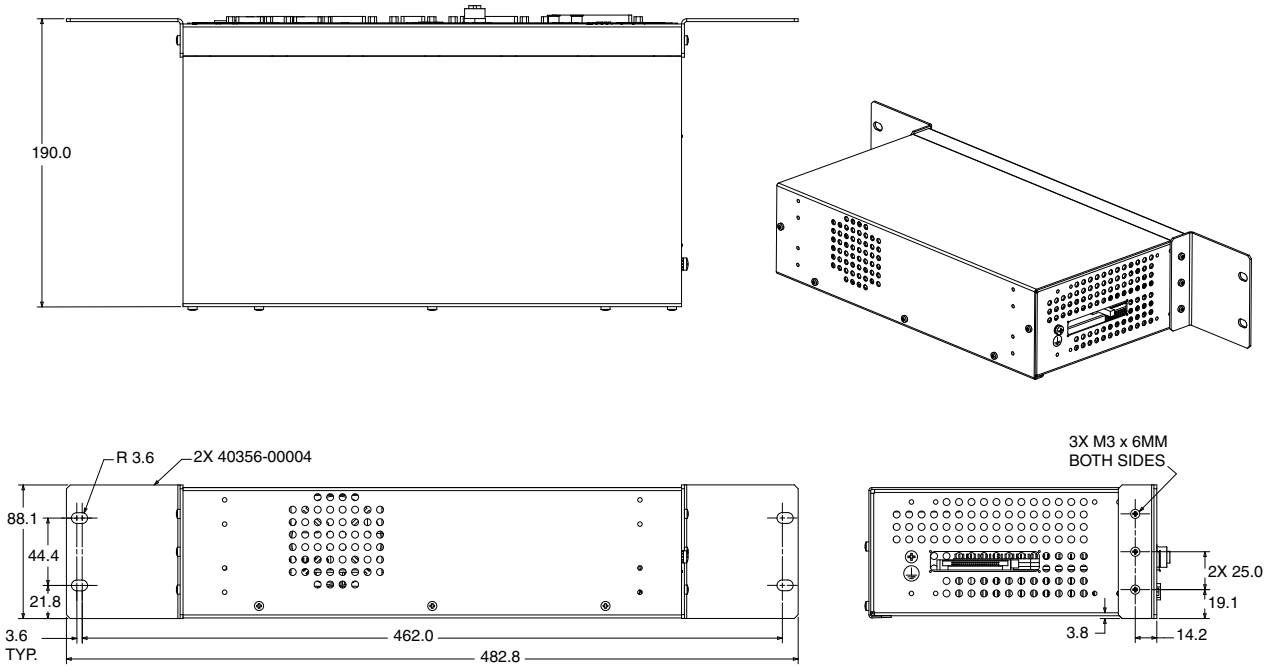


Figure 2-1. Rack-Mounting the SmartController

Panel-Mounting the SmartController

To panel-mount the SmartController, install two brackets on each side at the rear of the unit, as shown in **Figure 2-2**. Use the screws from the accessories kit.

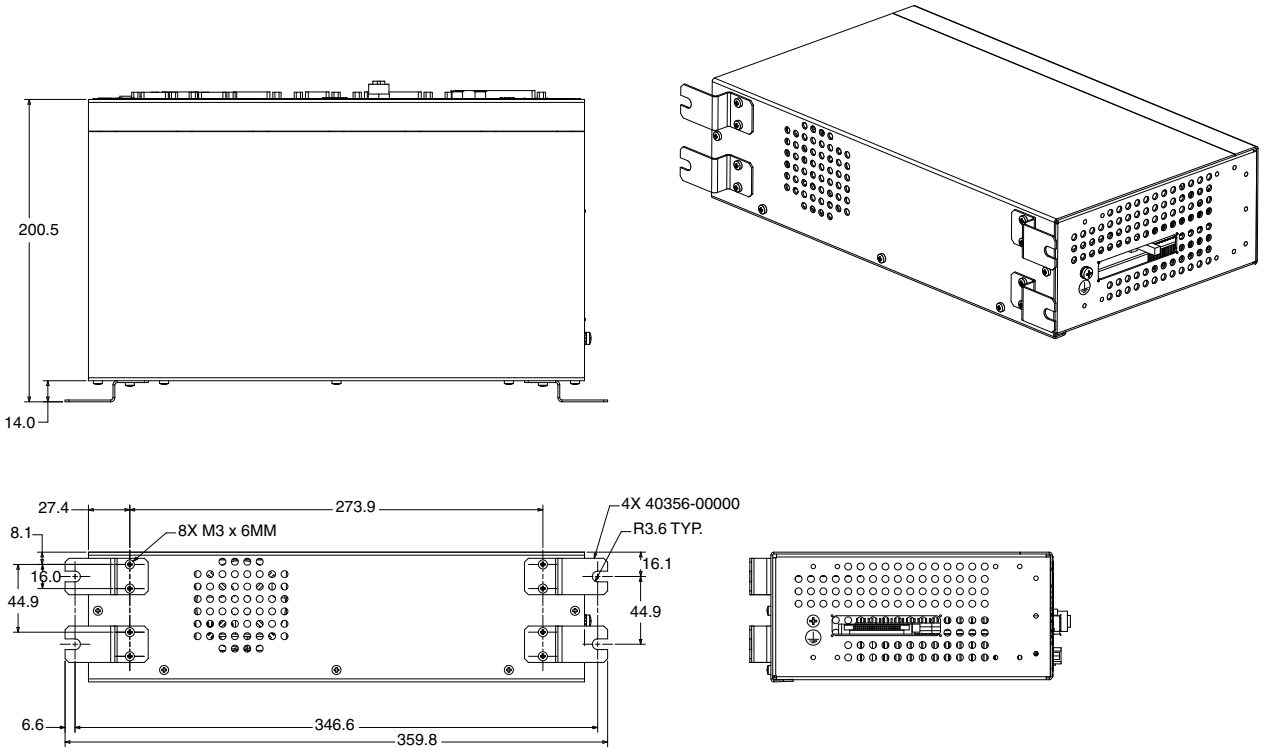


Figure 2-2. Panel-Mounting the SmartController

Table-Mounting the SmartController

To table-mount the SmartController, install two brackets on each side near the bottom of the unit, as shown in **Figure 2-3**. These brackets must be ordered separately. They do not come with the SmartController.

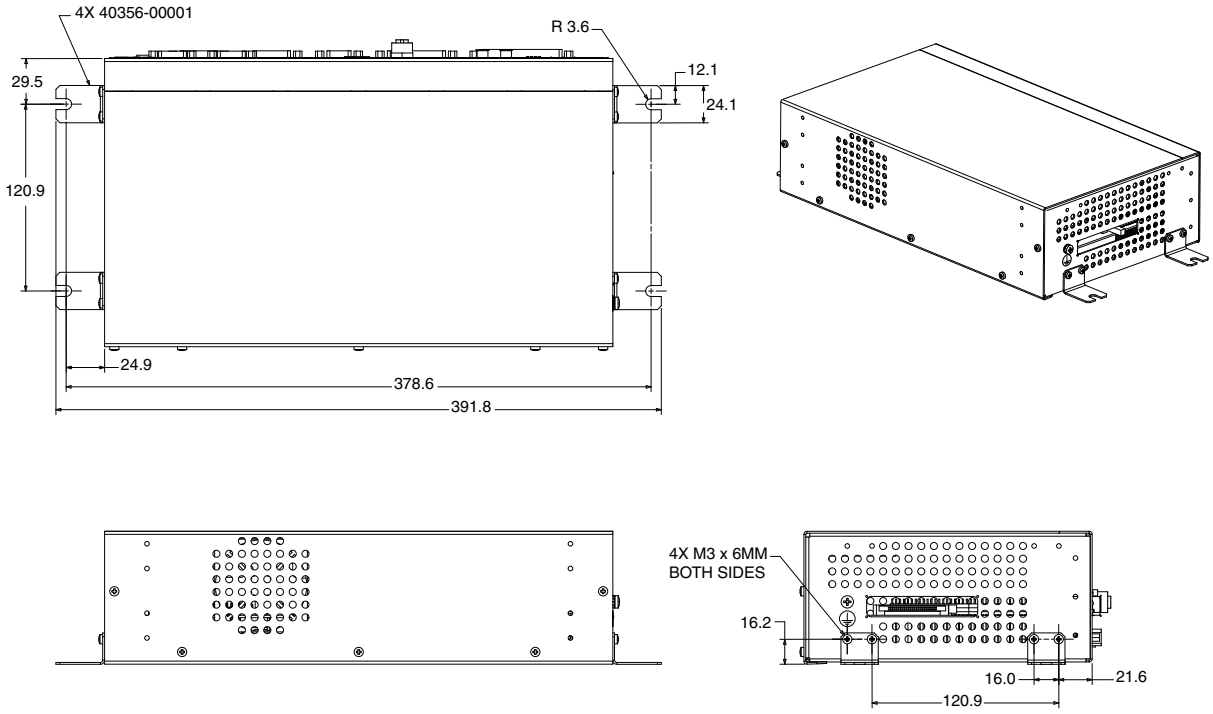


Figure 2-3. Table-Mounting the SmartController

Stack-Mounting Components

To stack-mount the SmartController and a compatible unit, such as an sDIO, install two brackets on each side of the units, as shown in **Figure 2-4**. These brackets are supplied with compatible Adept units.

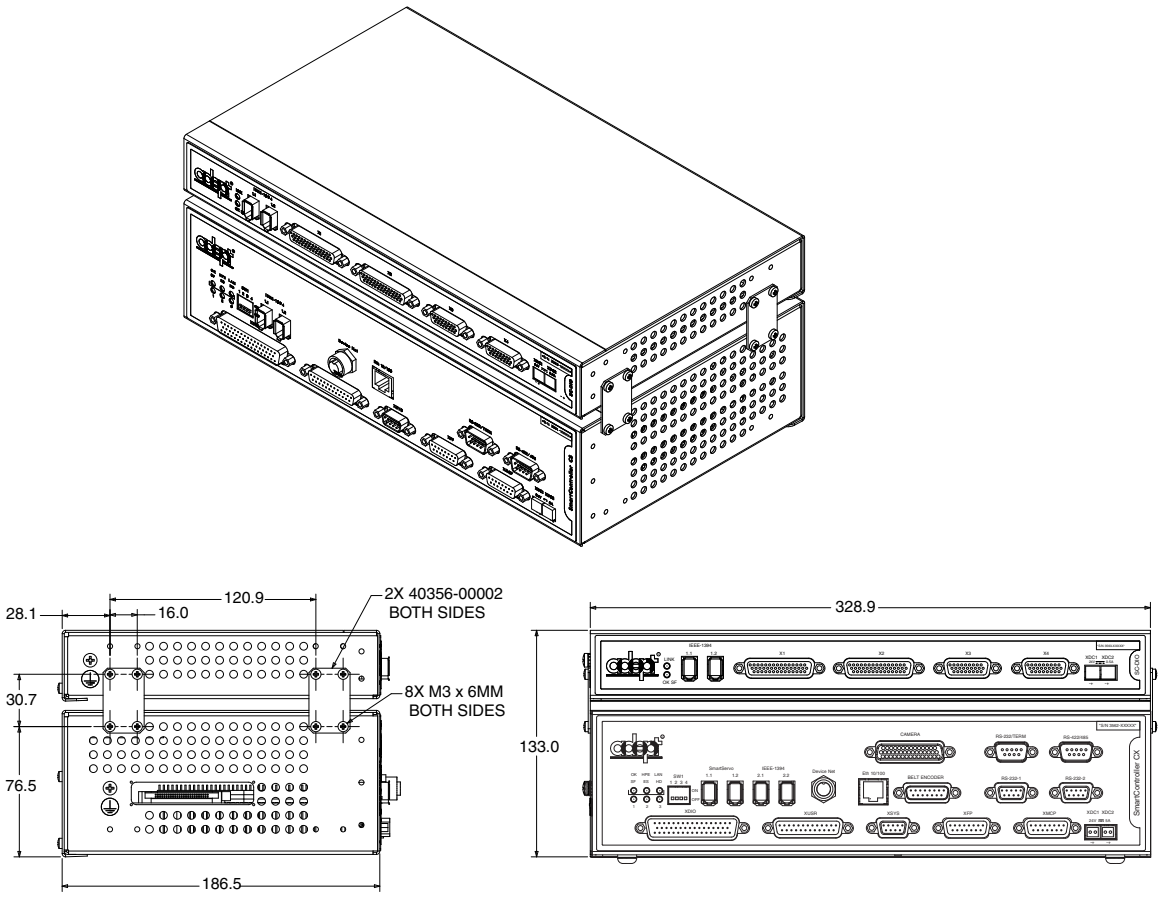


Figure 2-4. Stack-Mounting the SmartController and sDIO

CompactFlash Memory Card

The SmartController is equipped with a CompactFlash™ (CF). The CompactFlash is removable, and can be moved to another SmartController for replacement or testing.

The CF shipped with all systems is factory-configured and installed by Adept. The CF stores the V+ operating system, AIM software, application programs, data files, and Adept licenses.

Only the CF supplied by Adept will work with the SmartController.

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

CAUTION: Do not remove the CompactFlash when power is connected to the SmartController.

Removing CompactFlash

To remove a CompactFlash (CF) from a SmartController:

1. Make sure that the SmartController is disconnected from its power source.
2. Locate the CF compartment (see the following figure).

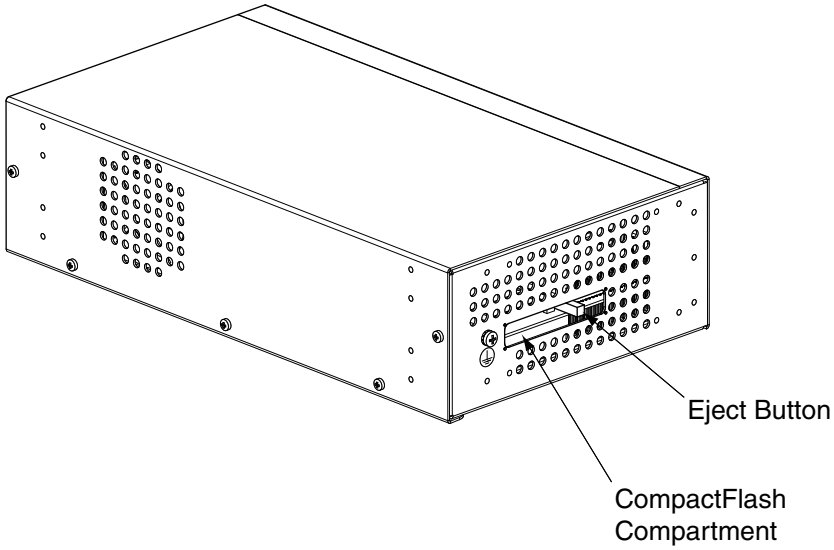


Figure 2-5. CompactFlash Memory Card Compartment

NOTE: If you are replacing an existing CF, the original must be sent to Adept for replacement.

3. Press the button inside the CF compartment to eject the card. Remove the card and return it to Adept. Contact Adept Customer Service.

Installing CompactFlash

To install a CompactFlash (CF) into a SmartController:

1. Make sure that the SmartController is disconnected from its power source.
2. Locate the CF compartment (see **Figure 2-5**).
3. Carefully remove the CF from the READ ME FIRST box or shipping container. Locate the CF slot and position the card so its contacts are facing towards the SmartController and the label is facing up.
4. Insert the CF into the SmartController.

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

Connecting Power

The SmartController and sDIO require filtered 24 VDC power.

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

24 VDC Power Specifications

Table 2-2. Specifications for 24 VDC User-Supplied Power Supply

Customer-Supplied Power Supply	24 VDC (-10%, +5%), 120 W (5 A)
Circuit Protection	Not more than 8 A (below the amperage rating of the cable used)
Power Cabling	1.5 - 1.85 mm^2 (16-14 AWG), full-cover, braided shield cable, maximum length 10 meters
Shield Termination	Braided shield connected to the marked frame ground screw on the right side of the controller (near the XDC connector). On the other end of the cable, the shield should be connected to the power supply chassis.

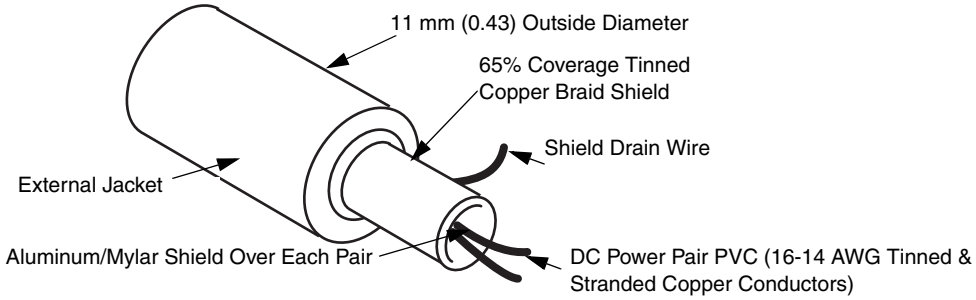


Figure 2-6. User-Supplied 24 VDC Cable

NOTE: The power requirements for the user-supplied power supply will vary depending on the configuration of the SmartController and connected devices. A minimum configuration of the controller, front panel, and pendant will require 2 A at 24 VDC. However, a 24 V, 5 A power supply is recommended to allow for additional current draw from connected devices, such as external IEEE 1394 devices and digital I/O loads.

24 VDC Power Cabling

In order to maintain compliance with standards in many countries, DC power must be delivered over a shielded cable, with the shield connected to the frame ground at both ends of the cable, as shown in **Figure 2-7**. Conductors should be 1.5 mm^2- 1.85 mm^2 (16 to 14 AWG) in size. The maximum length for the 24 VDC cable is 10 meters.

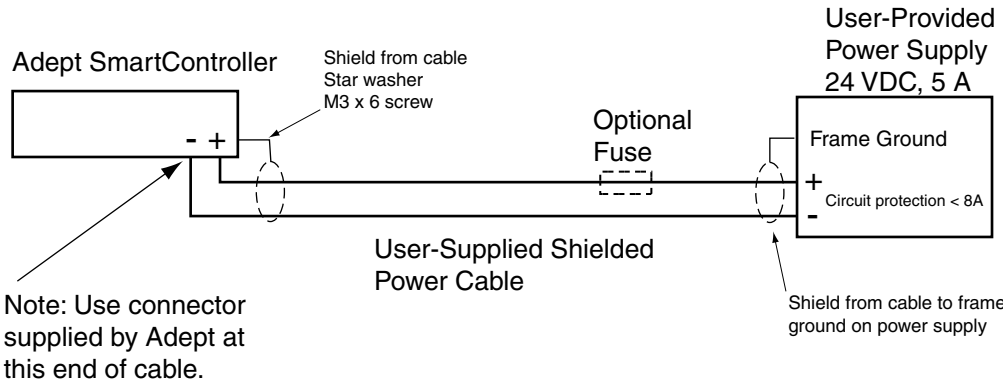


Figure 2-7. User-Supplied Power Cable

Daisy-Chaining Power

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

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

Grounding

The SmartController is equipped with a grounding point. See **Figure 2-8**. Adept recommends connecting a ground wire from the ground point on the controller to earth ground and that all other interconnected Adept components share the same electrical ground potential. The ground wire must meet all local regulations. Additional grounding information for other Adept products is provided in the documentation for those products.

NOTE: The maximum length for the ground wire for the SmartController is 3 meters.

