

IBM TotalStorage DS4500 Fibre Channel Storage
Subsystem



Installation, User's, and Maintenance Guide

IBM TotalStorage DS4500 Fibre Channel Storage
Subsystem



Installation, User's, and Maintenance Guide

Note:

Before using this information and the product it supports, be sure to read the general information in “Notices” on page 195.

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Safety

The caution and danger statements that this document contains can be referenced in the multilingual *IBM® Safety Information* document that is provided with your IBM TotalStorage® DS4500 Storage Subsystem. Each caution and danger statement is numbered for easy reference to the corresponding statements in the translated document.

- **Danger:** These statements indicate situations that can be potentially lethal or extremely hazardous to you. A danger statement is placed just before the description of a potentially lethal or extremely hazardous procedure, step, or situation.
- **Caution:** These statements indicate situations that can be potentially hazardous to you. A caution statement is placed just before the description of a potentially hazardous procedure step or situation.
- **Attention:** These notices indicate possible damage to programs, devices, or data. An attention notice is placed just before the instruction or situation in which damage could occur.

Before installing this product, read the following danger and caution notices.

Statement 1:



DANGER

Electrical current from power, telephone, and communication cables is hazardous.

To avoid a shock hazard:

- **Do not connect or disconnect any cables or perform installation, maintenance, or reconfiguration of this product during an electrical storm.**
- **Connect all power cords to a properly wired and grounded electrical outlet.**
- **Connect to properly wired outlets any equipment that will be attached to this product.**
- **When possible, use one hand only to connect or disconnect signal cables.**
- **Never turn on any equipment when there is evidence of fire, water, or structural damage.**
- **Disconnect the attached power cords, telecommunications systems, networks, and modems before you open the device covers, unless instructed otherwise in the installation and configuration procedures.**
- **Connect and disconnect cables as described in the following table when installing, moving, or opening covers on this product or attached devices.**

To Connect:	To Disconnect:
<ol style="list-style-type: none">1. Turn everything OFF.2. First, attach all cables to devices.3. Attach signal cables to connectors.4. Attach power cords to outlet.5. Turn device ON.	<ol style="list-style-type: none">1. Turn everything OFF.2. First, remove power cords from outlet.3. Remove signal cables from connectors.4. Remove all cables from devices.

Statement 2:



CAUTION:

When replacing the lithium battery, use only IBM Part Number 33F8354 or an equivalent type battery recommended by the manufacturer. If your system has a module containing a lithium battery, replace it only with the same module type made by the same manufacturer. The battery contains lithium and can explode if not properly used, handled, or disposed of.

Do not:

- **Throw or immerse into water**
- **Heat to more than 100°C (212°F)**
- **Repair or disassemble**

Dispose of the battery as required by local ordinances or regulations.

Statement 3:



CAUTION:

When laser products (such as CD-ROMs, DVD drives, fiber optic devices, or transmitters) are installed, note the following:

- Do not remove the covers. Removing the covers of the laser product could result in exposure to hazardous laser radiation. There are no serviceable parts inside the device.
- Use of controls or adjustments or performance of procedures other than those specified herein might result in hazardous radiation exposure.



DANGER

Some laser products contain an embedded Class 3A or Class 3B laser diode. Note the following.

Laser radiation when open. Do not stare into the beam, do not view directly with optical instruments, and avoid direct exposure to the beam.

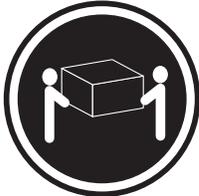
Class 1 Laser statement

Class 1 Laser Product
Laser Klasse 1
Laser Klass 1
Luokan 1 Laserlaite
Appareil À Laser de Calsse 1

IEC 825-11993 CENELEC EN 60 825

Statement 4:



		
≥ 18 kg (39.7 lb)	≥ 32 kg (70.5 lb)	≥ 55 kg (121.2 lb)

CAUTION:

Use safe practices when lifting.

Statement 5:



CAUTION:

The power control button on the device and the power switch on the power supply do not turn off the electrical current supplied to the device. The device also might have more than one power cord. To remove all electrical current from the device, ensure that all power cords are disconnected from the power source.



Statement 8:



CAUTION:

Never remove the cover on a power supply or any part that has the following label attached.



Hazardous voltage, current, and energy levels are present inside any component that has this label attached. There are no serviceable parts inside these components. If you suspect a problem with one of these parts, contact a service technician.

Cable Warning:

WARNING: Handling the cord on this product or cords associated with accessories sold with this product, will expose you to lead, a chemical known to the State of California to cause cancer, and birth defects or other reproductive harm. **Wash hands after handling.**

About this document

This document provides instructions for installing and customizing the configuration of your IBM TotalStorage DS4500 Storage Subsystem. It also provides maintenance procedures and troubleshooting information.

Who should read this document

This document is intended for system operators and service technicians who have extensive knowledge of Fibre Channel and network technology.

How this document is organized

Chapter 1, "Introduction," on page 1 describes the IBM TotalStorage DS4500 Storage Subsystem. This chapter includes an inventory checklist and an overview of the storage subsystem features, operating specifications, and components.

Chapter 2, "Installing the storage subsystem," on page 21 contains information on how to install the DS4500 Storage Subsystem in a standard rack cabinet and setting the interface options.

Chapter 3, "Cabling the storage subsystem," on page 47 contains fibre channel and power cabling information for the DS4500 Storage Subsystem.

Chapter 4, "Operating the storage subsystem," on page 117 contains information on how to power on and off the DS4500 Storage Subsystem, recover from an overheated power supply and fan unit, troubleshoot, and interpret LEDs.

Chapter 5, "Replacing components," on page 145 contains step-by-step instructions about how to install or remove customer replaceable units (CRUs), such as power supply, fan and communications module, redundant array of independent disk (RAID) controllers, battery unit, mini hubs, and storage subsystem fan.

Chapter 6, "Hardware maintenance," on page 163 describes problems and symptoms that are specific to the DS4500 Storage Subsystem. It also provides a parts list for the DS4500 Storage Subsystem.

Appendix A, "Records," on page 167 provides a table that you can use to record and update important information about your DS4500 Storage Subsystem, including serial number and device records.

Appendix B, "Rack mounting template," on page 171 provides the rack mounting templates for installation of the DS4500 Storage Subsystem. If you want to tear out the templates from the document for use during installation, use these copies of the templates.

Appendix C, "Power cords," on page 175 lists power cord information for the DS4500 Storage Subsystem.

Appendix D, "Additional DS4000 documentation," on page 179 lists additional DS4000™ documents.

Appendix E, "Accessibility," on page 189 details accessibility information.

Appendix F, “Product Recycling and Disposal,” on page 191 details the European directive about product recycling.

DS4000 Storage Subsystem installation tasks - General overview

Table 1 provides a sequential list of many installation and configuration tasks that are common to most DS4000 configurations. When you install and configure your DS4000 storage subsystem, refer to this table to find the documentation that explains how to complete each task.

See also: The *DS4000 Storage Subsystem and Storage Expansion Enclosure Quick Start Guide* provides an excellent overview of the installation process.

Table 1. Where to find DS4000 installation and configuration procedures

	Installation task	Where to find information or procedures
1	Plan the installation	<ul style="list-style-type: none"> • <i>DS4000 Storage Manager Concepts Guide</i> • <i>DS4000 Storage Manager Installation and Support Guide for AIX®, HP-UX, Solaris and Linux® on POWER™</i> • <i>DS4000 Storage Manager Installation and Support Guide for Windows® 2000/Server 2003, NetWare, ESX Server, and Linux</i> • <i>DS4100 Storage Server Installation, User's, and Maintenance Guide</i> • <i>DS4200 Express Storage™ Subsystem Installation, User's, and Maintenance Guide</i> • <i>DS4300 Fibre Channel Storage Server Installation and User's Guide</i> • <i>DS4400 Fibre Channel Storage Server Installation and Support Guide</i> • <i>DS4500 Fibre Channel Storage Server Installation and User's Guide</i> • <i>DS4700 Storage Subsystem Installation, User's, and Maintenance Guide</i> • <i>DS4800 Storage Subsystem Installation, User's, and Maintenance Guide</i>
2	Mount the DS4000 storage subsystem in the rack	<ul style="list-style-type: none"> • <i>DS4800 Installation, User's, and Maintenance Guide</i> • <i>DS4700 Installation, User's, and Maintenance Guide</i> • <i>DS4500 Installation and User's Guide</i> • <i>DS4400 and DS4500 Rack Mounting Instructions</i> • <i>DS4300 Rack Mounting Instructions</i> • <i>DS4200 Express Installation, User's, and Maintenance Guide</i> • <i>DS4100 Installation, User's and Maintenance Guide</i>
3	Mount the DS4000 EXP storage expansion unit in the rack	<ul style="list-style-type: none"> • <i>DS4000 EXP100 Storage Expansion Unit Installation, User's and Maintenance Guide</i> • <i>DS4000 EXP420 Storage Expansion Enclosures Installation, User's, and Maintenance Guide</i> • <i>DS4000 EXP700 and EXP710 Storage Expansion Enclosures Installation, User's, and Maintenance Guide</i> • <i>DS4000 EXP810 Storage Expansion Enclosures Installation, User's, and Maintenance Guide</i> • <i>FAStT EXP500 Installation and User's Guide</i>

Table 1. Where to find DS4000 installation and configuration procedures (continued)

	Installation task	Where to find information or procedures
4	Route the storage expansion unit Fibre Channel cables	<ul style="list-style-type: none"> • <i>DS4100 Fibre Channel Cabling Instructions</i> • <i>DS4200 Express Installation, User's, and Maintenance Guide</i> • <i>DS4300 Fibre Channel Cabling Instructions</i> • <i>DS4400 Fibre Channel Cabling Instructions</i> • <i>DS4500 Fibre Channel Cabling Instructions</i> • <i>DS4700 Installation, User's, and Maintenance Guide</i> • <i>DS4800 Installation, User's, and Maintenance Guide</i>
5	Route the host server Fibre Channel cables	<ul style="list-style-type: none"> • <i>DS4100 Fibre Channel Cabling Instructions</i> • <i>DS4200 Express Installation, User's, and Maintenance Guide</i> • <i>DS4300 Fibre Channel Cabling Instructions</i> • <i>DS4400 Fibre Channel Cabling Instructions</i> • <i>DS4500 Fibre Channel Cabling Instructions</i> • <i>DS4700 Installation, User's, and Maintenance Guide</i> • <i>DS4800 Installation, User's, and Maintenance Guide</i>
6	Power up the subsystem	<ul style="list-style-type: none"> • <i>DS4100 Storage Server Installation, User's, and Maintenance Guide</i> • <i>DS4200 Express Storage Subsystem Installation, User's, and Maintenance Guide</i> • <i>DS4300 Fibre Channel Storage Server Installation and User's Guide</i> • <i>DS4400 Fibre Channel Storage Server Installation and Support Guide</i> • <i>DS4500 Fibre Channel Storage Server Installation and Support Guide</i> • <i>DS4700 Storage Subsystem Installation, User's, and Maintenance Guide</i> • <i>DS4800 Storage Subsystem Installation, User's, and Maintenance Guide</i>
7	Configure DS4000 network settings	<ul style="list-style-type: none"> • <i>DS4100 Storage Server Installation, User's, and Maintenance Guide</i> • <i>DS4200 Express Storage Subsystem Installation, User's, and Maintenance Guide</i> • <i>DS4300 Fibre Channel Storage Server Installation and User's Guide</i> • <i>DS4400 Fibre Channel Storage Server Installation and Support Guide</i> • <i>DS4500 Fibre Channel Storage Server Installation and Support Guide</i> • <i>DS4700 Storage Subsystem Installation, User's, and Maintenance Guide</i> • <i>DS4800 Storage Subsystem Installation, User's, and Maintenance Guide</i>

Table 1. Where to find DS4000 installation and configuration procedures (continued)

	Installation task	Where to find information or procedures
8	Zone the fabric switch (SAN-attached only)	<ul style="list-style-type: none"> • <i>DS4000 Storage Manager Installation and Support Guide for AIX, HP-UX, Solaris and Linux on POWER</i> • <i>DS4000 Storage Manager Installation and Support Guide for Windows 2000/Server 2003, NetWare, ESX Server, and Linux</i> • <i>DS4000 Storage Manager Copy Services Guide</i> (describes switch zoning for the Remote Mirror Option) • See also the documentation provided by the switch manufacturer
9	Install DS4000 Storage Manager software on the management station	<ul style="list-style-type: none"> • <i>DS4000 Storage Manager Installation and Support Guide for AIX, HP-UX, Solaris and Linux on POWER</i> • <i>DS4000 Storage Manager Installation and Support Guide for Windows 2000/Server 2003, NetWare, ESX Server, and Linux</i> • DS4000 Storage Manager online help (for post-installation tasks)
10	Install host software (failover drivers) on host server	
11	Start DS4000 Storage Manager	
12	Set the DS4000 Storage Manager clock	
13	Set the DS4000 Storage Manager host default type	
14	Verify DS4000 subsystem health	<ul style="list-style-type: none"> • <i>DS4100 Storage Server Installation, User's, and Maintenance Guide</i> • <i>DS4200 Express Storage Subsystem Installation, User's, and Maintenance Guide</i> • <i>DS4300 Fibre Channel Storage Server Installation and User's Guide</i> • <i>DS4400 Fibre Channel Storage Server Installation and Support Guide</i> • <i>DS4500 Fibre Channel Storage Server Installation and Support Guide</i> • <i>DS4700 Storage Subsystem Installation, User's, and Maintenance Guide</i> • <i>DS4800 Storage Subsystem Installation, User's, and Maintenance Guide</i>

Table 1. Where to find DS4000 installation and configuration procedures (continued)

	Installation task	Where to find information or procedures
15	Enable DS4000 Storage Manager premium feature keys	<p>Copy Services premium features <i>DS4000 Storage Manager Copy Services Guide</i></p> <p>FC/SATA Intermix premium feature <i>DS4000 Fibre Channel and Serial ATA Intermix Premium Feature Installation Overview</i></p> <p>Storage Partitioning (and general premium features information)</p> <ul style="list-style-type: none"> • <i>DS4000 Storage Manager Concepts Guide</i> • <i>DS4000 Storage Manager Installation and Support Guide for AIX, HP-UX, Solaris and Linux on POWER</i> • <i>DS4000 Storage Manager Installation and Support Guide for Windows 2000/Server 2003, NetWare, ESX Server, and Linux</i>
16	Configure arrays and logical drives	<ul style="list-style-type: none"> • <i>DS4000 Storage Manager Installation and Support Guide for AIX, HP-UX, Solaris and Linux on POWER</i>
17	Configure host partitions	<ul style="list-style-type: none"> • <i>DS4000 Storage Manager Installation and Support Guide for Windows 2000/Server 2003, NetWare, ESX Server, and Linux</i>
18	Verify host access to DS4000 storage	<ul style="list-style-type: none"> • DS4000 Storage Manager online help

Getting information, help, and service

If you need help, service, or technical assistance or just want more information about IBM products, you will find a wide variety of sources available from IBM to assist you. This section contains information about where to go for additional information about IBM and IBM products, what to do if you experience a problem with your IBM @server xSeries® or IntelliStation® system, and whom to call for service, if it is necessary.

Before you call

Before you call, make sure that you have taken these steps to try to solve the problem yourself:

- Check all cables to make sure that they are connected.
- Check the power switches to make sure that the system is turned on.
- Use the troubleshooting information in your system documentation and use the diagnostic tools that come with your system.
- Check for technical information, hints, tips, and new device drivers at the following Web site:
www.ibm.com/servers/storage/support/disk/
- Use an IBM discussion forum on the IBM Web site to ask questions.

You can solve many problems without outside assistance by following the troubleshooting procedures that IBM provides in the online help or in the documents that are provided with your system and software. The information that comes with your system also describes the diagnostic tests that you can perform. Most xSeries and IntelliStation systems, operating systems, and programs come with information

that contains troubleshooting procedures and explanations of error messages and error codes. If you suspect a software problem, see the information for the operating system or program.

Using the documentation

Information about the xSeries or IntelliStation system and preinstalled software, if any, is available in the documents that come with your system. This includes printed documents, online documents, readme files, and help files. See the troubleshooting information in your system documentation for instructions on how to use the diagnostic programs. The troubleshooting information or the diagnostic programs might tell you that you need additional or updated device drivers or other software.

Web sites

IBM maintains pages on the World Wide Web where you can get the latest technical information and download device drivers and updates.

- For DS4000 information, go to the following Web site:
www.ibm.com/servers/storage/support/disk/
The support page has many sources of information and ways for you to solve problems, including:
 - Diagnosing problems using the IBM Online Assistant
 - Downloading the latest device drivers and updates for your products
 - Viewing frequently asked questions (FAQ)
 - Viewing hints and tips to help you solve problems
 - Participating in IBM discussion forums
 - Setting up e-mail notification of technical updates about your products
- You can order publications through the IBM Publications Ordering System at the following web site:
www.elink.ibm.com/public/applications/publications/cgibin/pbi.cgi/
- For the latest information about IBM xSeries products, services, and support, go to the following Web site:
www.ibm.com/eserver/xseries/
- For the latest information about IBM pSeries® products, services, and support, go to the following Web site:
www.ibm.com/eserver/pseries/
- For the latest information about the IBM IntelliStation information, go to the following Web site:
www-132.ibm.com/content/home/store_IBMPublicUSA/en_US/IntelliStation_workstations.html
- For the latest information about operating system and HBA support, clustering support, SAN fabric support, and Storage Manager feature support, see the TotalStorage DS4000 Interoperability Matrix at the following Web site:
www.ibm.com/servers/storage/disk/ds4000/interop-matrix.html

Software service and support

Through IBM Support Line, for a fee you can get telephone assistance with usage, configuration, and software problems with xSeries servers, IntelliStation workstations, and appliances. For information about which products are supported by Support Line in your country or region, go to the following Web site:

www.ibm.com/services/sl/products/

For more information about the IBM Support Line and other IBM services, go to the following Web sites:

- www.ibm.com/services/
- www.ibm.com/planetwide/

Hardware service and support

You can receive hardware service through IBM Integrated Technology Services or through your IBM reseller, if your reseller is authorized by IBM to provide warranty service. Go to the following Web site for support telephone numbers:

www.ibm.com/planetwide/

In the U.S. and Canada, hardware service and support is available 24 hours a day, 7 days a week. In the U.K., these services are available Monday through Friday, from 9 a.m. to 6 p.m.

Fire suppression systems

A fire suppression system is the responsibility of the customer. The customer's own insurance underwriter, local fire marshal, or a local building inspector, or both, should be consulted in selecting a fire suppression system that provides the correct level of coverage and protection. IBM designs and manufactures equipment to internal and external standards that require certain environments for reliable operation. Because IBM does not test any equipment for compatibility with fire suppression systems, IBM does not make compatibility claims of any kind nor does IBM provide recommendations on fire suppression systems.

How to send your comments

Your feedback is important in helping us to provide the most accurate and high-quality information. If you have comments or suggestions for improving this publication, you can send us comments electronically by using these addresses:

- Internet: starpubs@us.ibm.com
- IBMLink™ from U.S.A.: STARPUBS at SJEVM5
- IBMLink from Canada: STARPUBS at TORIBM
- IBM Mail Exchange: USIB3WD at IBMMAIL

You can also mail your comments by using the Reader Comment Form in the back of this manual or direct your mail to:

International Business Machines Corporation
Information Development
Dept. GZW
9000 South Rita Road
Tucson, AZ 85744-0001
U.S.A.

Chapter 1. Introduction

This chapter describes the operating specifications, features, and components for the IBM TotalStorage DS4500 Storage Subsystem (hereafter referred to as *DS4500* or *storage subsystem*).

This chapter also includes an inventory checklist and important information on best practices guidelines and product updates for your DS4500.

Overview

IBM DS4000 solutions support the large and growing data storage requirements of business-critical applications. These scalable IBM DS4000 solutions offer you data access and protection to meet your existing enterprise storage requirements and prepare for the future.

The DS4500 Storage Subsystem (Machine type 1742, models 90U and 90X) supports direct attachment of up to four hosts that contain two host adapters each, and is designed to provide maximum host-side and drive-side redundancy. By using external Fibre Channel switches in conjunction with the DS4500, you can attach up to 64 hosts with two adapters each to a DS4500 Storage Subsystem.

Each DS4500 Storage Subsystem contains several removable components, called customer replaceable units (CRUs), that you can access from either the front or back of the unit. These CRUs include the battery unit, RAID controllers, storage subsystem fan, power supplies, fan and communications module, and mini hubs. The DS4500 Storage Subsystem also has a removable front bezel.

The DS4500 Storage Subsystem functions with at least one external storage expansion enclosure containing Fibre Channel (FC) or Serial Advanced Technology Attachment (SATA) hard drives. The DS4500 Storage Subsystem supports a maximum of 224 hard drives when the drives are configured using IBM DS4000 EXP700, DS4000 EXP710, DS4000 EXP100, or DS4000 EXP810 storage expansion enclosures. If the drives are configured using IBM FASTT EXP500 storage expansion enclosures only, a maximum of 220 hard drives are supported.

Attention:

- To attach DS4000 EXP drive expansion enclosures to a DS4500, refer to the various sections in this *IBM TotalStorage DS4500 Fibre Channel Storage Subsystem Installation, User's, and Maintenance Guide* for the required software and firmware version, supported drive expansion enclosures and drive loop cabling rules and instructions. In addition, you must purchase the FC/SATA Enclosure Intermix premium option to combine DS4000 EXP100s or DS4000 EXP810s with SATA enhanced disk drive modules (E-DDMs) with DS4000 EXP700s, DS4000 EXP710s, or DS4000 EXP810s with fibre channel drives in the same DS4500 Storage Subsystem configuration. You can also refer to the *IBM System Storage™ DS4000 Hard Drive and Storage Expansion Enclosure Installation and Migration Guide* for additional information on the required version of the DS4500 controller firmware and the supported combination of enclosure types intermix behind a DS4500 subsystem.
- The DS4500 controller units are not compatible with the DS4400 or FAStT500 controller units. The DS4500 controller units are keyed to prevent them from being mistakenly inserted in the non-supported storage subsystem units. Do not force fit the controller units or the backplane might be damaged.

The DS4000 Storage Manager client is also available for the DS4500. This storage management software is designed to help centralize storage management, help simplify partitioning of the DS4000 series storage into as many as 64 virtual servers, and strategically allocate storage capacity to maximize storage space.

Operating system support

Microsoft® Windows 2000 Server and Advance Server, Microsoft Windows 2003 Server and Enterprise Edition, Sun®Solaris, IBM AIX, RedHat Enterprise Linux Server, and SuSE Linux Enterprise Server, HP-UX, Novell Netware, Linux on POWER and VMware ESX Server are the supported operating systems for host servers that have mapped LUNs created in the DS4500 with storage expansion enclosures. See the latest DS4000 Storage Manager host software readme file and the IBM DS4000 series products interoperability matrix at the following Web site for additional host operating system support:

www.ibm.com/servers/storage/disk/ds4000/interop-matrix.html

Fibre channel defined

Fibre channel technology is outlined in the *SCSI-3 Fibre Channel Protocol* (SCSI-FCP) standard. Fibre channel is a high-speed data transport technology that is used for mass storage and networking.

Using a fibre channel arbitrated loop (FC-AL), more than 100 fibre-channel devices can be supported, compared to 15 small computer system interface (SCSI) devices. The fibre channel connection speed from the DS4500 to storage expansion enclosures is either 2 Gbps depending on the type of enclosures to which the DS4500 is connected, allowing data transfer rates up to 200 Mbps half-duplex and 400 Mbps full-duplex on optical interfaces.

SATA defined

The Serial Advanced Technology Attachment (SATA) interface offers increased data rate performance over Parallel Advanced Technology Attachment (ATA), while maintaining the benefits of ATA. SATA is designed to overcome the performance barriers that have been forecasted for current parallel technologies while maintaining the cost-efficiency of Parallel ATA. SATA specifications allow for thinner,

more flexible cables, and lower pin counts. It also enables easier, more flexible cable routing management and the use of smaller connectors than is possible with the existing Parallel ATA technology.

The Serial ATA Working Group introduced the first SATA specification, Serial ATA 1.0, in 2001 (<http://www.serialata.org>).

Inventory checklist

After you unpack the DS4500, verify that you have the following items.

Note: Depending on your DS4500 order, your shipping box might contain additional materials not listed in the following checklist. Review the inventory checklist included in the DS4500 shipping box for any additional parts, and use that checklist in combination with the following information.

- **Hardware**

- Bezel (front cover) (1)
- RAID controllers (2)
- Battery unit (1)
- Storage subsystem fan (1)
- Power supplies (2)
- Host mini hubs (depends on order; 2 minimum, 4 maximum)
- Drive mini hubs (depends on order; 2 minimum, 4 maximum)
- Fan and communications module (1)
- Rack line cord jumpers (2)
- Rack-mounting hardware kit (1), including:
 - Rails (2) (right and left assembly)
 - M6 black hex-head slotted screws (8)
 - Clip nuts (8)
 - Cage nuts (8)
 - White tape dots

- **Software and documentation**

- Storage Manager version 9 support for Linux CD, a Storage Manager version 9 support for Netware CD, and a Storage Manager version 9 CD support for Microsoft Windows 2000 and Windows Server 2003, each including:
 - Storage Manager version 9 host software for appropriate OS.
 - Controller firmware and NVSRAM, storage expansion enclosure ESM firmware, and supported Fibre Channel (FC) HBA drivers.
 - Publications in Adobe Acrobat Portable Document Format (PDF).
- *IBM TotalStorage DS4500 Storage Subsystem Installation and User's Guide*
- *IBM TotalStorage DS4500 Storage Subsystem Fibre Channel Cabling Guide*
- *IBM Safety Information*
- IBM License Agreement
- Statement of Limited Warranty
- Entitlement for 16-partition storage partition premium feature
- LC wrap plug and coupler for FC diagnostics. Refer to the *IBM TotalStorage DS4000 Problem Determination Guide* for more information.

Note: Depending on your order, additional host attachment kits, storage partition entitlement, premium feature entitlement, mini hubs, SFPs, or fibre channel cables may also be shipped inside the box.

If an item is missing or damaged, contact your IBM reseller or your IBM marketing representative.

A rack mounting template and instructions for installing the support rails and the storage subsystem are provided in “Installing the support rails” on page 27. If you want to tear out the templates from this document for easier use, use the copies in Appendix B, “Rack mounting template,” on page 171.

Attention: The DS4500 does not ship with region-specific power cords. You must obtain the IBM-approved power cords for your region. See Appendix C, “Power cords,” on page 175 for the IBM-approved power cords for your region.

To connect your DS4500 to other devices, use the following options:

- IBM SFP module
- IBM LC-LC fibre-channel cable
- IBM LC-SC fibre-channel cable (for host-side connections only)
- IBM LC-SC Fibre Channel Cable Adapter
- IBM DS4500 Mini Hub

Note: You must order these options separately.

Product updates

Important

In order to keep your system up to date with the latest firmware and other product updates, use the information below to register and use the **My support** Web site.

Download the latest versions of the DS4000 Storage Manager host software, DS4000 storage subsystem controller firmware, DS4000 drive expansion enclosure ESM firmware, and drive firmware at the time of the initial installation and when product updates become available.

To be notified of important product updates, you must first register at the IBM Support and Download Web site:

www-1.ibm.com/servers/storage/support/disk/index.html

In the Additional Support section of the Web page, click **My support**. On the next page, if you have not already done so, register to use the site by clicking **Register now**.

Perform the following steps to receive product updates:

1. After you have registered, type your user ID and password to log into the site. The **My support** page opens.
2. Click **Add products**. A pull-down menu displays.
3. In the pull-down menu, select **Storage**. Another pull-down menu displays.

4. In the new pull-down menu, and in the subsequent pull-down menus that display, select the following topics:
 - **Computer Storage**
 - **Disk Storage Systems**
 - **TotalStorage DS4000 Midrange Disk Systems & FAStT Stor Svrs**

Note: During this process a check list displays. Do not check any of the items in the check list until you complete the selections in the pull-down menus.

5. When you finish selecting the menu topics, place a check in the box for the machine type of your DS4000 series product, as well as any other attached DS4000 series product(s) for which you would like to receive information, then click **Add products**. The My Support page opens again.
6. On the My Support page, click the **Edit profile** tab, then click **Subscribe to email**. A pull-down menu displays.
7. In the pull-down menu, select **Storage**. A check list displays.
8. Place a check in each of the following boxes:
 - a. **Please send these documents by weekly email**
 - b. **Downloads and drivers**
 - c. **Flashes**
 - d. Any other topics that you may be interested inThen, click **Update**.
9. Click **Sign out** to log out of My Support.

Best practices guidelines

To ensure optimal operation of your system, always follow these best practices guidelines:

- Ensure that your system is in an optimal state before you shut it down. Never turn the power off if any Fault LED is lit; be sure to resolve any error conditions before you shut down the system.
- Back up the data on your storage drives periodically.
- To maintain power redundancy, plug the DS4500 right and left power supply and fan units into two independent external power circuits through AC power distribution units inside a rack cabinet or directly into external receptacles. Similarly, the right and left power supplies of the DS4000 storage expansion enclosures attached to the DS4500 should be plugged into the same two independent external power circuits as the DS4500. This ensures that the DS4500 and all its attached storage expansion enclosures will have power in the event that only one power circuit is available. In addition, having all the right or all the left power cables plug into the same power circuit enables the DS4000 devices in the configuration to power on simultaneously during an unattended restoration of power.

Note: Do not overload the circuits that power your storage subsystem and storage expansion enclosures. Use additional pairs of AC power distribution units (PDUs) if necessary. Refer to Table 9 on page 16 for information on storage subsystem power requirements. Contact your IBM service representative for additional information if needed.

- Before any planned system shutdown or after any system additions, removals, or modifications (including firmware updates, logical drive creations, storage

partitioning definitions, hardware changes, and so on), save the storage subsystem profile as explained in the DS4000 Storage Manager guide for your operating system. Save the profile in a location other than in the logical drives created for the DS4500.