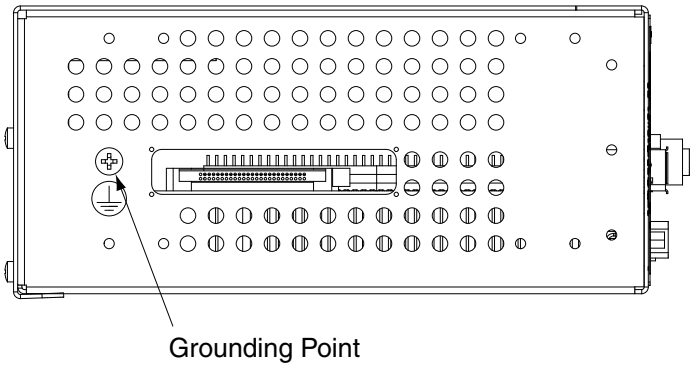


Figure 2-8. Chassis Grounding Point

Installing 24 VDC Connectors

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

1. Locate two 24 VDC connectors that are shipped with the controller. See **Figure 2-9 on page 28**.
2. Use 14 or 16 gauge wires to connect the 24 VDC power supply to the controller.
3. Strip 7 mm of insulation from the end of the wire that connects to the positive output of the 24 VDC supply.
4. Insert a small, flat-blade screwdriver (2.5 mm) into the top opening on the right-hand (positive) side of the connector. Push the blade in until the clamp in the lower opening folds back.
5. Insert the stripped end of the wire into the right-hand lower opening, then remove the screwdriver from the top opening. The clamp will close on the wire. Pull on the wire to confirm it is securely attached in the connector.
6. Visually inspect the connection to make sure that the clamp has closed on the wire, not the insulation.
7. Repeat this process for the wire from the negative side of the power supply to the left side of the connector.

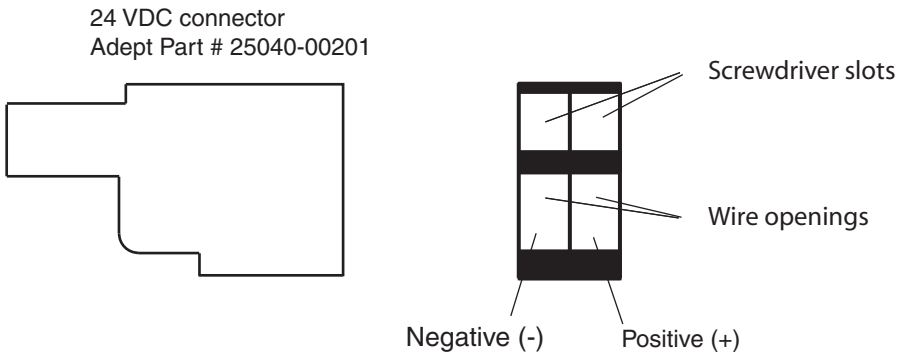


Figure 2-9. 24 V Connector

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

IEEE 1394 Cable Specifications

Adept supplies the IEEE 1394 cables to connect the SmartController to other Adept devices in the system. If you need a cable of a different length than those supplied by Adept, then you must purchase a cable from one of the Adept-approved vendors listed below:

- Newnex Technology Corp. Go to www.newnex.com
- Molex, Inc. Go to www.molex.com

These purchased cables must meet all specifications of the IEEE 1394 standard. Note that Adept uses 6-pin to 6-pin cables. The maximum length for a 1394 cable is 4.5 meters. The 1394 Trade Association provides detailed specifications for 1394 cables and other related information, see www.1394ta.org.

WARNING: You must use cables from vendors approved by Adept that meet all specifications of the IEEE 1394 standard. Using a non-approved or inferior quality IEEE 1394 cable can cause unpredictable system performance.

2.2 System Cable Installation

The Adept SmartController is used in many Adept systems, including Adept Python Linear Modules, Adept Cobra s-series robots, the Adept Viper line of six-axis robots, Adept Quattro robots, and the Adept sMI6 Module for the SmartMotion product.

See your specific product manual for complete details on system cabling for your Adept SmartController system.

3 SmartController Operation

3.1 SmartController CX Connectors and Indicators

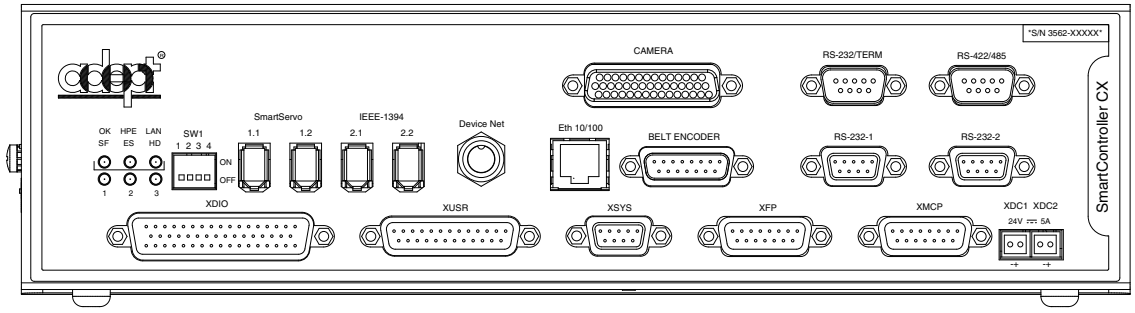


Figure 3-1. SmartController CX

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

Top Three Status LEDs

The top three two-color LEDs indicate diagnostic test, power control, and communication status.

Table 3-1. SmartController LEDs

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

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

Bottom Three Status LEDs

The bottom three LEDs on the front of the SmartController give the following information about the status of the main controller.

O = Off G = Green R = Red

Table 3-2. LED Status Indicators

LED Display 1 2 3	Error #	Description
O-O-O	0	No error.
R-O-O	1	System clock is dead or too fast. Clock interrupts are not being received.
O-R-O	2	Hardware configuration error.
O-O-R	4	Memory test failure. Free storage error.
O-R-R	6	Software serial I/O configuration error.
R-R-R	7	Initial display set by hardware before software has started.
G-O-O	9	Transient display set when PCI is configured.
O-O-G	C	Uninitialized trap.
G-O-G	D	Bus error detected.

If the SmartController displays an error, cycle the power off, then on again. If the problem persists, contact Adept Customer Service.

SW1 DIP switches

The DIP switches define certain configuration settings (including auto boot and user interface). See **"Configuring the Controller" on page 37** for information.

SmartServo 1.1 and 1.2

These ports connect any Adept SmartServo-compatible product to the controller via the IEEE-1394 cable. The 1.1 and 1.2 ports are interchangeable - either one can be used.

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

DeviceNet connector

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

Ethernet (Eth 10/100) connector

The shielded RJ-45 receptacle supports 10/100 BaseT Ethernet communications.

> **NOTE:** The default IP address for the controller is located on a label on the bottom side of the controller chassis.

RS-232 and RS-422/485 connectors

These ports support RS-232 and RS-422/485 devices, respectively. See **"Serial Ports" on page 38** for pin descriptions and locations.

XDIO connector

This connector includes 20 signal pairs; 8 digital outputs (100 mA max) and 12 digital inputs, including eight[1] fast inputs (the first eight input signals on this connector are the only input signals that can be configured as fast inputs). The digital outputs are short-circuit protected. This connector also supplies 24 VDC power for customer equipment. See **Section 3.6 on page 50** for more information.

XUSR connector

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

> **NOTE:** The SmartController ships with a terminator plug attached to the XUSR connector. The terminator plug must be installed in the absence of any customer-supplied safety equipment used to close the E-Stop circuit. For more information about the XUSR connector, see **Section 3.5 on page 41**.

XSYS connector

Connects to the XSLV connector on an Adept robot or servo controller.

XFP connector

Connects to the Front Panel. See **Section 3.5 on page 41** for information.

---

[1] Requires V+ system version 17.1 (edit B1 and later) with the SmartController CX (and controller FPGA revision 108 or later). Otherwise, the system is limited to fast digital input signals 1001 to 1004.

XMCP connector

The optional Adept T2 Pendant plugs into this connector, via the T1/T2 Pendant Adapter cable, which has the mating connector for the XMPC. The SmartController ships with a terminator plug attached to the XMCP connector. The terminator plug must be installed in the absence of a pendant. If nothing is connected to the XMCP, then the E-Stop circuit is open, and you will not be able to start the system.

24 VDC connectors

Connect power from a customer-supplied 24 VDC power supply to the XDC1 connector (see the **"Connecting Power" section on page 26**). If using an sDIO or an sMI6, connect a separate cable from the unused XDC connector on the SmartController to the XDC1 connector on the sDIO or sMI6.

Camera connector

This connector is not used.

IEEE-1394 ports 2.1 and 2.2

These ports are reserved for future use.

Do not use ports 2.1 or 2.2 to connect Adept Smart Servo-compatible products.

RS-232-1 and RS-232-2 connector

These are additional RS-232 serial ports for general use. See **Section on page 38** for more information.

Belt Encoder connector

This is a 15-pin D-Sub connector for up to two belt encoders in a conveyor-tracking installation. See **Section 3.7 on page 57** for more information.

3.2 Front Panel

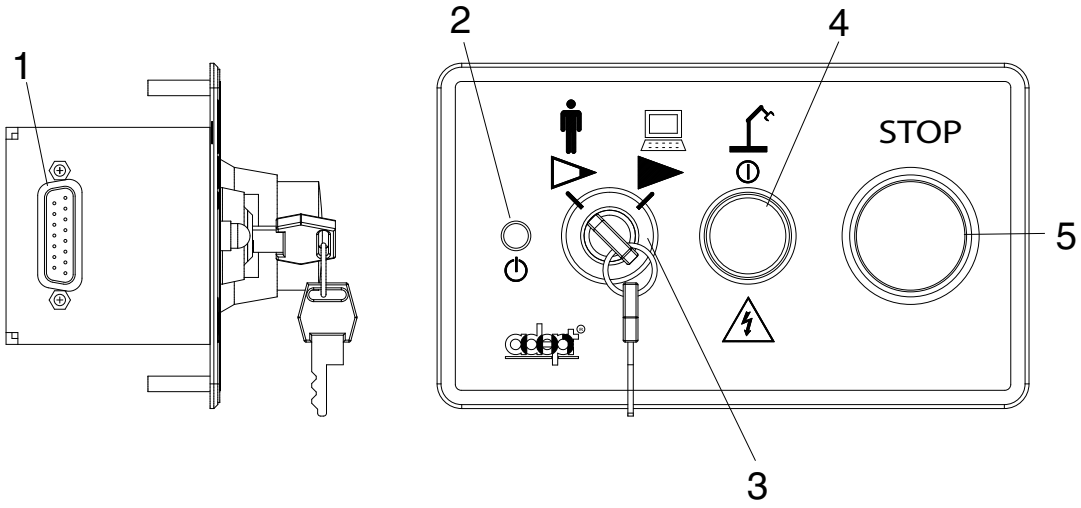


Figure 3-2. Front Panel

Before running programs, either the Adept Front Panel or customer-supplied switches for High Power On/Off, MAN/AUTO, and E-Stop must be connected to the XFP connector on the SmartController to enable power safely.

> **NOTE:** Safety regulations dictate the sequence of events required for the user to enable high power. For instance, a user may be required to press the High Power On button on the Front Panel after pressing the COMP/PWR button on the pendant or issuing the V+ "enable power" command. Users cannot jumper this button input and still enable power (see your robot manual for further details).

Figure 3-2 shows an Adept Front Panel.

1: XFP connector

Connects to the XFP connector on the SmartController.

2: System 5 V Power-On LED

Indicates whether or not power is connected to the controller.

3: Manual/Automatic Mode Switch

Switches between Manual and Automatic mode. In Automatic mode, executing programs control the mechanism, and the mechanism can run at full speed. In Manual mode, the system limits mechanism speed and torque so that an operator can safely work in the cell. Manual mode initiates software restrictions on robot speed, commanding no more than 250 mm/sec as required by RIA and ISO standards. Please refer to your robot manual for further details.

4: High Power On/Off Switch & Lamp

Controls high power, which is the flow of current to the robot motors. Enabling high power is a two-step process. An "Enable Power" request must be sent from the user terminal, an executing program, or a pendant. Once this request has been made, the operator must press this button and high power will be applied.

5: Emergency Stop Switch

The E-Stop is a dual-channel, passive E-Stop that supports Category 3 CE safety requirements. It supports a customer-programmable E-Stop delay that maintains motor power for a programmed time after the E-Stop is activated. This customizable feature allows the motors to decelerate under servo control to a stop. This can aid in eliminating coasting or overshooting on low friction mechanisms. It can also aid in the reduction of wear on highly-geared, high-inertia mechanisms, while maintaining safety compliance per all standards.

NOTE: Instructions on configuring the E-Stop delay using Adept ACE can be found in your robot user's guide.

3.3 Installing the Adept ACE Software

WARNING: Make sure that all cables are installed correctly and fully inserted and screwed down before applying power to the system. Failure to do this could cause unexpected robot motion. Also, a connector could be pulled out or dislodged unexpectedly.

NOTE: Connect the necessary Ethernet cabling between your PC and the Adept SmartController prior to turning on the PC and controller. See **Section 2.2 on page 29.**

NOTE: After installing the Adept ACE software, refer to the Adept ACE online help for additional information on setting up the user interface.

You install Adept ACE software from the Adept Software CD-ROM. You will need Microsoft .NET Framework. The Adept ACE Setup Wizard scans your PC for .NET, and installs it automatically, if needed.

1. Insert the CD-ROM into the CD-ROM drive of your PC. If Autoplay is enabled, the Adept Software CD-ROM menu is displayed - see Figure 3-4. If Autoplay is disabled, you will need to manually start the CD-ROM.

   NOTE: The online document that describes the installation process opens in the background when you select one of software installation steps below.

2. From the Adept Software CD-ROM menu, click Install the Adept ACE Software.
3. The Adept ACE Setup wizard opens. Follow the instructions as you step through the installation process.

4. When the install is complete, click Finish.
5. After closing the Adept ACE Setup wizard, click Exit on the CD-ROM menu and proceed to the Start-up Procedure.

   NOTE: You will have to restart the PC after installing the Adept ACE software

3.4 Configuring the Controller

The SmartController is shipped with the factory configuration described in this section. See **Figure 3-1 on page 31** for the location of DIP switch SW1. If you need to make changes to this configuration, set DIP switch SW1 as described here.

Factory Default Settings

Refer to row #5 in **Table 3-3 on page 37** for the factory default settings for DIP switch SW1.

With this default DIP switch setting, the system will read the configuration data from the CompactFlash. This allows you to set all the configuration options in software without changing the physical DIP switches.

DIP-Switch Settings

The following table shows the options for DIP switch SW1 on the SmartController.

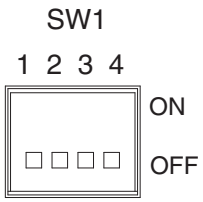


Table 3-3. SW1 Settings

Row #	SW1-1	SW1-2	SW1-3	SW1-4	Interpretation
1	ON	ON	ON	ON	No auto boot, all other settings per CompactFlash
2	OFF	ON	ON	ON	No auto boot, user interface via serial port
3	ON	ON	OFF	ON	No auto boot, user interface via Ethernet Adept ACE (use IP address in CompactFlash)
4	OFF	ON	OFF	ON	No auto boot, user interface via Ethernet Adept ACE (use default IP address)
5	OFF	OFF	OFF	OFF	Operation per CompactFlash and NVRAM settings

NOTE: SW1 is configured by Adept to a default configuration listed in row #5 of the preceding table (OFF-OFF-OFF-OFF) to use the CompactFlash and NVRAM settings. Adept recommends that the user maintain this default SW1 configuration for normal SmartController operation. The default NVRAM settings are *auto boot*, *Ethernet*, and *use IP address from CF card*. If the CF card IP address is not set (0.0.0.0), the system will use the default IP address. The use of any settings other than those in **Table 3-3** will cause unpredictable results.

NOTE: The default IP address for the controller is located on a label on the bottom side of the controller chassis.

Adept ACE Software

When using the Adept ACE software, DIP switch SW1 cannot be set to the switch settings shown in row #2 of **Table 3-3**.

CAUTION: Adept strongly recommends using shielded Ethernet cables to connect the SmartController to an Ethernet network. Use only switches (not hubs) that provide shielded RJ-45 connectors. Adept cannot ensure reliable operation of the Ethernet connection without proper shielding of all the Ethernet connectors and cables.

NOTE: Adept recommends using switches instead of hubs when making Ethernet connections to the controller. When connecting to a switch, use a straight-through cable that connects the "Transmit" and the "Receive" pairs to the same pins on both ends of the cable. When connecting to a server/PC directly, use a cross-over cable that swaps the placement of the transmit and receive pairs on the opposite ends.

AUTO Boot

When using the SmartController in an AUTO Boot configuration, DIP-switch SW1 must be set to the switch settings shown in row #5 of **Table 3-3** and the NVRAM switches set for AUTO boot.

Serial Ports

The SmartController CX has four serial I/O ports:

- RS-232/Term
- RS-422/485
- RS-232-1
- RS-232-2

See **"SmartController CX" on page 31** for the connector locations.

All three types of RS-232 connectors are 9-pin DB9 male (standard PC) connectors. The user-supplied cable to connect to the RS-232 connectors should be a DB9, F/F, null-modem data-transfer cable. The pin assignments are the same for all three connectors and are shown in **Table 3-4**.

These ports support the DTR, DCD, RTS, and CTS signals used for hardware handshaking (also known as modem control). By default, these signals are not enabled. To configure hardware handshaking and other communication parameters, use the Adept ACE software.

RS-232 Pin Assignments

Table 3-4. RS-232 Connector Pin Assignments

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

NOTE: To configure the port speed and other communications parameters, use the Adept ACE software.

Table 3-5. Serial Connectors and V+ Designations

Connector	V+ Designation
RS-422/485	LOCAL.SERIAL:1
RS-232/Term	LOCAL.SERIAL:2
RS-232-1	SERIAL:1
RS-232-2	SERIAL:2

RS-422/485 Connector

The RS-422/485 connector is a 9-pin DB9 male connector. The pin assignments are shown in **Table 3-6**. RS-422 is a point-to-point protocol for connecting to a single destination. This port can also be configured as a multidrop port (RS-485).

To change the configuration of the RS-422/485 port, use the Adept ACE software. See **Table 3-5** for the V+ designation when referenced in a V+ ATTACH or FSET instruction.

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

Pin	Signal	Type
1	NC	
2	RXD+	Input
3	TXD+	Output
4	TXD-	Output
5	GND	Ground
6	RXD–	Input
7	NC	
8	NC	
9	NC	

Serial Port Configuration

From the Adept ACE software:

1. Double-click on the controller in the tree structure pane.

   This opens the object editor for the controller.
2. Select Configure > Configure .
3. Click Configuration.
4. Select SERIAL
5. Click Add, to create a new entry

   or

   Highlight an entry and click Edit, to modify the existing values.
6. Set the values as appropriate for your port.
7. Click Accept.
8. Click Done.
9. Click Yes, to write the values to the system disk.
10. Click Yes to reboot the controller, so the values you just set will take effect.

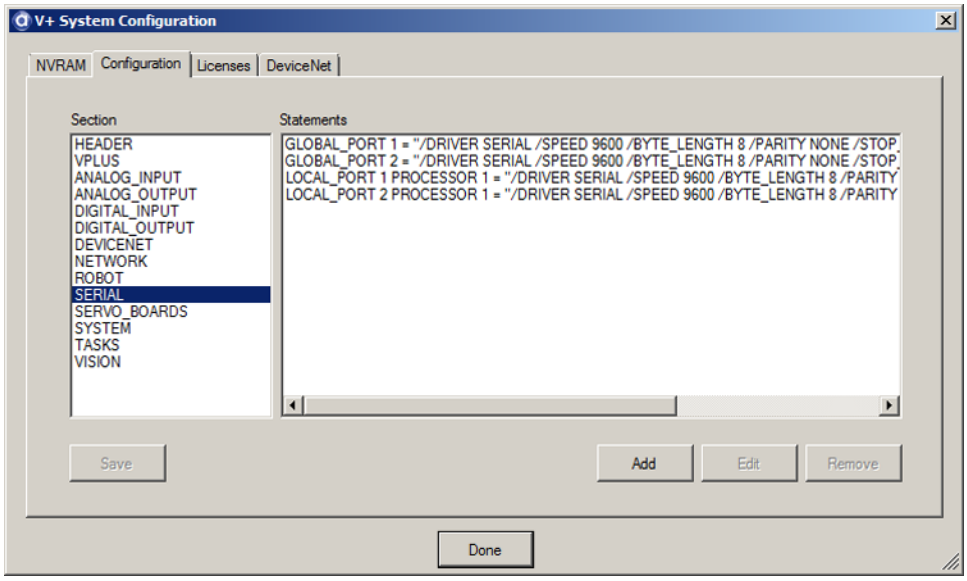


Figure 3-3. Configuring Serial Ports

3.5 Connecting Customer-Supplied Safety and Power-Control Equipment

Connecting Equipment to the System

The connection of the customer-supplied safety and power-control equipment to the system is done through the XUSR and XFP connectors on the SmartController. The XUSR connector (25-pin) and XFP (15-pin) connector are both female D-sub connectors located on the front panel of the SmartController. Refer to **Table 3-7** for the XUSR pin-out descriptions. Refer to **Table 3-8 on page 43** for the XFP pin-out descriptions. See **Figure 3-4 on page 45** for the XUSR wiring diagram.

Table 3-7. Contacts Provided by the XUSR Connector

Pin Pairs	Description	Comments	Shorted if NOT Used
Voltage-Free Contacts Provided by Customer			
1, 14	User E-Stop CH 1 (mushroom push-button, safety gates, etc.)	N/C contacts	Yes
2, 15	User E-Stop CH 2 (same as pins 1, 14)	N/C contacts	Yes
3, 16	Line E-Stop (used for other robot or assembly line E-Stop interconnection. Does not affect E-Stop indication (pins 7, 20))	N/C contacts	Yes
4, 17	Line E-Stop (same as pins 3, 16)	N/C contacts	Yes
5, 18	Muted safety gate CH 1 (causes E-Stop in Automatic mode only)	N/C contacts	Yes
6, 19	Muted Safety Gate CH 2 (same as pins 5, 18)	N/C contacts	Yes
Voltage-Free Contacts provided by Adept			
7, 20	E-Stop indication CH 1	Contacts are closed when Front Panel, pendant, and customer E-Stops are *not* tripped	
8, 21	E-Stop indication CH 2 (same as pins 7, 20)	Contacts are closed when Front Panel, pendant, and customer E-Stops are *not* tripped	
9, 22	Manual/Automatic indication CH 1	Contacts are closed in Automatic mode	
10, 23	Manual/Automatic indication CH 2	Contacts are closed in Automatic mode	
11, 12, 13, 24, 25	No connection		

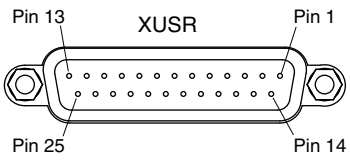
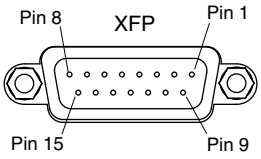


Table 3-8. Contacts Provided by the XFP Connector

Pin Pairs	Description	Requirements for User-Supplied Front Panel
Voltage-Free Contacts Provided by Customer		
1, 9	Front Panel E-Stop CH 1	User must supply N/C contacts
2, 10	Front Panel E-Stop CH 2	User must supply N/C contacts
3, 11	Remote Manual/Automatic switch CH 1. Manual = Open Automatic = Closed	Optional - jumper closed for Auto Mode-only operation
4, 12	Remote Manual/Automatic switch CH 2. Manual = Open Automatic = Closed	Optional - jumper closed for Auto Mode-only operation
6, 14	Remote High Power on/off momentary push-button	User must supply momentary push-button to enable High Power to system
Nonvoltage-Free Contacts		
5, 13[a]	Adept Supplied 5 VDC and GND for High Power On/Off Switch Lamp	User must supply lamp, or use 1 W, 47 ohm resistor - system will not operate if not present
7, 15[a]	SmartController system 5 V power on LED, 5 V, 20 mA	Optional - indicator only
8	No connection	
		
See **Figure 3-5 on page 46** for a schematic diagram of the Adept Front Panel.		

[a] Users must exercise caution to avoid inadvertently connecting 24 V signals to these pins, because this will damage the electronics.

NOTE: The system was evaluated by Underwriters Laboratory with an Adept Front Panel. If you provide a substitute Front Panel, this could violate UL compliance.

Table 3-9. Remote Pendant Connections on the XMCP Connector

Pin XMCP (15-Pin D-Sub)	Pin Pendant (16-Pin CPC)	Description
1, 9	6, 7	Pendant E-Stop PB CH 1
2, 10	11, 12	Pendant E-Stop PB CH 2
3, 11	14, 16	Pendant Enable CH 1 (Hold-to-run)
4, 12	13, 15	Pendant Enable CH 2 (Hold-to-run)
13	1, 4	Serial GND/Logic GND
7	2	Pendant TXD: "V^+ to Pendant TXD"
8	3	Pendant RXD: "V^+ to Pendant RXD"
14	5	+12 VDC (max 350 mA)
15	8	–12 VDC (max 50 mA)
Shield	9	Shield GND
6		24 V
5	10	No connection

Table 3-10. XSYS Connector Pin Assignments[a]

Pin	Signal	Description
1	ESTOPGND	GND Return
2	MANUAL1	Manual Mode ESTOP Ckt. CH 1
3	MANUAL2	Manual Mode ESTOP Ckt. CH 2
4	HIPWRDIS	High Power Disable
5	HIPWRREQ	High Power Request
6	AUTO1	Auto Mode ESTOP Ckt. CH 1
7	AUTO2	Auto Mode ESTOP Ckt. CH 2
8	N/C	No Connection
9	ESTOPSRC	24 V Output to Slave ESTOP

[a] Note: The XSYS connector is used to link the E-Stop system to Adept robots. It is not intended for customer connections.

The following figure shows an E-Stop diagram for the Adept SmartController.

E-Stop, High Power On/Off, and MANUAL/AUTO Controls for SmartController

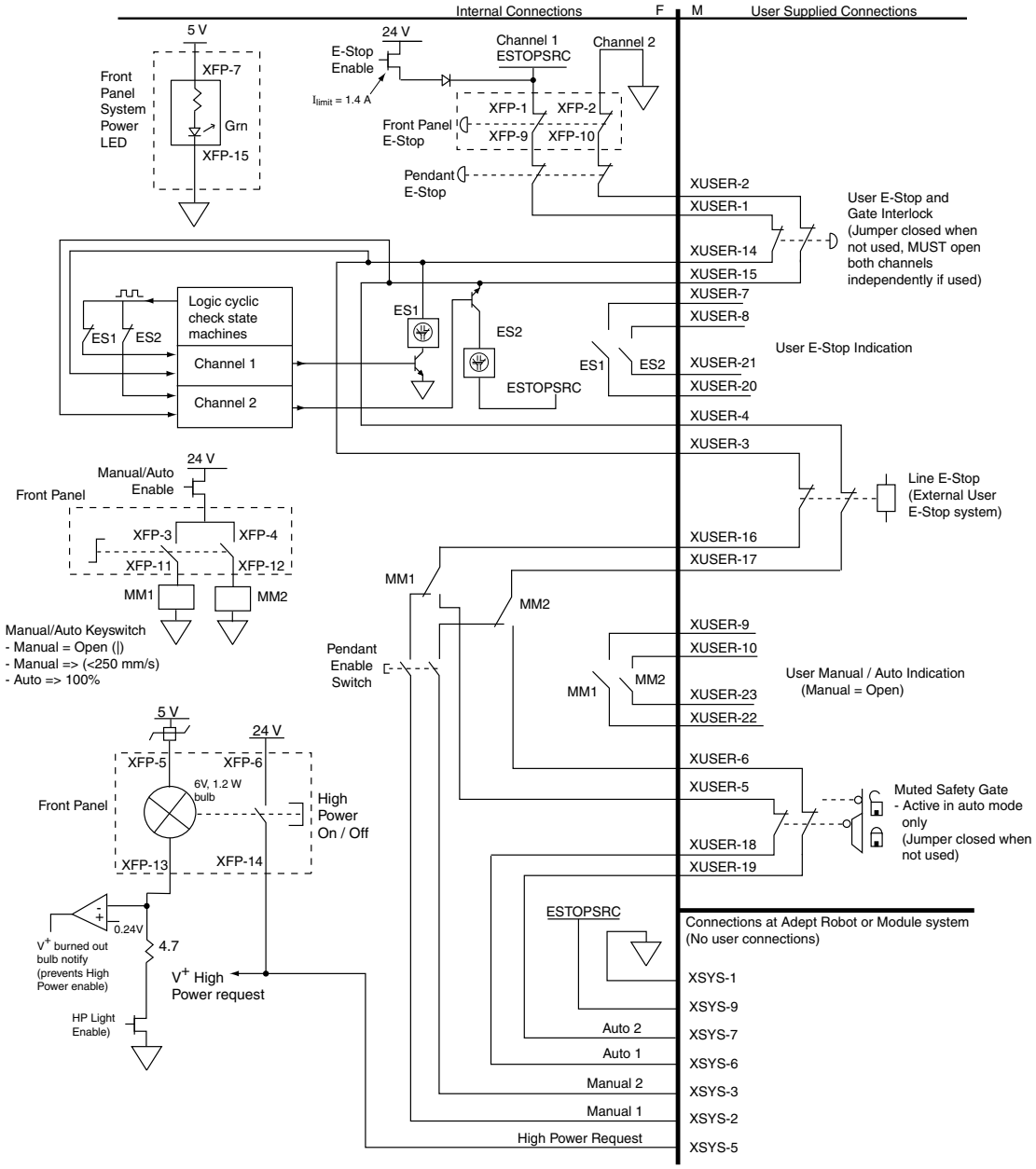


Figure 3-4. E-Stop Circuit on XUSR and XFP Connectors

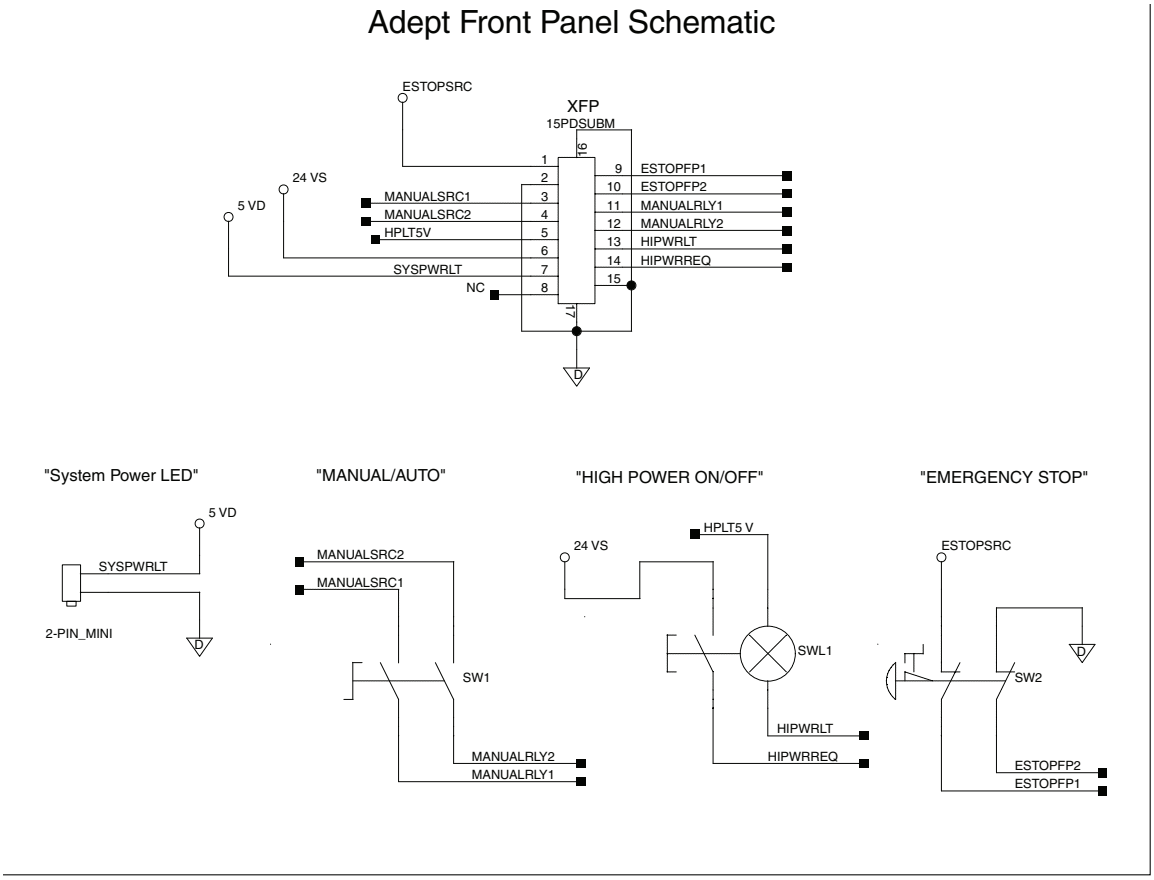


Figure 3-5. Front Panel Schematic

Emergency Stop Circuits

The SmartController provides connections for Emergency Stop (E-Stop) circuits on the XUSR and XFP connectors. This gives the SmartController system the ability to duplicate E-Stop functionality from a remote location using voltage-free contacts. See **Figure 3-4 on page 45**.

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

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

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

A method has been provided to indicate the status of the ESTOP chain, inclusive of the Front Panel Emergency Stop push-button, the pendant Emergency Stop push-button, and the User Emergency Stop Contacts. Note: These contacts do not indicate the status of any connections below the User E-Stop contacts. Thus, they will NOT indicate the status of the Line E-Stop, MCP ENABLE, or the Muted Safety gate. If you have a specific need in this area, contact Adept Customer Service for information on alternate indicating modes.

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

These voltage-free contacts are provided by a redundant, cyclically checked, positive-drive, safety relay circuit for Category 3 operation (see **Figure 3-4 on page 45** and **Table 3-7 on page 42** for the customer E-Stop circuitry).

Line E-Stop Input

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

The Line E-Stop input comes into the circuit at a point where it cannot affect the customer E-Stop indication relays and will not cause such a lock-up situation. For any situation where two systems should be "cross-coupled," for example, the customer E-Stop indication of one SmartController is to be connected to the input of another SmartController, the Line E-Stop input is the point to bring in the other SmartController's output contacts. See **Figure 3-4 on page 45** for more information.

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

Muted Safety Gate E-Stop Circuitry

Two pairs of pins on the XUSR connector (pins 5, 18 and 6, 19) provide connections for a safety gate designed to yield an E-Stop allowing access to the workspace of the robot in Manual mode only, *not* in Automatic mode. It is up to the customer to determine if teaching the robot in Manual Mode, by a skilled programmer (See "Qualification of Personnel" in the ***Adept Robot Safety Guide***), wearing safety equipment and carrying an Adept pendant, is allowable under local regulations. The E-Stop is said to be "muted" in Manual mode (see **Figure 3-4 on page 45**, **Table 3-7 on page 42**, **Table 3-8 on page 43**, and **Table 3-9 on page 44** for the customer E-Stop circuitry).

The muted capability is useful for a situation where a shutdown must occur if the cell gate is opened in Automatic mode, but you need to open the gate in Manual mode. If the mute gate is opened in Automatic mode, the robot defaults to Manual mode operation when power is re-enabled. In muted mode, the gate can be left open for personnel to work in the robot cell. However, safety is maintained because of the speed restriction.

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

Remote Manual Mode

The Front Panel provides for a Manual Mode circuit (see **Figure 3-4 on page 45**, **Table 3-7 on page 42**, and **Table 3-8 on page 43**, and your robot manual for further details about the customer Remote Manual Mode circuitry).

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

If the user needs to control the Manual/Automatic mode selection from other control equipment, then a custom splitter cable or complete replacement of the Adept Front Panel may be required. See **Figure 3-5 on page 46** for the Front Panel schematic. In this situation, a pair of contacts should be wired *in series* with the Adept Front Panel Manual/Automatic mode contacts. Thus, both the Adept Front Panel and the customer contacts need to be closed to allow Automatic mode.

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

User Manual/Auto Indication

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

User High Power On Indication

A V^+-controlled, normally-open relay contact, on the XDIO connector (pins 45, 46, see **Table 3-13 on page 55**), will close when high power has been enabled. The user can use this feature to power an indicator lamp or other device, that signals high power is ON. The limit on these contacts is 1 A at 30 VDC or 30 VAC.

Remote High Power On/Off Control

The easiest and most effective way to provide the high power on/off control in a remote location is to mount the Adept Front Panel in the desired location with an extension cable.

However, if the user needs to control high power on/off from other control equipment or from a location other than the Adept Front Panel, then a custom splitter cable will be required. See the Front Panel schematic (**Figure 3-5 on page 46**) for details of the Front Panel's wiring. In this situation, a second momentary contact for high power on/off would be placed *in parallel with* the Adept Front Panel push-button contact. This second contact should be suppressed when in Manual mode (see the note on "Single Point of Control" below).

This method allows relocating the push-button switch to a more convenient location. Implementation of this method must conform to applicable standards recommendations.

For each robot system operator station to have a readily accessible emergency stop device, the manual intervention and reset procedure to restart the robot system after an emergency stop must take place outside the restricted space.

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

Pins 6, 14 and 5, 13 of the XFP connector provide this remote capability. Pins 5, 13 provide power for the lamp, +5 VDC and ground, respectively. Pins 6, 14 are inputs for voltage-free N/O contacts from a customer-supplied momentary push-button switch.

WARNING: To fulfill the "Single Point of Control" requirement, do not place the Manual/Automatic and High Power On controls in multiple locations. To put the robot into Manual mode, the operator should remove the key for safety purposes. The system should not be wired so that a PLC or another operator can put the system back into Automatic mode.

High Power On/Off Lamp

The Front Panel High Power On/Off Lamp (P/N 27400-29006) will cause a V^+ error if the lamp burns out. This error prevents High Power from being turned on. This safety feature prevents a user from not realizing that High Power is enabled because the High Power indicator is burned out. See **Section 4.1 on page 59** for information on changing this lamp.

Remote Front Panel or User-Supplied Control Panel Usage

Users can mount the Front Panel remotely by using an extension cable or by wiring a customer-supplied Front Panel (control panel) to the SmartController using the 15-pin XFP connector. The Front Panel contains no active components, only switches and lights. Customers should be able to adapt the Front Panel's functionality into their own Front Panel design. To automatically control the Front Panel's signals, use relay contacts instead of switches. See **Figure 3-5 on page 46** for a schematic drawing of the Front Panel and **Table 3-8 on page 43** for a summary of connections and pin numbers.

NOTE: The system was evaluated by Underwriters Laboratory with an Adept Front Panel. If you provide a substitute Front Panel, the system may no longer be UL compliant.

Customers can build an extension cable to place the Front Panel in a remote location. The extension cable must conform to the following specifications:

- Wire Size: must be larger than 26 AWG.
- Connectors: must be 15-pin, standard D-sub male and female.
- Maximum cable length is 10 meters.

NOTE: The XMCP and XFP connectors on the SmartController can be interchanged without electrical damage. However, neither the Front Panel nor the pendant will work properly unless they are plugged into the correct connector.

Remote Pendant Usage

Customers can build an extension cable to place the pendant in a remote location. The extension cable must conform to the following specifications:

- Wire Size: must be larger than 26 AWG.
- Connectors: must be 15-pin, standard D-sub male and female.
- Maximum cable length is 10 meters.

CAUTION: Do not modify the cable that is attached to the pendant. This could cause unpredictable behavior from the robot system.

3.6 Connecting Customer-Supplied Digital I/O Equipment

The SmartController contains two options for connecting Inputs and Outputs (I/O). I/O can be hard-wired to the XDIO and /or Controller Area Network (CAN) connectors.

DeviceNet Connector

The DeviceNet connector on the SmartController is used to interface to a CAN using the DeviceNet protocol. See **"Adept DeviceNet" on page 87** for more details.