- During any maintenance or attended power-up procedure, carefully follow the power-up sequence listed in “Powering on the storage subsystem” on page 119. Check that each component of the subsystem is powered-on in the proper order during this entire power-up procedure to ensure the controller will be able to optimally access all of your storage subsystems.
- The storage subsystem supports simultaneous power-up to the system components; however, you should always follow the power-up sequence listed in “Powering on the storage subsystem” on page 119 during any attended power-up procedure.
- A storage subsystem in an optimal state should recover automatically from an unexpected shutdown and unattended simultaneous restoration of power to system components. After power is restored, call IBM support if any of the following conditions occur:
 - The storage subsystem logical drives and subsystems are not displayed in the DS4000 Storage Manager graphical user interface (GUI).
 - The storage subsystem logical drives and subsystems do not come online.
 - The storage subsystem logical drives and subsystems seem to be degraded.

Storage subsystem components

The storage subsystem has the following removable components. These components, called customer replaceable units (CRUs), are accessible from the front or back of the storage subsystem.

- One bezel (front cover)
- Two RAID controllers
- One storage subsystem fan
- One battery unit
- Up to four host mini hubs
- Up to four drive mini hubs
- One fan and communications module
- Two power supplies

Figure 1 on page 7 shows the front view of the DS4500 Storage Subsystem without the front bezel.

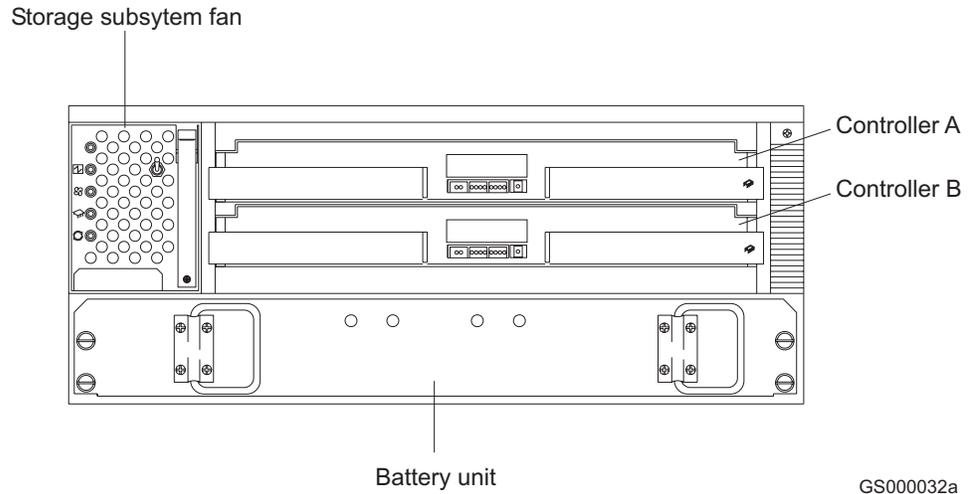


Figure 1. IBM TotalStorage DS4500 Storage Subsystem - front view

Figure 2 shows the back view of the DS4500 Storage Subsystem.

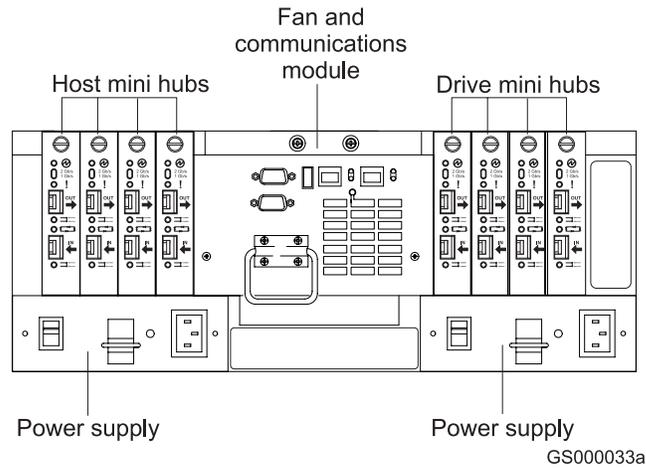
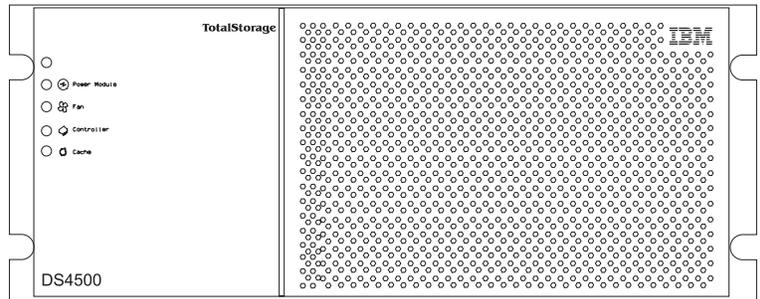


Figure 2. IBM TotalStorage DS4500 Storage Subsystem - back view

Bezel

The bezel is a removable front cover with holes for viewing status LEDs and for boosting air circulation. Figure 3 on page 8 shows the DS4500 Storage Subsystem front bezel.



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Figure 3. DS4500 Storage Subsystem bezel

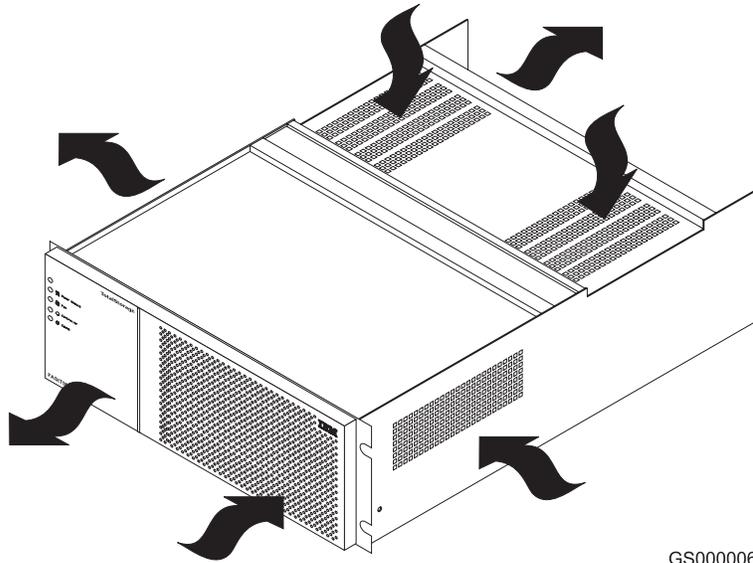
Storage subsystem fan

The storage subsystem fan is a single, removable unit that contains two cooling fans and temperature monitoring circuitry. The storage subsystem fan plugs directly into a slot on the front of the DS4500 Storage Subsystem, to the left of the controllers (see Figure 1 on page 7). There are five LEDs that provide overall system status information (see Figure 88 on page 127). The dual fans in the storage subsystem fan unit provide a redundant cooling system to both controller CRUs. If one fan fails, the other continues to operate, providing sufficient air circulation to prevent the controllers from overheating until you can replace the entire storage subsystem fan.

To prevent cooling problems, the DS4500 Storage Subsystem must have proper air circulation throughout the chassis. Cooling problems include any malfunctions or obstructions that impede air flow and cause one or more components in the DS4500 Storage Subsystem to overheat. Make sure that the ambient air temperature around the DS4500 Storage Subsystem is within the environmental requirements. To boost air circulation, the DS4500 Storage Subsystem chassis has air vents along its top and sides. These vents serve as air intake and exhaust passages. Always keep vents clean and free of obstructions.

Figure 4 on page 9 shows the DS4500 Storage Subsystem air flow. Make sure your installation site allows adequate ventilation to the DS4500 Storage Subsystem during operation.

Note: Allow at least 60 cm (2 ft) of clearance in front of and behind the DS4500 Storage Subsystem for proper ventilation.



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Figure 4. DS4500 Storage Subsystem airflow

Controllers

The DS4500 Storage Subsystem supports RAID technology. The DS4500 contains two removable units that each contain one RAID controller with 1 GB cache memory.

Each controller, shown in Figure 1 on page 7, slides into one of two controller slots on the front of the DS4500 Storage Subsystem and attaches to hosts through Fibre Channel connections. Two handles lock the controller in place. Each controller slot has a controller slot designation that identifies the physical location of the controller in the chassis: controller slot A (top) or controller slot B (bottom). Each controller CRU has ten indicator lights: one power, one fault, and eight status indicator lights.

Attention: The DS4500 controller units are not compatible with the controller units from the DS4400 or FASt500 Fibre Channel Storage subsystems. DS4500 controller units normally have the metallic gold latch handle. Do not mix the DS4500 controller units with IBM DS4400 or FASt500 controller units in the same storage subsystem units. The DS4500 controller units are also keyed to prevent them from being mistakenly inserted in the non-supported storage subsystem units. Do not force the controller units or the backplane might be damaged.

Battery unit

The battery unit CRU contains lead-acid, rechargeable batteries and a battery-charger board. The battery unit CRU plugs into the front of the DS4500 Storage Subsystem (see Figure 1 on page 7) where it provides backup power to the cache memory in both controllers. During a power outage, a properly charged battery unit CRU maintains electrical current to the controllers for up to three days with 1 GB cache memory installed. All data stored in memory is preserved as long as the batteries can sustain power to the cache memory. However, the battery does not provide power to the rest of the system during a power outage. Therefore, the system is not able to write data to hard disk drives without a backup power source.

Mini hubs

The mini hubs are located on the back of the DS4500 Storage Subsystem (see Figure 2 on page 7). A mini hub is a single, removable unit that provides the Fibre Channel interface between a DS4500 and hosts or drive expansion enclosures. The back of the DS4500 can accommodate eight mini hubs: up to four host-side and up to four drive-side mini hubs. The standard DS4500 Storage Subsystem ships with two mini hubs installed in host-side mini hubs slots 1 and 2 and two mini hubs installed in drive-side mini hubs slots 4 and 2. Each mini hub has two ports. An SFP module is installed in a mini-hub port; then, a fiber-optic interface cable is connected into the SFP module. For more information, see “Working with SFPs and fiber-optic cables” on page 47.

Note: Although the drive-side mini hubs have two ports, only one of the ports are used for drive loop connection. The other port must be left empty, with no SFP module inserted and no FC connection made to the port.

Fan and communications module

The fan and communications module is a single, removable unit that contains two cooling fans and two Ethernet ports. This module plugs into a slot at the center back of the DS4500 Storage Subsystem, just above the power supplies (see Figure 2 on page 7). There are two captive screws and a rectangular handle for securing and removing the module. The module contains dual fans that provide a redundant cooling system to both power supplies. If one fan within the module fails, the other continues to operate. A single fan provides sufficient air circulation to prevent the power supplies from overheating until you can replace the entire fan and communications module.

Power supply

The DS4500 Storage Subsystem power system consists of two power supplies. The power supplies slide into either of the two slots on the back of the DS4500 (see Figure 2 on page 7). The power supplies provide power to the internal components by converting incoming ac voltage to dc voltage. The power supplies are interchangeable and redundant. Each power supply uses one power cord. It is recommended that you plug each cord into a separate circuit for power redundancy. One power supply can maintain electrical power to the DS4500 if the other power supply is turned off or malfunctions.

Software and hardware compatibility and upgrades

The latest DS4000 controller firmware and NVSRAM, the storage expansion enclosure drive enclosure ESM firmware, and the fibre channel drive CRUs firmware must be installed to ensure optimal functionality, manageability, and reliability.

Software and firmware support code upgrades

To enable support for the DS4500, you *must* ensure that your system's software and firmware are at the levels shown in Table 2:

Table 2. Software and firmware levels for the DS4500 Storage Subsystem

Software/firmware	Level
DS4000 Storage Manager software	9.19

Table 2. Software and firmware levels for the DS4500 Storage Subsystem (continued)

Software/firmware	Level
DS4500 controller firmware and NVSRAM	06.19.xx.xx or higher.
ESM firmware for attached storage expansion enclosures	<ul style="list-style-type: none"> • EXP810 - 9877 or higher • EXP710 - 9640 or higher • EXP100 - 9565 or higher • EXP700 - 9330 or higher • EXP500 - 9166 or higher
Drive firmware	<p>You can find the latest drive firmware at the IBM DS4000 TotalStorage Support Web site:</p> <p>www.ibm.com/servers/storage/support/disk/</p>

You can also find the latest DS4000 Storage Manager software, DS4500 controller firmware, and NVSRAM firmware at the IBM DS4000 System Storage Support Web site:

www.ibm.com/servers/storage/support/disk/

See the *IBM System Storage DS4000 Storage Manager 9.19 Installation and Support Guide* for your operating system for instructions that describe how to install the DS4000 Storage Manager 9.19 host software.

The DS4500 is shipped with controller firmware version 6.19.xx.xx, which supports EXP810, EXP710, and EXP100 storage expansion enclosures only.

If you need further assistance, please contact IBM technical support, your IBM reseller, or IBM representative.

DS4500 hardware and software compatibility

Table 3 lists the DS4500 hardware and software compatibility. In the latest release of the DS4500, you can connect EXP810 to the DS4500 Storage Subsystem.

Note: For the latest information about supported servers and operating systems, refer to the interoperability matrix at the following Web site:

www.ibm.com/servers/storage/disk/ds4000/interop-matrix.html

Table 3. DS4500 hardware and software compatibility

Drive expansion enclosure	Storage management software	Controller Firmware	Notes
EXP810, EXP710, EXP100	IBM DS4000 Storage Manager Version 9.19	06.19.xx.xx or higher	EXP700 is not supported by 06.19.xx.xx. The EXP700 can be upgraded by using the <i>DS4000 EXP700 Models 1RU/1RX Switched-ESM Option Upgrade Kit</i> to make it compatible with 06.19.xx.xx and to intermix with EXP810.

Table 3. DS4500 hardware and software compatibility (continued)

Drive expansion enclosure	Storage management software	Controller Firmware	Notes
EXP710, EXP700, EXP100	IBM DS4000 Storage Manager Version 9.19 or later	06.12.xx.xx	06.12.xx.xx is the latest version of DS4500 controller firmware that supports EXP700.
EXP100	IBM DS4000 Storage Manager Version 9.19 or later	05.41.xx.xx or higher (6.19.xx.xx is recommended)	05.41.xx.xx supports only EXP100.
EXP700, EXP500	IBM DS4000 Storage Manager Version 9.16	05.40.xx.xx	EXP500 is supported by 05.40.xx.xx only.

Determining firmware levels

There are two different methods to determine the DS4000 storage subsystem and firmware versions. Each method uses the DS4000 Storage Manager client that manages the DS4500 Storage Subsystem.

Method One:

Go to the Subsystem Management window and select **View → Storage Subsystem Profile**. When the Storage Subsystem Profile window opens, select the **All** tab and scroll through the Profile For Storage Subsystem list to locate the following information.

Note: The Profile For Storage Subsystem list contains all the profile information for the entire subsystem. Therefore, it may be necessary to scroll through a large amount of information to locate the firmware version numbers.

DS4000 Storage Server

- NVSRAM version
- Appware version
- Bootware version

Drives

- Drive Firmware version
- ATA translator card firmware for EXP810 SATA enhanced disk drive module (E-DDM)

ESM

- ESM card firmware version

Method Two:

Complete the appropriate procedure to obtain the specified firmware version.

To obtain the controller firmware version:

Right-click the Controller icon in the Physical View pane of the Subsystem Management window and select **Properties**. The Controller Enclosure properties window opens and displays the properties for that controller.

You must perform this step for each individual controller.

To obtain the drive firmware (and ATA translator card firmware, if appropriate) version:

Right-click the Drive icon in the Physical View pane of the Subsystem

Management window and select **Properties**. The Drive Properties window opens and displays the properties for that drive.

You must perform this step for each individual drive.

To obtain the drive enclosure component ESM firmware version:

1. In the Physical View pane of the Subsystem Management window, click the Drive Enclosure Component icon, which is the icon furthest to the right. The Drive Enclosure Component Information window opens.
2. Click the ESM icon in the left pane. The ESM information displays in the right pane of the Drive Enclosure Component Information window.
3. Locate the firmware version of each ESM in the drive enclosure.

Specifications

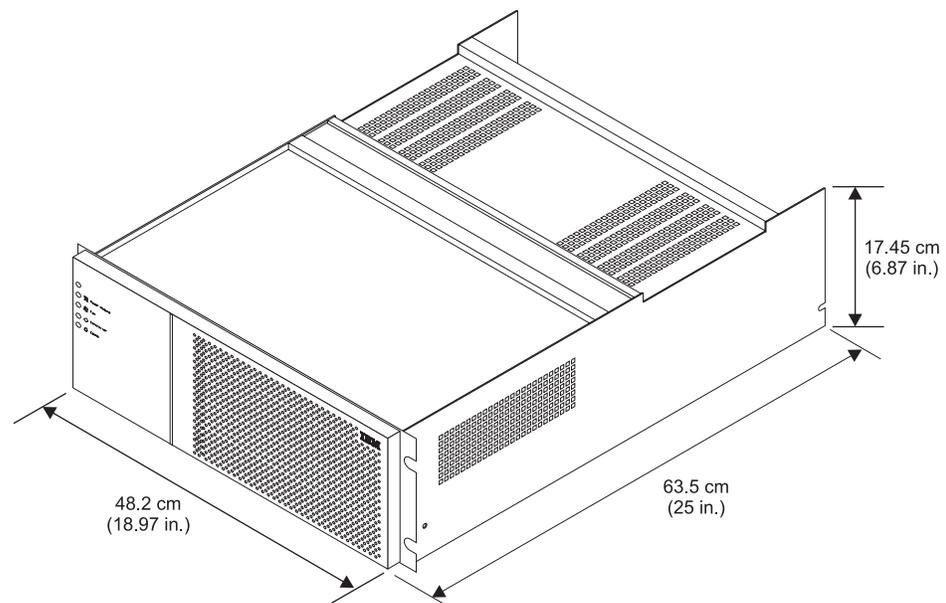
This section provides site specifications for the DS4500 Storage Subsystem. Before installing, you must either verify that your planned installation site meets these requirements, or prepare the site so that it does meet these requirements. Preparations might involve meeting area requirements, environmental requirements, and electrical requirements for DS4500 Storage Subsystem installation, service, and operation.

Area requirements

The floor space at the installation site must provide enough strength to support the weight of the storage subsystem and associated equipment; sufficient space to install, operate, and service the storage subsystem; and sufficient ventilation to provide a free flow of air to the unit.

Dimensions

Figure 5 shows the dimensions of the DS4500, which conforms to the 19-inch rack standard.



d3nu4001a

Figure 5. DS4500 Storage Subsystem dimensions

Weight

The total weight of the storage subsystem depends on the number of components installed. Table 4 lists the maximum, empty, and shipping weights for the storage subsystem. Table 5 lists the weight of each component.

Table 4. DS4500 weights

Weight		
Maximum ¹	Empty ²	Shipping
43.99 kg (97 lb)	18.07 kg (39.84 lb)	57.2 kg (125.9 lb)

¹ Chassis with all eight mini hubs.

² Chassis and backplane only, without CRUs.

Table 5. DS4500 component weights

Unit	Weight
Mini hub	0.567 kg (1.25 lb)
Fan and communications module	1.84 kg (4.06 lb)
Storage subsystem fan	0.9 kg (1.9 lb)
Battery unit	9.7 kg (21.4 lb)
Controller	3.0 kg (6.6 lb)
Power supply	1.5 kg (3.3 lb)

Shipping dimensions

Table 6 lists shipping carton dimensions. The height shown includes the height of the pallet.

Table 6. DS4500 shipping carton dimensions

Height	Width	Depth
44.4 cm (17.5 in.)	62.2 cm (24.5 in.)	78.7 cm (31.0 in.)

Environmental requirements and specifications

This section describes the environmental conditions that are prerequisite to installing the unit, and heat and sound conditions that are generated by normal operation of the storage subsystem.

Temperature and humidity

Table 7 on page 15 lists the acceptable temperature and humidity ranges in which the storage subsystem is designed to operate.

Important: The recommended operating environment air temperature is 22° C (72° F) or lower.

Table 7. DS4500 temperature and humidity requirements

Condition	Parameter	Requirement
Temperature ¹	Operating range	10° - 35° C (50° - 95° F)
	Maximum rate of change	10° C (18° F) per hour
	Storage range	-10° - 65° C (14° - 149° F)
	Maximum rate of change	15° C (27° F) per hour
	Transit range	-40° C to 65° C (-40° F to 149° F)
	Maximum rate of change	20° C (36° F) per hour
Relative humidity (no condensation)	Operating range	20% to 80%
	Storage range	8% to 90%
	Transit range	5% to 95%
	Maximum dew point	26° C (79° F)
	Maximum gradient	10% per hour

Note: Substantial deviations from the suggested operating range, in either direction, if sustained for extended periods of time, will expose the unit to greater risk of failure from external causes.

Altitude

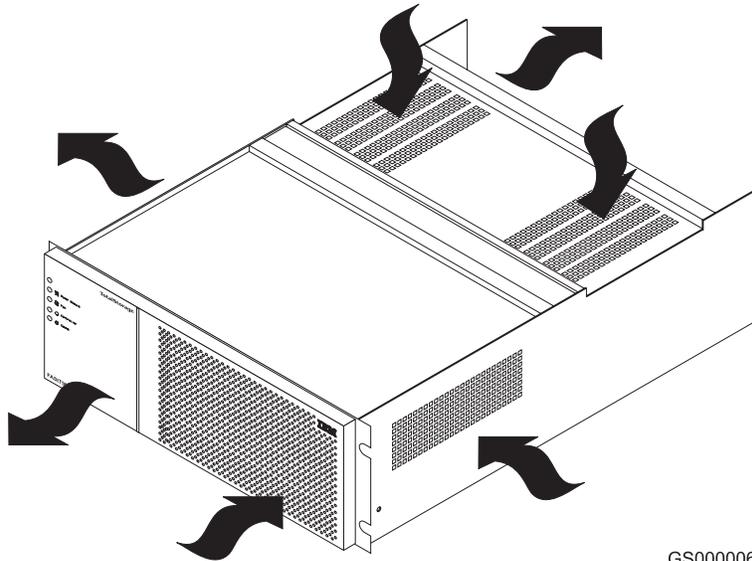
Table 8 lists the acceptable altitudes for operating, storing, and shipping the DS4500.

Table 8. DS4500 altitude ranges

Environment	Altitude
Operating	0 m (0 ft.) to 2133 m (7000 ft.) above sea level
Storage	30.5 m (100 ft.) below sea level to 3000 m (9842 ft.) above sea level
Transit	30.5 m (100 ft.) below sea level to 12,000 m (40,000 ft.) above sea level

Airflow and heat dissipation

Figure 6 on page 16 shows the intended airflow for the DS4500. Allow at least 30 inches in front of the storage subsystem and at least 24 inches behind the storage subsystem for service clearance, proper ventilation, and heat dissipation.



GS000006

Figure 6. DS4500 airflow

Table 9 lists the KVA, watts, and Btu calculations. These values assume the power supplies have a 70 percent efficiency and a power factor of 0.99. These tabulated power and heat dissipation values are typical for the storage subsystem. Maximum configuration units are typically operated at higher data rates, have larger random access memory (RAM) capacities, or have different host interface boards.

Table 9. DS4500 power and heat dissipation

KVA	Watts (AC)	Btu per hour
0.23	230	786.6

Acoustic noise

Table 10 lists the maximum sound levels emitted by the storage subsystem.

Table 10. DS4500 sound levels

Measurement	Level
Sound power (normal operation)	6.5 bels
Sound pressure (normal operation)	65 dBA

These levels are measured in controlled acoustical environments according to ISO 7779 and are reported in accordance with ISO 9296. The declared sound power levels indicate an upper limit, below which a large portion of machines operate. Sound pressure levels in your location might exceed the average 1-meter values stated because of room reflections and other nearby noise.

Electrical requirements

This section provides information regarding site power and wiring, storage subsystem AC power requirements, and power cord routing instructions.

Consider the following information when preparing the installation site:

- Protective ground – Site wiring must include a protective ground connection to the AC power source.

Note: Protective ground is also known as safety ground or chassis ground.

- Circuit overloading – Power circuits and associated circuit breakers must provide sufficient power and overload protection. To prevent possible damage to the unit, isolate its power source from large switching loads (such as air conditioning motors, elevator motors, and factory loads).
- Power failures – If a total power failure occurs, the unit automatically performs a power-up recovery sequence without operator intervention after power is restored.

Table 11. DS4500 AC power requirements

	Low Range	High Range
Nominal Voltage	90 to 136 VAC	198 to 257 VAC
Frequency (Hertz)	50 to 60 Hz	50 to 60 Hz
Idle Current	2 A ^a	1 A ^b
Maximum Operating Current	2 A ^a	1 A ^b
Maximum Surge Current	3 A ^a	2 A ^b

^a. Typical voltage: 120 VAC, 60 Hz, assumes 70% power-supply efficiency and 0.99 power factor

^b. Typical voltage: 240 VAC, 60 Hz, assumes 70% power-supply efficiency and 0.99 power factor

Site wiring and power

The storage subsystem uses wide-ranging redundant power supplies that automatically accommodate voltages to the AC power source. The power supplies operate within the range of 90 VAC to 257 VAC, at a minimum frequency of 50 Hz and a maximum frequency of 60 Hz. The power supplies meet standard voltage requirements for both domestic (inside USA) and international (outside USA) operation. They use standard industrial wiring with line-to-neutral or line-to-line power connections.

The agency ratings for the DS4500 Storage Subsystem are 2 amps at 100 VAC and 1 amp at 240 VAC. These are the overall maximum operating currents for this system.

AC power recovery

After normal power is restored after a total AC power failure, the storage subsystem performs power-up recovery procedures automatically without operator intervention.

Power cords and receptacles

The storage subsystem ships with two high-voltage line cord jumpers used to connect to the rack PDU. You must purchase the power cords that are appropriate for use in a typical outlet in the destination country. See Appendix C, “Power cords,” on page 175 for more information.

Shock and vibration requirements

Operational Shock: The DS4500 will be able to withstand a free-fall drop from 0.5 inches onto a hard surface. Subjecting the equipment to a single shock pulse with the following characteristics will simulate this level of shock:

- Velocity change = 20 inches per second
- Wave form = Triangular, 25g @ 4.00 ms

Operational Vibration (Sweep): While in its normal operating position, the DS4500 will continue operating when subjected to the following vibration sweep:

- Frequency sweep = 3 Hz -150 Hz -3 Hz
- Wave form = Sinusoidal, 0.25g

Operational Vibration (Random): While in its normal operating position, the DS4500 will continue operating when subjected to a random vibration test using the criteria shown in Table 12. This test uses the indicated spectral power density for 30 minutes in each of the three axes.

Table 12. Random Vibration Power Spectral Density

Hz	5	17	45	48	62	65	150	200	500
g ² /Hz	2.0x10 ⁻⁷	2.2x10 ⁻⁵							

Heat output, airflow, and cooling

See “Airflow and heat dissipation” on page 15 for heat output, airflow, and cooling specifications.

Note: In general, disk subsystem reliability tends to decrease as the ambient temperature of the environment in which it is being used increases. The ambient temperature in the immediate area of the disk enclosure unit should be kept near 22° C (72° F), or lower, to provide better reliability.

When racks that contain many DS4500s are to be installed together, the following requirements must be met to ensure that the DS4500s are adequately cooled:

- Air enters at the front of the rack and leaves at the back. To prevent the air that is leaving the rack from entering the intake of another piece of equipment, you must position the racks in alternate rows, back-to-back and front-to-front. This arrangement is known as “cold aisle/hot aisle” and is shown in Figure 7 on page 19.
- Where racks are in rows, each rack must touch the rack that is next to it to reduce the amount of hot air that can flow around from the back of the rack into the intakes of the storage expansion enclosures that are in that rack. You should use Suite Attach Kits to completely seal any gaps that remain between the racks. For details about Suite Attach Kits, contact your marketing representative.
- Where racks are in rows front-to-front or back-to-back, a gap of at least 1220 mm (48 in.) must separate the rows across the cold aisle.
- To ensure correct airflow in each rack, the rack filler plates must be installed in unused positions. Also, all the gaps in the front of the racks must be sealed, including the gaps between the storage subsystems.

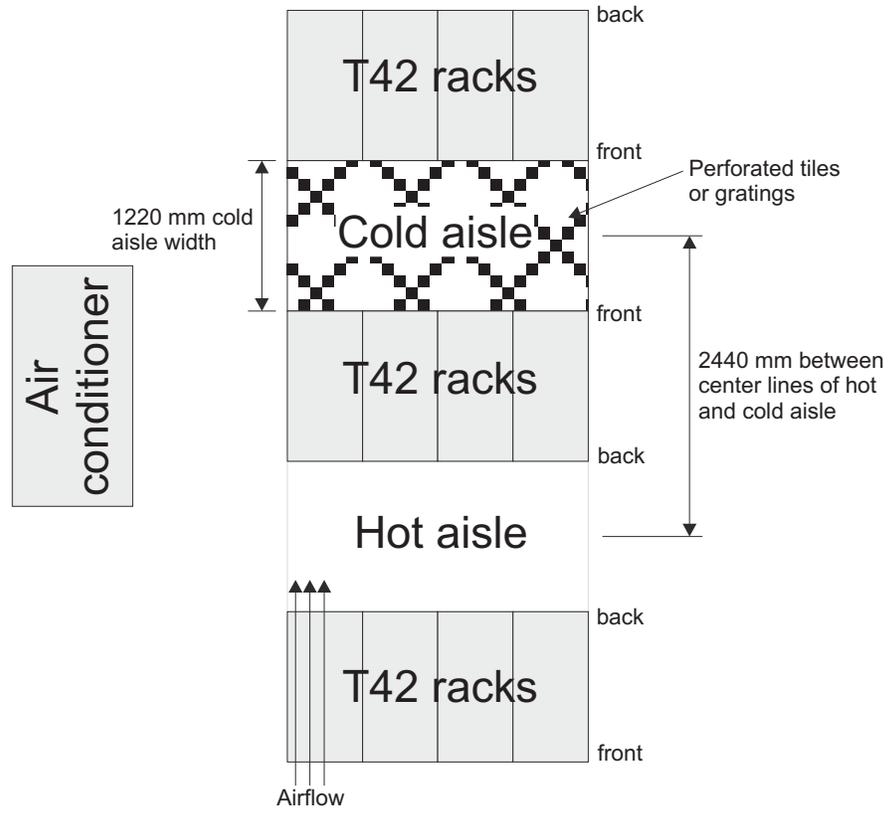


Figure 7. Example of cold aisle/hot aisle rack configuration

Chapter 2. Installing the storage subsystem

This chapter provides the information that you need to install the DS4500 Storage Subsystem into a rack cabinet.

Before you begin the installation, review the safety information in “Safety” on page xiii.