XDIO Connector

The XDIO connector on the SmartController is a 50-pin, standard density D-Sub female connector (see **Figure 3-1 on page 31** for location). There are 12 inputs and 8 outputs, each optically isolated from the circuitry of the SmartController. The signals are numbered 1001 through 1012 for the inputs and 1 through 8 for the outputs. All the signals have independent source and ground connections. These inputs contain the four high-speed

inputs that are used by the system for interrupts and latching. The outputs, although independent, have a lower current rating of 100 mA compared to 700 mA for the extended outputs on the sDIO (described in **Section A.6 on page 75**). See the ***V+ Language User's Guide*** for information on digital I/O programming.

The connector also provides 24 V pins for powering customer equipment. There are four 24 V pins and four ground pins, which are limited to a total of 1 A of current. The source of the 24 V is the XDC connector on the front of the SmartController.

Input Signals

The XDIO connector handles input signals 1001 to 1012. Each channel has an input and a corresponding return line. See the following table for input specifications. The connector pin-outs are shown in **Table 3-13 on page 55**.

Table 3-11. DIO Input Circuit Specifications (XDIO connector)

Operational voltage range	0 to 30 VDC
"Off" state voltage range	0 to 3 VDC
"On" state voltage range	10 to 30 VDC
Typical threshold voltage	V_{in} = 8 VDC
Operational current range	0 to 7.5 mA
"Off" state current range	0 to 0.5 mA
"On" state current range	2.5 to 7.5 mA
Typical threshold current	2.0 mA
Impedance (V_{in}/I_{in})	3.9 K Ω minimum
Current at V_{in} = +24 VDC	$I_{in} \leq$ 6 mA
Turn-on response time (hardware) Software scan rate/response time	5 µsec maximum 16 ms scan cycle/ 32 ms max response time
Turn-off response time (hardware) Software scan rate/response time	5 µsec maximum 16 ms scan cycle/ 32 ms max response time

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

NOTE: When the program task priorities are properly set, there is a 2 ms maximum latency for fast inputs 1001 to 1008 when used with the V+ INT.EVENT instruction.

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

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

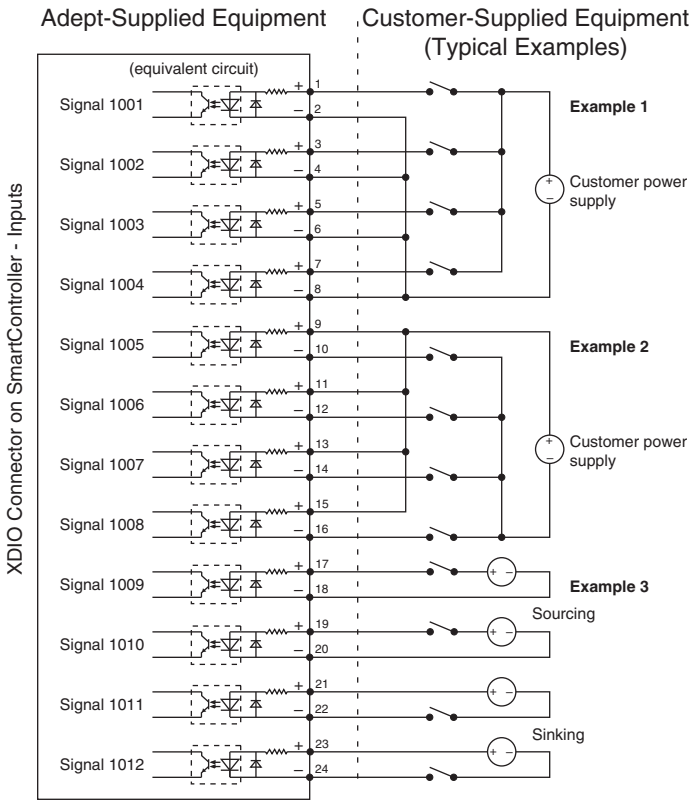


Figure 3-6. Digital Input Wiring Examples (XDIO Connector)

NOTE: Power from pins 41-44 and 47-50 can be substituted for the customer power supply. See **Figure 3-7 on page 54** and **Table 3-12 on page 53** for additional information.

REACT Input Signals 1001 to 1012

Inputs 1001 to 1012 (only) may be used by the V+ REACT and REACTI instructions. See the *V+ Language Reference Guide* for information on these instructions. If you are going to use these instructions, you should plan your digital I/O channel usage accordingly.

Fast Input Signals 1001 to 1008[1]

In addition to functioning as normal input signals, signals 1001 to 1008 can have the following special uses:

- Fast DIO V+ Interrupt Events (INT.EVENT)
- Robot and Encoder Position Latch
- Vision Trigger

[1] Requires V+ system version 17.1 (edit B1 and later) with the SmartController CX (and controller FPGA revision 108 or later). Otherwise, the system is limited to fast digital input signals 1001 to 1004.

Fast DIO interrupt events (using INT.EVENT) require the optional V+ Extensions License. When the program task priorities are properly set, there is a 2 ms maximum latency for fast inputs 1001 to 1008 when used with the V+ INT.EVENT instruction.

See the *V+ Language Reference Guide* for a description of the INT.EVENT instruction.

Output Signals

The XDIO connector handles output signals 0001 to 0008. Refer to **Table 3-12** for output specifications. The locations of the signals on the connector are shown in **Table 3-13 on page 55**. The XDIO connector provides separate positive and negative connections for each channel (no internal common connections). This allows the choice of wiring for current-sourcing or current-sinking modes.

Table 3-12. DIO Output Specifications (XDIO connector)

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

Figure 3-7 on page 54 shows two examples of different connections to the digital outputs on the XDIO connector. The examples are negative common and positive common using the internal 24 V and ground connections.

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

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

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

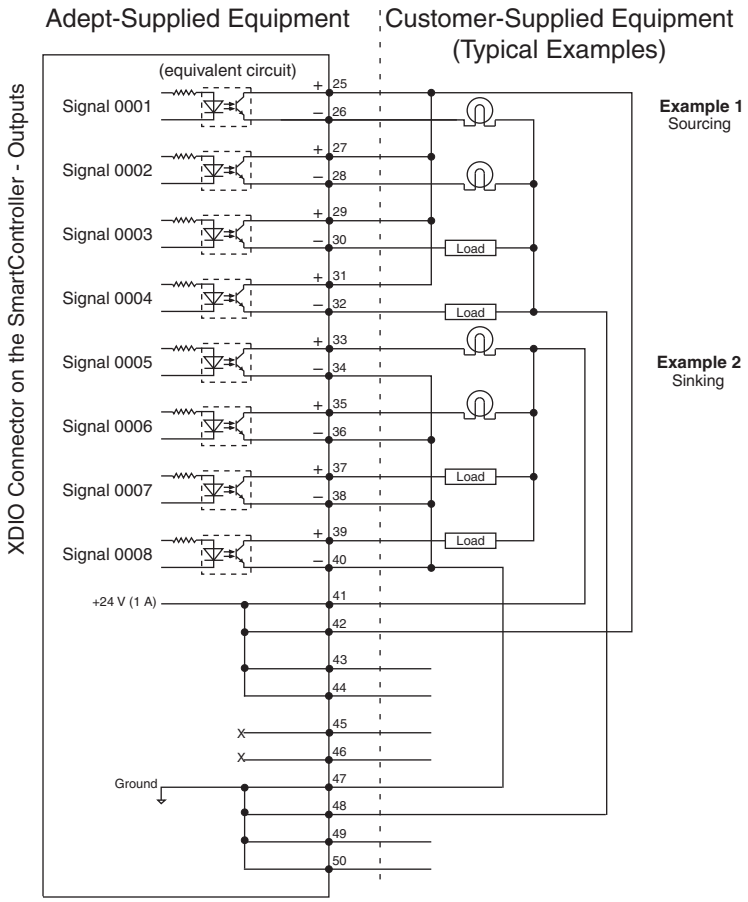
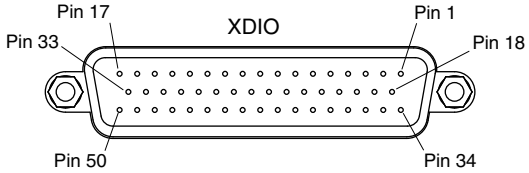


Figure 3-7. Digital Output Wiring for XDIO Connector

Table 3-13. XDIO Digital I/O Connector Pin Assignments

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



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

Digital I/O Connector Ordering Details (Third-Party Sources)

The XDIO connector on the SmartController is a 50-pin, standard-density D sub-miniature female socket. The customer-supplied cable must terminate in a suitable 50-pin Male D-sub plug. The plug is not supplied by Adept.

Compatible connectors are manufactured by AMP and by Thomas and Betts. Contact your nearest AMP or T&B Sales Office to find your local distributor.

AMP Part Numbers for 50-Pin Male D-Sub HDP-20 series D-Sub Connectors. Crimp snap-in contacts. Order item 1 (includes cover) or item 2 (no cover). Contact pins not included, order separately (item 3, quantity 50).

1. 747960-1 Kit (Connector body, shield, enclosure, jackscrews)
2. 205212-3 Connector body only (alternatives: 205212-1, 205212-2)

3. 1-66682-1 Contact Pin, Male, wire size 28-24AWG (0.08-0.2mm 2)
   (Alternatives: 66682-9, 66682-2, 66682-4, 66682-6, 66682-8)
   (Pins also available for other wire sizes, contact AMP)

Thomas and Betts Part Numbers for 50-Pin Male D-Sub HOLMBERG-series D-Sub Connectors. Crimp snap-in contacts. Contact pins not included, order separately (item 2, quantity 50).

1. HM50A Connector body only (alternative: HM50B)
2. 1008424C-02-25 Contact Pin, Male, wire size 28-24AWG (0.08-0.2mm 2)
   (Alternatives: 1008404C-02-25, 1008429C-02-25, 1008449C-02-25)
   (Pins also available for other wire sizes, contact T&B)

Screw-Terminal Field-Wiring Adapter Blocks

Several manufacturers make screw-terminal field-wiring blocks, usually DIN-rail mountable. These can be connected to the XDIO via a suitable shielded 50-pin cable (user-supplied).

Phoenix Contact Inc. FLKM-D 50 SUB/B “DIN rail mount interface block screw terminal to 50-pin D connector (female).” (Alternative: FLK-D 50 SUB/B)

Weidmüller AD911886 - RD 50 ASJS -”D-Sub to wire transition module, 50-pin female D-Sub with jackscrews.”

3.7 Belt Encoder Interface on SmartController CX

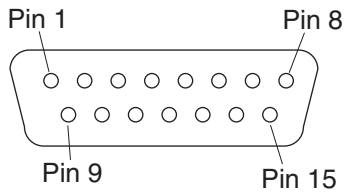
For use with conveyor tracking, the SmartController CX supports two independent external belt encoders through a 15-pin, male, D-sub connector. The pin assignments for the Belt Encoder connector are shown in the following table. See **Figure 3-8 on page 58** for a typical input circuit drawing.

Adept strongly recommends using differential encoder outputs for maximum noise immunity. See the ***V+ Language User's Guide*** for more information on setting up and programming a conveyor-tracking application.

> **NOTE:** Conveyor tracking requires a V+ Extensions License, which can be obtained from Adept.

Table 3-14. Belt Encoder Connector Pin Assignments

Channel 1		Channel 2	
Signal	**Pin**	**Signal**	**Pin**
A+	15	A+	11
A–	7	A–	3
B+	14	B+	10
B–	6	B–	2
I+	13	I+	9
I–	5	I–	1
Encoder 5 V out	4	Encoder 5 V out	4
Encoder ground	12	Encoder ground	12
not used	8	not used	8



Belt Encoder Connector Pinout

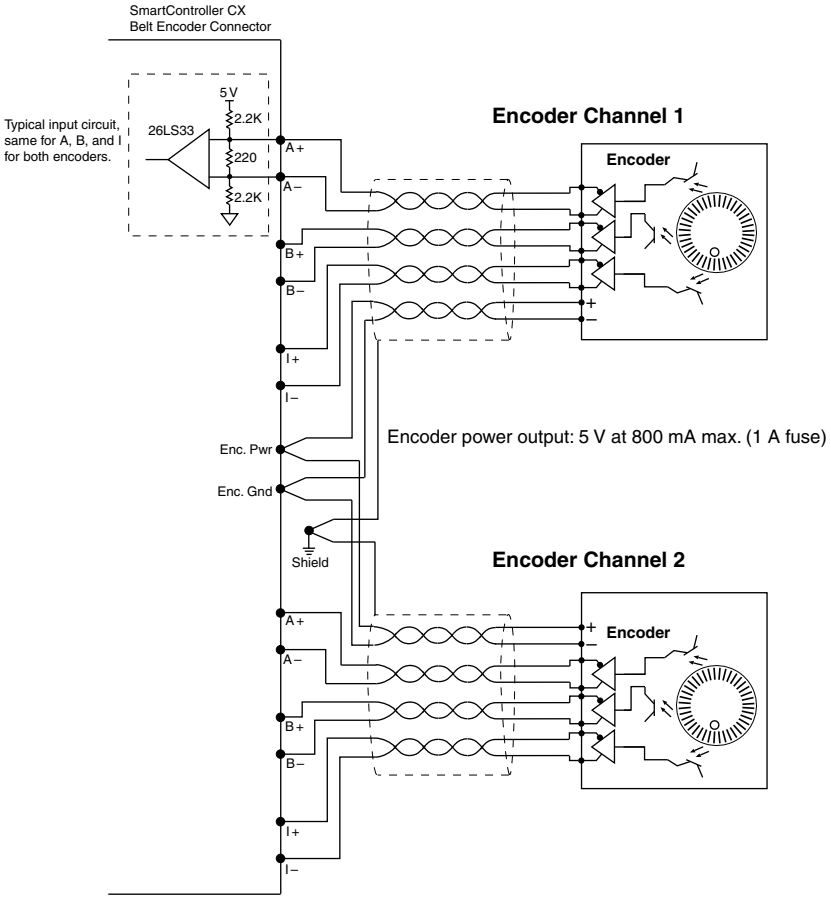


Figure 3-8. Belt Encoder Typical Input Circuit

SmartController Maintenance 4

4.1 Changing the Lamp in the Front Panel High-Power Indicator

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

WARNING: Lockout and tagout power before servicing.

WARNING: The procedures and replacement of parts mentioned in this section should be performed only by trained, authorized personnel. The access covers on the SmartController are not interlocked – turn off and disconnect power if covers have to be removed.

1. Turn off system power to the SmartController.
2. Disconnect the cable between the Front Panel and the SmartController.
3. Remove the Front Panel from its mounting location.
4. Remove the two screws on the back of the Front Panel.
5. Carefully pull the front cover away from the body of the Front Panel. You will encounter some resistance as there are three plug-type connectors that you need to disconnect as you pull the front cover away from the body.

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

6. Locate the lamp body in the center of the back side of the front cover. Turn the lamp body approximately 20° in either direction and then pull straight back.

7. The lamp body is now free. You can remove the old lamp and insert a new one.
8. Replace the lamp body by pushing it straight into the lamp housing receptacle. Make sure the contacts on the lamp body are properly oriented. See **Figure 4-1 on page 60**.
9. Make sure to reconnect the wires from the LED if you disconnected them earlier. Push the front cover into the body, taking care to align all of the plug-type connectors. Verify that the wires do not get crimped as you reinstall the cover.
10. Replace the two screws on the back of the body.
11. Reinstall the Front Panel in its mounting.
12. Reconnect the cable between the Front Panel and the SmartController.

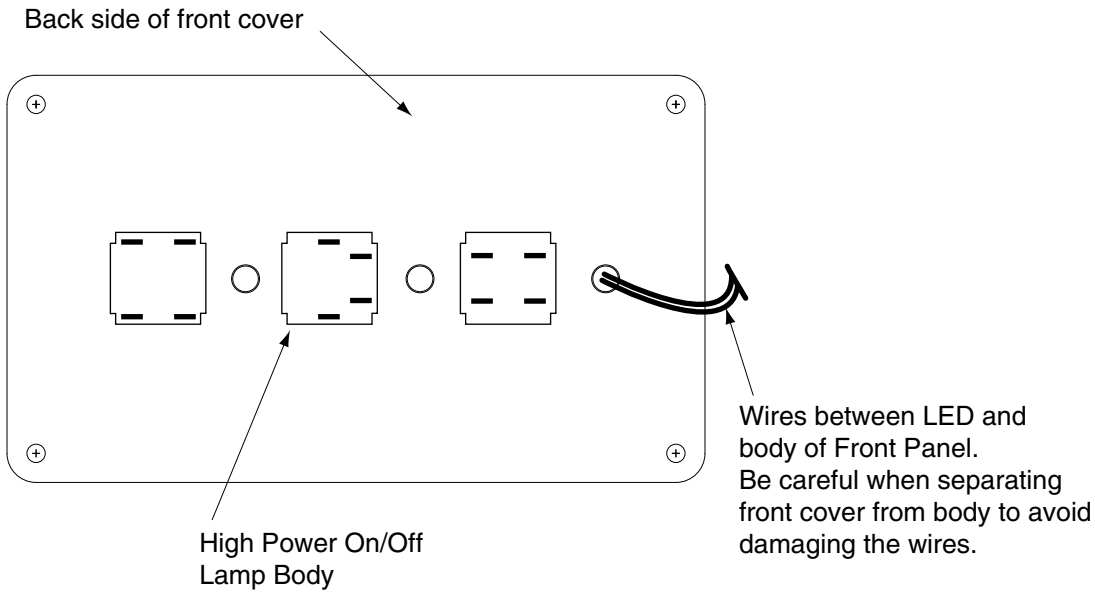


Figure 4-1. Lamp Body Contact Alignment

5 Technical Specifications

This chapter shows the dimensions of the SmartController, sDIO, Adept Front Panel, and T2 pendant.