“Installation overview” provides an overview of the entire DS4500 installation process. Read this overview before you begin the installation.

Installation overview

Statement 4:



≥ 18 kg (39.7 lb)	≥ 32 kg (70.5 lb)	≥ 55 kg (121.2 lb)

CAUTION: Use safe practices when lifting.

Attention: A fully configured DS4500 weighs up to 43.99 kg (97 lb). At least two other people should help you lift the DS4500 from the shipping box. If desired, open the sides of the shipping box and remove the CRUs from the DS4500 before you lift it from the shipping box in order to lighten the storage subsystem. See “Removing the CRUs” on page 31.

The following steps summarize the DS4500 installation process. Each step below is detailed in this chapter or next two chapters, Chapter 3, “Cabling the storage subsystem,” on page 47 and Chapter 4, “Operating the storage subsystem,” on page 117.

1. Review the preparation recommendations. See “Preparing for installation” on page 24.
2. Prepare the installation site. See “Preparing the site” on page 25.
3. Prepare the rack cabinet. See “Preparing the rack cabinet” on page 26.
4. Fold down and open the sides of the shipping box. Without removing the DS4500 from box, you can remove the DS4500 rack mounting rails and hardware from the box. The DS4500 rack mounting rails and hardware are placed on the bottom of the shipping box (under the DS4500 Storage Subsystem). Install the support rails in the rack cabinet. See “Installing the support rails” on page 27.

5. Before removing the DS4500 from the shipping box, remove the components from the DS4500 chassis to lighten the unit. See “Removing the CRUs” on page 31.
6. Record the serial number, machine type and model number, and RAID controller MAC addresses for your DS4500 Storage Subsystem in Appendix A, “Records,” on page 167.

The serial number, machine type, and model number are located on the rear lip at the back of the unit as shown in Figure 8.

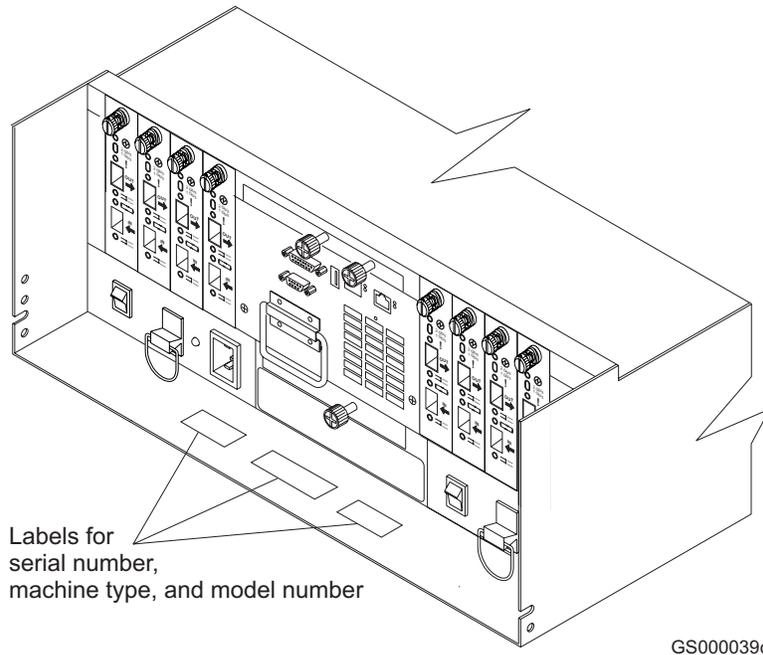


Figure 8. Example of DS4500 serial number, machine type, and model number location

The MAC addresses, located on the front of each controller, indicate the Ethernet port that is associated with that controller.

7. Install and secure the DS4500 chassis in the rack cabinet. See “Installing the DS4500 into a rack on the support rails” on page 38.
8. If needed, replace the components in the installed DS4500 chassis. See “Replacing the components” on page 40.
9. Install in the rack cabinet the DS4500 storage expansion enclosure or enclosures you will cable to the DS4500. Follow the instructions in the *Installation, User’s, and Maintenance Guide* for your DS4000 storage expansion enclosure to set up and mount the storage expansion enclosures.

Attention

Before powering on the DS4500 Storage Subsystem, each attached storage expansion enclosure must be populated with at least two drives. If at least two drives are not installed in each attached storage expansion enclosure, when you power on the DS4500 and its attached storage expansion enclosure(s), your standard storage partition key might be lost and must be regenerated using instructions on the IBM DS4000 Solutions and Premium Features Web site:

<https://www-912.ibm.com/PremiumFeatures/>

In addition, the resulting insufficient load to the enclosure power supplies might cause them to intermittently appear as failed, falsely indicating the power supplies are bad. All drives in the connected storage expansion enclosure(s) must contain no prior configuration data.

10. Use SFP modules and fibre channel cables to cable the DS4500 to the DS4000 storage expansion enclosure or enclosures. See “Connecting storage expansion enclosures to the DS4500” on page 61.
11. Set the enclosure IDs for all storage expansion enclosures in the configuration. See “Storage expansion enclosure ID settings” on page 102.

Note: Perform this step if the attached storage expansion enclosures are not EXP810s. The EXP810 storage expansion enclosure IDs are automatically set by the controllers to be unique when they are cabled together.
12. Perform one of the following cabling tasks to enable management of the DS4500 configuration:
 - If you are using out-of-band management, cable the DS4500 Ethernet ports to either the management workstation or the host.
 - If you are using in-band management, cable the DS4500 host channels to the fibre channel host bus adapters (HBAs) in either the hosts or the fibre channel switch that connects to the host HBAs. See “Connecting hosts to the DS4500” on page 106.
13. Connect the power cables for the DS4500. See “Cabling the power supply” on page 111.
14. Power on the attached storage expansion enclosure and the DS4500 Storage Subsystem using the procedure described in “Powering on the storage subsystem” on page 119.
15. Install the DS4500 Storage Manager 9.19 host software on the management workstation (for out-of-band management) or on the host (for in-band management). Refer to the *IBM System Storage DS4000 Storage Manager 9.19 Installation and Support Guide* for the appropriate operating system for instructions on how to install the DS4000 Storage Manager 9.19 host software.
16. Use the DS4000 Storage Manager 9.19 host software to verify the configuration.
17. Review and perform the procedures described in “Performing the DS4000 Health Check process” on page 117.

Handling static-sensitive devices

Attention: Static electricity can damage electronic devices and your system. To avoid damage, keep static-sensitive devices in their static-protective packages until you are ready to install them.

To reduce the possibility of electrostatic discharge, observe the following precautions:

- Limit your movement. Movement can cause static electricity to build up around you.
- Handle the device carefully, holding it by its edges or its frame.
- Do not touch solder joints, pins, or exposed printed circuitry.
- Do not leave the device where others can handle and possibly damage the device.
- While the device is still in its static-protective package, touch it to an unpainted metal part of the system unit for at least two seconds. This drains static electricity from the package and from your body.
- Remove the device from its package and install it directly into your system unit without setting it down. If it is necessary to set the device down, place it in its static-protective package. Do not place the device on your system unit cover or on a metal table.
- Take additional care when handling devices during cold weather because heating reduces indoor humidity and increases static electricity.

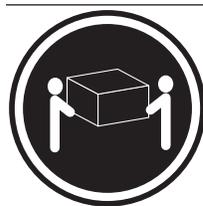
Preparing for installation

Before installing the DS4500 Storage Subsystem, create a detailed plan of how this unit will be used in your storage configuration. The plan should include determining RAID levels, fallover requirements, operating systems to be used, and total storage capacity requirements.

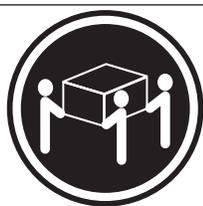
Complete the following steps to prepare the DS4500 Storage Subsystem for installation into a rack cabinet:

1. Prepare the site to meet all area, environmental, power, and site requirements. For more information, see “Specifications” on page 13.
2. Move the shipping box that contains the DS4500 to the site.

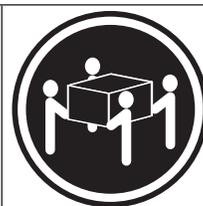
Statement 4:



≥ 18 kg (39.7 lb)



≥ 32 kg (70.5 lb)



≥ 55 kg (121.2 lb)

CAUTION:
Use safe practices when lifting.

3. Remove the mounting rails, mounting hardware, and line cord jumpers from the DS4500 shipping box. Do not remove the DS4500 from the shipping box at this time.

Attention: The mounting rails, mounting hardware, and line cord jumpers may be packed beneath the DS4500 in the shipping box. To remove these items from the shipping box without first removing the DS4500, open the two long sides of the shipping box. Then open and fold flat the two short sides of the shipping box. This enables you to access the mounting rails, mounting hardware, and line cord jumpers without first removing the DS4500 from the shipping box.

After you open the DS4500 shipping container and remove the mounting rails, mounting hardware, and line cord jumpers, check the remaining contents (see “Inventory checklist” on page 3) without removing the DS4500 from the shipping box. If any items are missing, contact your IBM reseller or representatives before proceeding.

4. Verify that you have the appropriate host software kit for your operating system. The standard DS4500 ships with the Microsoft Windows, Linux, Netware host software attachment kits. The host software kit grants you permission to attach host servers using the appropriate operating system to the DS4500. Additional operating system host attachment kits can be purchased separately. For supported operating systems, see “Operating system support” on page 2. For the latest controller firmware and the DS4000 Storage Manager host software, check the IBM support Web site for DS4000 storage products: www.ibm.com/servers/storage/support/disk/
5. Read the appropriate readme files that are included in the Storage Manager host software or DS4500 controller firmware packages for any updated information about hardware, software, or firmware products.
6. Continue with “Preparing the site.”

Tools and hardware required

Gather the tools and equipment you will need for installation. These might include:

- Rack line cord jumpers (2) supplied with the DS4500
- Medium flat blade screwdriver
- #2 Phillips screwdriver
- Antistatic protection (such as a grounding wrist strap)
- Fibre channel and Ethernet interface cables and cable straps
- SFP modules
- Rack-mounting hardware that ships with the DS4500

Preparing the site

This section lists the floor space requirements and weight information for the DS4500. For information on interface cables and connections, see Chapter 3, “Cabling the storage subsystem,” on page 47.

Floor space: The floor area at the installation site must provide the following conditions:

- Sufficient space to install the DS4500
- Enough stability to support the weight of the fully configured DS4500 and associated systems. A fully configured DS4500 weighs 43.99 kg (97 lb).

Ensure that all requirements, such as floor space, air conditioning, and electrical service, have been met. Other site preparation activities include the following tasks:

- Make sure that heat output, air flow, and cooling concerns are addressed as specified in “Heat output, airflow, and cooling” on page 18.
- Make sure that there is enough room to move around the cabinet and install modules; clear space at the installation area.
- Install uninterruptible power supply (UPS) devices.
- If applicable, install host servers with fibre channel host bus adapters (HBAs), fibre channel switches, or other devices.
- Route interface cables from the fibre channel HBA ports in the hosts or fibre channel switches to the installation area.
- Route main power cords to the installation area.

Continue with “Preparing the rack cabinet.”

Preparing the rack cabinet

Important: Before you install the DS4500 in a rack cabinet, keep in mind the following considerations:

- Review the documentation that comes with your rack enclosure for safety and cabling considerations.
- Install the DS4500 in a recommended 22° C (72° F) environment. See “Environmental requirements and specifications” on page 14 for details.
- To ensure proper airflow, do not block the air vents; ensure at least 15 cm (6 in.) of air space.
- To ensure rack stability, load the rack starting at the bottom.
- If you install multiple components in the rack, do not overload the power outlets.
- Always connect the storage subsystem to a properly grounded outlet.
- Always connect the IBM-certified rack power distribution units (PDUs) to at least two independent power circuits or sources.

Complete the following steps to prepare the rack cabinet before you install the DS4500:

1. Move, unpack, and level the rack at the installation site (if needed).
2. Remove the external rack panels.
3. If necessary, stop all I/O activity to the devices in the rack.
4. If necessary, turn off all drive enclosure and rack power. Disconnect existing power, network, and other external cables.
5. Install any additional interface cables and power cables.

After you have completed these steps, continue with “Installing the support rails” on page 27.

Installing the support rails

Attention: Duplicate copies of the rack mounting templates are provided in Appendix B, “Rack mounting template,” on page 171. If you want to tear out the templates from this document for easier use, use the copies in Appendix B, “Rack mounting template,” on page 171 rather than the copies provided in this section.

Use the rack mounting templates (Figure 9 on page 28 and Figure 10 on page 29) to identify the proper locations for inserting M6 screws when mounting the support rails and DS4500 Storage Subsystem to a rack cabinet. The locations for the M6 screws are highlighted in the templates.

Hold the appropriate template up to each side of the rack cabinet at the 4-U section where you will install the DS4500. U boundaries are shown as horizontal dashed lines in the rack mounting templates. The highlighted squares on each side of the template mark the positions where you will thread the M6 screws that secure the rails and the DS4500 to the front and rear of the cabinet.

Note: The mounting holes that are shown in the following templates are square. The holes in your rack might be round, square, or threaded.

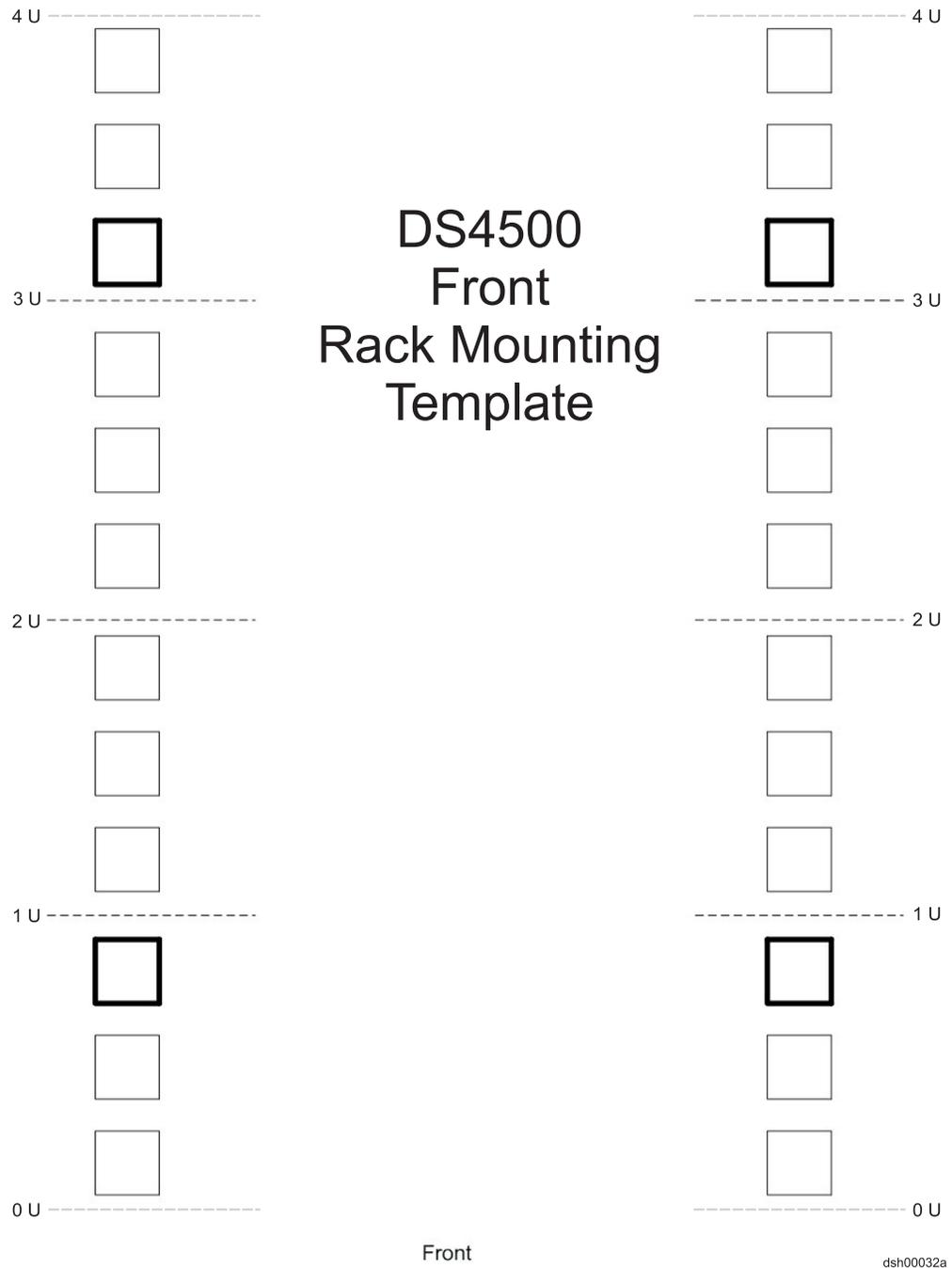


Figure 9. Front rack mounting template

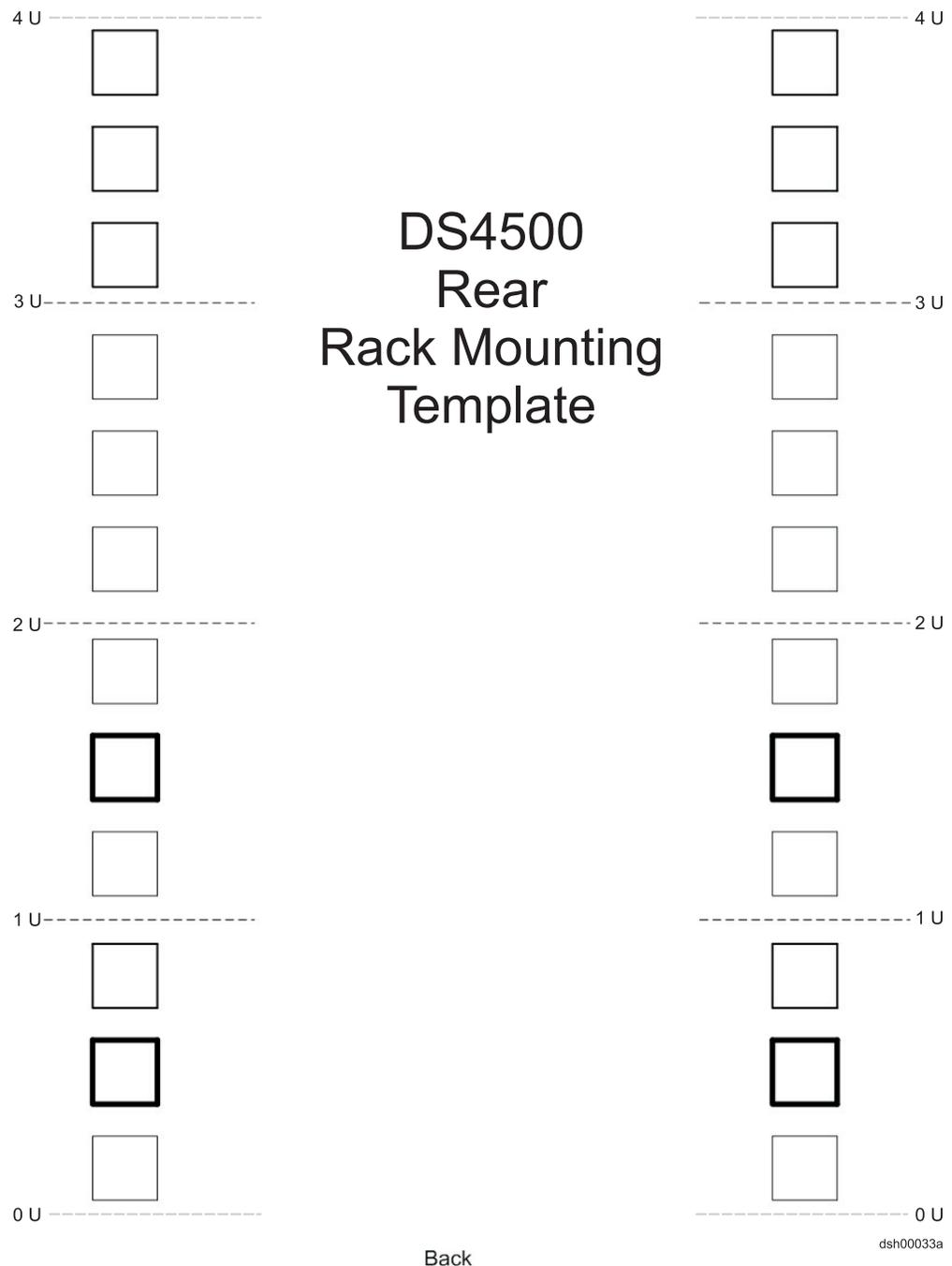
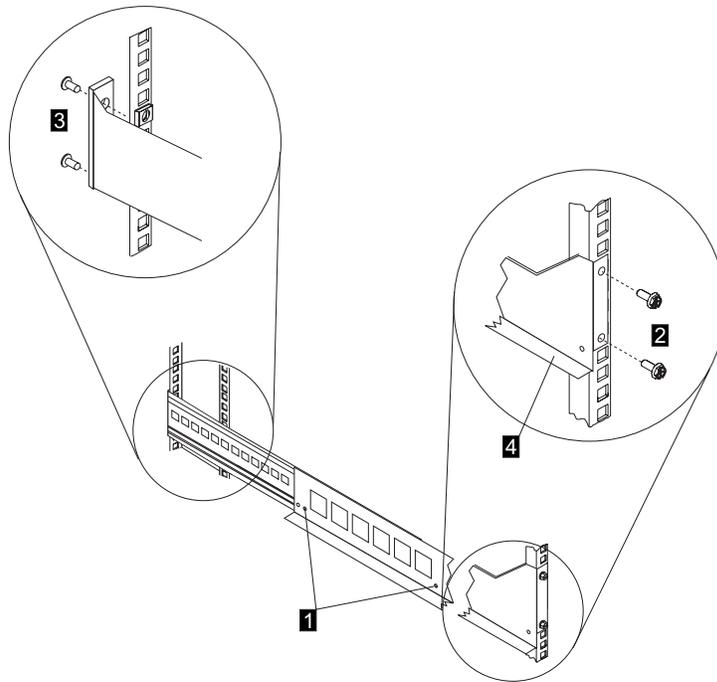


Figure 10. Rear rack mounting template

Before installing the DS4500 in a rack cabinet, you must install the rails and rack-mounting hardware that come with your storage subsystem. The DS4500 requires an Electronic Industries Association (EIA) 310-D Type A 19-inch rack cabinet. The distance between EIA rails, from the front to the rear of the rack, is 60.96 cm (24 in.) minimum and 81.28 cm (32 in.) maximum. This rack conforms to the EIA standard. Where you place the support rails in the rack depends on where you intend to position the storage subsystem.

Complete the following steps to install the support rails:



d3luatm2a

Figure 11. Installing the support rails

1. Ensure that the rack cabinet has already been installed.
2. Ensure that a stabilizer has been correctly attached to the bottom front of the rack to prevent the rack from tipping forward while the DS4500 is being installed.
Refer to the installation and service guide, or equivalent, for the rack as required.
3. Locate the two support rails, eight M6 screws, eight clip nuts, and eight cage nuts that are supplied with the DS4500.

Note: The M6 screws may already be attached to the support rails. If so, remove them from the support rails.

4. The rack-mounted unit is four EIA units high. Decide accordingly where you are going to install the support rails.

Attention: Use the rack mounting template provided in Figure 9 on page 28 and Figure 10 on page 29 to locate the proper rack mounting holes for installing the support rails into the rack.

Note the following considerations before you choose where to install the rails:

- If you are installing the DS4500 into an empty rack, install it into the lowest available position so that the rack does not become unstable.
- If you are installing more than one DS4500 in the rack, start at the lowest available position, and work upward.
- If appropriate, allow for possible later installation of other units.
- If necessary, remove the rack power distribution unit before you install the support rails.
- For procedures and more information, refer to the installation and service guide, or equivalent, for the rack.

- The lip on the rail should line up with the bottom of the storage subsystem (the 0 U boundary in Figure 10 on page 29).
5. Insert the cage nuts or the slide clip nuts, as required for the rack, into all of the marked holes. Use the cage nut insertion tool or a flat-blade screwdriver to insert cage nuts.

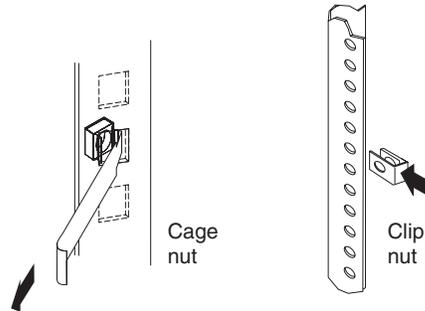


Figure 12. Cage nut and slide clip nut insertion

6. On the rail marked **R**, using a #2 Phillips screwdriver, loosen both screws on the inside of the rail (**1**).
7. Hold the front of the rail against the outside of the rack mounting flange; then, insert and loosely tighten the two front screws (**2**).
8. Extend the rail to the outside of the rear rack-mounting flange; then, insert and loosely tighten the two rear screws (**3**).
9. Using the medium flat blade screwdriver, securely tighten the four M6 screws.
10. Securely tighten the two screws on the left support rail that hold the two parts of the rail together (**1**).
11. Repeat step 6 through step 10 for the support rail marked **L**.

Note: Because the mounting holes on the rack are not always the same size as the mounting screws, the lip (**4**) of each of the support rails may not line up evenly. Make minor adjustments as needed to ensure that the lip of the left and right support rails are lined up evenly on the racks. Failure to do so will cause the storage subsystem to fit unevenly in the rack.

12. Continue with “Installing the DS4500.”

Installing the DS4500

This section provides instructions on installing the DS4500. The installation process includes:

- “Removing the CRUs”
- “Installing the DS4500 into a rack on the support rails” on page 38
- “Replacing the components” on page 40

Removing the CRUs

This section describes how to remove the CRUs to minimize the weight of the DS4500 before you install it in the rack. However, if you have three or more people available to lift and install the DS4500 in a rack, you might not find it necessary to remove the CRUs before you install the DS4500. If this is the case, you can skip the CRU removal instructions provided in this section. Instead, continue with

“Installing the DS4500 into a rack on the support rails” on page 38, and then skip the CRU replacement instructions provided in “Replacing the components” on page 40.

Attention: For safety reasons, IBM strongly recommends that you remove CRUs from the DS4500 chassis to lessen the weight to make it easier to transfer the DS4500 Storage Subsystem from the shipping box to the rack.

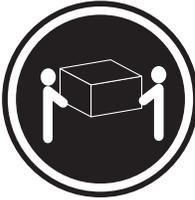
Use the following procedures to remove the CRUs from the DS4500 before installation. Use these instructions after you have completed all applicable site, rack, and preparations (as listed in “Preparing for installation” on page 24) and installed the support rails (as listed in “Installing the support rails” on page 27). Alternately, if necessary, you can use these instructions to lighten the DS4500 before removing it from the shipping box. The shipping box opens to provide access to the storage subsystem CRUs.

The DS4500 comes with a rack-mounting hardware kit for installing it in a rack. It is easier to lift the DS4500 and install it in a rack cabinet if you remove all the CRUs first. You will need an antistatic wrist strap and a cart or level surface (to hold the CRUs). Observe the precautions listed in “Handling static-sensitive devices” on page 24. In the following procedure, you will remove the following CRUs from the storage subsystem before you install it in the rack:

- Storage subsystem fan
- Controllers
- Battery unit
- Power supplies
- Fan and communications module
- mini hubs

Statement 4:



		
≥ 18 kg (39.7 lb)	≥ 32 kg (70.5 lb)	≥ 55 kg (121.2 lb)

CAUTION:
Use safe practices when lifting.

Removing the front bezel

The storage subsystem comes with a bezel that is attached to the front of the unit. To access several of the components from the front, you must first remove the bezel.

Complete the following steps to remove the bezel:

Note: Before you remove the bezel, place the DS4500 Storage Subsystem on a flat surface to avoid damaging the hooks on the bezel. If you pull the cover out too far, you can damage the plastic hooks at the top. Be sure the front of the DS4500 extends beyond the edge approximately 5 cm (2 in.).

1. Carefully pull out the bottom of the bezel on the front of the chassis to release the pins.
2. Slide the bezel down, as shown in Figure 13.

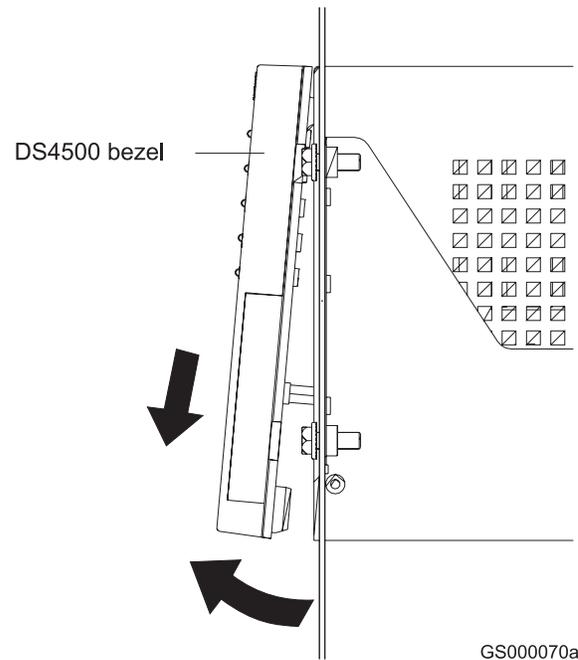


Figure 13. DS4500 Storage Subsystem bezel removal

Removing a storage subsystem fan

Complete the following steps to remove a storage subsystem fan:

1. Lift the storage subsystem fan lever to its open position (so that the lever is horizontal and 90°); then, grasp the fan handle and pull out firmly to remove the fan and save it for later reinstallation.
2. Slowly pull the lever away from the chassis to remove the storage subsystem fan from the bay, as shown in Figure 14 on page 34.
3. Place the storage subsystem fan on a level surface.

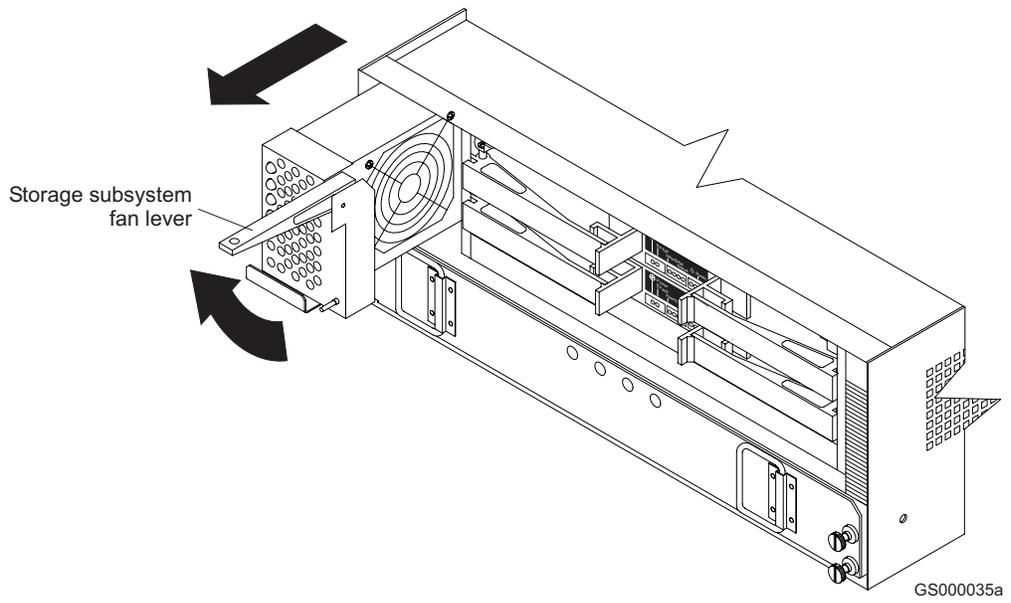


Figure 14. Storage subsystem fan removal

Removing a controller

Complete the following steps to remove a controller:

1. Using your thumbs, squeeze the two center tabs to unlock the controller levers; then, using your fingers, pull the levers open 90° to release the controller from the latch.
2. Slowly pull the levers to slide the controller from the chassis bay, as shown in Figure 15.
3. Place the controller on a level surface.
4. Repeat step 1 through step 3 for the second controller.

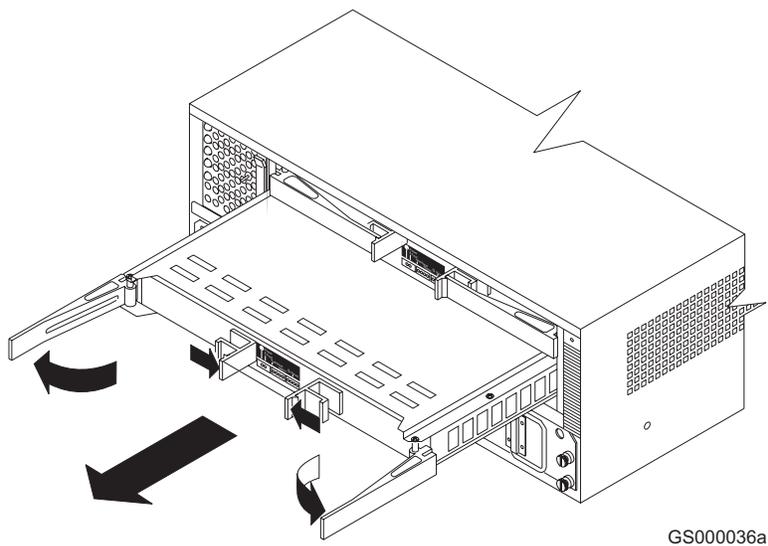
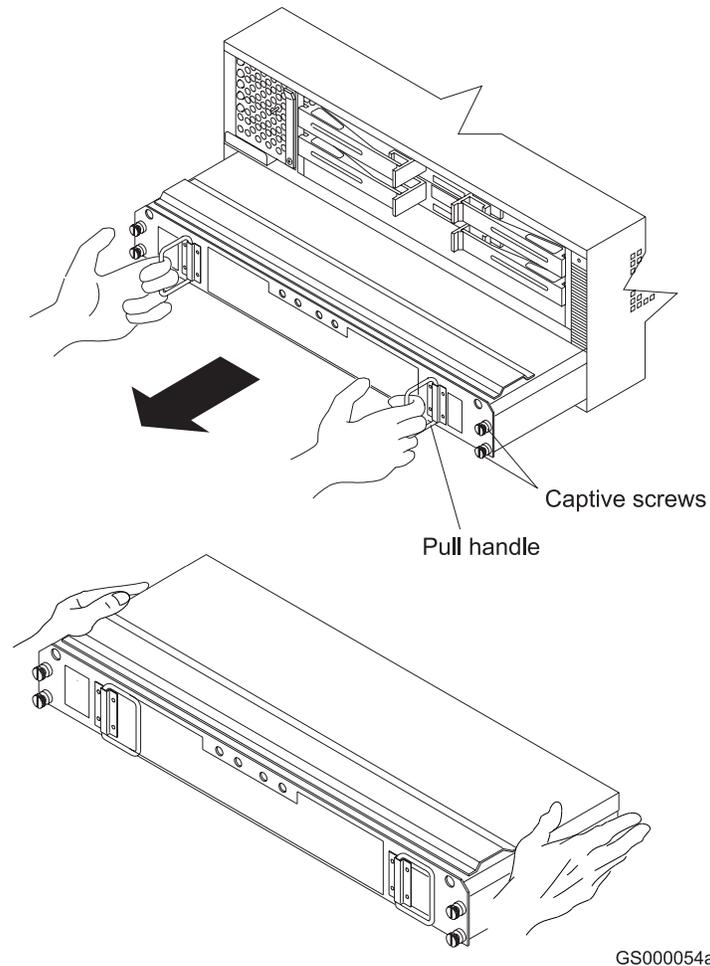


Figure 15. Controller removal

Removing a battery unit

Complete the following steps to remove a battery unit:

1. Loosen the four captive screws on the battery. If necessary, use a flat blade screwdriver to loosen the screws.
2. Using both pull handles, slide out the battery about 5 cm (2 in.) as shown in Figure 16.
3. Grasp the sides of the unit with both hands and pull it out of the chassis.
4. Place the battery unit on a level surface.



GS000054a

Figure 16. Battery unit removal

Removing a power supply

Complete the following steps to remove a power supply:

1. Lift up and pull out on the pull handle to release the power supply.
2. Slide the power supply out of the chassis, as shown in Figure 17 on page 36.
3. Grasp the sides of the unit with both hands and pull it from the chassis.
4. Place the power supply on a level surface.
5. Repeat step 1 through step 4 for the second power supply.

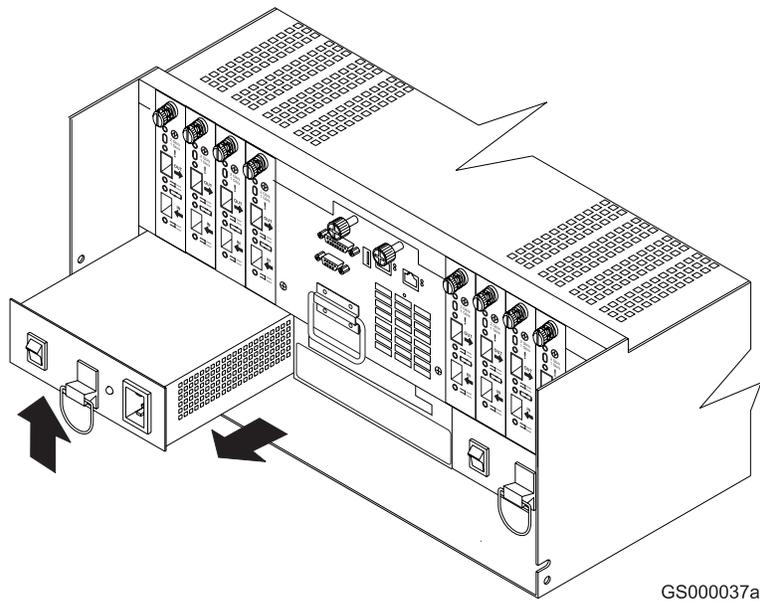
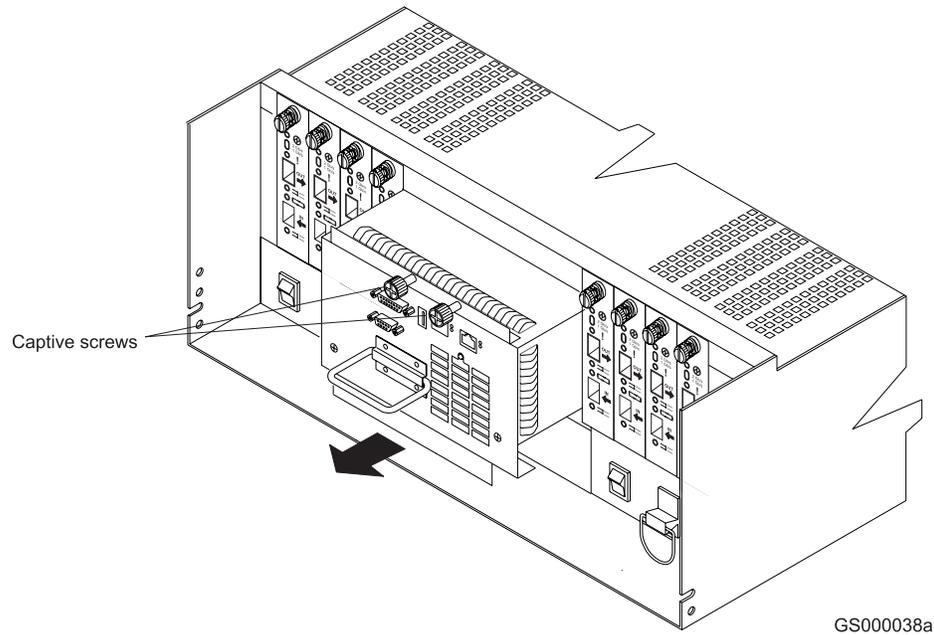


Figure 17. Power supply removal

Removing a fan and communications module

Complete the following steps to remove a fan and communications module:

1. Using a flat-blade screwdriver, loosen the two captive screws on the fan and communications module.
2. Lift up and pull out on the pull handle to slide the module out of the slot a few inches, as shown in Figure 18 on page 37.
3. Grasp the sides of the module with both hands and pull it from the chassis.
4. Place the module on a level surface.



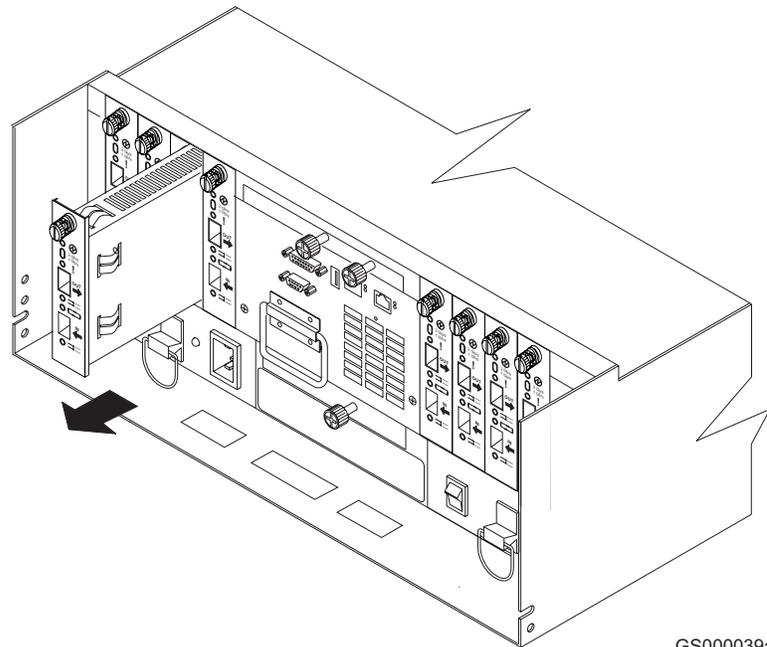
GS000038a

Figure 18. Fan and communications module removal

Removing a mini hub

Complete the following steps to remove a mini hub:

1. Loosen the captive screw on the mini hub.
2. Grasp the screw and pull the mini hub from the chassis, as shown in Figure 19 on page 38.
3. Place the module on a level surface.



GS000039a

Figure 19. Mini hub removal

Attention: When you handle static-sensitive devices, take precautions to avoid damage from static electricity. For details about handling static-sensitive devices, see “Handling static-sensitive devices” on page 24.

Installing the DS4500 into a rack on the support rails

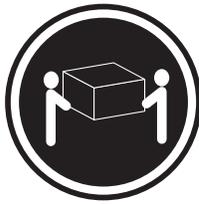
Complete the following steps to install the DS4500 in the rack cabinet.

CAUTION:

Do not install modules or other equipment in the top half of a rackmount cabinet while the bottom half is empty. Doing so can cause the cabinet to become top-heavy and tip over. Always install hardware in the lowest available position in the cabinet.

Statement 4:



		
≥ 18 kg (39.7 lb)	≥ 32 kg (70.5 lb)	≥ 55 kg (121.2 lb)

CAUTION:

Use safe practices when lifting.

1. Put on antistatic protection, and keep it on while performing all of the remaining procedures in this chapter.
2. Using a #2 Phillips screwdriver, remove the four screws from the rails (two screws in each rail). Carefully place these screws to the side; they are used to secure the DS4500 to the rails.

Note: Front screws and rear screws are different sizes. Keep them separate when you remove them.

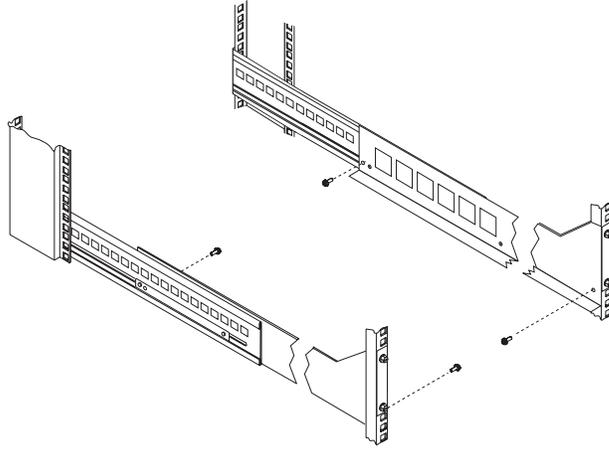


Figure 20. Controller unit screw removal

3. Place the storage subsystem in the rack.

Note: If you have removed the CRUs from the DS4500, you should be able to lift the unit into the cabinet with the help of one other person. If you have not removed the CRUs before the installation, you should have at least two other people available to help you lift the DS4500 into the rack.

- a. Move the storage subsystem to the front of the rackmount cabinet.
- b. With help from another person, place the back of the storage subsystem on the support rails, and then slide the unit into the rack as shown in Figure 21.

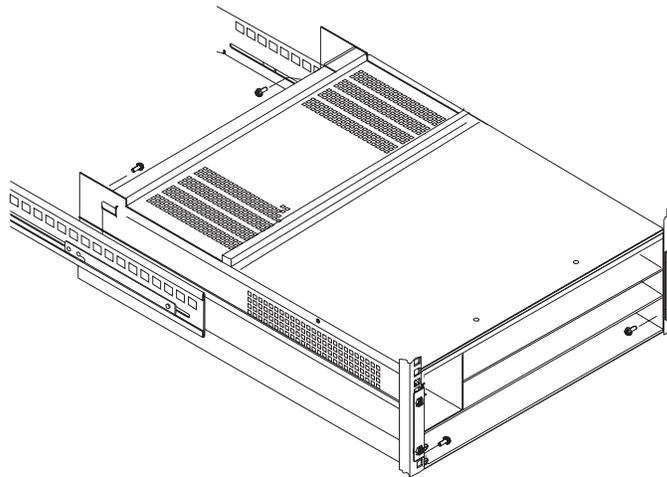


Figure 21. DS4500 Storage Subsystem mounting

4. Using the screws that you removed in step 2 on page 38, secure the sides in the back of the DS4500 to the rack rails.
5. Continue with one of the following actions:
 - If you did remove the DS4500 CRUs before installation (as described in “Removing the CRUs” on page 31), continue with “Replacing the components” on page 40.
 - If you did not remove the DS4500 CRUs before installation, continue with Chapter 3, “Cabling the storage subsystem,” on page 47.

Replacing the components

Use the following procedures to replace the components in the DS4500 after it is installed successfully in a rack cabinet.

Replacing a storage subsystem fan

Complete the following steps to replace the storage subsystem fan that you removed before the installation:

1. Slide the new storage subsystem fan all the way into the slot.

Attention: Be sure that the lever is pulled straight out (in a horizontal position) as you slide the unit into the storage subsystem, as shown in Figure 22.

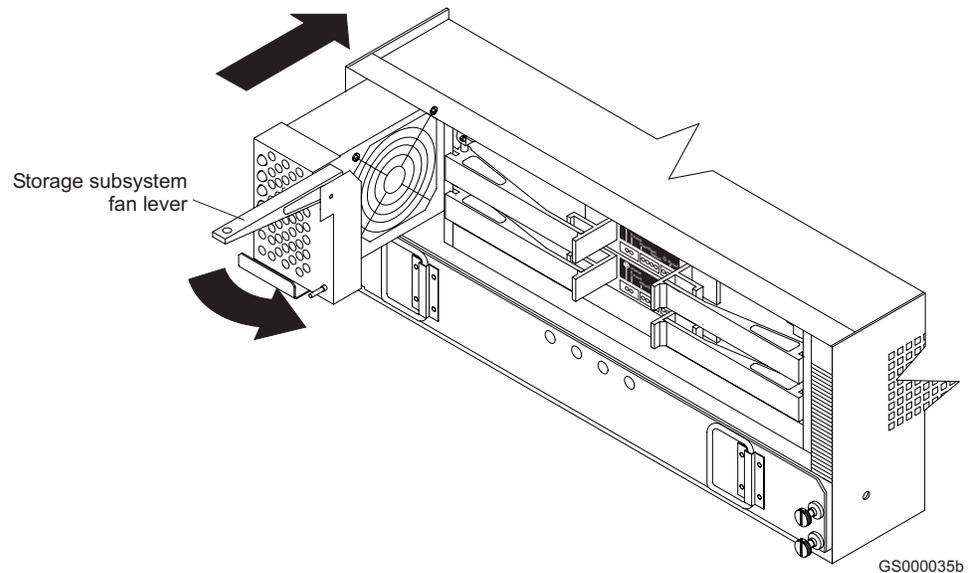


Figure 22. Replacing the storage subsystem fan

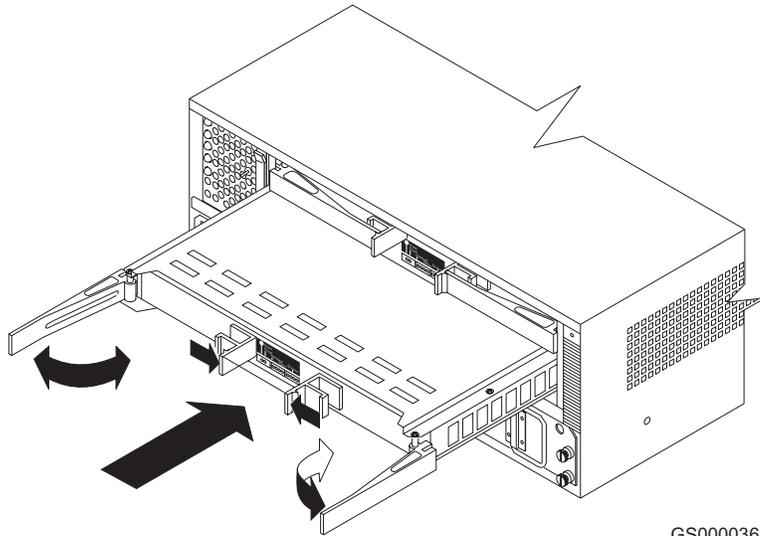
2. Press down on the lever and snap the lever into place.

Replacing a controller

Complete the following steps to replace the controller that you removed before the installation:

1. Using your thumbs, squeeze the two center tabs and pull both controller handles outward with your fingers.

Attention: Be sure that the lever is pulled straight out (open 90°) as you slide the unit into the storage subsystem, as shown in Figure 23 on page 41.



GS000036b

Figure 23. Replacing a controller

2. Using the handles, slide the controller into the slot until the back edge of both handles hooks onto the frame.
3. Close both handles and snap into place.
4. Repeat step 1 on page 40 and step 3 to replace the second controller.

Replacing a battery unit

Complete the following steps to replace the battery unit that you removed before the installation:

1. Grasp the battery unit with both hands and slide the unit into the slot about 5 cm (2 in.), as shown in Figure 24 on page 42.

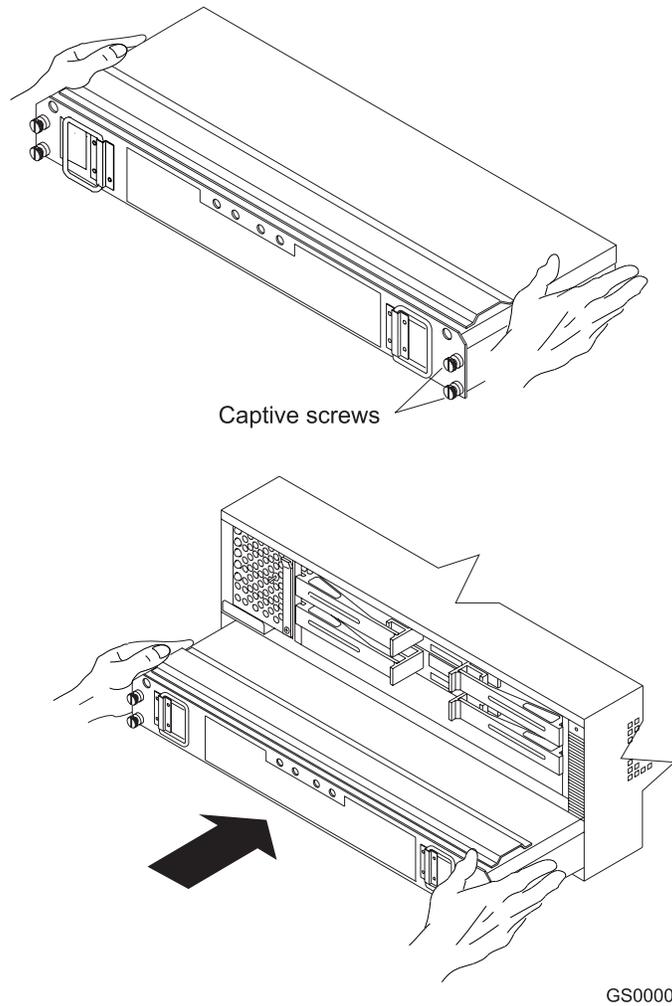


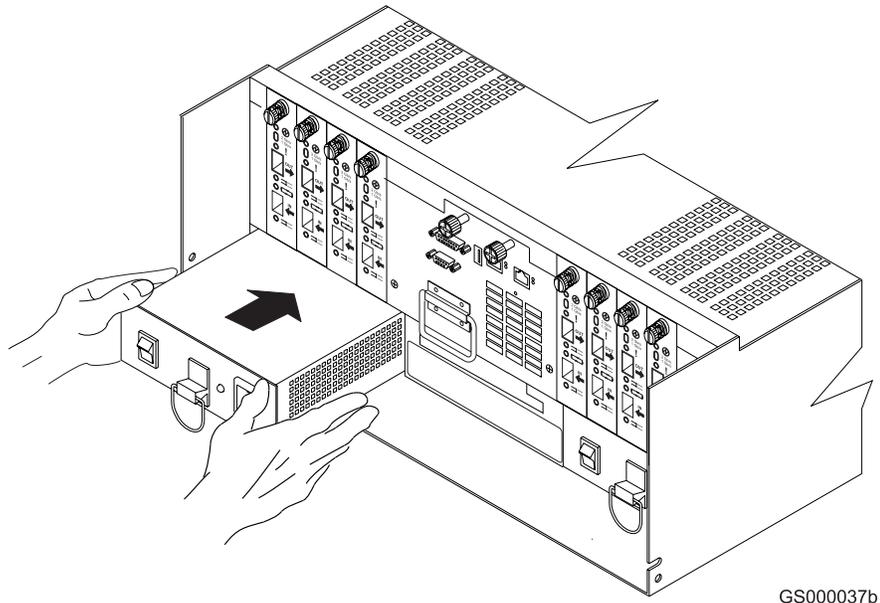
Figure 24. Replacing a battery unit

2. Slowly push the battery completely into the slot.
3. Using a flat-blade screwdriver, tighten the four captive screws.

Replacing a power supply

Complete the following steps to replace the power supply that you removed before the installation:

1. Grasp the power supply with both hands and slide the module into the chassis slot, as shown in Figure 25 on page 43.



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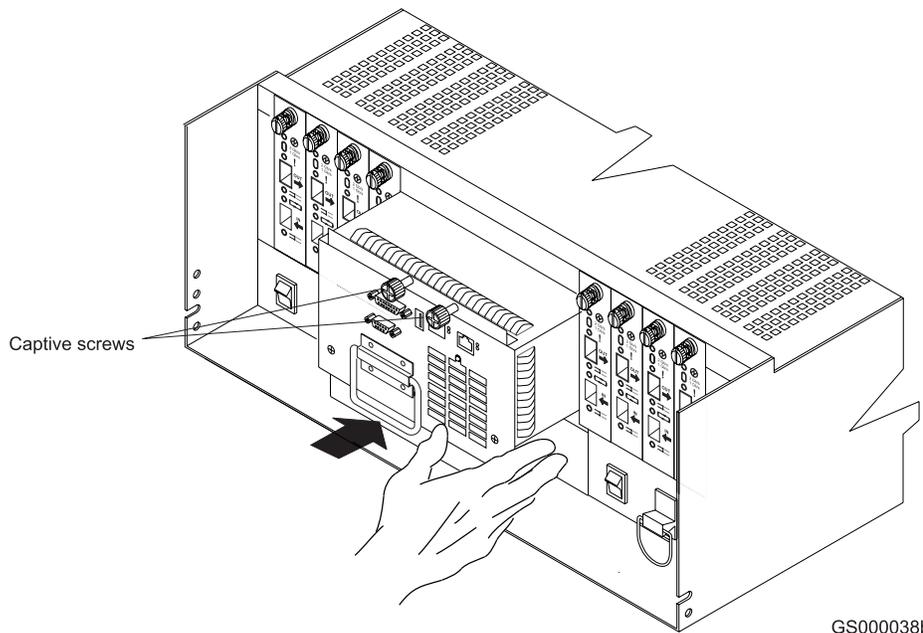
Figure 25. Replacing a power supply

2. Gently push the front of the power supply to ensure that it is fully seated.
3. Repeat step 1 on page 42 and step 2 to replace the second power supply.

Replacing a fan and communications module

Complete the following steps to replace the fan and communications module that you removed before the installation:

1. Grasp the fan and communications module with both hands and completely slide the module into the chassis slot, as shown in Figure 26.



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Figure 26. Replacing a fan and communications module

2. Using a flat-blade screwdriver, tighten the two captive screws on the new module, securing it into place.

Replacing a mini hub

Complete the following steps to replace a mini hub that you removed before the installation:

1. Completely slide the mini hub into the appropriate slot, as shown in Figure 27.

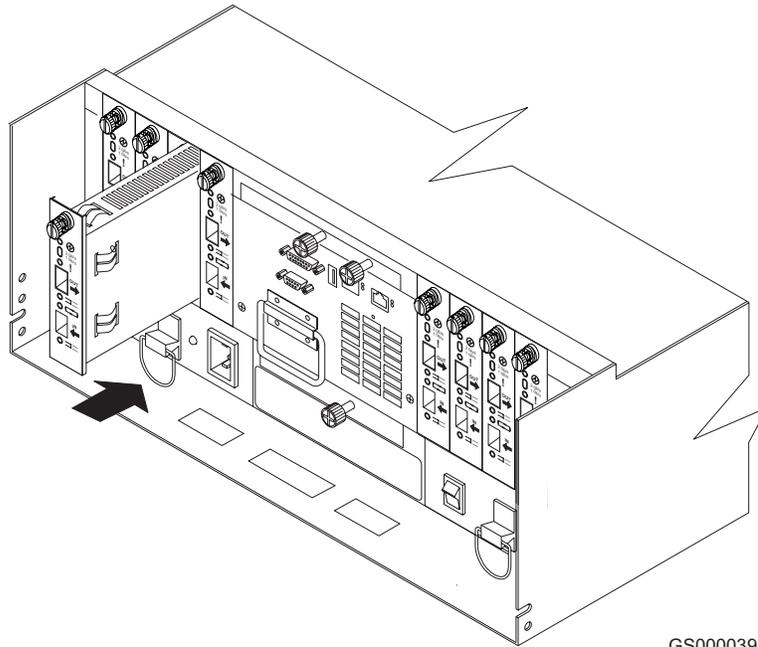


Figure 27. Replacing a mini hub

2. Using a flat-blade screwdriver, tighten the captive screw.
3. Repeat step 1 and step 2 to replace additional mini hubs.

Replacing the front bezel

Complete the following steps to replace the bezel:

1. Slip the top edge of the bezel under the top lip of the chassis.
2. Push the bottom of the bezel until the pins snap into the mounting holes, as shown in Figure 28 on page 45.

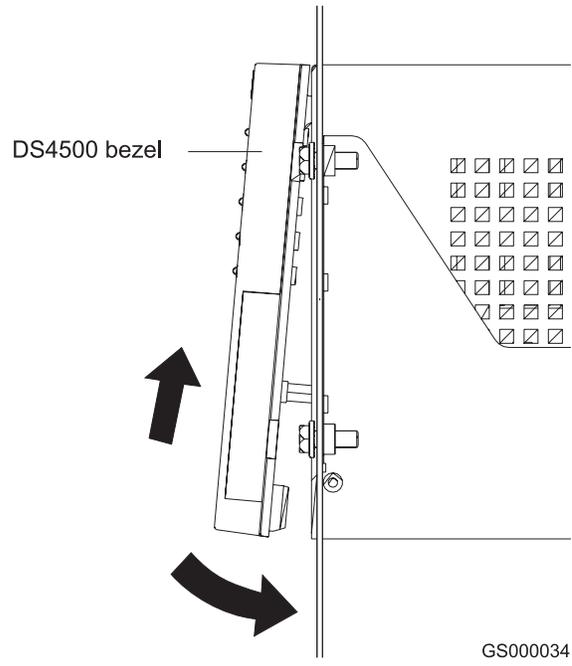


Figure 28. Replacing the front bezel

Chapter 3. Cabling the storage subsystem

After the storage subsystem is installed in its permanent location, you must cable it to hosts, drives, and other external devices, depending on your hardware configuration.