5.1 SmartController Dimensions

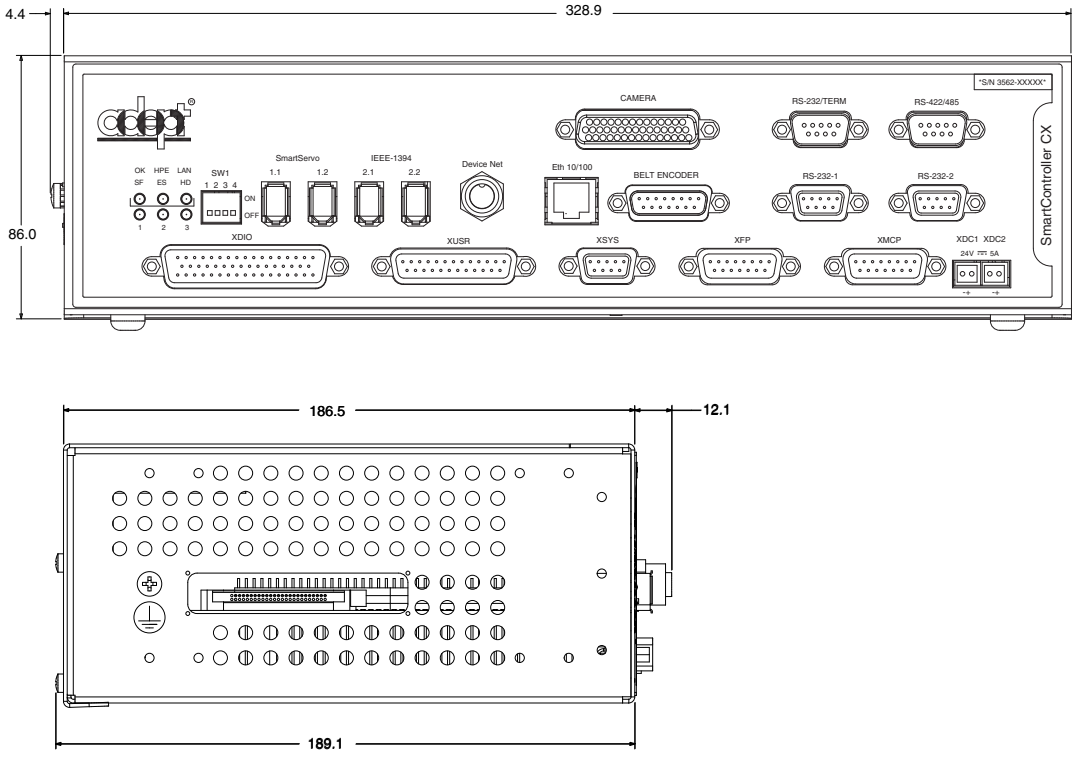


Figure 5-1. SmartController Dimensions

5.2 sDIO Dimensions

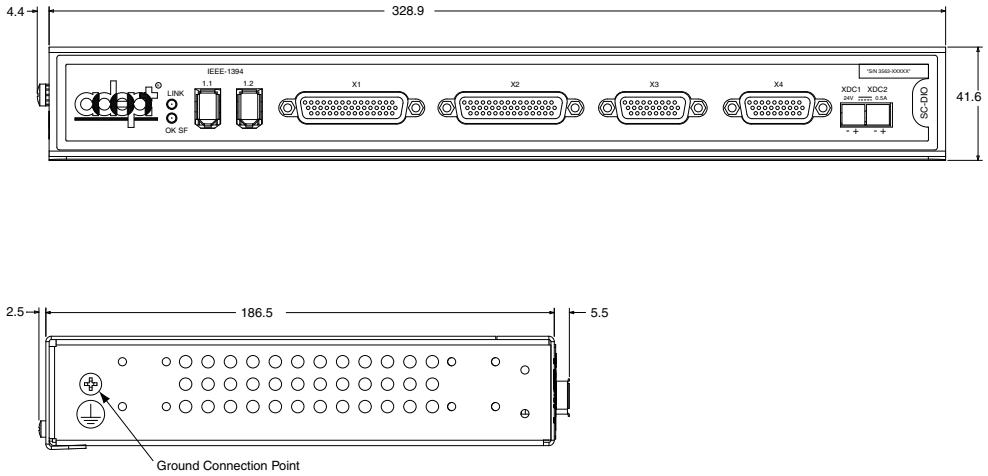


Figure 5-2. sDIO Dimensions

5.3 Adept Front Panel Dimensions

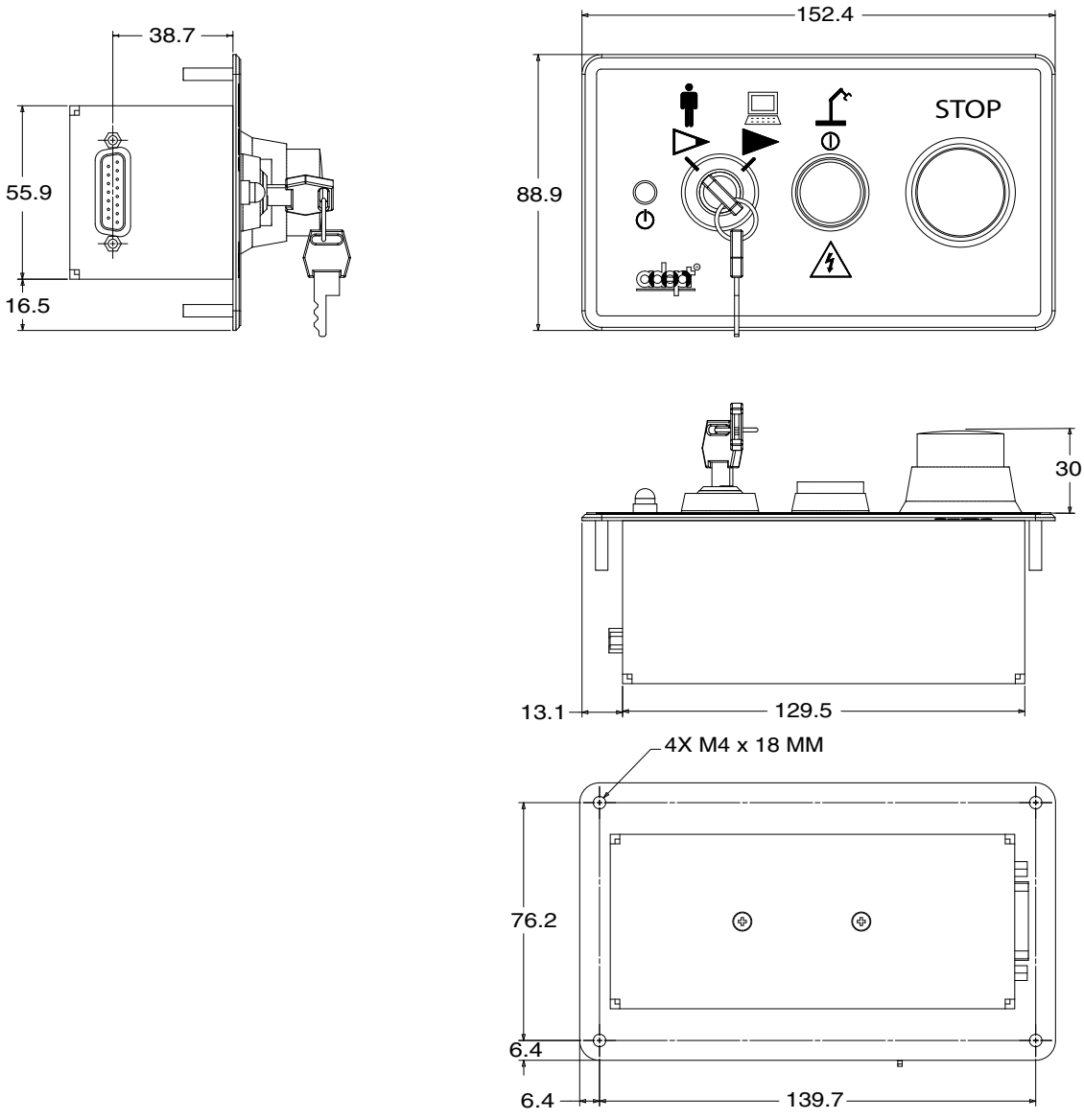


Figure 5-3. Adept Front Panel Dimensions

5.4 Adept T2 Pendant Dimensions

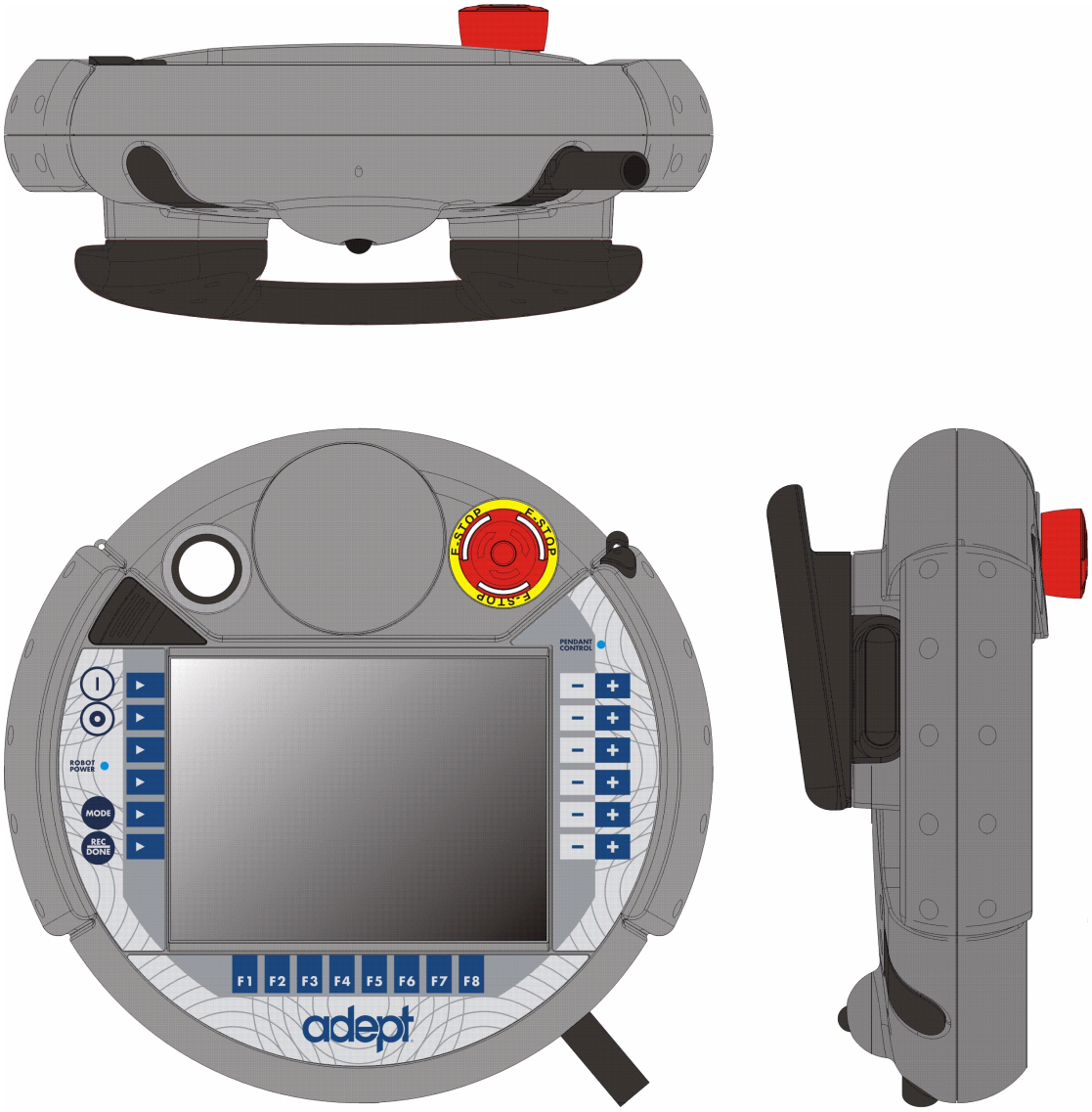


Figure 5-4. T2 Pendant Dimension

sDIO Module A

The sDIO expansion module provides 32 optically-isolated digital inputs and 32 optically-isolated outputs and also includes an IEEE 1394 interface.

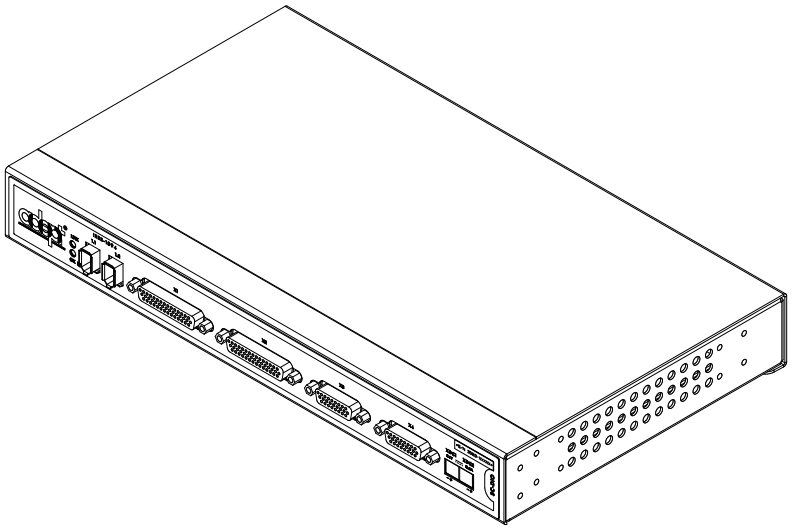


Figure A-1. sDIO Module

A.1 Mounting the sDIO

The following mounting options are available for the sDIO:

- Rack mounting
- Panel mounting
- Table mounting
- Stack mounting

NOTE: To maintain compliance with European standards in European installations, the mounting of the controller and all terminations at the controller must be performed in accordance with applicable standards.

Rack-Mounting the sDIO

To rack-mount the sDIO module in a standard 19-inch equipment rack, you must first install the mounting brackets (see **Figure A-2**) on each side of the unit. These brackets must be ordered separately, they do not come with the sDIO.

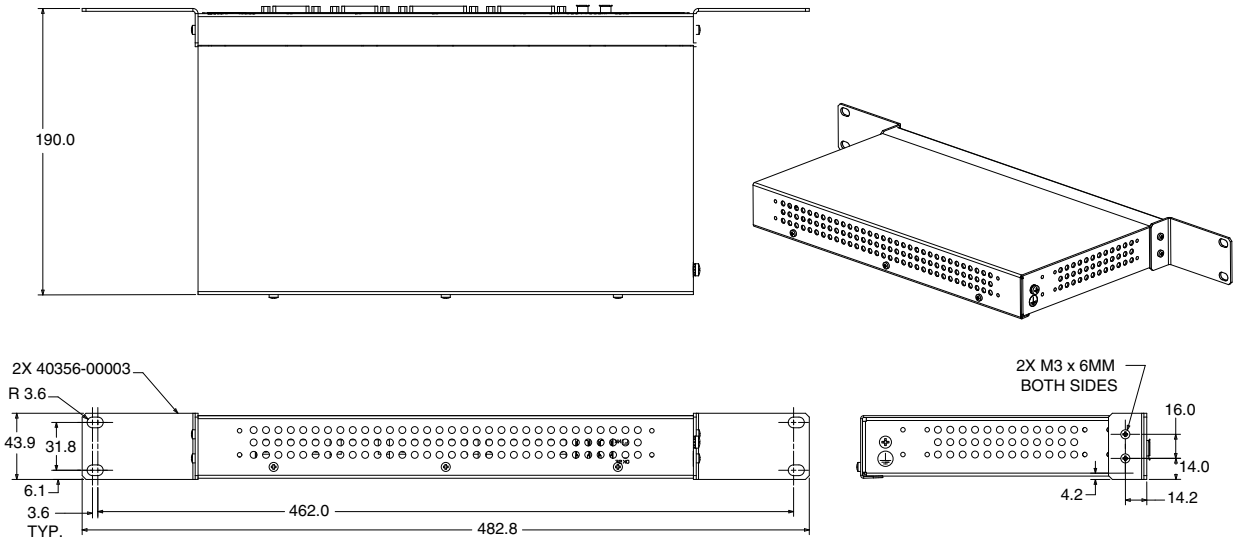


Figure A-2. Rack-Mounting the sDIO

Panel-Mounting the sDIO

To panel-mount the sDIO, install one bracket on each side of the back of the unit. Use the screws from the accessories kit. See the following figure.

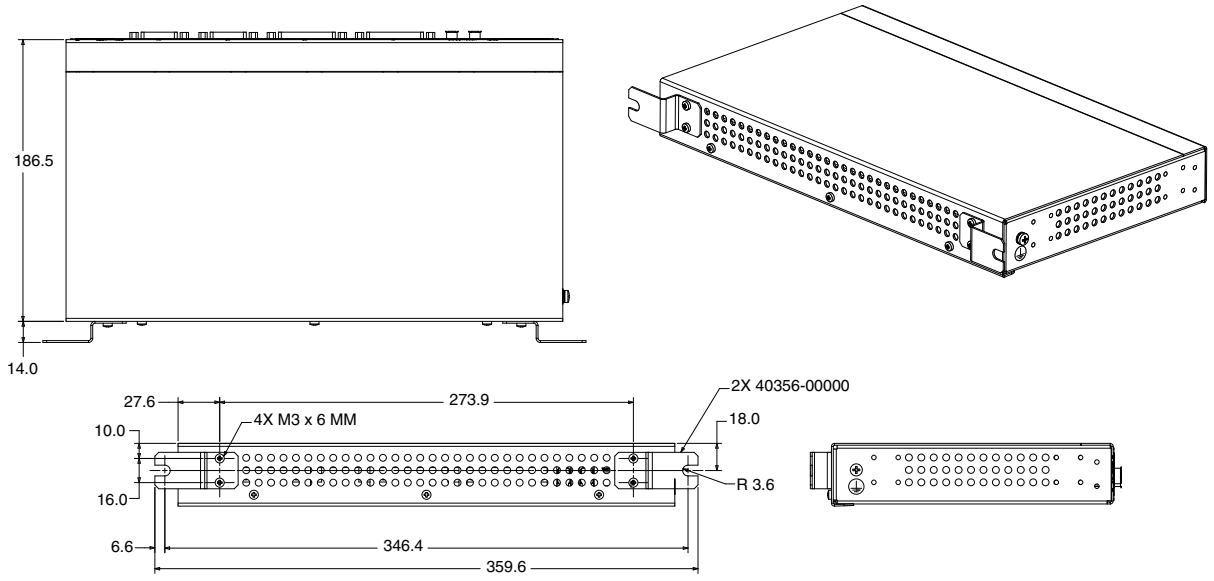


Figure A-3. Panel-Mounting the sDIO

Table-Mounting the sDIO

To table-mount the sDIO, install two brackets on each side near the bottom of the unit. See the following figure. These brackets must be ordered separately. They do not come with the sDIO.

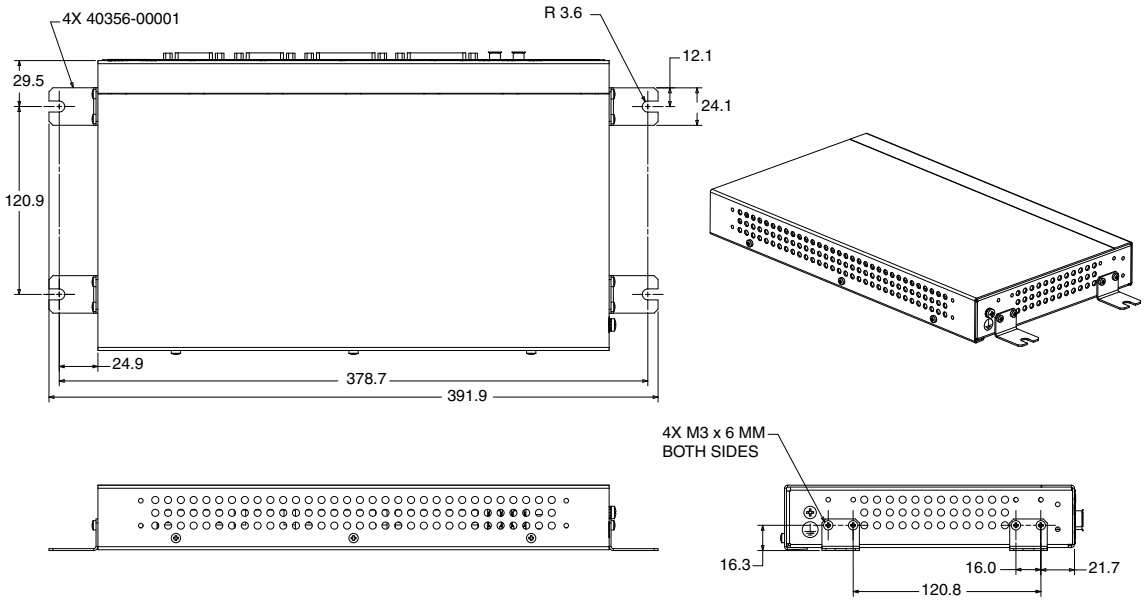


Figure A-4. Table-Mounting the sDIO

Stack-Mounting the sDIO

See the **"Stack-Mounting Components" section on page 24** for information on stack-mounting the sDIO and SmartController.

A.2 Installing the sDIO

The following procedure details the steps required to install the sDIO.

To install the sDIO module:

1. Remove the sDIO module from its box and mount it as described in **"Mounting the sDIO" on page 65**.
2. Ensure that the 24 VDC input power to the SmartController is disengaged.
3. Connect a 24 VDC cable from the unused XDC port on the SmartController to the XDC1 port on the sDIO. Continue to daisy-chain the input power from each sDIO to the next. See **"Connecting Power" on page 26** for cabling requirements.

   NOTE: European installations must conform with applicable standards.

4. Connect an IEEE 1394 cable from one of the SmartServo ports (1.1 or 1.2) on the SmartController to one of the IEEE 1394 ports on the sDIO. Continue to daisy-chain IEEE 1394 cables from each sDIO to the next.