This chapter addresses the following cabling and configuration topics:

- “Working with SFPs and fiber-optic cables”
- “Connecting storage expansion enclosures to the DS4500” on page 61
- “Connecting secondary interface cables” on page 103
- “Configuring the storage subsystem” on page 104
- “Installing the storage subsystem configuration” on page 111
- “Cabling the power supply” on page 111

Working with SFPs and fiber-optic cables

When fully configured, the back of the DS4500 Storage Subsystem can accommodate up to four host-side and four drive-side mini hubs. Each mini hub is a single, removable unit that provides the Fibre Channel interface between a DS4500 Storage Subsystem, host computers, and drives. Each mini hub has two small form-factor pluggable (SFP) module ports. An SFP module is inserted into a mini-hub port; then, a fiber-optic cable is inserted into the SFP module. Figure 29 shows the Fibre Channel components and connections.

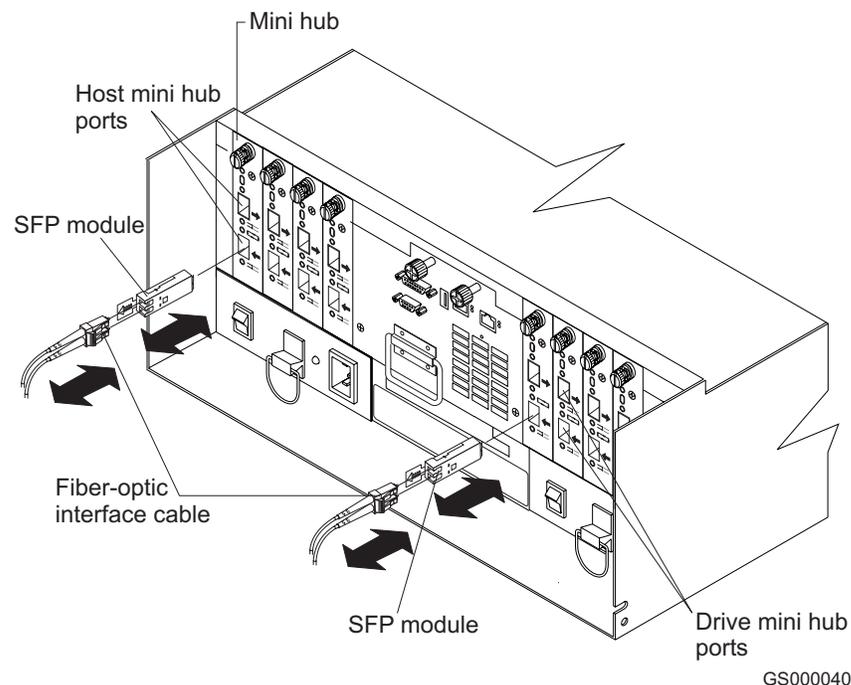


Figure 29. Fibre Channel interface connections

The DS4500 Storage Subsystem uses fiber-optic cables to connect to other Fibre Channel devices. The fiber-optic cables that you need depend on the type of optical connectors in the device to which you are connecting the DS4500 Storage Subsystem. If the device uses SFP modules or optical interface connectors, then

you must use LC-LC Fibre Channel cables. If the device uses Gigabit Interface Converters (GBICs) as the optical interface connector, you must use LC-LC Fibre Channel cables and LC-SC Fibre Channel cable adapters (Part number 19K1250) to connect to the DS4500 Storage Subsystem.

Statement 3:



CAUTION:

When laser products (such as CD-ROMs, DVD drives, fiber optic devices, or transmitters) are installed, note the following:

- Do not remove the covers. Removing the covers of the laser product could result in exposure to hazardous laser radiation. There are no serviceable parts inside the device.
- Use of controls or adjustments or performance of procedures other than those specified herein might result in hazardous radiation exposure.



DANGER

Some laser products contain an embedded Class 3A or Class 3B laser diode. Note the following.

Laser radiation when open. Do not stare into the beam, do not view directly with optical instruments, and avoid direct exposure to the beam.

Types of interface ports

The DS4500 Storage Subsystem has the following types of interface ports:

- Host mini hub
- Drive mini hub
- Ethernet

The SFP mini-hub ports are used for data transfer between hosts or storage expansion enclosures and RAID controllers in the DS4500 Storage Subsystem. Ethernet ports are available for storage subsystem-management. The DS4500 Storage Subsystem interface ports are shown in Figure 30 on page 49.

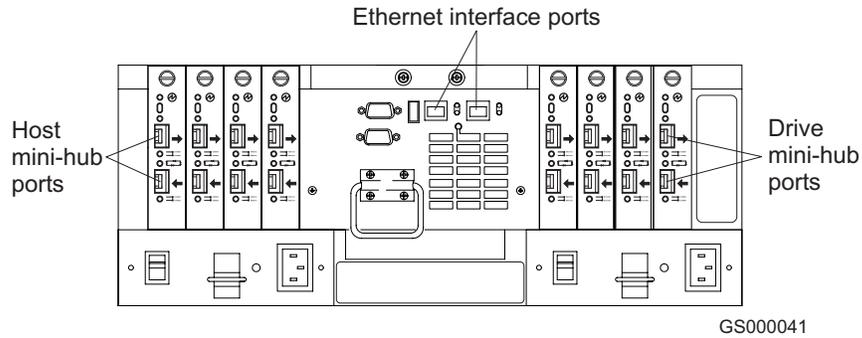


Figure 30. DS4500 Storage Subsystem interface ports

Host interface ports

The DS4500 Storage Subsystem comes with host-side mini hubs 1 and 2 installed. Each mini hub provides host loop connectivity and self-diagnostic features. Host mini hubs connect to the controller in pairs. When fully configured, the DS4500 Storage Subsystem can accommodate four host-side mini hubs, two per controller. Mini hubs 1 and 3 connect to the top controller (Controller A) and mini hubs 2 and 4 connect to the bottom controller (Controller B), as shown in Figure 31. To ensure redundancy, you must connect each host to both controllers through the appropriate mini hub.

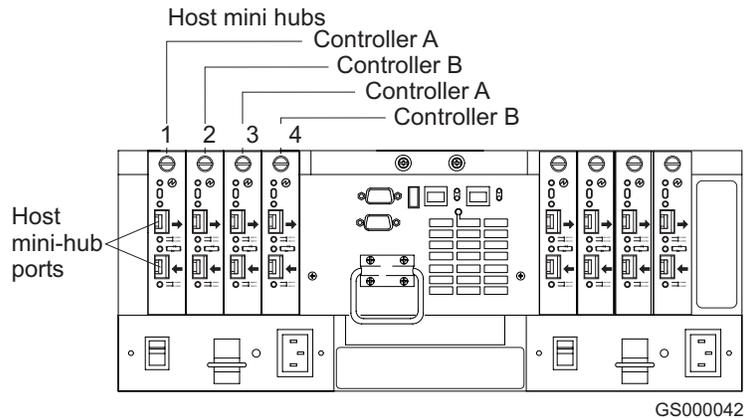


Figure 31. Host-side mini hub interface ports

Drive interface ports

The standard DS4500 Storage Subsystem ships with drive-side mini hubs 2 and 4 installed. (In previous releases, the DS4500 was shipped with the drive-side mini hubs installed in slots 1 and 2.) Each drive mini hub connects to Controller A and Controller B and represents a single drive loop. The drive loops must be set up in pairs to support redundant drive loop configurations (two data paths per storage expansion enclosure). DS4500 uses only redundant drive-loop configurations. For information about cabling the DS4500 drive loops, see “Overview: Cabling a DS4500 with two drive mini hubs” on page 77 and “Overview: Cabling a DS4500 with four drive mini hubs” on page 79. See Figure 32 on page 50 for an illustration of the drive-side mini-hub interface ports.

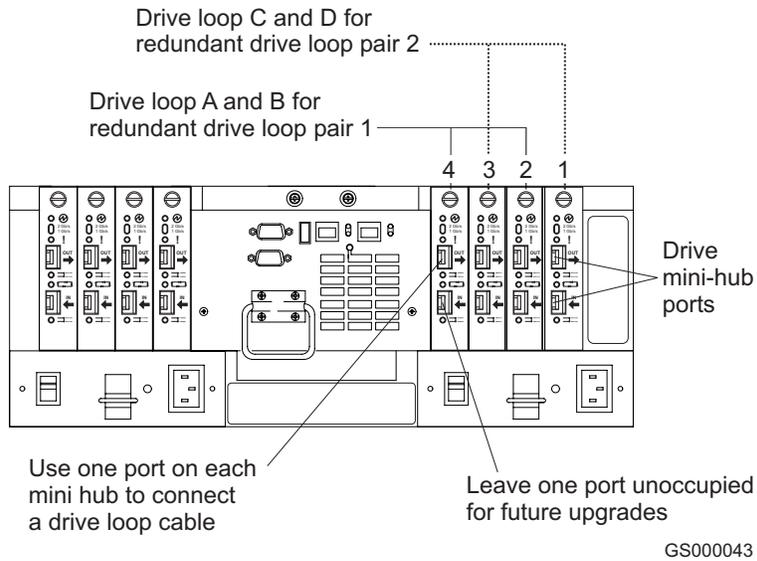


Figure 32. Drive-side mini hub ports

Ethernet interface ports

There are two Ethernet interface ports, one for each controller (Controller A and Controller B). Use the Ethernet ports to directly manage storage subsystems. Figure 33 shows the location of these ports.

Note: Note: The default IP address for controller A and B Ethernet ports are 192.168.128.101 and 192.168.128.102, respectively. The default subnet mask for these ports is 255.255.255.0.

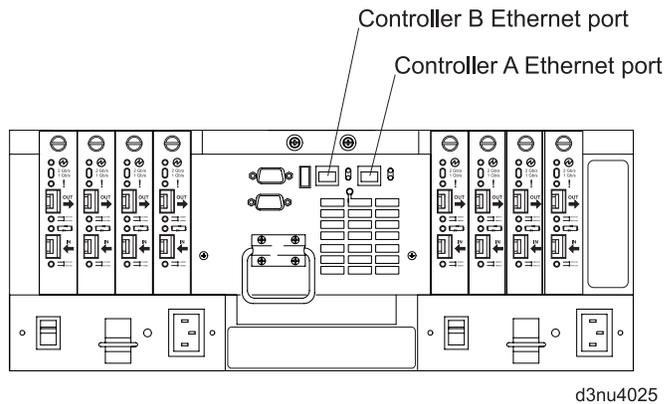


Figure 33. Ethernet ports

Handling fiber-optic cables

Attention: To avoid damage to your fiber-optic cables, follow these guidelines:

- Do not route the cable along a folding cable-management arm.
- For devices on slide rails, leave enough slack in the cables so they do *not* bend to a diameter of less than 76 mm (3 in.), or a radius less than 38 mm (1.5 in.), when extended or become pinched when retracted.

- Route the cable away from places where it can be damaged by other devices in the rack cabinet.
- Do not use plastic cable ties in place of the provided cable straps.
- Do not overtighten the cable straps or bend the cables to a diameter of less than 76 mm (3 in.), or a radius less than 38 mm (1.5 in.).
- Do not put excess weight on the cable at the connection point. Be sure that the cable is well supported.
- The following are the recommended maximum cable lengths:
 - 1 Gbps: 500 meters 50/125 um fiber, 300 meters 62.5/125 um fiber
 - 2 Gbps: 300 meters 50/125 um fiber, 150 meters 62.5/125 um fiber

Installing SFP modules

The DS4500 requires SFP modules, which are not supplied with the DS4500 but must be purchased separately. SFP modules convert electrical signals to optical signals that are required for fibre channel transmission to and from RAID controllers. After you install the SFP modules, you use fiber-optic cables to connect the DS4500 to other fibre channel devices.

Before installing SFP modules and fiber-optic cables, read the following information:

- Do not mix long-wave SFPs and short-wave SFPs on a single storage subsystem. Use only short-wave SFPs. You can use the DS4000 Storage Manager client to view the Storage Subsystem Profile to verify that you are not mixing long-wave and short-wave SFPs.

Attention: In addition, do not use long-wave SFPs or GBICs in any of the fibre channel ports in the DS4500 controllers. (Long-wave SFPs and GBICs are not supported for use in the DS4500 or any of the attached DS4000 storage expansion enclosures. Long-wave SFPs and GBICs are only supported in the fibre channel switch ports to which the DS4500 Storage Subsystem connects.)
- The SFP module housing has an integral guide key that is designed to prevent you from inserting the SFP module improperly.
- Use minimal pressure when inserting an SFP module into an SFP port. Forcing the SFP module into a port could cause damage to the SFP module or to the port.
- You can insert or remove the SFP module while the port is powered on.
- The operational or redundant loop performance is not affected when you install or remove an SFP module.
- You must insert the SFP module into a port before you connect the fiber-optic cable.
- You must remove the fiber-optic cable from the SFP module before you remove the SFP module from the port. Refer to “Removing SFP modules” on page 53 for more information.
- The maximum operating speed of the fibre channel port is determined by two factors: the speed of the SFP module that is installed and the speed of the fibre channel connection. For example, a 2-Gbps SFP that is plugged into a 4-Gbps-capable port will limit the speed of that port to a maximum of 2 Gbps. Conversely, a 4-Gbps SFP that is plugged into a 2-Gbps-capable port will be limited by the speed of the port to a maximum of 2 Gbps.

Attention: Carefully check the SFP's IBM part number, option number, and FRU part number to identify its speed. There are no physical features that distinguish a 4 Gbps from a 2 Gbps SFP.

Statement 3:



CAUTION:

When laser products (such as CD-ROMs, DVD drives, fiber optic devices, or transmitters) are installed, note the following:

- Do not remove the covers. Removing the covers of the laser product could result in exposure to hazardous laser radiation. There are no serviceable parts inside the device.
- Use of controls or adjustments or performance of procedures other than those specified herein might result in hazardous radiation exposure.



DANGER

Some laser products contain an embedded Class 3A or Class 3B laser diode. Note the following.

Laser radiation when open. Do not stare into the beam, do not view directly with optical instruments, and avoid direct exposure to the beam.

Attention: When you handle static-sensitive devices, take precautions to avoid damage from static electricity. For details about handling static-sensitive devices, see “Handling static-sensitive devices” on page 24.

To install an SFP module, complete the following steps:

1. Remove the SFP module from its static-protective package.
2. Remove the protective cap from the SFP module, as shown in Figure 34. Save the protective cap for future use.

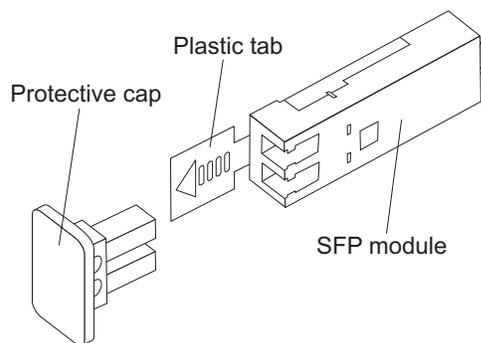


Figure 34. SFP module and protective cap

3. Remove the protective cap from the SFP port. Save the protective cap for future use.
4. Insert the SFP module into the host port until it clicks into place. See Figure 35 on page 53.

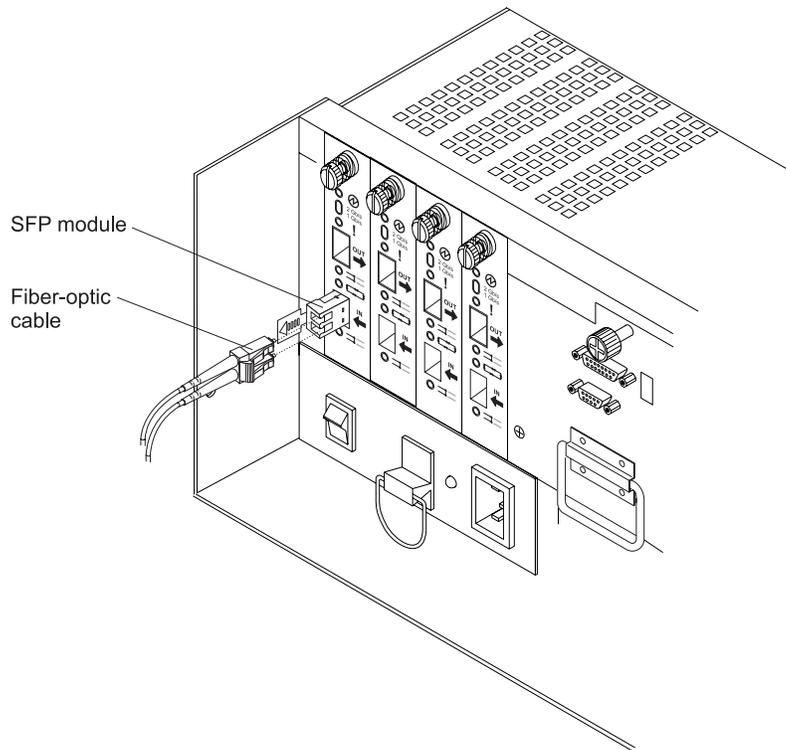


Figure 35. Installing an SFP module into the host port

5. Connect an LC-LC fibre-channel cable. For information about the LC-LC cable, see “Using LC-LC fibre-channel cables” on page 54.

Removing SFP modules

Complete the following steps to remove the SFP module from the host port:

Attention: To avoid damage to the cable or to the SFP module, make sure that you unplug the LC-LC fibre-channel cable *before* you remove the SFP module.

1. Remove the LC-LC fibre-channel cable from the SFP module. For more information, see “Removing an LC-LC fibre-channel cable” on page 56.
2. Unlock the SFP module latch:
 - For SFP modules that contain plastic tabs, unlock the SFP module latch by pulling the plastic tab outward 10°, as shown in Figure 36 on page 54.

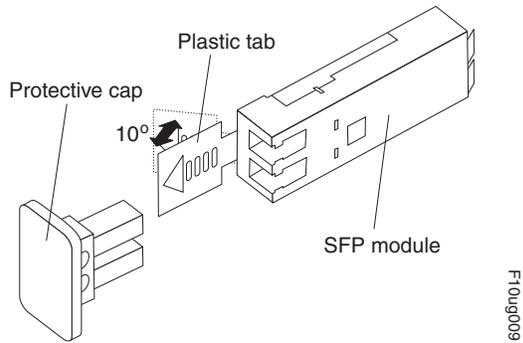


Figure 36. Unlocking the SFP module latch - plastic variety

- For SFP modules that contain wire tabs, unlock the SFP module latch by pulling the wire latch outward 90°, as shown in Figure 37.

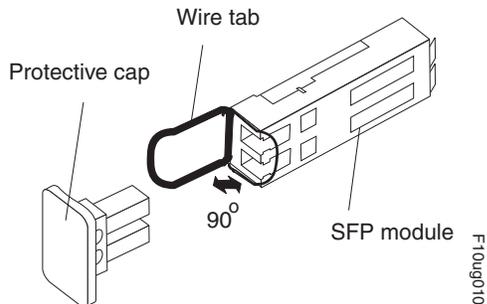


Figure 37. Unlocking the SFP module latch - wire variety

3. With the SFP latch in the unlocked position, extract the SFP module.
 - For SFP modules that contain plastic tabs, slide the SFP module out of the port.
 - For SFP modules that contain wire tabs, grasp the wire latch and pull the SFP module out of the mini-hub port.
4. Replace the protective cap on the SFP module.
5. Place the SFP module into a static-protective package.
6. Replace the protective cap on the host port.

Using LC-LC fibre-channel cables

The LC-LC fibre-channel cable is a fiber-optic cable that you use to connect into one of the following devices:

- An SFP module installed in a fibre channel switch port
- An SFP module of the host bus adapter port
- An SFP module installed in an IBM DS4000 storage expansion enclosure

See Figure 38 on page 55 for an illustration of the LC-LC fibre-channel cable.

For more information about cabling these devices, see the documentation that comes with the LC-LC fibre-channel cable.

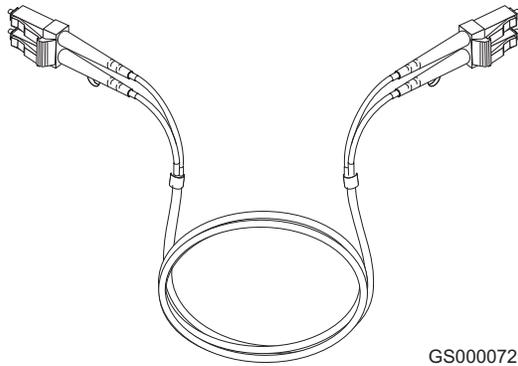


Figure 38. LC-LC fibre-channel cable

Connecting an LC-LC cable to an SFP module

Complete the following steps to connect an LC-LC fibre-channel cable to an SFP module:

Statement 3:



CAUTION:

When laser products (such as CD-ROMs, DVD drives, fiber optic devices, or transmitters) are installed, note the following:

- Do not remove the covers. Removing the covers of the laser product could result in exposure to hazardous laser radiation. There are no serviceable parts inside the device.
- Use of controls or adjustments or performance of procedures other than those specified herein might result in hazardous radiation exposure.

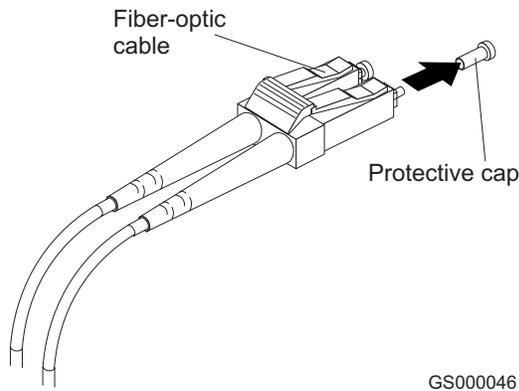


DANGER

Some laser products contain an embedded Class 3A or Class 3B laser diode. Note the following.

Laser radiation when open. Do not stare into the beam, do not view directly with optical instruments, and avoid direct exposure to the beam.

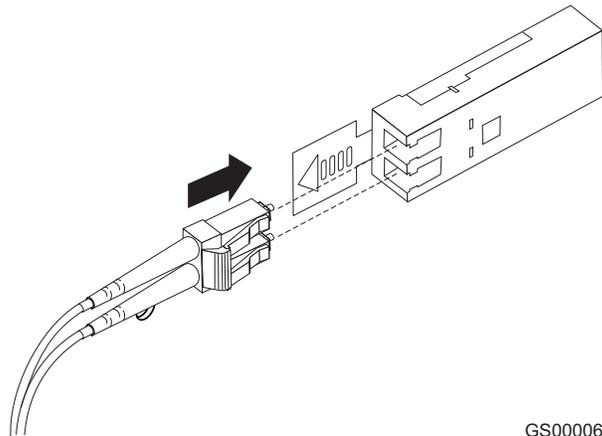
1. Read the information in “Handling fiber-optic cables” on page 50.
2. If necessary, remove the protective cap from the SFP module, as shown in Figure 34 on page 52. Save the protective cap for future use.
3. Remove the two protective caps from one end of the LC-LC cable, as shown in Figure 39 on page 56. Save the protective caps for future use.



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Figure 39. Removing fiber-optic cable protective caps

4. Carefully insert this end of the LC-LC cable into an SFP module that is installed in the DS4500. The cable connector is keyed to ensure it is inserted into the SFP module correctly. Holding the connector, push in the cable until it clicks into place, as shown in Figure 40.



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Figure 40. Inserting an LC-LC fibre-channel cable into an SFP module

5. Remove the two protective caps from the other end of the LC-LC cable. Save the protective caps for future use.
6. Connect this end of the LC-LC cable to one of the following devices:
 - An SFP module that is installed in a separate EXP100 or EXP710 storage expansion enclosure
 - An SFP module that is installed in a fibre channel switch port
 - A fibre channel host bus adapter port
 - LC-SC Fibre Channel cable adapter (for more information, see “Connecting an LC-SC cable adapter to a device” on page 58.)

Removing an LC-LC fibre-channel cable

Complete the following steps to remove an LC-LC fibre-channel cable:

Attention: To avoid damaging the LC-LC cable or SFP module, make sure that you observe the following precautions:

- Press and hold the lever to release the latches before you remove the cable from the SFP module.
 - Ensure that the levers are in the released position when you remove the cable.
 - Do not grasp the SFP module plastic tab when you remove the cable.
1. On the end of the LC-LC cable that connects into the SFP module or host bus adapter, press down and hold the lever to release the latches, as shown in Figure 41.

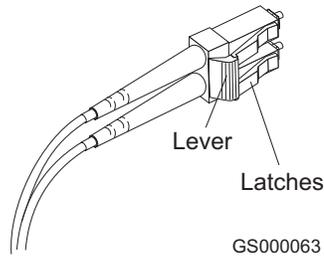


Figure 41. LC-LC fibre-channel cable lever and latches

2. While pressing down the cable lever, carefully pull on the connector to remove the cable from the SFP module, as shown in Figure 42.

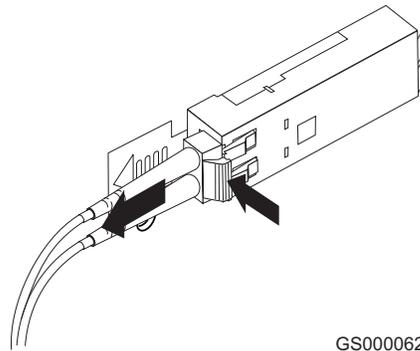


Figure 42. Removing the LC-LC fibre-channel cable

3. Replace the protective caps on the cable ends.
4. Replace the protective cap on the SFP module.

Using LC-SC fibre-channel cable adapters

The LC-SC fibre-channel cable adapter is a fiber-optic cable that is used to connect an LC connector into one of the following devices that require SC connectors:

- 1-Gbps fibre channel switch
- Fibre channel host bus adapter
- EXP500 storage expansion enclosure (Machine type 3560)
- 1 Fibre Channel Managed hub (Machine type 3534)

For more information about connecting to these devices, see the documentation that comes with the LC-SC fibre-channel cable adapter.

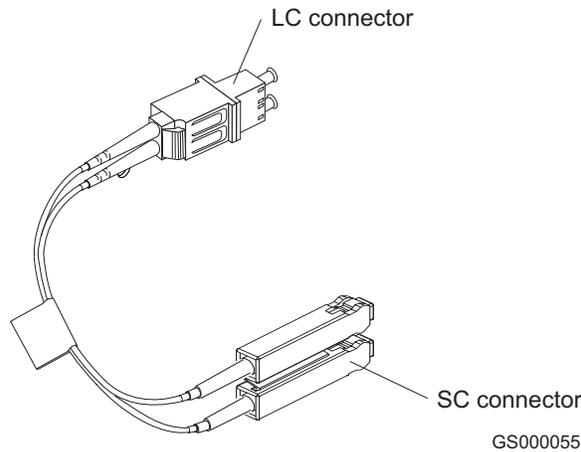


Figure 43. LC-SC fibre-channel cable adapter

The following sections provide the procedures for properly connecting and removing an LC-SC fibre-channel cable.

Connecting an LC-SC cable adapter to a device

Complete the following steps to connect an LC-SC fibre-channel cable adapter to a device:

Statement 3:



CAUTION:

When laser products (such as CD-ROMs, DVD drives, fiber optic devices, or transmitters) are installed, note the following:

- Do not remove the covers. Removing the covers of the laser product could result in exposure to hazardous laser radiation. There are no serviceable parts inside the device.
- Use of controls or adjustments or performance of procedures other than those specified herein might result in hazardous radiation exposure.



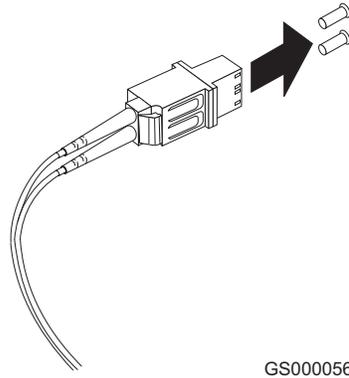
DANGER

Some laser products contain an embedded Class 3A or Class 3B laser diode. Note the following.

Laser radiation when open. Do not stare into the beam, do not view directly with optical instruments, and avoid direct exposure to the beam.

1. Read the information in “Handling fiber-optic cables” on page 50.
2. Connect one end of an LC-LC cable to an SFP module in the DS4500. For instructions, see “Using LC-LC fibre-channel cables” on page 54.

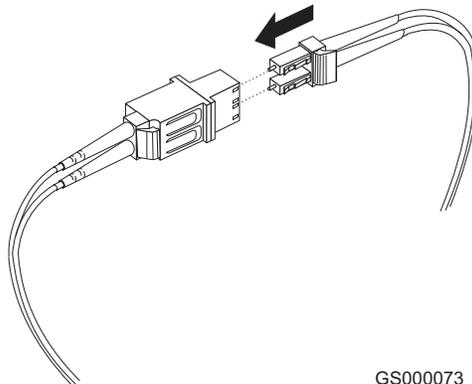
3. Remove the two protective caps from the LC connector end of the LC-SC cable adapter as shown in Figure 44. Save the protective caps for future use.



GS000056

Figure 44. Removing the LC-SC cable adapter protective caps

4. Carefully insert the other end of the LC-LC cable into the LC connector end of the LC-SC cable adapter as shown in Figure 45. Push in the connector until it clicks into place.



GS000073

Figure 45. Connecting an LC-LC cable into the LC-SC cable adapter

5. If you are connecting the DS4500 to a 1-Gbps fibre channel switch or fibre channel host bus adapter, connect the SC connector end of the LC-SC cable adapter to a Gigabit Interface Converter (GBIC) that is installed in the 1-Gbps fibre channel switch or fibre channel host bus adapter. For more information about connecting to these devices, see the documentation that comes with the device.

Removing an LC-LC cable from an LC-SC cable adapter

Complete the following steps to remove an LC-LC cable from an LC-SC cable adapter:

Attention: To avoid damaging the LC-LC cable, make sure you press and hold the lever to release the latches before you remove the cable from an LC-SC cable adapter. Ensure that both levers are in the released position when removing the cable. When removing the cable from the SFP module, make sure you do not grasp the SFP module plastic tab.

1. On the end of the cable that connects into the LC connector end of the LC-SC cable adapter, press down and hold the lever to release the latches. Figure 46 shows the location of the lever and latches.

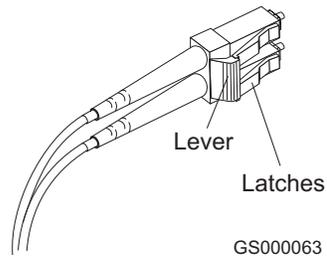


Figure 46. LC-LC fibre-channel cable lever and latches

2. Carefully pull on the connector to remove it. Make sure you grasp the connector and not the cable when removing the LC-LC cable from the LC-SC cable adapter as shown in Figure 47.

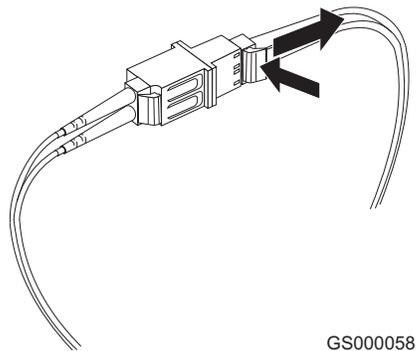


Figure 47. Removing the LC-LC fibre-channel cable from an LC-SC fibre-channel cable adapter

3. Replace the protective caps on the cable ends.

Connecting storage expansion enclosures to the DS4500

Attention

Before powering on the DS4500 Storage Subsystem, each attached storage expansion enclosure must be populated with at least two drives. If at least two drives are not installed in each attached storage expansion enclosure, when you power on the DS4500 and its attached storage expansion enclosure(s), your standard storage partition key might be lost and must be regenerated using instructions on the IBM DS4000 Solutions and Premium Features Web site:

<https://www-912.ibm.com/PremiumFeatures/>

In addition, the resulting insufficient load to the enclosure power supplies might cause them to intermittently appear as failed, falsely indicating the power supplies are bad. All drives in the connected storage expansion enclosure(s) must contain no prior configuration data.

In the initial installation of the DS4500, you can add only *new* storage expansion enclosures to the DS4500 Storage Subsystem. This means that there must be no existing configuration information on the storage expansion enclosures that you want to install.

If the storage expansion enclosures that you want to install currently contain logical drives or configured hot spares, and you want them to be part of the DS4500 Storage Subsystem configuration, refer to the *IBM System Storage DS4000 Hard Drive and Storage Expansion Enclosure Installation and Migration Guide*. Improper drive migration might cause loss of configuration and other storage subsystem problems. Contact your IBM technical support representative for additional information.

The maximum number of storage expansion enclosures that can be connected per pair of redundant drive loops depends on the IBM DS4000 storage expansion enclosure models used. The following DS4000 storage expansion enclosure types are supported by the DS4500 Storage Subsystem:

- FASTt EXP500
- DS4000 EXP700
- DS4000 EXP710
- DS4000 EXP100
- DS4000 EXP810

If the drives are configured using only EXP700, EXP710, EXP100, or EXP810 storage expansion enclosures, the DS4500 Storage Subsystem supports a maximum of 224 hard drives.

If the drives are configured using only FASTt EXP500 storage expansion enclosures, the DS4500 Storage Subsystem supports a maximum of 220 hard drives.

Attention: To attach DS4000 EXP drive expansion enclosures to a DS4500, refer to the *IBM System Storage DS4000 Hard Drive and Storage Expansion Enclosure Installation and Migration Guide* for the latest information on the required version of the DS4500 controller firmware and the supported combination of enclosure types intermix behind a DS4500 subsystem. In addition, you must purchase the FC/SATA Enclosure Intermix premium option to combine DS4000 EXP100s or DS4000 EXP810s with SATA enhanced disk drive modules (E-DDMs) with DS4000 EXP700s, DS4000 EXP710s, or DS4000 EXP810s with fibre channel drives in the same DS4500 Storage Subsystem configuration. The EXP700 expansion enclosure must be upgraded to EXP710 by using the *DS4000 EXP700 Models 1RU/1RX Switched-ESM Option Upgrade Kit* for intermixing with the EXP810 expansion enclosures.

For detailed information about how to cable the storage subsystem and storage expansion enclosures, see “Configuring the drive loops with storage expansion enclosures” on page 77.

Supported storage expansion enclosure configurations and intermix combinations

Although the DS4500 Storage Subsystem supports various types of DS4000 storage expansion enclosures, not all combinations of these supported storage expansion enclosures are possible or supported as storage expansion enclosures intermix within a DS4500 Storage Subsystem configuration. In addition, if you intermix storage expansion enclosures with SATA and FC drives within a DS4500 Storage Subsystem configuration, an FC/SATA intermix premium feature must be purchased for that DS4500 Storage Subsystem. For additional information about Intermix configurations, see the *IBM TotalStorage DS4000 Fibre Channel and Serial ATA Intermix Premium Feature Installation Overview* (GC26-7713-01).

Table 13 shows the maximum number of enclosures in a DS4500 drive loop, as well as the maximum number of enclosures in the drive loop when intermixing supported enclosures.

Table 13. Storage expansion enclosure configurations

	EXP500	EXP100	EXP700	EXP710	EXP810
Maximum number of enclosures in a DS4500 drive loop	11	8	8	8	7
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP500	11	Not Supported	10	Not Supported	Not Supported
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP700	10	8	8	8	Not Supported ¹
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP100	Not Supported	8	8	8	7
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP710	Not Supported	8	8	8	7

Table 13. Storage expansion enclosure configurations (continued)

	EXP500	EXP100	EXP700	EXP710	EXP810
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP810	Not Supported	7	Not Supported ¹	7	7
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP500 and EXP700	10	Not Supported	10	Not Supported	Not Supported
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP700 and EXP100	Not Supported	8	8	8	Not Supported ¹
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP700 and EXP710	Not Supported	8	8	8	Not Supported ¹
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP100 and EXP710	Not Supported	8	8	8	7
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP100 and EXP810	Not Supported	7	Not Supported ¹	7	7
Maximum number of enclosures in a DS4500 drive loop when intermixing with EXP710 and EXP810	Not Supported	7	Not Supported ¹	7	7

¹ Supported only when EXP700 upgraded to EXP710 with the *DS4000 EXP700 Models 1RU/1RX Switched-ESM Option Upgrade Kit*.

DS4000 storage expansion enclosure models can be mixed in the pair of redundant drive loops. Table 14 on page 64 shows whether an existing storage expansion enclosure within a DS4500 redundant drive loop can support the addition of new storage expansion enclosures of another model type. Table 15 on page 65 lists possible storage expansion enclosure intermix combinations between 10-drive and 14-drive storage expansion enclosures or between 14-drive and 16-drive storage expansion enclosures, as well as total number of drives for each combination.

Note: Since the maximum number of drives that can be supported in the DS4500 redundant drive loop pair is 112, IBM does not support the use of partially filled drive enclosures when intermixing storage expansion enclosures of different drive slot capacities to prevent the possibility of going over the maximum of 112 drives in a drive loop. Intermixing drive expansion enclosures with different number of drive slots will reduce the maximum number of drives that can be configured in a redundant drive loop pair, as shown in Table 15 on page 65.

Table 14. Support for new storage expansion enclosures within a DS4500 drive loop

Existing EXP drive expansion enclosure in drive loop	New EXP drive expansion enclosure				
	EXP500	EXP100	EXP700	EXP710	EXP810 (FC or SATA)
EXP500	Yes	No ¹	Yes ²	No ¹	No ¹
EXP100	No ¹	Yes ³	Yes ^{3, 6}	Yes ^{3, 4, 6}	Yes ^{5, 6, 8}
EXP700	Yes ²	Yes ^{3, 6}	Yes	Yes ⁴	No ⁷
EXP710	No ¹	Yes ^{3, 4, 6}	Yes ⁴	Yes ⁴	Yes ^{5, 6, 8}
EXP810 (FC or SATA)	No ¹	Yes ^{5, 6, 8}	No ⁷	Yes ^{5, 6, 8}	Yes ^{5, 6, 8}

¹ EXP500 operates at 1 Gbps FC speed only. EXP100 and EXP710 operate at 2 Gbps FC speed only. EXP810 operates at 2 Gbps and 4 Gbps FC speed.

² Requires DS4500 controller firmware version 5.40.xx.xx. The drive mini hubs and EXP710 speed switch must be set to 1 Gbps.

³ EXP100 requires DS4500 controller firmware version 5.41.xx.xx or higher. Controller firmware version 6.12.xx.xx is required for intermixing EXP100 and EXP700/EXP710 storage enclosures behind a DS4500 Storage Subsystem. It is recommended that you use the latest general released firmware version 6.19.xx.xx if there are not any EXP700 enclosures in the DS4500 configuration.

⁴ EXP710 requires DS4500 controller firmware version 6.1x.xx.xx or higher. The drive mini hubs and EXP710 speed switch must be set to 2 Gbps. It is recommended that you use the latest general released firmware version 6.19.xx.xx if there are not any EXP700 enclosures in the DS4500 configuration.

⁵ EXP810 requires DS4500 controller firmware version 6.19.xx.xx or higher.

⁶ FC/SATA intermix premium feature is required if there is a mix of FC and SATA drives in the DS4500 Storage Subsystem.

⁷ EXP700 requires the purchase of the *DS4000 EXP700 Models 1RU/1RX Switched-ESM Option Upgrade Kit* if it is to be attached to EXP810s.

⁸ EXP810 speed switch must be set to 2 Gbps.

Table 15. Possible combinations of storage expansion enclosures per drive loop

Number of FAST EXP500 units (10 drives/unit)	Number of DS4000 EXP700 units (14 drives/unit)	Number of DS4000 EXP710/EXP100 units (14 drives/unit)	Number of DS4000 EXP810 units (16 drives/unit)	Total number of storage expansion enclosures	Total number of drives
0	8	N/A	N/A	8	112
1	7	N/A	N/A	8	108
2	6	N/A	N/A	8	104
3	6	N/A	N/A	9	114
4	5	N/A	N/A	9	110
5	4	N/A	N/A	9	106
6	3	N/A	N/A	9	102
7	3	N/A	N/A	10	112
8	2	N/A	N/A	10	108
9	1	N/A	N/A	10	104
10	0	N/A	N/A	10	100
11	0	N/A	N/A	11	110
N/A	N/A	8	0	8	112
N/A	N/A	6	1	7	100
N/A	N/A	5	2	7	102
N/A	N/A	4	3	7	104
N/A	N/A	3	4	7	106
N/A	N/A	3	5	7	108
N/A	N/A	1	6	7	110
N/A	N/A	0	7	7	112

For the latest information on requirements such as enclosure cabling schemes, minimum version of controller, or enclosure ESM firmware required for intermixing DS4000 storage expansion enclosures, refer to the *IBM TotalStorage DS4000 Hard Drive and Storage Expansion Enclosure Installation and Migration Guide*.

Overview: Connecting storage expansion enclosures to a storage subsystem

This section contains the following topics:

1. “General rules and recommendations for cabling storage expansion enclosures”
2. “Storage expansion enclosure cabling diagrams” on page 68
3. “Steps for connecting storage expansion enclosures to a storage subsystem” on page 75

General rules and recommendations for cabling storage expansion enclosures

Refer to these general rules and recommendations when you complete the steps described in “Steps for connecting storage expansion enclosures to a storage subsystem” on page 75.

Note: This section also refers to the cabling diagrams in “Storage expansion enclosure cabling diagrams” on page 68.

The following are general rules or limitations to follow as a guideline when you connect storage expansion enclosures to the storage subsystem:

- The DS4500 Storage Subsystem supports the connection of a maximum of two redundant drive loop pairs. The maximum number of drive enclosures per drive loop depends on the type of storage expansion enclosure and whether intermixing storage expansion enclosures of different drive slots. For detailed information, see Table 13 on page 62 and Table 15 on page 65.
- The DS4500 currently supports a maximum of 110 drives in 11 10-drive storage expansion enclosures or 112 drives in either eight 14-drive or seven 16-drive storage expansion enclosures per drive loop in each controller. Two drive loops from the DS4500 drive mini hubs must be connected to the same set of storage expansion enclosures to provide drive loop redundancy.
- When connecting the storage expansion enclosures to DS4500 drive mini hubs, do not use all ports in each of the drive mini hubs. Connect the FC cable to only one port of the drive mini hub and leave the other port unoccupied.
- When cabling different types of storage expansion enclosures, if possible, do not mix different types of storage expansion enclosures in the same redundant drive loop pair. Also, when mixing different types of storage expansion enclosures in the same drive channel pair, the Link Rate Setting must be the same for each storage expansion enclosure. IBM does not support different enclosure speed settings in the same drive loop.

In addition to the previously outlined general rules, it is *strongly* recommended that you observe the following rules when connecting storage expansion enclosures to the storage subsystem:

- Ensure that the single digit (x1) of the enclosure ID for every enclosure in a redundant drive loop pair is unique. (In addition to expansion enclosures, this includes any storage subsystem that has drives installed.)

Enclosure IDs (sometimes known as tray IDs) consist of two digits (x10 and x1). In 14-drive expansion enclosures (EXP100/EXP700/EXP710), the enclosure ID may be set manually. In 16-drive expansion enclosures (EXP810), the enclosure ID is set automatically by the EXP810 ESM and the controller firmware. Please refer to the *Installation, User's, and Maintenance Guide* of your appropriate enclosures for information on how to manually set the switches.

If you do not set the enclosure IDs to be unique among enclosures, then drive loop errors might be randomly posted in the DS4500 subsystem Major Event Log (MEL) when intermixing different types of storage expansion enclosures in a redundant drive loop pair, such as an EXP100 with an EXP810. For example, with four enclosures attached to the DS4500 in a redundant drive loop pair, the correct enclosure ID settings should be x1, x2, x3, and x4 (where x can be any digits that can be set). Examples of incorrect settings would be 11, 21, 31, and 41; or 12, 22, 32 and 62. These examples are incorrect because the x1 digits are the same in all enclosure IDs (either 1 or 2).

If the enclosure IDs in your DS4000 subsystem configuration are not currently set to have unique single digit values for the enclosures in the same redundant drive loop pair, make the changes to the enclosure IDs in the next maintenance schedule. This will prevent unnecessary downtime when you add enclosures of different type (especially EXP810s) to the existing enclosures in the redundant drive loop pair.

Table 16 on page 67 displays the recommended enclosure ID schemes for the first and second redundant drive loop pair.

Table 16. Recommended enclosure ID schemes for the first and second redundant drive loop pair

Enclosure	Enclosure ID of	
	First redundant drive loop pair	Second redundant drive loop pair ¹
1	00	10 ²
2	01	11
3	02	12
4	03	13
5	04	14
6	05	15
7	06	16
8	07	17

¹ In the DS4500 configuration with a maximum of 14 EXP810s, the enclosure IDs of the EXP810s will be automatically set to 0-13.

² The x10 digit of the enclosure IDs can be any value as long as combining it with the single-digit value creates a unique enclosure ID in the whole DS4500 configuration, not just in a given redundant drive loop pair.

Important: Ensure that the single digit (x1) of the enclosure ID for every enclosure in a redundant drive loop pair is unique. (In addition to expansion enclosures, this includes any storage subsystem that has drives installed.)

Note: The EXP810 enclosure ID can be changed via the menu option in the DS4000 Storage Manager subsystem management window only.

- If it is not possible to avoid mixing different enclosure types in the same redundant drive loop pair, this rule must be strictly observed. When mixing EXP810 and EXP710 enclosures in the same drive loop with EXP100 enclosures, all of the EXP810s and EXP710s must be grouped together with the EXP100 connected to either end of the EXP810/EXP710 drive expansion enclosure group. The primary reason for this grouping is because the controller firmware considers the EXP810s and EXP710s to be the same enclosure type (switched disk expansion unit type which have an ESM-embedded Fibre channel loop switch) despite being different models. These two enclosure models must be grouped together if they are contained within a drive loop.

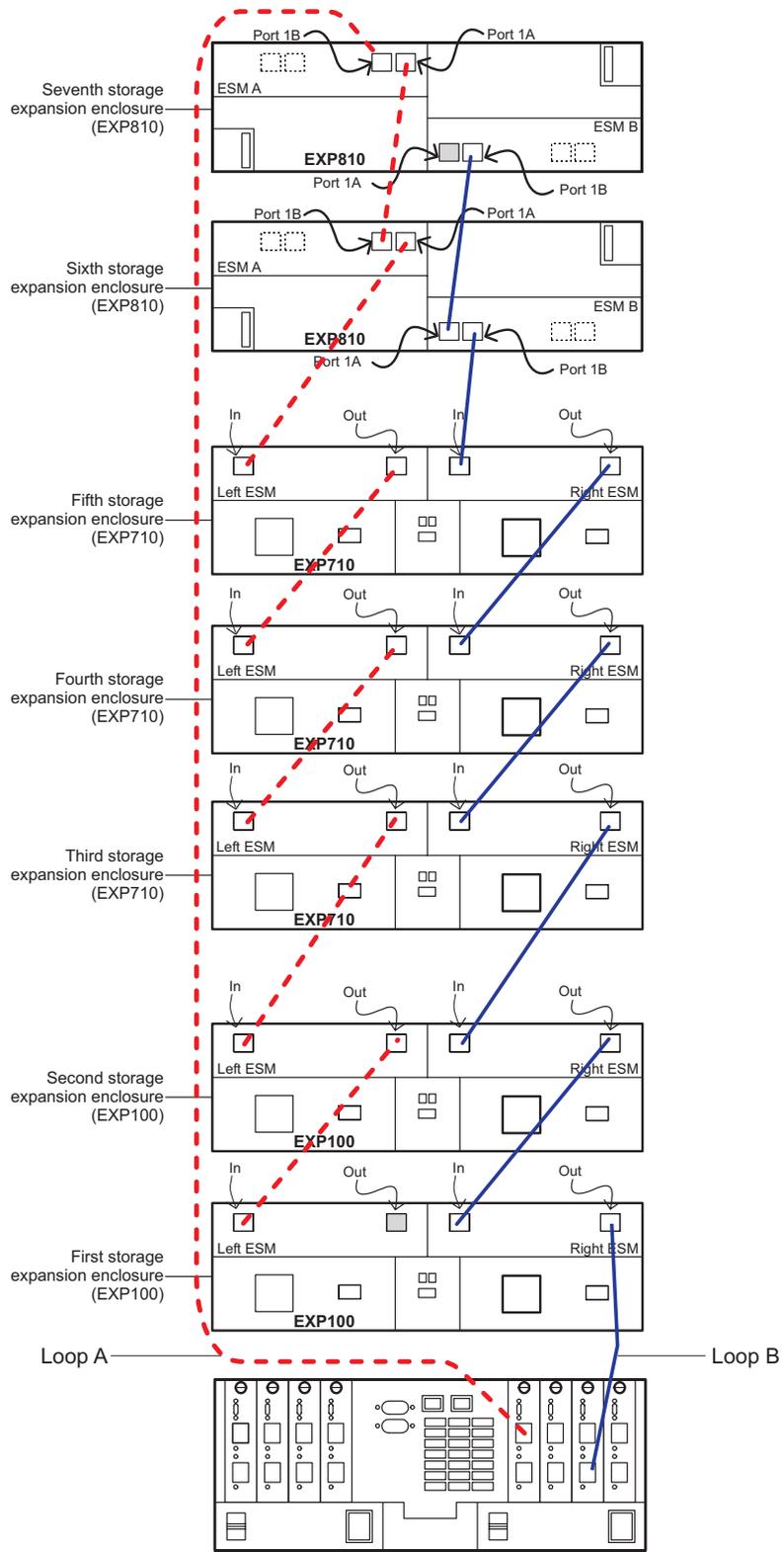
Note: You must cable all of the EXP810 together, then followed by all of the EXP710 or vice versa. Figure 48 on page 69 and Figure 49 on page 70 are examples of correctly cabling the intermix of EXP100 with EXP810 and EXP710 enclosures. Figure 50 on page 71 and Figure 51 on page 72 are examples of incorrectly cabling the intermix of these enclosures. One shows the EXP100s cabled between the EXP810s and EXP710s, while the other shows the EXP810s and EXP710s intermingled, not with the EXP810s grouped separately from the EXP710s as recommended.

- The DS4500 drive mini hub port must always be connected to the EXP810 port 1B, regardless of whether the port is on the EXP810 ESM A or ESM B. Figure 52 on page 73 is an example of correctly cabling the EXP810 1B ports to the DS4500 drive mini hub port. Figure 53 on page 74 is an example of incorrect cabling showing the connection from the drive mini hub port to the incorrect EXP810 port, labeled 1A.

- The DS4500 drive mini hub port must always be connected to the 10- or 14-drive storage expansion enclosure left ESM In port of the last enclosure in the group of enclosures that are cabled in a redundant drive loop pair. In addition, the DS4500 drive mini hub port must always be connected to the 10- or 14-drive storage expansion enclosure right ESM Out port of the first enclosure in the group of enclosures that are cabled in a redundant drive loop pair. Figure 54 on page 75 shows this correct cabling to the 10- or 14-drive storage expansion enclosure ESM ports.

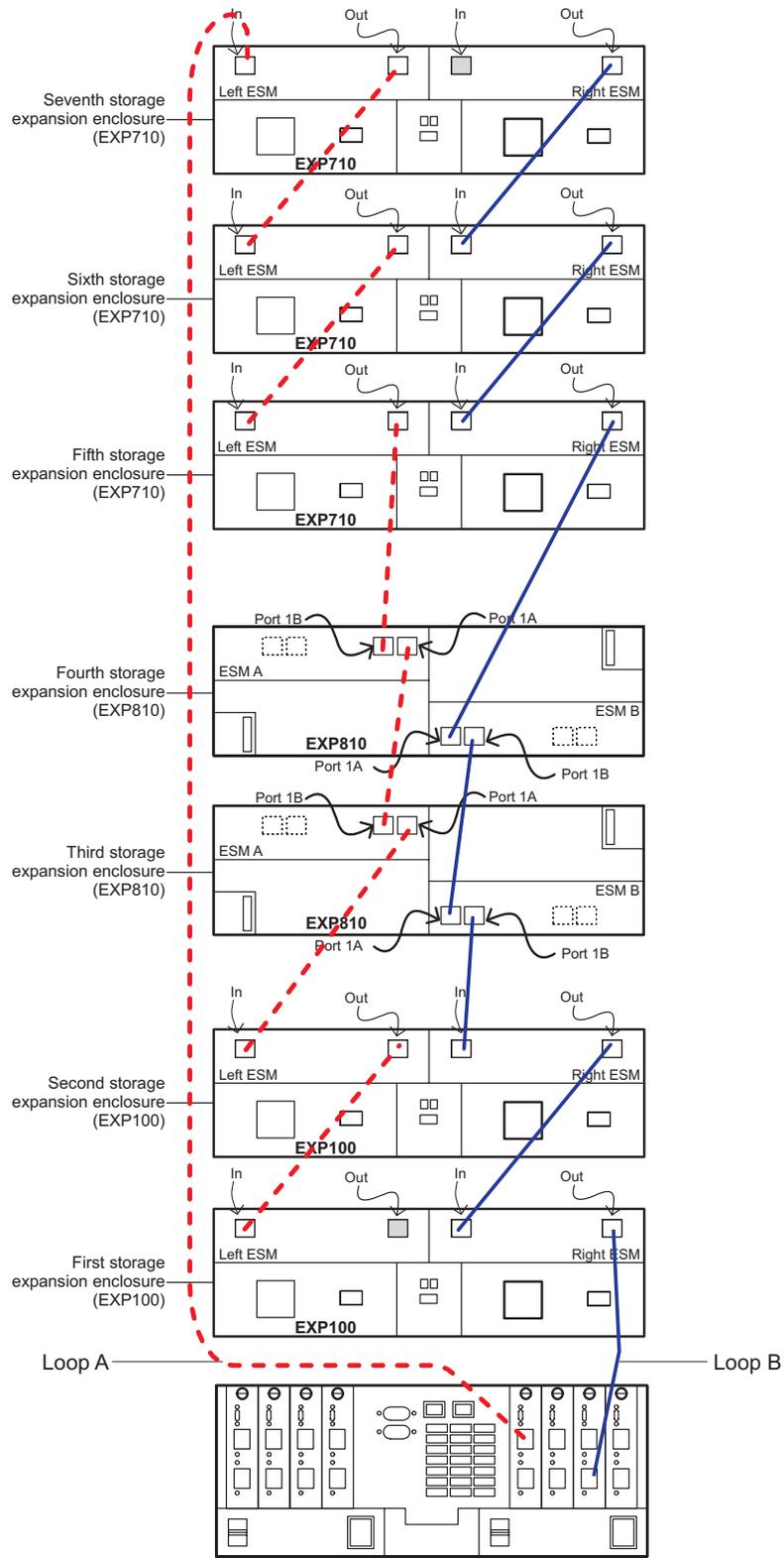
Storage expansion enclosure cabling diagrams

These diagrams help describe the information that is listed in “General rules and recommendations for cabling storage expansion enclosures” on page 65.



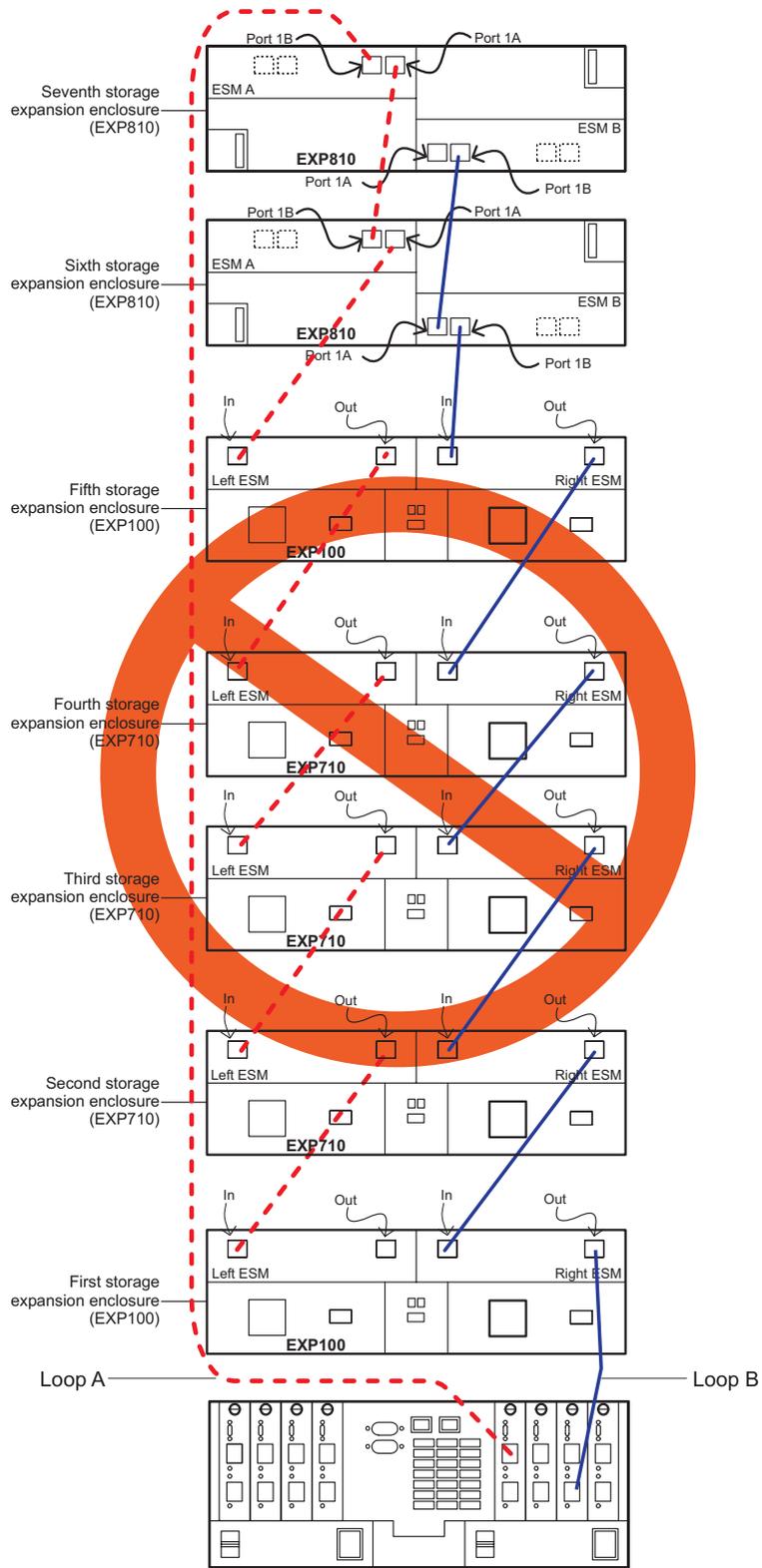
ds4500_mix3

Figure 48. Correct cabling for an intermix of EXP100, EXP710, and EXP810 storage expansion enclosure (example 1)