WARNING: Remove power from the SmartController before plugging in or unplugging any IEEE-1394 cables to SmartServo IEEE-1394 connectors. Failure to remove power could result in unpredictable behavior by the system.

5. Connect a user-supplied ground wire to earth ground on each sDIO.
6. Connect the 24 VDC input power to the SmartController.

A.3 Configuring an sDIO

The SmartController is preconfigured to support two sDIO modules. Its configuration is based upon an I/O block assignment method that uses 4 bytes per block and 8 signals per byte. Thus, each byte within a block represents a range of eight Input or Output signals.

Block numbers for general digital I/O can range from 16 to 31. The default block is 16 for sDIO #1, and 17 for sDIO #2. Input blocks and output blocks are numbered independently so you can use the same number for both an input and an output block. You must be sure that the block number you specify is not used for the same type of block (Input or Output) in any other sDIO module (or IO Blox device) in your system.

Default sDIO I/O Configuration

Two sDIO modules can be used with the default I/O signal configuration and no additional configuration is required. The default configuration consists of the settings shown in the following table.

Table A-1. Default I/O Configuration for sDIO #1 and #2

	Input Signal Numbers	Block	Byte		Output Signal Numbers	Block	Byte
sDIO #1	1033 to 1040	16	1		0033 to 0040	16	1
	1041 to 1048	16	2		0041 to 0048	16	2
	1049 to 1056	16	3		0049 to 0056	16	3
	1057 to 1064	16	4		0057 to 0064	16	4
sDIO #2	1065 to 1072	17	1		0065 to 0072	17	1
	1073 to 1080	17	2		0073 to 0080	17	2
	1081 to 1088	17	3		0081 to 0088	17	3
	1089 to 1096	17	4		0089 to 0096	17	4

Modifying the Default sDIO Configuration

In most system installations you can use the default I/O configurations, and you will not have to modify the I/O configuration. If you need to modify the I/O configuration, use the steps given in **Configuration Procedure**.

> **NOTE:** Blocks 1-15 are typically reserved for robot signals. Blocks 1-6 are preconfigured for Robots 1-6 for the 3000 series hand control signals, including the signals used by the V+ OPEN, OPENI, CLOSE, CLOSEI, RELAX, RELAXI statements. See the V+ documentation for more details about these statements.

In the following situations, you must go through a configuration process to modify the sDIO modules:

- when you have more than two sDIO modules
- when you choose not to use the default I/O configuration (blocks 16 and 17)
- when you replace an sDIO in either of the two preceding situations

> **NOTE:** The first sDIO can use the default configuration; each additional sDIO must be assigned unique block numbers, between 16 and 31.

In these cases you will use Adept ACE software to select the block number and to assign the Input and Output signals.

Configuration Procedure

From the Adept ACE software:

1. Double-click on the controller in the tree structure pane. This will open the object editor for the controller.
2. Click the Configure tab, then Configure V+.
   - Select DIGITAL_INPUT to modify the input settings.
   - Select DIGITAL_OUTPUT to modify the output settings.

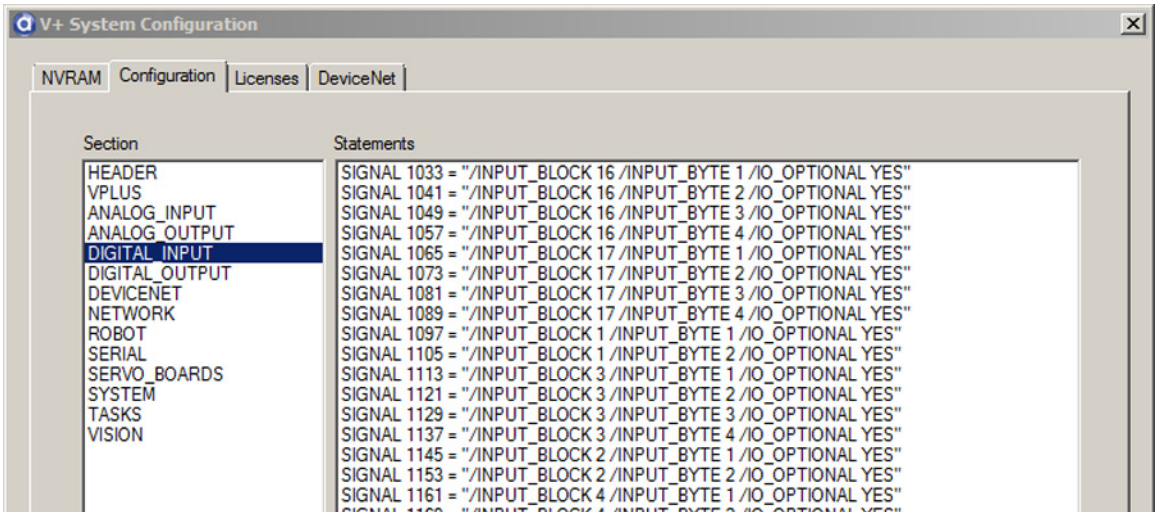


Figure A-5. Configuring Digital Input

3. If a signal range is not present, click Add to add it.

   Modify existing values with Edit.

4. For Statement Type select SIGNAL.
5. Enter the values for the signal. See **Figure A-6**.

   For IO_OPTIONAL enter YES.

6. When you have configured all of the I/O, click Done.

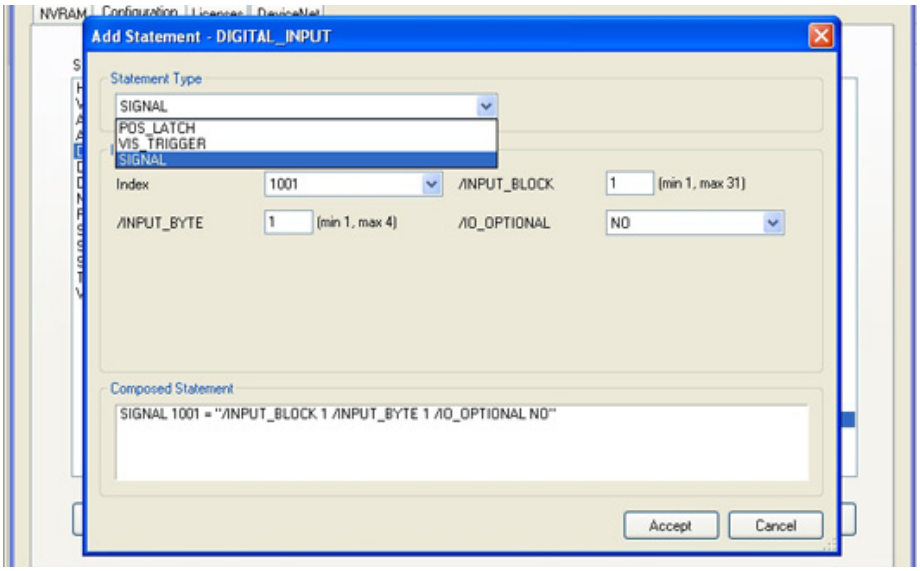


Figure A-6. Modifying a Digital Signal

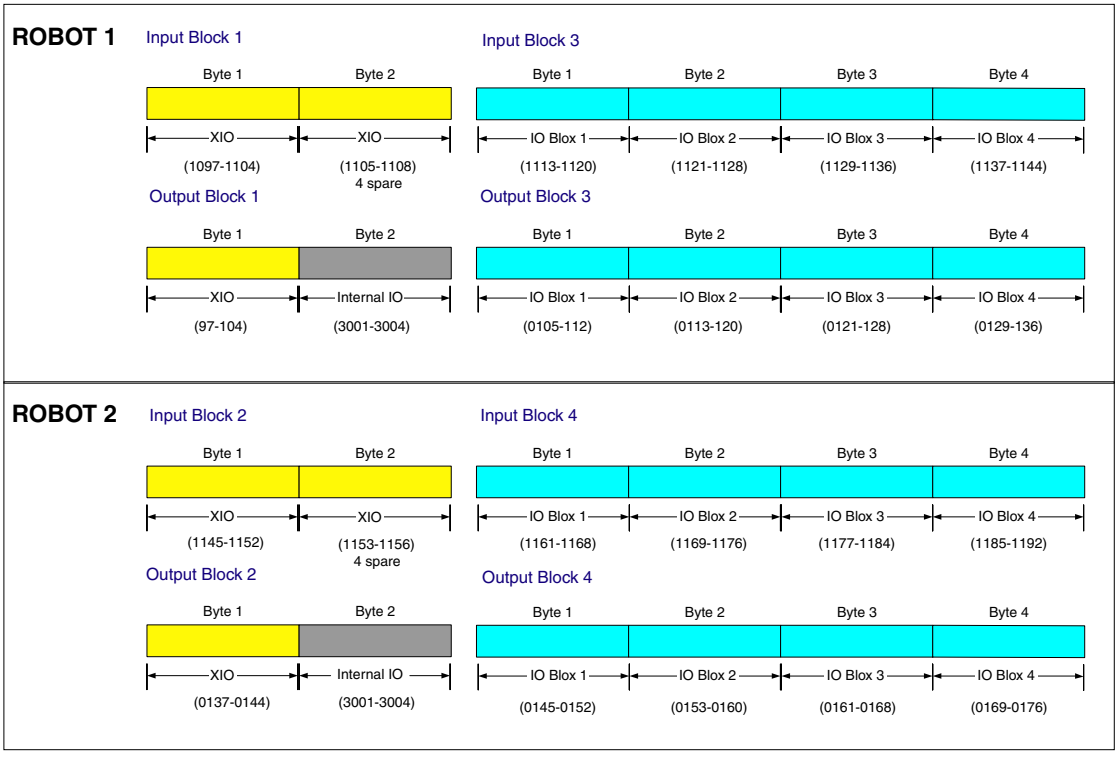


Figure A-7. I/O Blocks for Robot 1 and Robot 2

sDIO Inputs/Outputs

Up to four sDIO modules can be added to a system. The first sDIO occupies the first 4 bytes of block 16. See **Figure A-8 on page 72**. Additional sDIO modules need to be configured using the controller object editor in Adept ACE.
Refer to the steps under **"Configuration Procedure" on page 69**, and the values in **Figure A-8**.
After selecting block numbers, you must assign groups of signal numbers to each block.

> **NOTE:** You must select a unique block number for the Inputs and Outputs of each sDIO in your system. Repeat the procedure above for each sDIO.

Assigning I/O Signal Numbers

The I/O signal number ranges are valid for the sDIO:

- Inputs 1033 to 1512
- Outputs 0033 to 0512

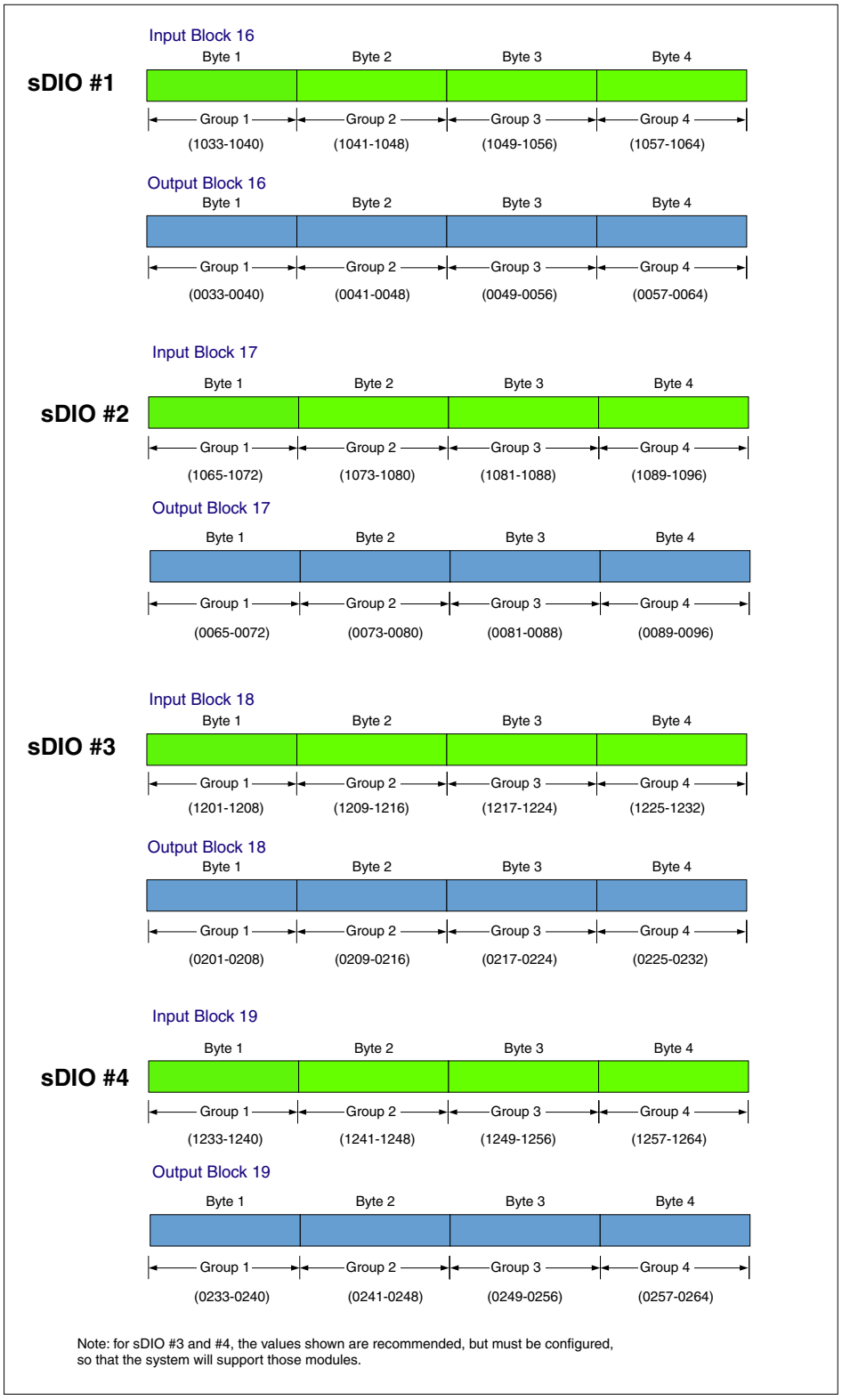


Figure A-8. Input/Output Block Configuration for sDIO Modules

A.4 Using Multiple sDIO Modules

Additional sDIO modules can be added to a system. The recommended maximum is eight sDIO modules. See **Figure A-9** for cabling and configuration information. Note that each sDIO must have a unique block number (between 16 and 31) for both the input and output signals.

1. Connect a 24 VDC cable from the XDC2 port on sDIO #1 to the XDC1 port on sDIO #2. See the **"Connecting Power" on page 26** for cabling requirements.
2. Connect an IEEE 1394 cable from one of the IEEE 1394 ports on sDIO #1 to one of the IEEE 1394 ports on sDIO #2.
3. Using Adept ACE software, select a block number for sDIO #3. Block 18 is recommended. See **"Modifying the Default sDIO Configuration" on page 69** for details on this process.
4. Continue to assign groups of signal numbers to bytes 1 to 4 in the block. See **"" on page 72**.
5. Repeat steps 1 to 4 for each additional sDIO module.

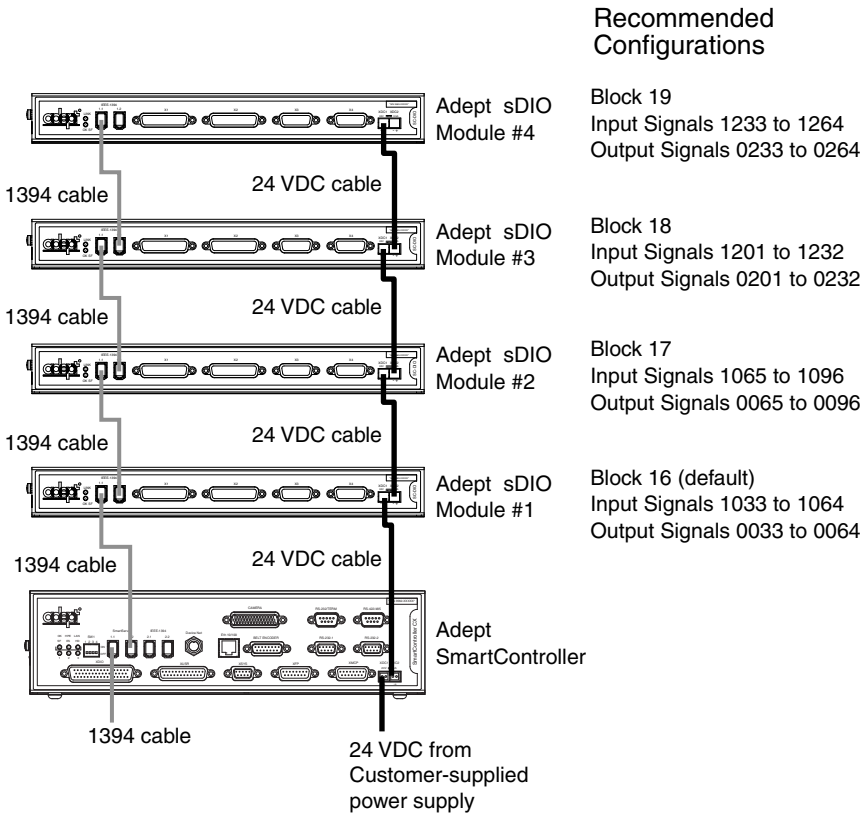


Figure A-9. Using Multiple sDIO Modules

NOTE: When adding additional sDIO modules, each additional sDIO module must be grounded per all applicable regulations.

A.5 sDIO Module Connectors and Indicators

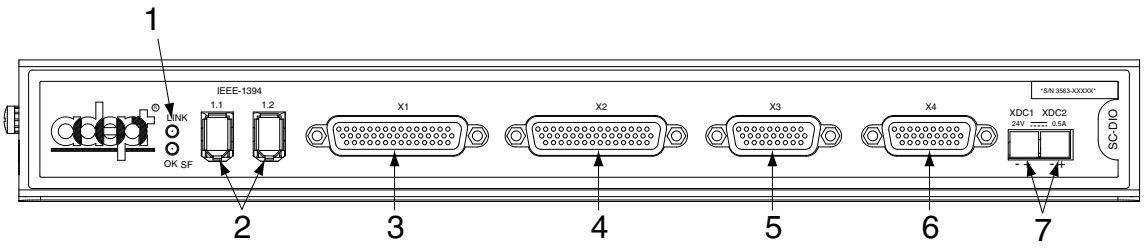


Figure A-10. sDIO

1. **Status LEDs**.

   Two LEDs indicate link status of the IEEE 1394 connection and system status.

   LINK: Green LED = communication with another device over IEEE 1394 connection OK.

   OK/SF: Red LED = output driver fault detected due to excessive temperature or current (output is automatically shut down), solid green LED = communication with controller OK, blinking green = not configured in software.

2. **IEEE 1394 ports:** Connects to one of the SmartServo ports on SmartController or IEEE 1394 ports on additional sDIO units.
3. **X1 Output:** 44-pin female D-sub connector, for digital output signals 0033-0048.
4. **X2 Output**: 44-pin female D-sub connector, for digital output signals 0049-0064.
5. **X3 Input**: 26-pin female D-sub connector, for digital input signals 1033-1048.
6. **X4 Input**: 26-pin female D-sub connector, for digital input signals 1049-1064.

   NOTE: For installations that use two or more sDIO modules, the above signal numbers apply to the signals for the first sDIO. See **"Running H/F 4" section on page Right** for information on configuring two or more sDIO modules.

7. **Two 24 VDC connectors:** Connect power from the unused XDC connector on the SmartController to the XDC1 connector on the sDIO (see the **"Connecting Power" section on page 26** for power specifications).

A.6 sDIO Digital I/O Signals

The sDIO module's digital I/O signals are 64 optically-isolated digital I/O channels (32 output and 32 input). They are wired to connectors X1 through X4, which are located on the front of the sDIO (see **Figure A-10 on page 74**). The electrical specifications for the inputs are similar to the XDIO inputs, but have a different wiring configuration. The sDIO inputs cannot be used for REACTI programming, high-speed interrupts, or vision triggers. See the ***V+ Language User's Guide*** for information on digital I/O programming.

> **NOTE:** The signals on the sDIO connectors can be superseded by another sDIO that is installed and addressed as sDIO #1. To use two sDIO modules, address the first as sDIO #1 and the second as sDIO #2.

sDIO Inputs

The 32 input channels are arranged in four groups of eight. Each group is electrically isolated from the other groups and is optically isolated from the sDIO module's circuitry. The eight inputs within each group share a common ground.

The inputs are accessed through the two female 26-pin D-sub input connectors on the front of the sDIO. Each connector provides access to two input groups. Each group requires ten pins, eight input signals, and two ground references. An input is activated by providing a positive potential on its input pin relative to the ground pin of its group. This type of input is considered sinking. That is, current must flow into the input pin to turn it on.

Table A-2. sDIO Input Specifications

Operational voltage range	0 to 30 VDC
"Off" state voltage range	0 to 3 VDC
"On" state voltage range	10 to 30 VDC
Typical threshold voltage	V_{in} = 8 VDC
Operational current range	0 to 7.5 mA
"Off" state current range	0 to 0.5 mA
"On" state current range	2.5 to 7.5 mA
Typical threshold current	2.0 mA
Impedance (V_{in}/I_{in})	3.9 K Ω minimum
Current at V_{in} = +24 VDC	$I_{in} \leq$ 6 mA
Turn on response time (hardware) Software scan rate/response time	5 µsec maximum 16 ms scan cycle/ 32 ms max response time
Turn off response time (hardware) Software scan rate/response time	5 µsec maximum 16 ms scan cycle/ 32 ms max response time

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

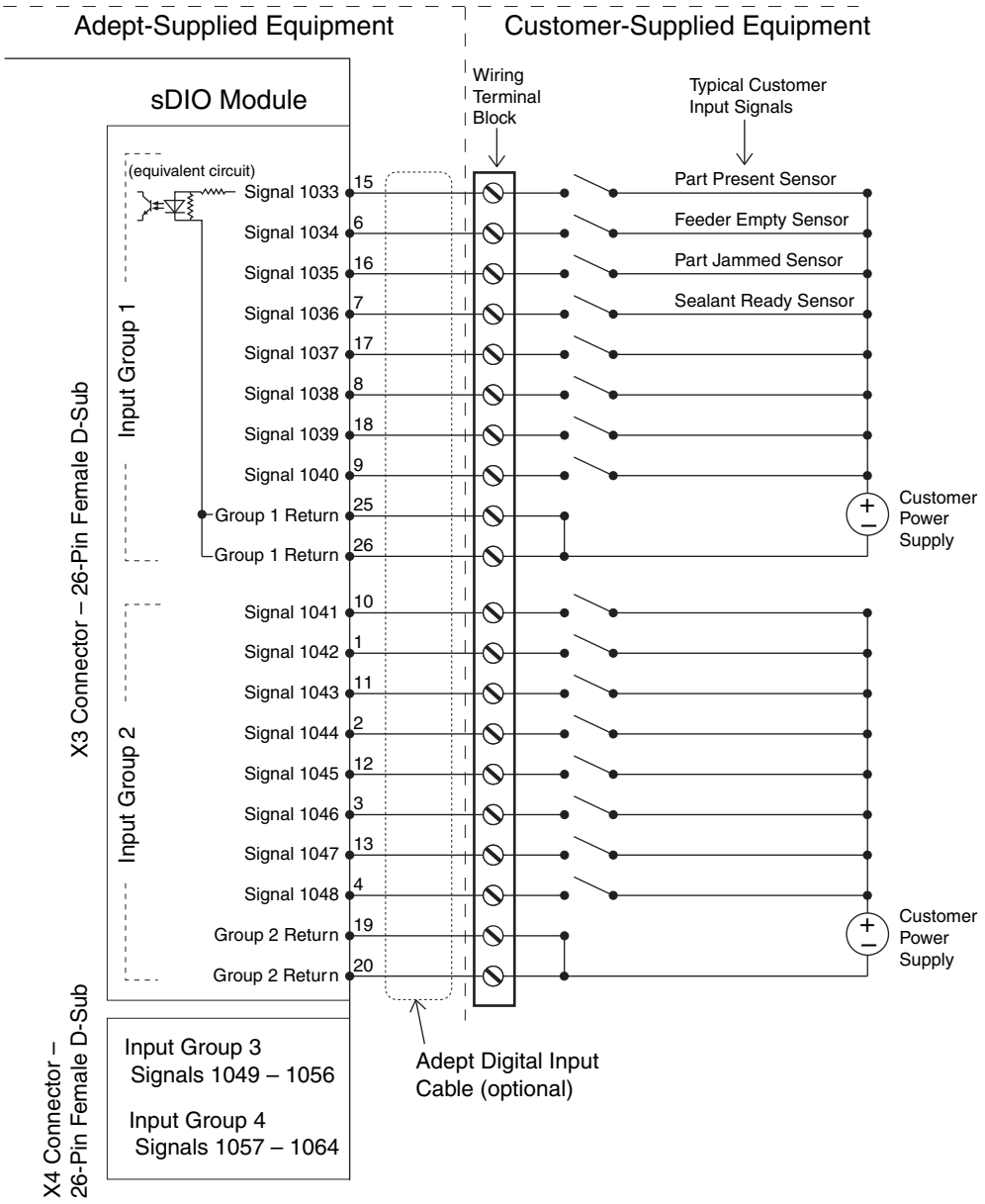


Figure A-11. Typical sDIO Input Wiring

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

sDIO Outputs

The 32 output channels are arranged in four groups of eight. Each group is isolated from the other groups and is optically isolated from the sDIO circuitry. The eight outputs within each group share a common power supply and a common ground.

The outputs are accessed through the two female 44-pin D-sub output connectors on the front of the sDIO. Each connector provides access to two output groups. Each group requires 19 pins: 8 output signals, 1 test signal, 9 power supply (all tied together), and 1 power supply ground reference. When an output is on, current will flow in through the power supply pins and out through the output pins. This type of output is considered sourcing, that is, in the On condition, current flows out of the output pin. See **Figure A-12 on page 80** for details on typical digital output wiring.

Testing sDIO Outputs

Like many solid-state I/O systems, when an output is off, a small leakage current will flow out of the output. This will raise the potential of the output to the power supply voltage level if there is no load. With a load connected, the output will function normally. However, if you need to test the output with a voltmeter with a load disconnected, you will get a false reading. The test signal provides a bias that can be used as a pull-down resistor for system-level troubleshooting. When this is connected to an output, the output will assume the ground potential when it is off.

sDIO LEDs

A pair of two-color LEDs on the sDIO module indicate link status over the IEEE 1394 connection and system status. The upper LED lights green when an IEEE 1394 connection is established. The lower LED blinks green when the software is active and switches to solid green after the controller software has found and configured the DIO block. The lower LED lights solid red whenever an output fault (excessive current or temperature) is detected on any of the 32 outputs. Refer to **Table A-3 on page 78** for information about the LEDs and **Figure A-10 on page 74** for information on their location.

> **NOTE:** A fault indication is the result of an over-temperature or over-current condition on one or more of the outputs, usually due to a short-circuit. As a result, the output driver IC will oscillate on and off as the chip tries to drive the load.

Note that this red fault LED is active only when:

- An extended output (for example, a SIGNAL in the range of 33 to 64) has been turned on by a V^+ command.
- An activated output has a thermal-overload problem, usually due to a short in the user's wiring from the output pin to the user's ground.

Table A-3. sDIO Chassis LEDs

Illumination	Upper LED (LINK)	Lower LED (OK SF)
None	No IEEE 1394 link	Local software not running
Blinking Green	Not Applicable	Local software active, not configured in V+
Solid Green	IEEE 1394 link good	Local software active, and configured in V+
Blinking Red	Not Applicable	Output fault
Solid Red	Not Applicable	Output fault

A diagnostic software indicator is not available for the XDIO outputs. In a short-circuit condition, the XDIO outputs will simply fold back, supplying the maximum short-circuit current to the output pin.

sDIO Output Power Supply Current Selection

The nine power pins for each group are connected together on the sDIO module's board, and the current supplied from the output pins is drawn from these power pins. The number of power pins used in a particular application depends on the total current supplied through that group's outputs. A total of nine power pins are provided to allow for more wire connections to decrease the voltage drop across the power supply wires.

The supply current should be limited to a maximum of one amp per power pin. Use this limitation to select the number of power pins you need.

For example, each output can source up to 700 mA, giving a maximum total current (for a group of eight outputs) of 5.6A that will be required from the power supply. In this case, a minimum of six power pins should be used. If you experience an excessive voltage drop, make connections to additional power pins.

The ground connection should connect to the power supply directly, not the ground connection of the load. This will isolate the board from any voltage drop across the ground return for the load.

Table A-4. sDIO Output Circuit Specifications

Parameter	Value
Power supply voltage range	10 VDC ≤ V_{sup} ≤ 30 VDC
Under voltage shutdown	5 VDC ≤ V_{usd} ≤ 8 VDC
Power supply ground current	I_g ≤ 60 mA
Operational current range, per channel	I_{out} ≤ 700 mA
On state resistance (I_{out} = 0.5 A)	Ron ≤ 0.32 Ω @ 85° C (Ron 0.4 Ω @ 125° C)
Output leakage current	I_{out} ≤ 25 µA
Turn on response time	175 µsec. max., 80 µsec typical (hardware only)
Turn off response time	60 µsec. max., 28 µsec typical (hardware only)
Output voltage at inductive load turnoff (I_{out} = 0.5 A, Load = 1 mH)	(V_{sup} - 65) ≤ V_{demag} ≤ (V_{sup} - 45)
DC short circuit current limit	0.7 A ≤ I_{LIM} ≤ 2.5 A
Peak short circuit current	I_{ovpk} ≤ 4 A

CAUTION: The above specs. apply only to the output channels on the sDIO. See **Table 3-12 on page 53** for specs. on the XDIO connectors' digital output channels.

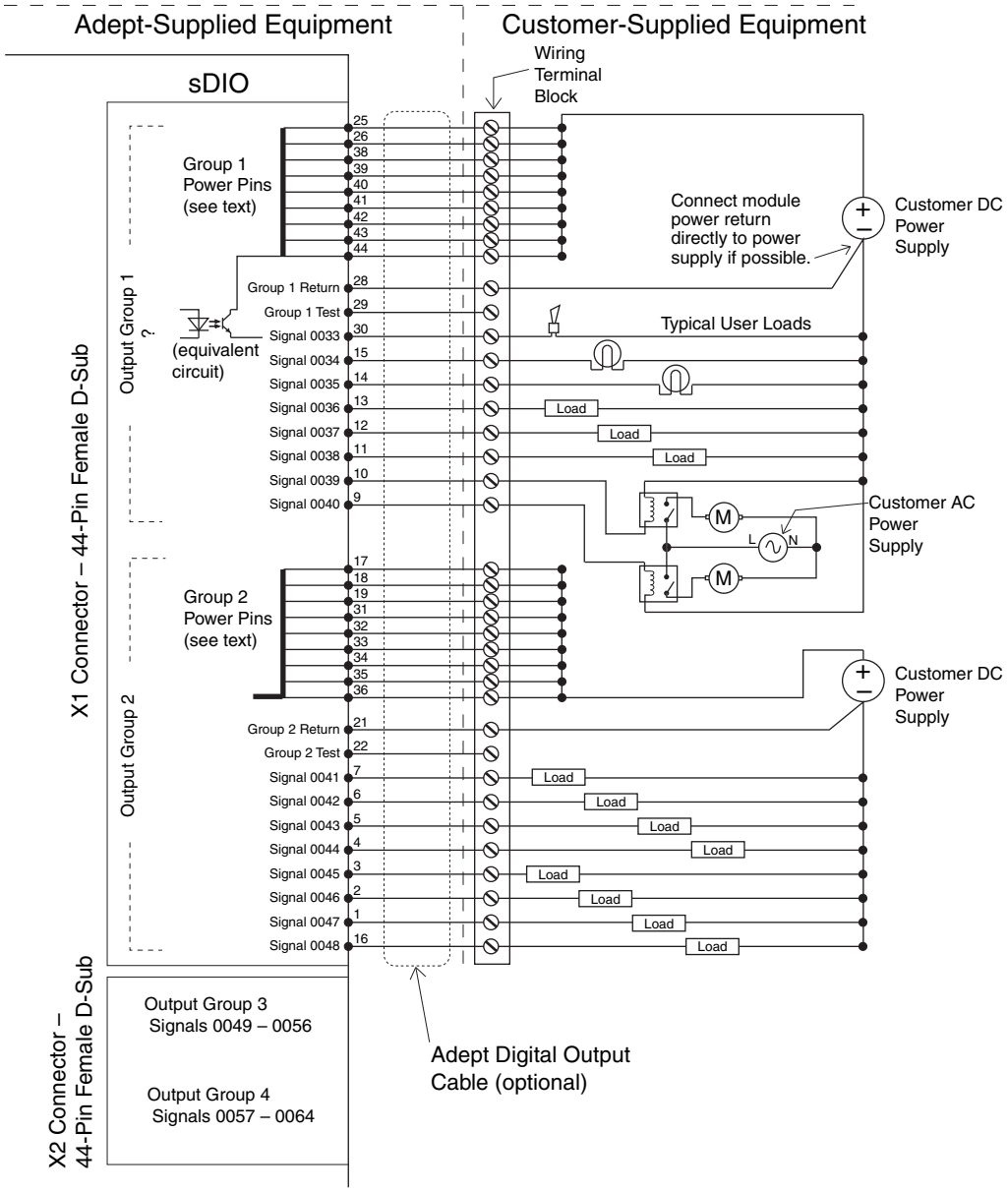


Figure A-12. Typical sDIO Output Wiring

Optional DIO Cables

The cables that connect to the input and output connectors on the sDIO can be ordered as a set of four cables: two input cables and two output cables. These cables have a mating plug on one end and unterminated flying leads on the other end. The wire size of the Adept cables is 0.18 mm^2 (24 AWG). You can use these cables to connect to the digital inputs/outputs in your system or to a wiring block.

To comply with IEC 1131, if you choose to supply a wiring block, it should be capable of accepting wire in the range of 0.18 mm^2 (24 AWG) to 2.0 mm^2 (14 AWG).

Labeling Cables

The X3 and X4 input connectors on the front of the sDIO are similar except that X3 handles the group 1 and group 2 input signals and X4 handles the group 3 and group 4 input signals. The optional digital input cables can be connected to either X3 or X4. Make sure to clearly label the cables once you have completed your installation so that the cables do not get swapped by mistake; see the warning that follows.

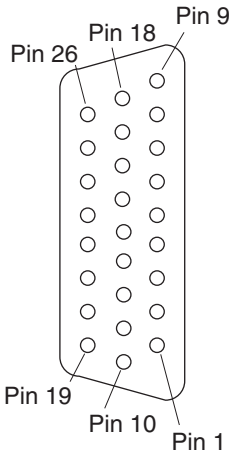
The X1 and X2 output connectors are also similar except that X1 handles the group 1 and group 2 output signals and X2 handles the group 3 and group 4 output signals. The optional digital output cables can be connected to either X1 or X2. Make sure to clearly label the cables once you have completed your installation so that the cables do not get swapped by mistake; see the warning that follows.

WARNING: Make sure to clearly label the X1 to X4 digital I/O cables so that they are always plugged into the correct connectors. Swapping the X3 and X4 or X1 and X2 cables could cause damage to your equipment. Depending on the installation, this could potentially cause injury to personnel in the area.

Input and Output Cable Wiring Information

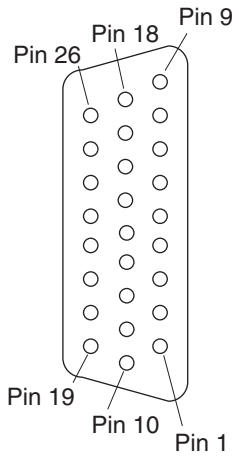
The pinouts, signal names, and wire color information for the input and output cables are shown in the next four tables.

Table A-5. X3 Input Cable Pin Assignments

Pin Number	Signal Group	Signal	Wire Color	Pin Locations
X3–15	1	1033	red/white	
X3–6	1	1034	orange	
X3–16	1	1035	green/white	
X3–7	1	1036	blue	
X3–17	1	1037	blue/white	
X3–8	1	1038	white/black	
X3–18	1	1039	black/red	
X3–9	1	1040	red/black	
X3–25	1	group 1 return	blue/red	
X3–26	1	group 1 return	red/green	
X3–10	2	1041	green/black	
X3–1	2	1042	black	
X3–11	2	1043	orange/black	
X3–2	2	1044	white	
X3–12	2	1045	blue/black	
X3–3	2	1046	red	
X3–13	2	1047	black/white	
X3–4	2	1048	green	
X3–19	2	group 2 return	white/red	
X3–20	2	group 2 return	orange/red	

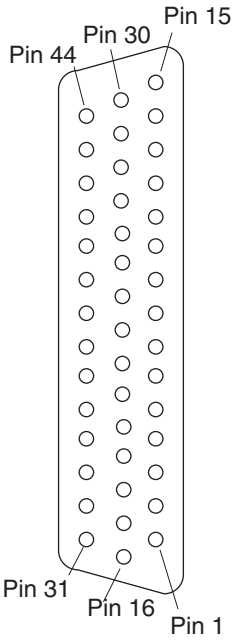
X3 26-pin female input connector on sDIO front panel

Table A-6. X4 Input Cable Pin Assignments

Pin Number	Signal Group	Signal	Wire color	Pin Locations
X4–15	3	1049	red/white	
X4–6	3	1050	orange	
X4–16	3	1051	green/white	
X4–7	3	1052	blue	
X4–17	3	1053	blue/white	
X4–8	3	1054	white/black	
X4–18	3	1055	black/red	
X4–9	3	1056	red/black	
X4–25	3	group 3 return	blue/red	
X4–26	3	group 3 return	red/green	
X4–10	4	1057	green/black	
X4–1	4	1058	black	
X4–11	4	1059	orange/black	
X4–2	4	1060	white	
X4–12	4	1061	blue/black	
X4–3	4	1062	red	
X4–13	4	1063	black/white	
X4–4	4	1064	green	
X4–19	4	group 4 return	white/red	
X4–20	4	group 4 return	orange/red	

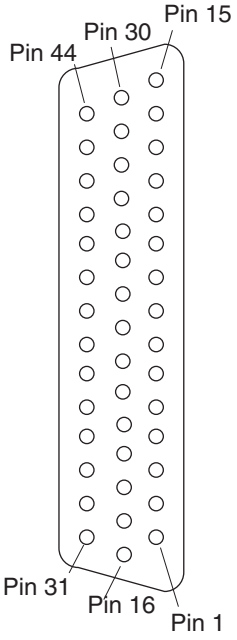
X4 26-pin female input connector on sDIO front panel

Table A-7. X1 Output Cable Pin Assignments

Pin Number	Group Number	Signal name	Wire Color	Pin Locations
X1–30	1	0033	green/black/white	
X1–15	1	0034	green/white	
X1–14	1	0035	red/white	
X1–13	1	0036	black/white	
X1–12	1	0037	blue/black	
X1–11	1	0038	orange/black	
X1–10	1	0039	green/black	
X1–9	1	0040	red/black	
X1–25	1	power	orange/green	
X1–26	1	power	black/white/red	
X1–38	1	power	orange/black/green	
X1–39	1	power	blue/white/orange	
X1–40	1	power	black/white/orange	
X1–41	1	power	white/red/orange	
X1–42	1	power	orange/white/blue	
X1–43	1	power	white/red/blue	
X1–44	1	power	black/white/green	
X1–28	1	group 1 return	white/black/red	
X1–29	1	group 1 test	red/black/white	
X1–7	2	0041	white/black	
X1–6	2	0042	blue	
X1–5	2	0043	orange	
X1–4	2	0044	green	
X1–3	2	0045	red	
X1–2	2	0046	white	
X1–1	2	0047	black	
X1–16	2	0048	blue/white	
X1–17	2	power	black/red	
X1–18	2	power	white/red	
X1–19	2	power	orange/red	
X1–31	2	power	orange/black/white	
X1–32	2	power	blue/black/white	
X1–33	2	power	black/red/green	
X1–34	2	power	white/red green	
X1–35	2	power	red/black/green	
X1–36	2	power	green/black/orange	
X1–21	2	group 2 return	blue/red	
X1–22	2	group 2 test	red/green	

X1 44-pin female output connector on sDIO front panel

Table A-8. X2 Output Cable Pin Assignments

Pin Number	Group Number	Signal Name	Wire Color	Pin Locations
X2–30	3	0049	green/black/white	
X2–15	3	0050	green/white	
X2–14	3	0051	red/white	
X2–13	3	0052	black/white	
X2–12	3	0053	blue/black	
X2–11	3	0054	orange/black	
X2–10	3	0055	green/black	
X2–9	3	0056	red/black	
X2–25	3	power	orange/green	
X2–26	3	power	black/white/red	
X2–38	3	power	orange/black/green	
X2–39	3	power	blue/white/orange	
X2–40	3	power	black/white/orange	
X2–41	3	power	white/red/orange	
X2–42	3	power	orange/white/blue	
X2–43	3	power	white/red/blue	
X2–44	3	power	black/white/green	
X2–28	3	group 3 return	white/black/red	
X2–29	3	group 3 test	red/black/white	
X2–7	4	0057	white/black	
X2–6	4	0058	blue	
X2–5	4	0059	orange	
X2–4	4	0060	green	
X2–3	4	0061	red	
X2–2	4	0062	white	
X2–1	4	0063	black	
X2–16	4	0064	blue/white	
X2–17	4	power	black/red	
X2–18	4	power	white/red	
X2–19	4	power	orange/red	
X2–31	4	power	orange/black/white	
X2–32	4	power	blue/black/white	
X2–33	4	power	black/red/green	
X2–34	4	power	white/red/green	
X2–35	4	power	red/black/green	
X2–36	4	power	green/black/orange	
X2–21	4	group 4 return	blue/red	
X2–22	4	group 4 test	red/green	

X2 44-pin female output connector on sDIO front panel

Adept DeviceNet B

DeviceNet is a low-cost communications link that connects industrial devices to a network and eliminates expensive hard-wiring. The direct connectivity provides improved communication between devices as well as important device-level diagnostics not easily available using hard-wired I/O interfaces.