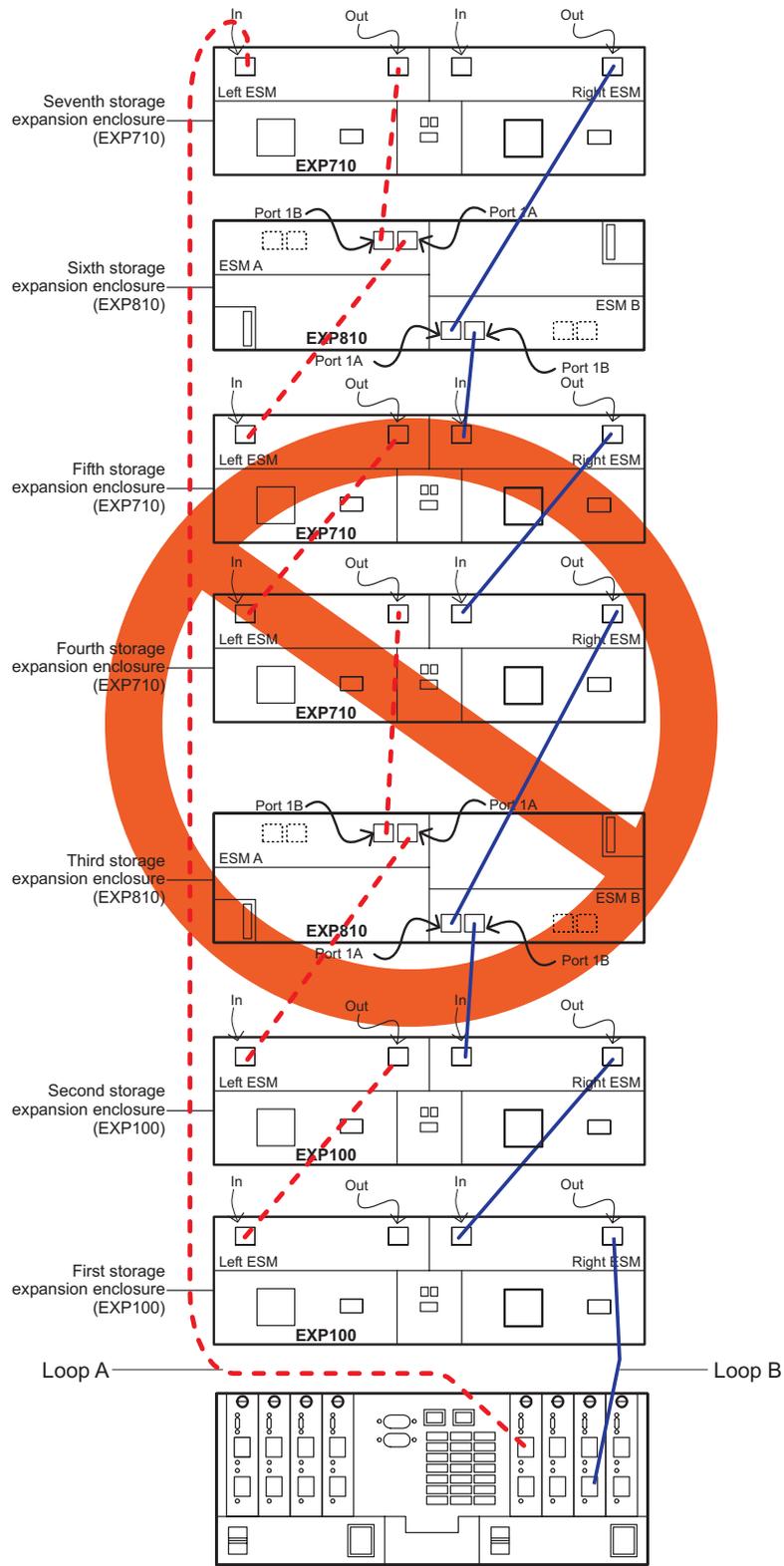
ds4500_mix4

Figure 49. Correct cabling for an intermix of EXP100, EXP710, and EXP810 storage expansion enclosure (example 2)



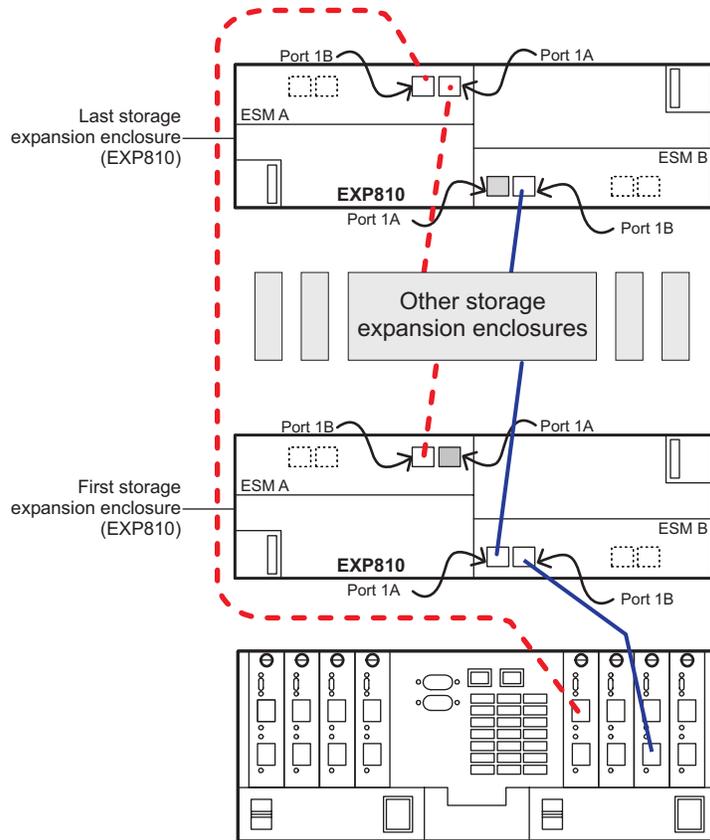
ds4500_mix5

Figure 50. Incorrect cabling for an intermix of EXP100, EXP710, and EXP810 storage expansion enclosure (example 1)



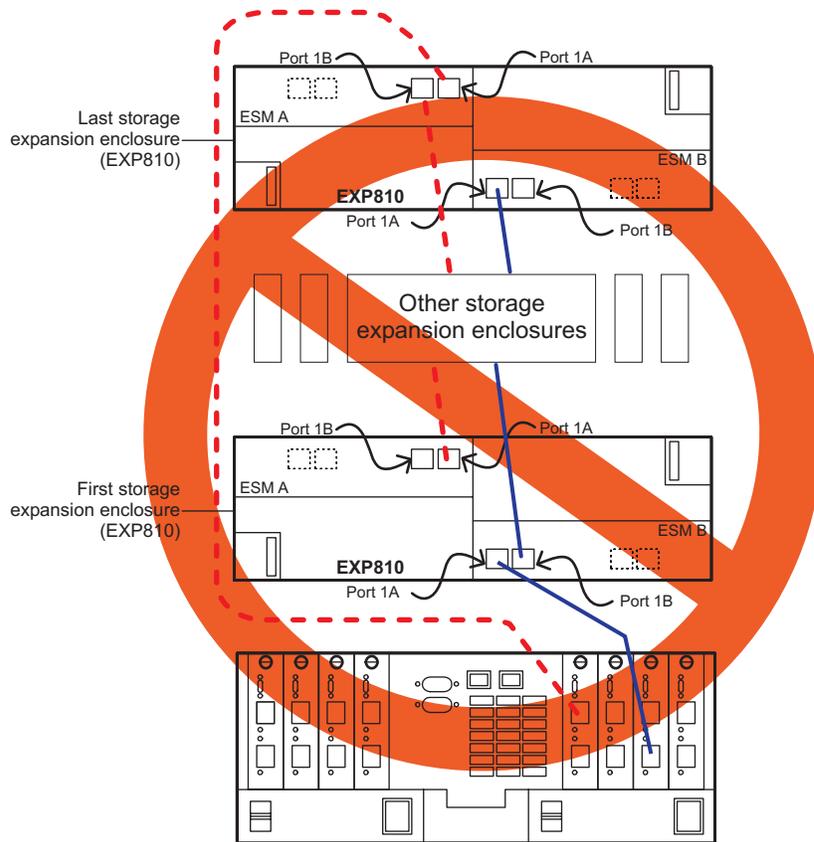
ds4500_mix6

Figure 51. Incorrect cabling for an intermix of EXP100, EXP710, and EXP810 storage expansion enclosure (example 2)



ds4500_8109

Figure 52. Correct cabling to EXP810 port 1B



ds4500_8110

Figure 53. Incorrect cabling to the EXP810 port

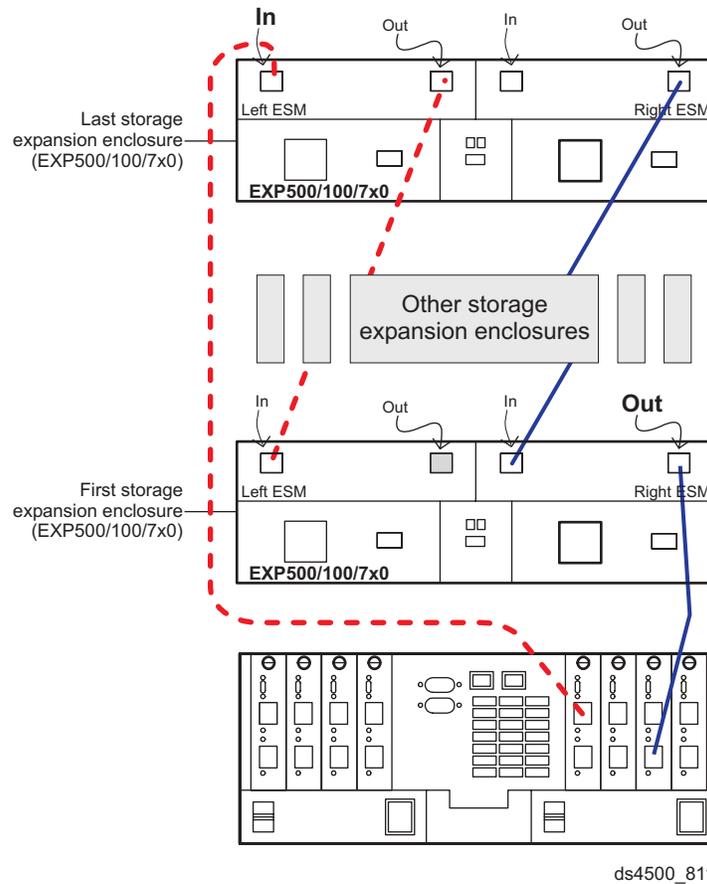


Figure 54. Incorrect cabling to the EXP500/EXP100/EXP700/EXP710 ports

Steps for connecting storage expansion enclosures to a storage subsystem

Before you begin, please review the information listed in “General rules and recommendations for cabling storage expansion enclosures” on page 65.

When connecting storage expansion enclosures to the storage subsystem, use the following procedure as a general guideline and overview of the connection process:

Note: The following procedure is for a “cold-case” situation (where the DS4500 is powered down when storage expansion enclosures are connected, as in the case of initial installation). For a “hot-case” scenario (where the DS4500 is powered on when storage expansion enclosures are connected), refer to the *IBM System Storage DS4000 Hard Drive and Storage Expansion Enclosure Installation and Migration Guide*.

1. Follow the instructions in the *Installation, User's, and Maintenance Guide* for your DS4000 storage expansion enclosure to set up and mount the storage expansion enclosures.
2. Determine a plan regarding the appropriate number of storage expansion enclosures you will connect to the DS4500. If you are connecting external storage expansion enclosures to the DS4500, ensure that the storage expansion enclosures are populated with at least two drives before you power them on.

3. Depending on the type of storage expansion enclosure (10-/14-drive or 16-drive) that you plan to connect to the DS4500 drive mini hub ports, see “Using EXP500, EXP100, EXP700, or EXP710 storage expansion enclosures” on page 81 or “Using EXP810 storage expansion enclosures” on page 90 for instructions on how to connect the DS4500 to the enclosures.
4. In non-EXP810 storage expansion enclosures, such as EXP710 or EXP100, set unique enclosure IDs for all storage expansion enclosures that are cabled to the DS4500. See “DS4000 storage expansion enclosure ID settings” on page 103, and then refer to your storage expansion enclosure installation manual for details on setting the enclosure ID.

The DS4500 Storage Subsystem locates the drives in the storage expansion enclosures after you power on the configuration. Always connect power to the storage expansion enclosures first and then connect power to the DS4500. After you have powered on the configuration, use the DS4000 Storage Manager client to check the status of the new drives, correct any errors found, and configure the new drives.

Redundant drive loop cabling overview

The DS4500 Storage Subsystem supports two redundant drive loops. A redundant drive loop consists of one or more storage expansion enclosures connected to a controller using two sets of fibre channel cables. If one data path fails, the controller uses the other data path to maintain the connection to the drive group.

Figure 55 on page 77 shows a storage subsystem containing one storage subsystem and two redundant drive loops with four storage expansion enclosures each. Each storage expansion enclosures group uses redundant drive loops to connect to the DS4500 Storage Subsystem. Loop A and loop B make up one redundant pair of drive loops. Loop C and loop D make up a second redundant pair.

Attention: To prevent loss of storage expansion enclosure redundancy, connect the storage expansion enclosures as shown in Figure 55 on page 77.

Note: The illustrations in this document might differ slightly from the hardware.

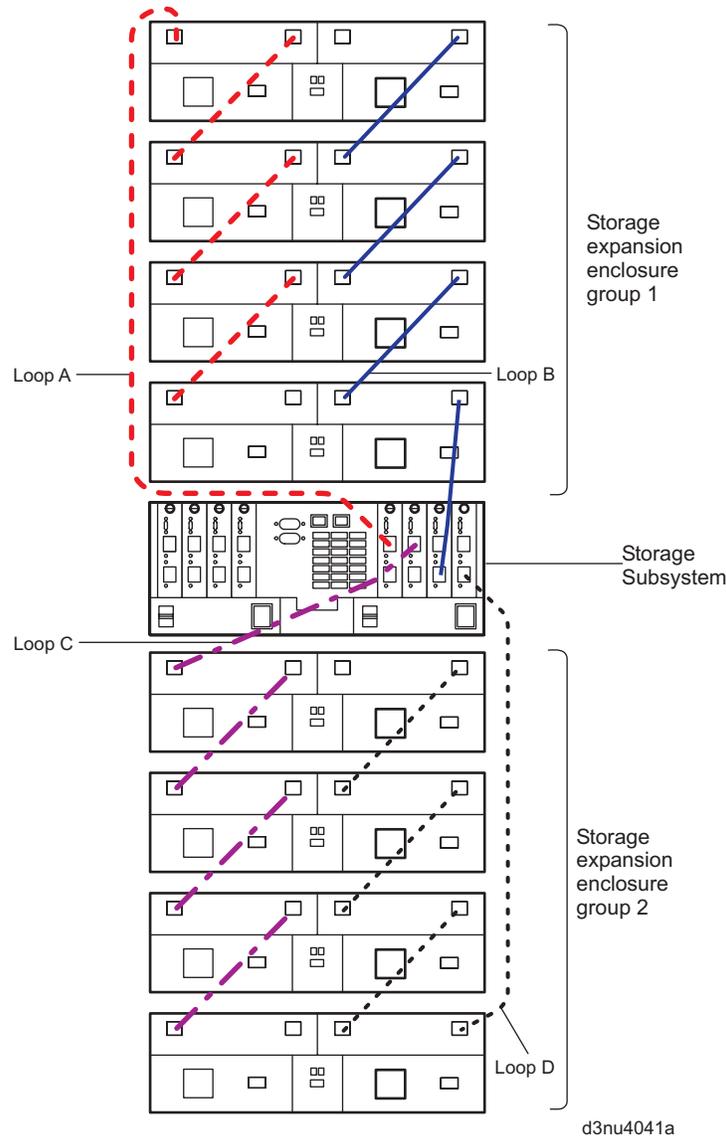


Figure 55. Redundant drive loop cabling overview

For specific information about how to cable the storage subsystem and storage expansion enclosures, see “Configuring the drive loops with storage expansion enclosures” and the *IBM TotalStorage DS4500 Fibre Channel Storage Subsystem Cabling Guide*.

Configuring the drive loops with storage expansion enclosures

This section provides information on how to connect supported storage expansion enclosures in a redundant drive loop.

Overview: Cabling a DS4500 with two drive mini hubs

The base DS4500 Storage Subsystem currently contains two drive mini hubs installed in mini hub slots 4 and 2 (previously, these two mini hubs were installed in slots 1 and 2). Figure 56 on page 78 depicts the cabling of the base DS4500.

If this is a new DS4500 Storage Subsystem configuration and the DS4500 contains the two drive mini hubs installed in mini hub slots 1 and 2, IBM recommends that you remove the mini hub from slot 1 (the right most-position) and swap it with the blank mini hub inserted in drive mini hub slot 4 (the leftmost position). Then cable the storage expansion enclosures as shown by “Storage Expansion Enclosures - Group 1” in Figure 56. By swapping these mini hubs, you will not need to schedule down time later for re-cabling the drive loop if additional mini hubs are installed to enable a second redundant drive loop.

Attention: Re-cabling of drive loops to different drive mini hubs in an operating DS4500 Storage Subsystem configuration requires down time for the configuration.

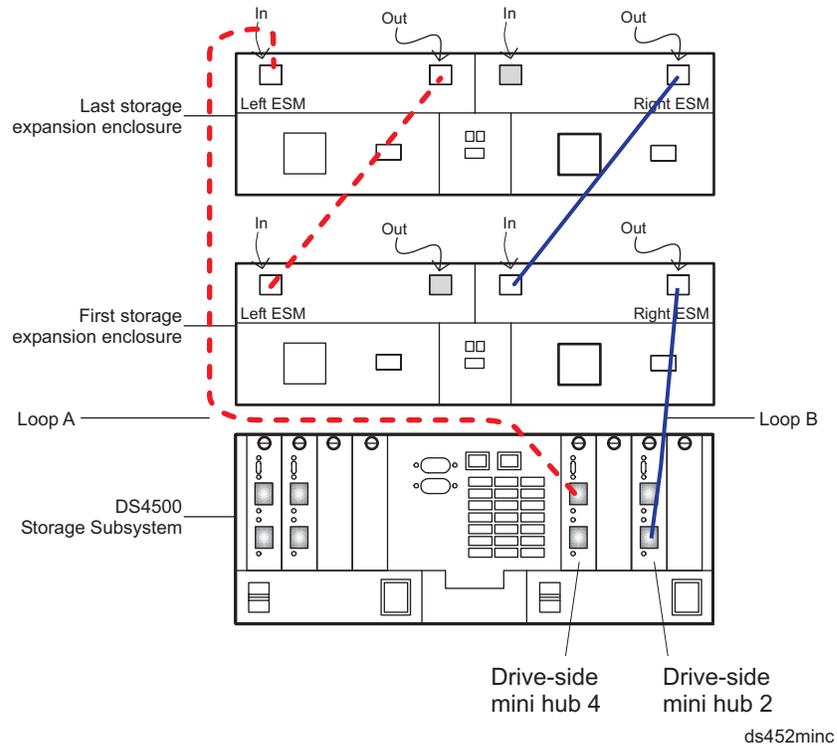


Figure 56. Redundant drive loop cabling overview with two drive mini hubs in slots 4 and 2

If you have an existing DS4500 Storage Subsystem configuration with mini hubs in slots 1 and 2 and you plan to add an additional redundant drive loop, you must re-cable your existing configuration as shown in Figure 56. If you can schedule down time before you are ready to add the new drive loop in the system (or whenever it is possible to make the changes to the mini hubs and the drive side FC cabling), you will not have to schedule down time when you are ready to add the new drive loop in the system.

Note: If you have an existing DS4500 Storage Subsystem configuration with mini hubs in slots 1 and 2 (as shown in Figure 57 on page 79), and you do not plan to add an additional redundant drive loop, do not make any changes to the positions of your mini hubs.

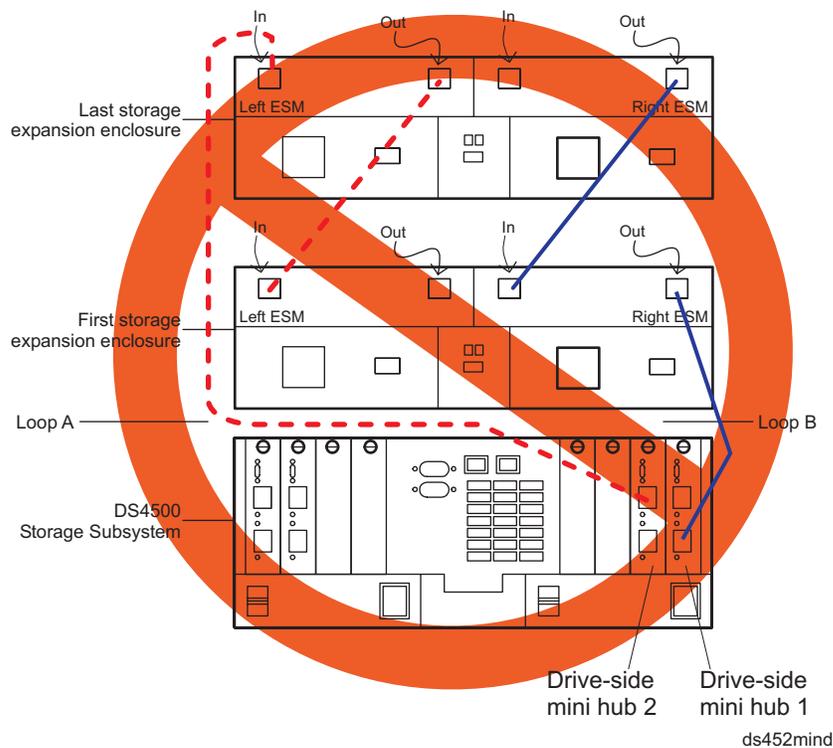


Figure 57. Redundant drive loop cabling overview with two drive mini hubs in slots 1 and 2 - **Not for use unless you meet the requirements in the Note above**

Overview: Cabling a DS4500 with four drive mini hubs

Figure 55 on page 77 shows a storage subsystem containing one DS4500 Storage Subsystem and two redundant drive loops with four storage expansion enclosures each. The DS4500 configuration shown requires four drive mini hubs to be installed. Each storage expansion enclosure group uses redundant drive loops to connect to the DS4500 Storage Subsystem. Loop A and loop B make up one redundant pair of drive loops, which is labeled “Storage Expansion Enclosures - Group 1.” Loop C and loop D make up a second redundant pair, which is labeled “Storage Expansion Enclosures - Group 2.”

Attention: To prevent loss of storage expansion enclosure redundancy in a DS4500 Storage Subsystem configuration with four drive mini hubs installed, connect the storage expansion enclosures as shown in Figure 58 on page 80. Note especially that drive loop B connects to mini hub 2 and drive loop C connects to mini hub 3.

Note: The illustrations in this document might differ slightly from the hardware.

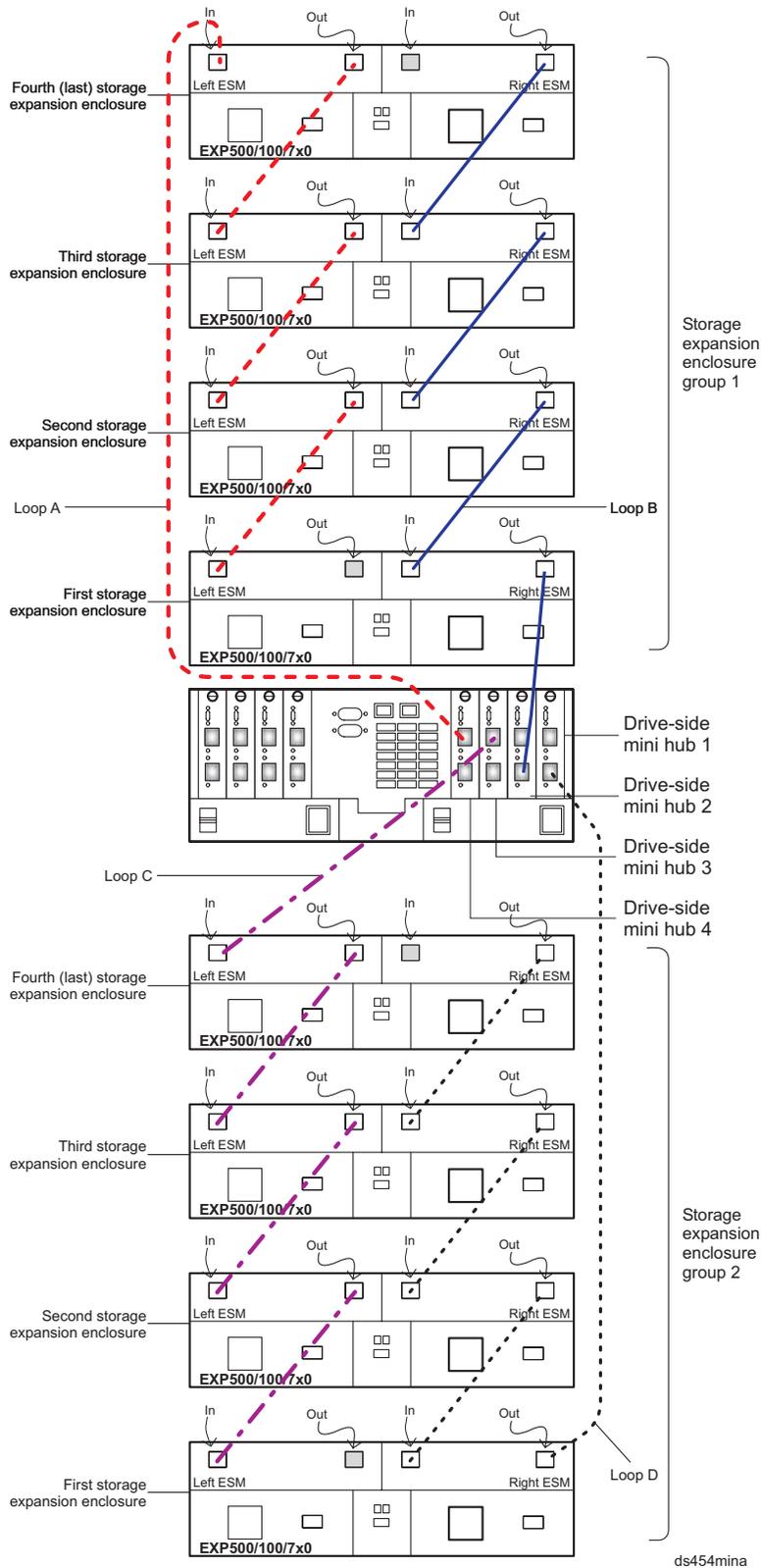


Figure 58. Redundant drive loop cabling overview — four drive mini hubs

Using EXP500, EXP100, EXP700, or EXP710 storage expansion enclosures

The section provides instructions on how to connect one group of four EXP500, EXP100, EXP700, or EXP710 storage expansion enclosures in a redundant drive loop. Instructions for how to connect a second group of four EXP500, EXP100, EXP700, or EXP710 storage expansion enclosures in a redundant drive loop are also included in this procedure. In addition, this procedure is also applicable when you have any number of enclosures, up to the maximum number that can be attached in the redundant drive loop pair.

To complete this procedure, you will need two fiber-optic cables per storage expansion enclosure.

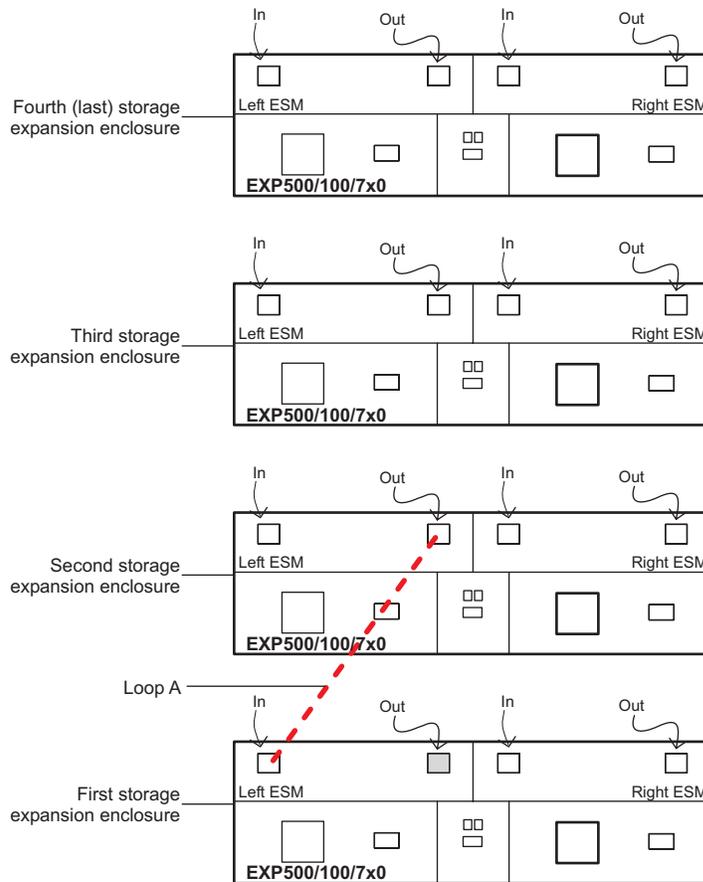
Attention: Handle and install fiber-optic cables properly to avoid degraded performance or loss of communications with devices. Do not overtighten the cable straps or bend the cables to a diameter of less than 76 mm (3 in.) or a radius less than 38 mm (1.5 in.).

Connecting EXP500, EXP100, EXP700, or EXP710 in a redundant pair of drive loop: This procedure describes how to cabling of intermixing 10-drive and 14-drive storage expansion enclosures together in a redundant pair of drive loops.

Note: Not all of these EXP500, EXP100, EXP700, or EXP710 enclosures can be cabled together. For information on supported combinations, see “Supported storage expansion enclosure configurations and intermix combinations” on page 62.

1. Connect the first two storage expansion enclosures to drive loop A, as shown in Figure 59 on page 82.

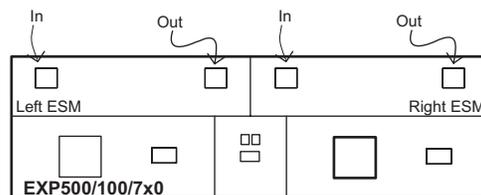
Starting with the first storage expansion enclosure, connect a fiber-optic cable from the In port on the left environmental services module (ESM) board to the Out port on the left ESM board in the second (next) storage expansion enclosure.



d3nu4042c

Figure 59. Connecting two EXP500, EXP100, EXP700, or EXP710 storage expansion enclosures into drive loop A

For the location of the ports on the storage expansion enclosure ESM board, see Figure 60.