B.1 DeviceNet Specifications

Adept Technology is a member of the Open DeviceNet Vendor Association (ODVA), which is independently run and operated and not directly associated with any one company. The ODVA controls DeviceNet technical specifications with help from Special Interest Groups (SIGs). Each SIG develops device profiles for one line of product features to ensure interoperability. These profiles become part of the technical specifications.

The DeviceNet Specification is divided into two volumes and defines the following elements:

Volume 1

- DeviceNet Communication Protocol and Application (Layer 7 - Application Layer[1])
- Controller Area Network (CAN) and its use in DeviceNet (Layer 2 - Data Link Layer)
- DeviceNet Physical Layer and Media (Layer 1 - Physical Layer)

Volume 2

- Device profiles to obtain interoperability and interchangeability among like products

DeviceNet incorporates CAN, which defines the syntax or form of the data transmitted. The DeviceNet application layer defines the semantics or meaning of the data transmitted. For more information on the basics of a DeviceNet cable system, contact ODVA at:

ODVA Technology and Training Center
4220 Varsity Drive, Suite A
Ann Arbor, MI 48108-5006 USA
Phone Number: 1-734-975-8840
Fax Number: 1-734-922-0027
www.odva.org

[1] These layers are based on the Open Systems Interconnect (OSI) model.

B.2 Limitations of the Adept DeviceNet Scanner

The DeviceNet Scanner that Adept has incorporated into the SmartController hardware and the V+ operating system currently supports only a subset of full DeviceNet functionality. The following is a summary of the DeviceNet implementation:

- Implemented the *Master-Slave* operation. This is a complete subset of Peer-to-Peer operation.
- Implemented the *Unconnected Message Manager* (UCMM) in its DeviceNet Scanner to establish connections.
- UCMM is used to establish *I/O Connections*.
- The Adept DeviceNet Scanner can be a *Client* or a *Server* on the network.
- The Adept DeviceNet Scanner currently does **not** support *Cyclic* or *Change-of-State* connections.
- Only *I/O Messaging* is supported. I/O messages contain only data.
- Currently, only the *Message Group 2* of the *Predefined Master/Slave Connection Set* is supported.
- Adept Message Group 2 I/O connections support only the *I/O Poll Command/Response Message* of the possible message types.

B.3 Adept Supplied DeviceNet Hardware

Adept supplies the following DeviceNet hardware in the SmartController:

Micro-style 12 mm thread DIN connector (female). See **Table B-1** for Pin assignments.

Table B-1. DeviceNet Signal to Pin Locations

Pin	Signal Name
1	Drain
2	V+
3	V-
4	CAN_H
5	CAN_L

See **Figure B-6 on page 96** for a drawing of the connectors.

NOTE: Adept does not supply 24 V on the SmartController to power the DeviceNet bus. A separate power supply is required to power the components on the DeviceNet bus.

WARNING: The DeviceNet specification requires that the CAN_H and CAN_L signal lines tolerate voltages up to 18 V. Since the supply voltage exceeds 18 V, improperly wiring the supply voltage to these signal lines may cause equipment damage.

B.4 DeviceNet Physical Layer and Media

The DeviceNet physical layer and media specifications are published in the ODVA manual, chapter 9, volume 1. It describes possible topologies and components of the physical layer of the DeviceNet.

Figure B-1 on page 89 shows several possible topologies. The DeviceNet specifications also specify system grounding, mixing of thick and thin cable media, termination, and power distribution.

The basic topology is the trunkline-dropline topology. This topology uses separate twisted-pair buses for the distribution of signals and power. The specifications allow trunklines and droplines made of thick or thin cable. The baud rate, maximum distance from end-to-end of the network, and cable size are dependent on each other. See **Table B-2 on page 91** for further details.

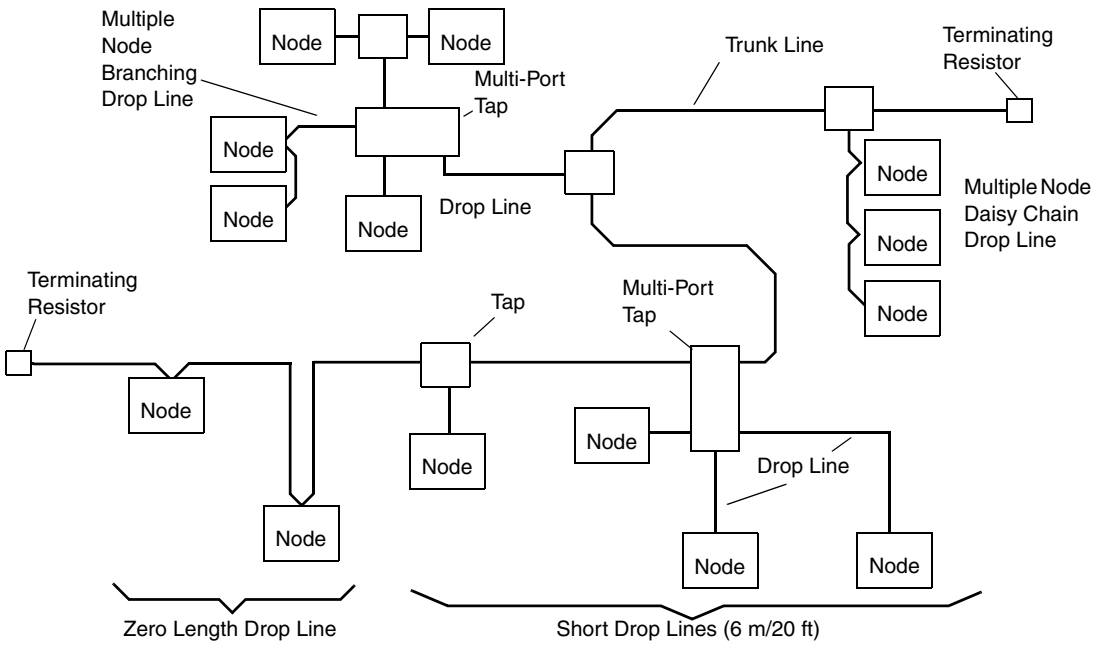


Figure B-1. Trunklines and Droplines Made of Thick and Thin Cable

DeviceNet allows devices to be powered directly from the bus, and devices can use the same cable to communicate with other devices on the bus. DeviceNet nodes are hot-plugable — you can remove or add components on the bus without powering down the network.

> **NOTE:** This hot-plugable feature is not fully supported. If you add a new component to the network, you must make changes with the Adept ACE software. Those changes are not active until you reboot the Adept SmartController.

The power distribution on the network/bus does not need to be in one place. The distribution of power supplies needs to be well planned since there are certain constraints on the power supply. In general, power supplies can be placed at any point in the network. The maximum current rating of a trunkline is 8 amps. DeviceNet allows opto-isolated, externally powered devices (e.g., AC drive starters and solenoid valves) to operate on the same bus cable. For detailed information, see the DeviceNet Technical Specifications.

Table B-2. Features of a DeviceNet Network

Network Size	A maximum of 64 nodes [0...63]
Network Length	Selectable, end-to-end network distance varies with speed
Baud Rate	Distance (thick cable)
125 Kbps	500 m (1,640 ft.)
250 Kbps	250 m (820 ft.)
500 Kbps	100 m (328 ft.)
Data Packets	0-8 bytes
Bus Topology	Linear (trunkline/dropline); power and signal on the same network cable
Bus Addressing	Multi-Master and Master/Slave special case; polled
System Features	Removal and replacement of devices from the network under power not supported by Adept

The baud rate of the system depends on the length of the network (end-to-end) and the type of cable. The following table shows how cable selection and trunkline length affect the maximum data rate on the network. **Figure B-2 on page 92** shows a thick cable, and **Figure B-3** shows a thin cable.

Table B-3. DeviceNet Data Rates Relative to Cable Type and Length

Data Rates	125 Kbps	250 Kbps	500 Kbps
Thick Trunk Length	500 m (1,640 ft.)	250 m (820 ft.)	100 m (328 ft.)
Thin Trunk Length	100 m (328 ft.)	100 m (328 ft.)	100 m (328 ft.)
Maximum Drop Length	6 m (20 ft.)	6 m (20 ft.)	6 m (20 ft.)
Cumulative Drop Length	156 m (512 ft.)	78 m (256 ft.)	39 m (128 ft.)

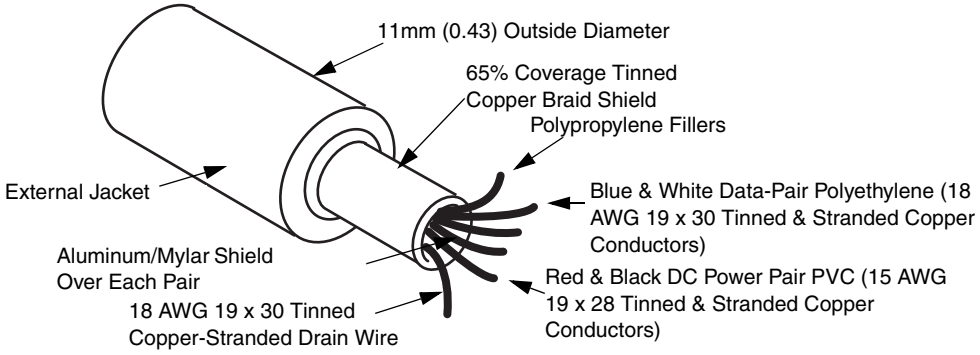


Figure B-2. DeviceNet Thick Cable

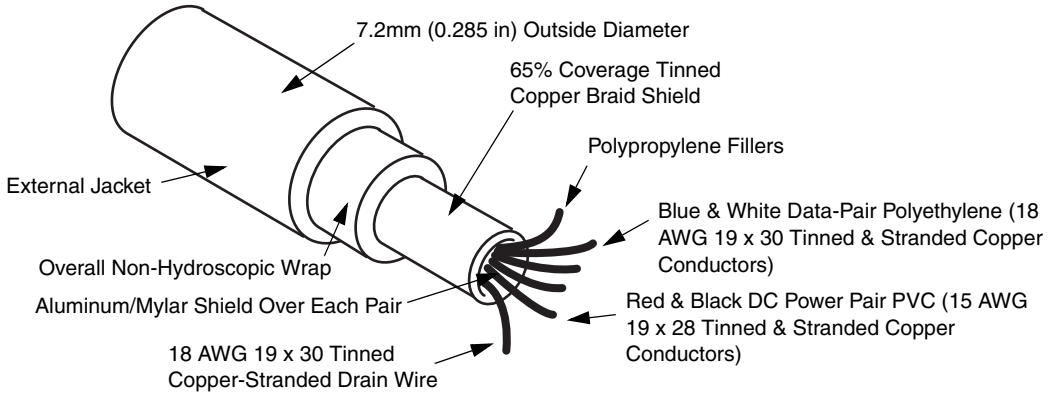


Figure B-3. DeviceNet Thin Cable

DeviceNet Connectors

DeviceNet allows different connectors, which may be grouped into open and sealed connectors. The open connectors are available with screw or with crimp connectors. The sealed connectors are available in mini-style and micro-style sizes. See **Figure B-4** and **Table B-4** for more details.

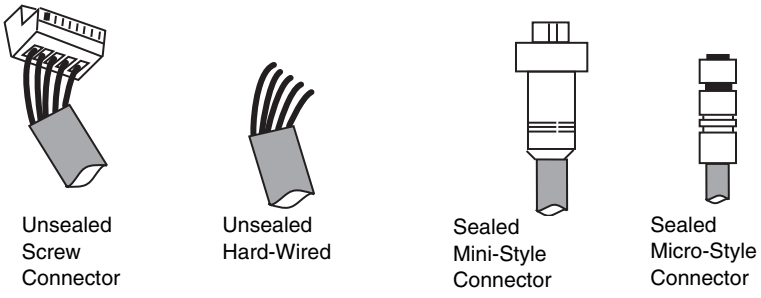


Figure B-4. DeviceNet Connectors

Table B-4. DeviceNet Connector Styles

Connector	Description
Open plugable	Uses screws to attach cable wires to a removable connector
Open hard-wire	Uses wires attached directly to screw terminals
Sealed mini-style	Attaches to taps and thick or thin cable
Sealed micro-style	Attaches to thin cable only – has a reduced current rating

Termination of the DeviceNet Network

The DeviceNet network uses the Controller Area Network (CAN) bus as the physical layer. This requires that the trunk line of your DeviceNet network be terminated with a resistor at each end. This terminates the signal lines.

The terminating resistor:

- Prevents reflection of communication signals on the network.
- Connects the two signal conductors.
- Must be sealed if the end node uses a sealed tee.
- Must be open if the end node uses an open-style tap.

When using the open-style terminating resistor, connect a 121 ohm, ¼ W resistor to CAN_H and CAN_L (between blue and white data-pair wires).

> **NOTE:** A terminating resistor must also be used whenever a short drop line exceeds 6 m (20 ft.).

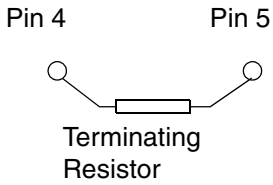


Figure B-5. Example of a Terminating Resistor Installation on a DeviceNet Bus

Power Supply and the DeviceNet Bus

The DeviceNet network allows distribution of power supplies on the network cable system. Follow these general rules to achieve safe and reliable operation:

- Use power supplies rated at 24 V
- Minimize installation problems by using a single power supply with sufficient current to operate all the attached nodes. This must comply with national and international safety standards.
- Make sure that each power supply incorporates current-limit protection.
- Make sure each power supply is temperature compensated.
- Provide over-current protection for each segment of your DeviceNet cable installation.

NOTE: Adept does not supply the 24 V operating voltage for the DeviceNet bus on the SmartController or any other Adept component.

Power Capabilities of a DeviceNet Cable System

WARNING: The DeviceNet specification requires that the CAN_H and CAN_L signal lines tolerate voltages up to 18 V. Since the supply voltage exceeds 18 V, improperly wiring the supply voltage to these signal lines may cause equipment damage.

A DeviceNet cable system has several power rating constraints. The cable type and the length of the cable specify the maximum current on a cable. Thick and thin cable have:

- 24 VDC power rating
- Optional power-supply tabs

If the power supplies are equipped with Schottky diodes, the optional power supply tabs must be protected from bus back-feeding of current among the power supplies on the bus. We also recommended the use of fuse protection for every trunkline in the cable system.

The maximum current rating of a thick cable trunk line is 8 A.Verify that this complies with your national and international standards. It might be necessary to limit the maximum current to a lower value if standards in the U.S. or Canada apply. The maximum current value is a theoretical value. The cable size supports a higher current than 8 A. Depending on the topology of nodes relative to the power supply, higher currents might be possible. See the DeviceNet technical specifications for further information.

The maximum current rating of a thin cable trunk line is 3 A. If you use the thin cable on a long line, the resistance of the cable decreases the maximum current value. See **Table B-5** and the DeviceNet technical specifications for further information.

Table B-5. Maximum Current on a Dropline Relative to its Length

Length of Dropline	Maximum Current
1.5 m (5 ft.)	3 A
2.0 m (6.6 ft.)	2 A
3.3 m (10 ft.)	1.5 A
4.5 m (15 ft.)	1 A
6 m (20 ft.)	0.75 A

For the calculation of the maximum current at a specific length, use the following formula:

$$i = \frac{4.57}{l}$$

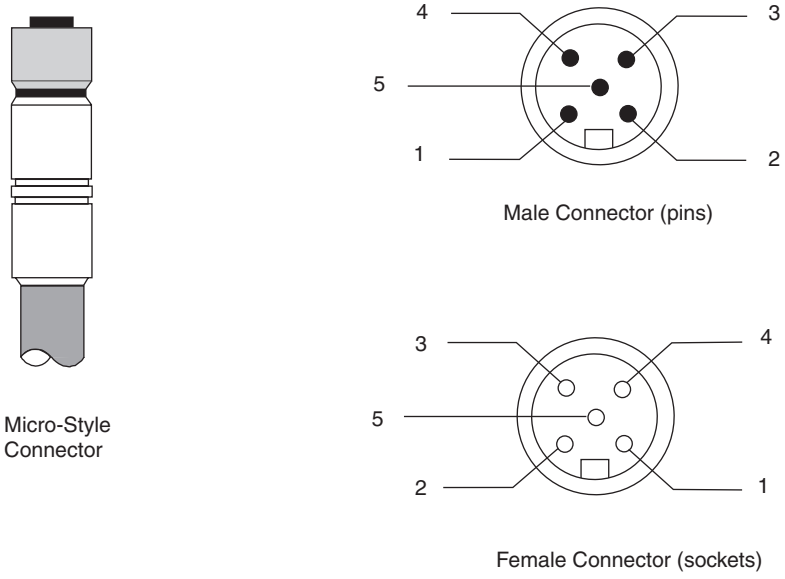
Where:

l= Length of the drop line in meters (m)

i= Maximum current in amps

This calculation applies to the sum of the currents of all the nodes on the selected drop line. The length (l) is not the cumulative length of the drop line; it is the maximum distance from any node on the dropline to the trunk line.

It is important to note that voltage differences between the V– and V+ conductors need to be between 11 V and 25 V. The common-mode voltage between any two places on the V– wire must not exceed 5 V.



LEGEND:

1 Drain (bare)
2 V+ (red)
3 V- (black)
4 CAN_H (white)
5 CAN_L (blue)

Figure B-6. DeviceNet Connector Pinouts

Index

U

V

X

P/N: 00356-00100, Rev. K

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