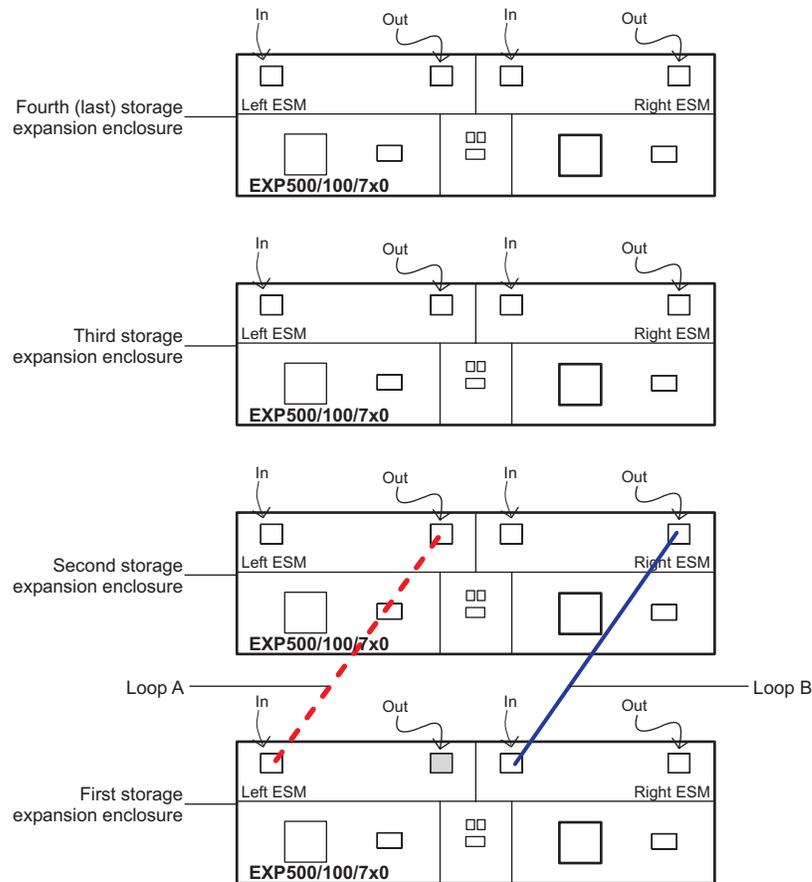


d3nu4205a

Figure 60. EXP500, EXP100, EXP700, or EXP710 storage expansion enclosure ESM board In and Out ports

2. Connect the same first two storage expansion enclosures to drive loop B, as shown in Figure 61 on page 83.

Starting with the first storage expansion enclosure, connect a fiber-optic cable from the In port on the right ESM board to the Out port on the right ESM board in the second (next) storage expansion enclosure.



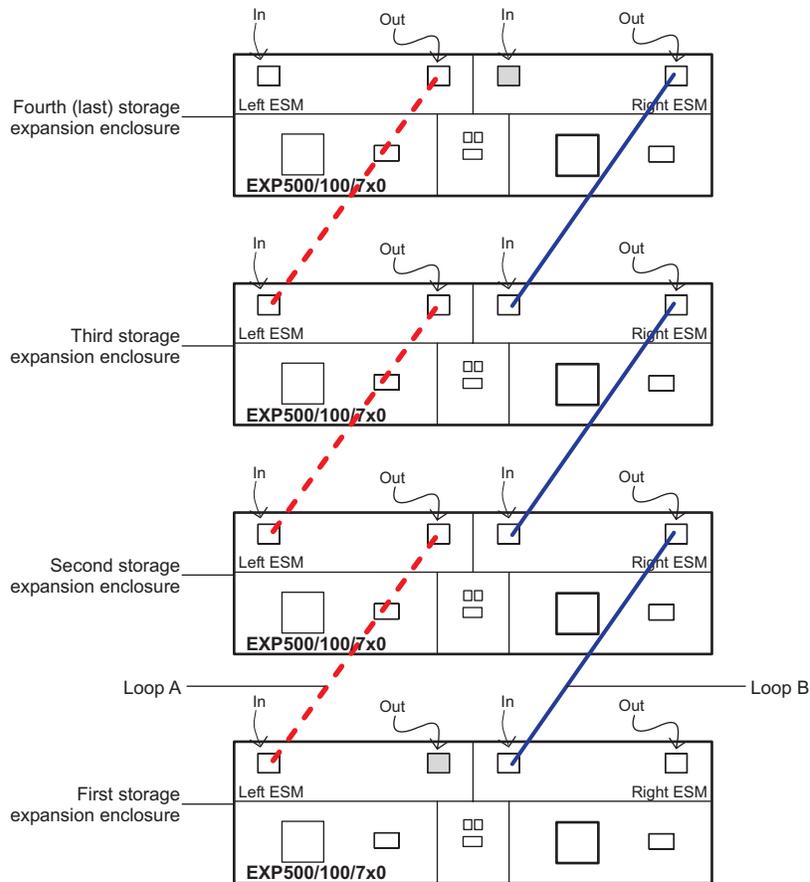
d3nu4042d

Figure 61. Connecting two EXP500, EXP100, EXP700, or EXP710 storage expansion enclosures into redundant drive loop B

If you want to connect more storage expansion enclosures into drive loops A and B, continue with Step 3; otherwise, go to “Connecting the redundant EXP500, EXP100, EXP700, or EXP710 drive loop to the DS4500” on page 86.

3. Connect additional storage expansion enclosures to drive loops A and B, as shown in Figure 62 on page 84.

Starting with the second storage expansion enclosure, connect each additional storage expansion enclosure into drive loops A and B in the same manner. Leave the In port on the last storage expansion enclosure in the loop and the Out port on the first storage expansion enclosure unoccupied.



d3nu4043c

Figure 62. Connecting additional EXP500, EXP100, EXP700, or EXP710 storage expansion enclosures to drive loops A and B

If you want to connect a second storage expansion enclosure group, repeat Step 1 on page 81 through Step 3 on page 83. Otherwise, go to “Connecting the redundant EXP500, EXP100, EXP700, or EXP710 drive loop to the DS4500” on page 86. Figure 63 on page 85 shows a second redundant storage expansion enclosure group (loop C and loop D on storage expansion enclosure group 2).

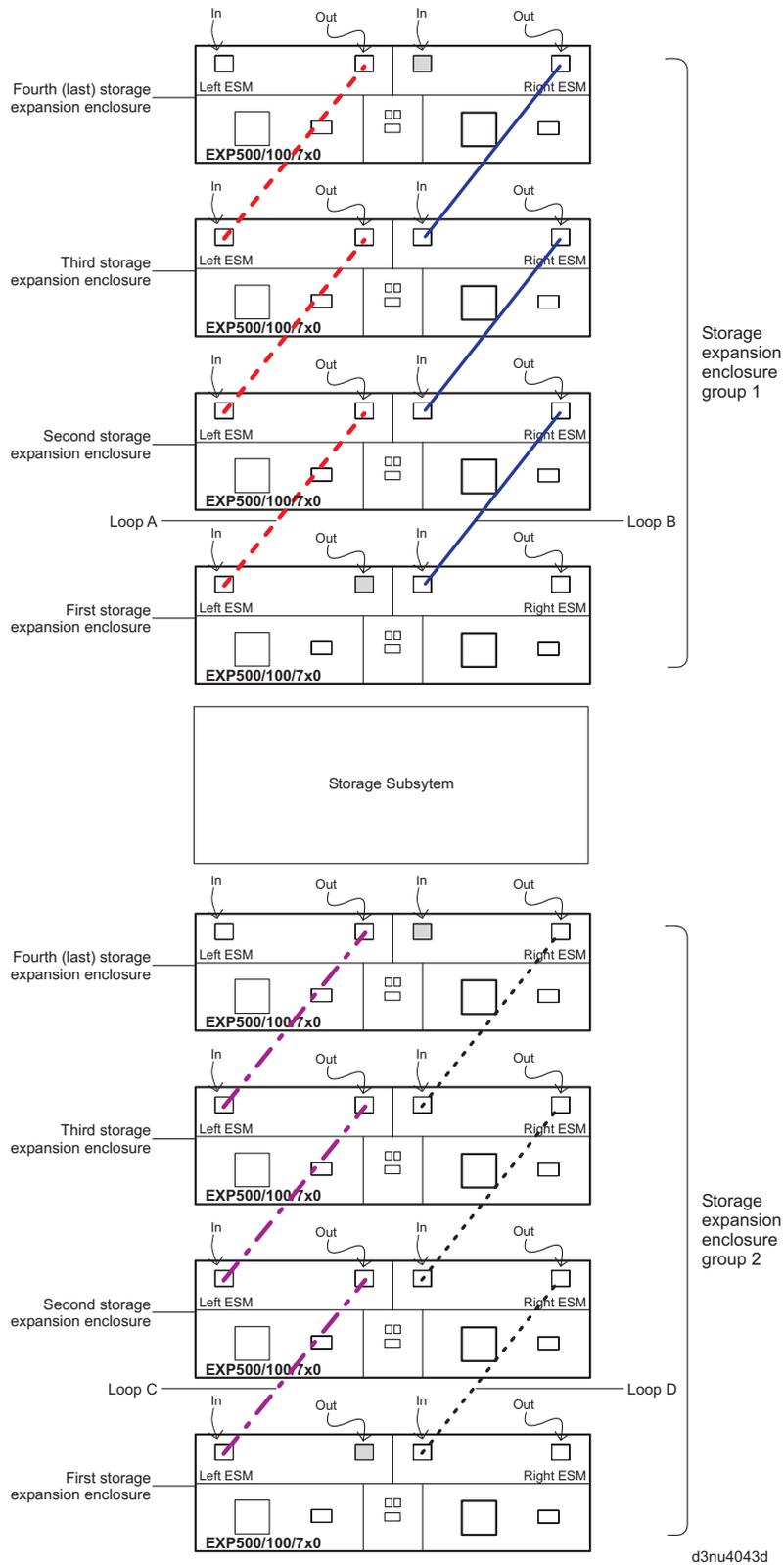


Figure 63. Connecting a second redundant EXP500, EXP100, EXP700, or EXP710 storage expansion enclosure group (loops C and D)

Connecting the redundant EXP500, EXP100, EXP700, or EXP710 drive loop to the DS4500: After you configure the redundant drive loop using the EXP500, EXP100, EXP700, or EXP710 storage expansion enclosures, use the following procedure to connect a redundant drive loop to the DS4500 Storage Subsystem. You will need two fiber-optic cables for each redundant pair of loops (for example, loop A and loop B) that you are connecting to the DS4500 Storage Subsystem.

1. Connect drive loop A to the DS4500 Storage Subsystem, as shown in Figure 64.

Starting with the last storage expansion enclosure in loop A, connect the In port on the left ESM board to the Out (upper) port on drive mini hub 4 on the DS4500 Storage Subsystem.

Leave the Out port on the left ESM board on the first storage expansion enclosure and the In (lower) connector on drive mini hub 4 unoccupied.

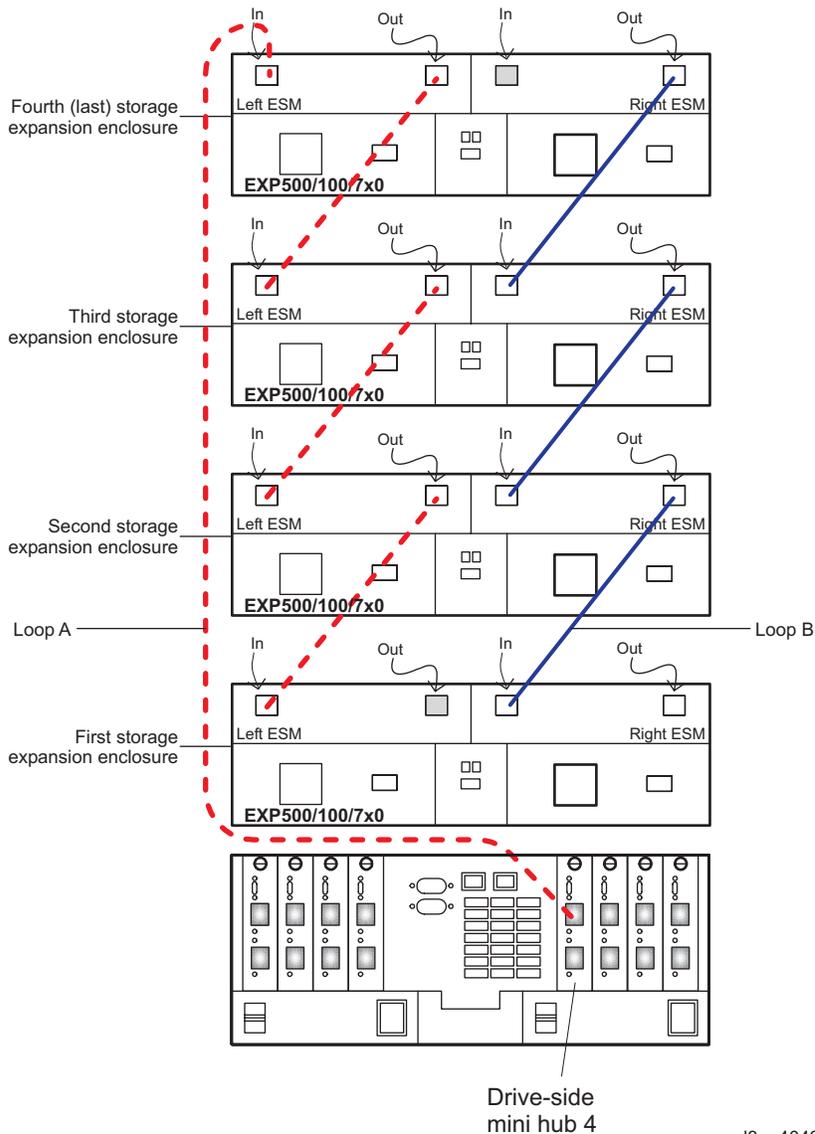


Figure 64. Connecting EXP500, EXP100, EXP700, or EXP710 drive loop A to the DS4500

2. Connect drive loop B to the DS4500 Storage Subsystem, as shown in Figure 65 on page 87.

Starting with the first storage expansion enclosure in the loop, connect the Out port on the right ESM board to the In (lower) port on drive mini hub 2. Leave the In port on the right ESM board on the last storage expansion enclosure and the Out (upper) port on drive mini hub 2 unoccupied.

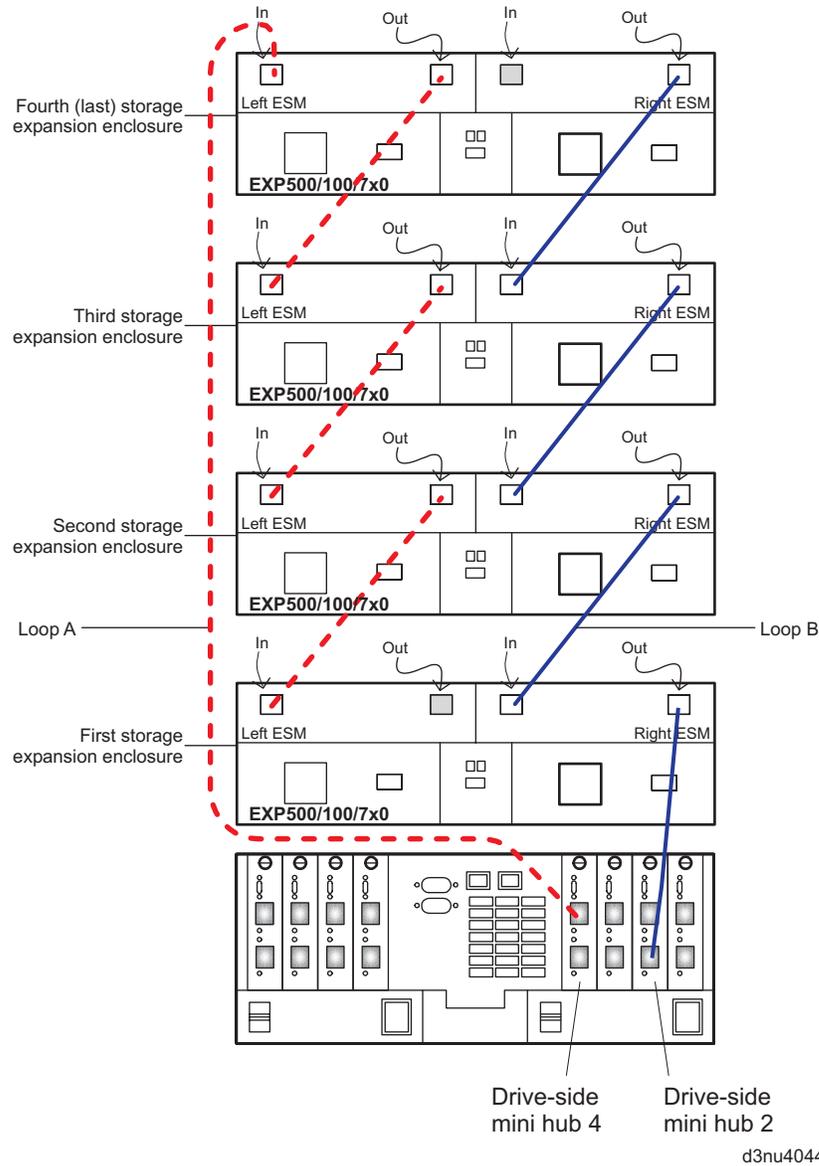


Figure 65. Connecting redundant EXP500, EXP100, EXP700, or EXP710 drive loops to the DS4500

To connect a second redundant storage expansion enclosure group to the DS4500 Storage Subsystem, continue with Step 3.

3. Connect drive loop C to the DS4500 Storage Subsystem, as shown in Figure 66 on page 89.

Starting with the first storage expansion enclosure in group 2, connect the In port on the left ESM board to the Out (upper) port on drive mini hub 3.

Leave the Out port on the left ESM board on the last storage expansion enclosure in group 2 and the In (lower) port on the drive mini hub 3 unoccupied.

4. Connect drive loop D to the DS4500 Storage Subsystem, as shown in Figure 66 on page 89.

Starting with the last storage expansion enclosure in group 2, connect the Out port on the right ESM board to the In (lower) port on mini hub 1.

Leave the In port on the right ESM board on the first storage expansion enclosure in group 2 and the Out (upper) port on drive mini hub 1 unoccupied.

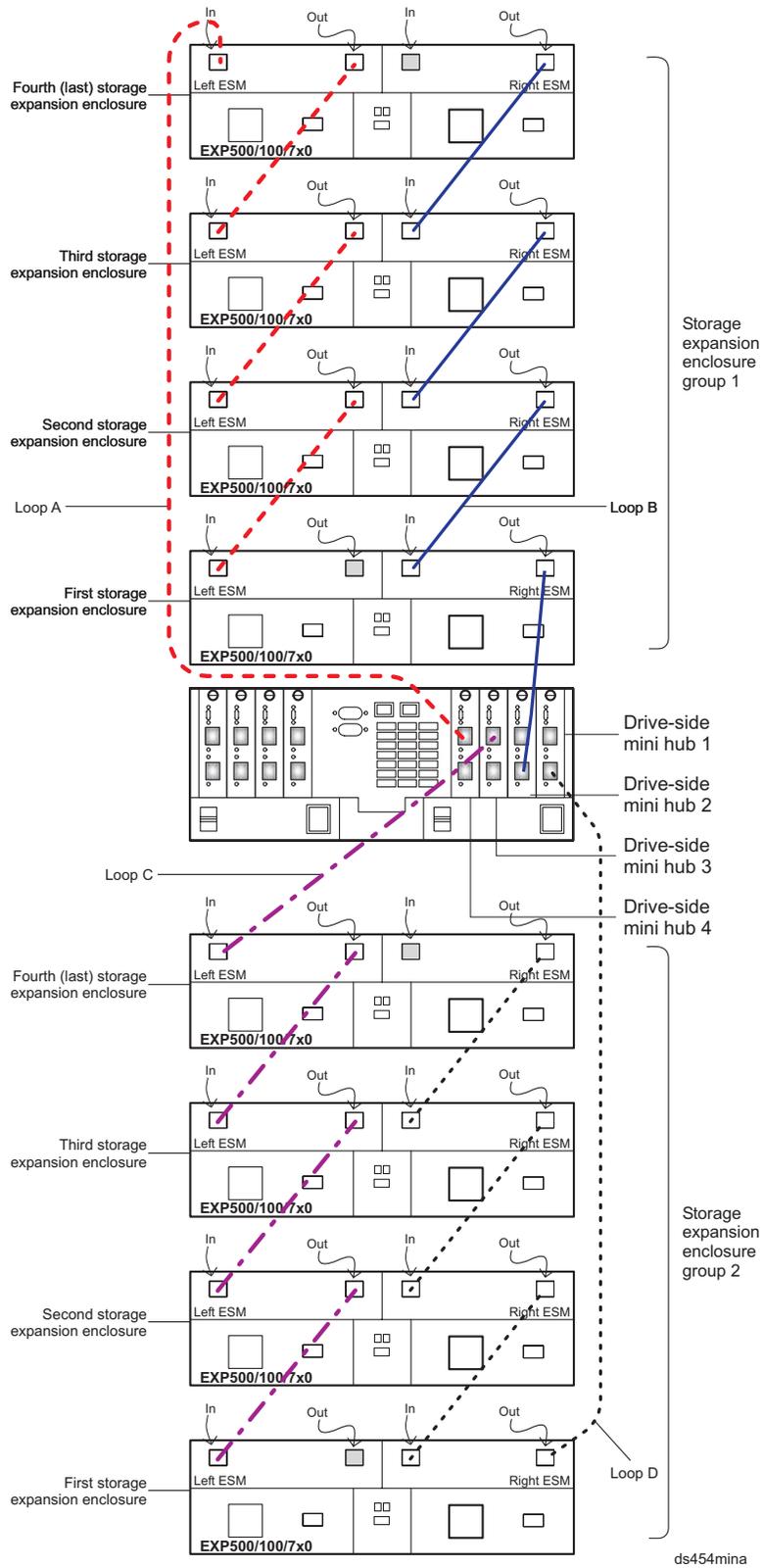


Figure 66. Connecting two redundant EXP500, EXP100, EXP700, or EXP710 storage expansion enclosure groups

Using EXP810 storage expansion enclosures

The section provides instructions on how to connect one group of four EXP810 storage expansion enclosures in a redundant drive loop. Instructions for how to connect a second group of four EXP810 storage expansion enclosures in a redundant drive loop are also included in this procedure. In addition, this procedure is also applicable when you have any number of enclosures, up to the maximum number that can be attached in the redundant drive loop pair.

To complete this procedure, you will need two fiber-optic cables per storage expansion enclosure.

Attention: Handle and install fiber-optic cables properly to avoid degraded performance or loss of communications with devices. Do not overtighten the cable straps or bend the cables to a diameter of less than 76 mm (3 in.) or a radius less than 38 mm (1.5 in.).

Connecting EXP810 in a redundant pair of drive loop: This procedure describes how to cable 16-drive EXP810 storage expansion enclosure together in a redundant pair of drive loops.

1. Connect the first two storage expansion enclosures to drive loop A, as shown in Figure 67.

Starting with the first storage expansion enclosure, connect a fiber-optic cable from port 1B on the ESM A board to port 1A on the ESM A board in the second (next) storage expansion enclosure.

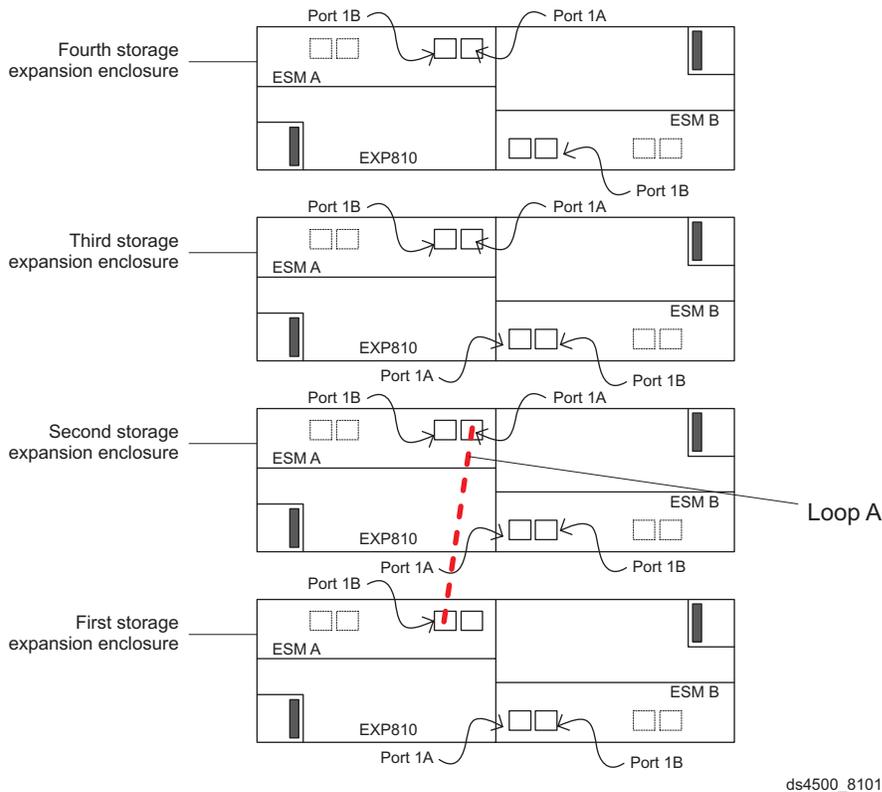


Figure 67. Connecting two EXP810 storage expansion enclosures into drive loop A

For the location of the ports on the storage expansion enclosure ESM board, see Figure 68 on page 91.

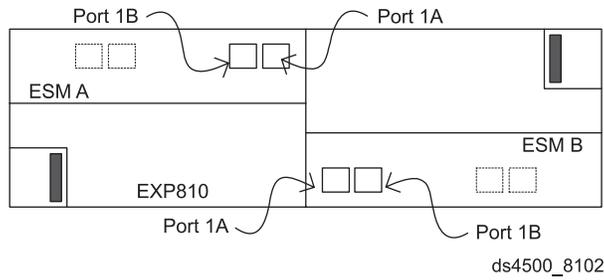


Figure 68. EXP810 storage expansion enclosure ESM board ports 1A and 1B

2. Connect the same first two storage expansion enclosures to drive loop B, as shown in Figure 69.

Starting with the first storage expansion enclosure, connect a fiber-optic cable from port 1A on the ESM B board to port 1B on the ESM B board in the second (next) storage expansion enclosure.

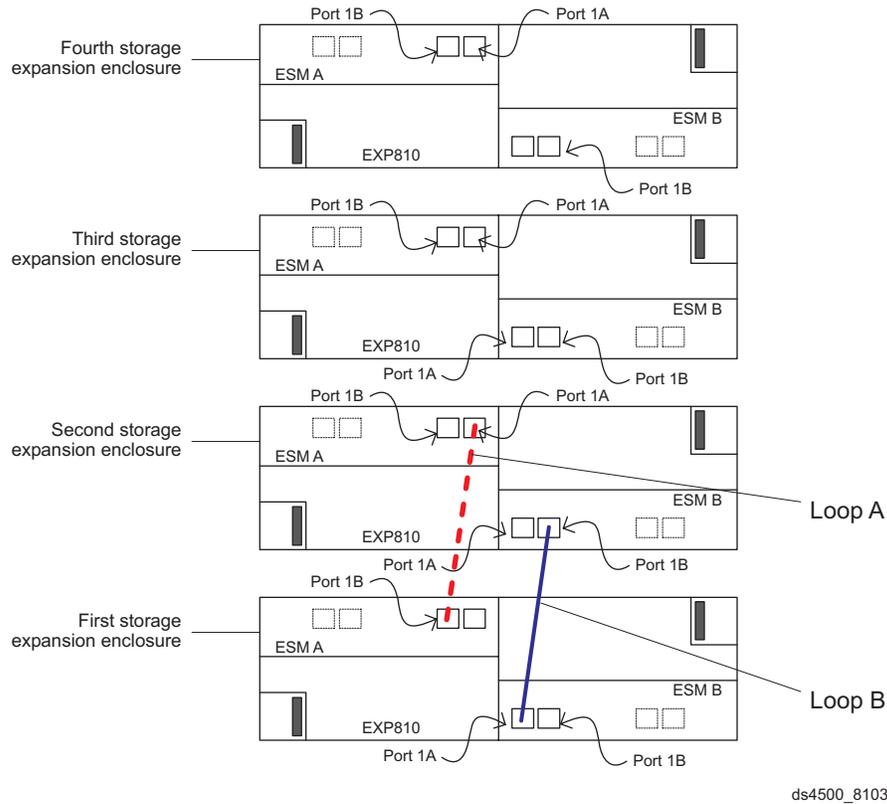


Figure 69. Connecting two EXP810 storage expansion enclosures into redundant drive loop B

If you want to connect more storage expansion enclosures into drive loops A and B, continue with Step 3; otherwise, go to “Connecting the redundant EXP810 drive loop to the DS4500” on page 93.

3. Connect additional storage expansion enclosures to drive loops A and B, as shown in Figure 70 on page 92.

Starting with the second storage expansion enclosure, connect each additional storage expansion enclosure into drive loops A and B in the same manner.

Leave port 1A on the ESM B of the last (fourth) storage expansion enclosure in the loop and port 1A on the ESM A of the first storage expansion enclosure unoccupied.

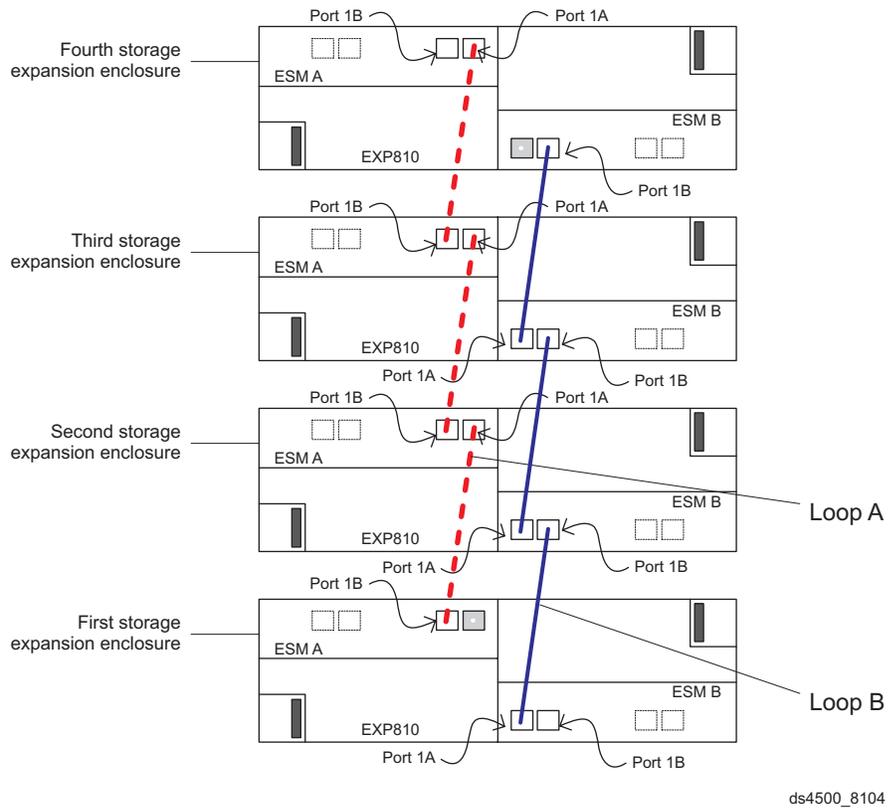
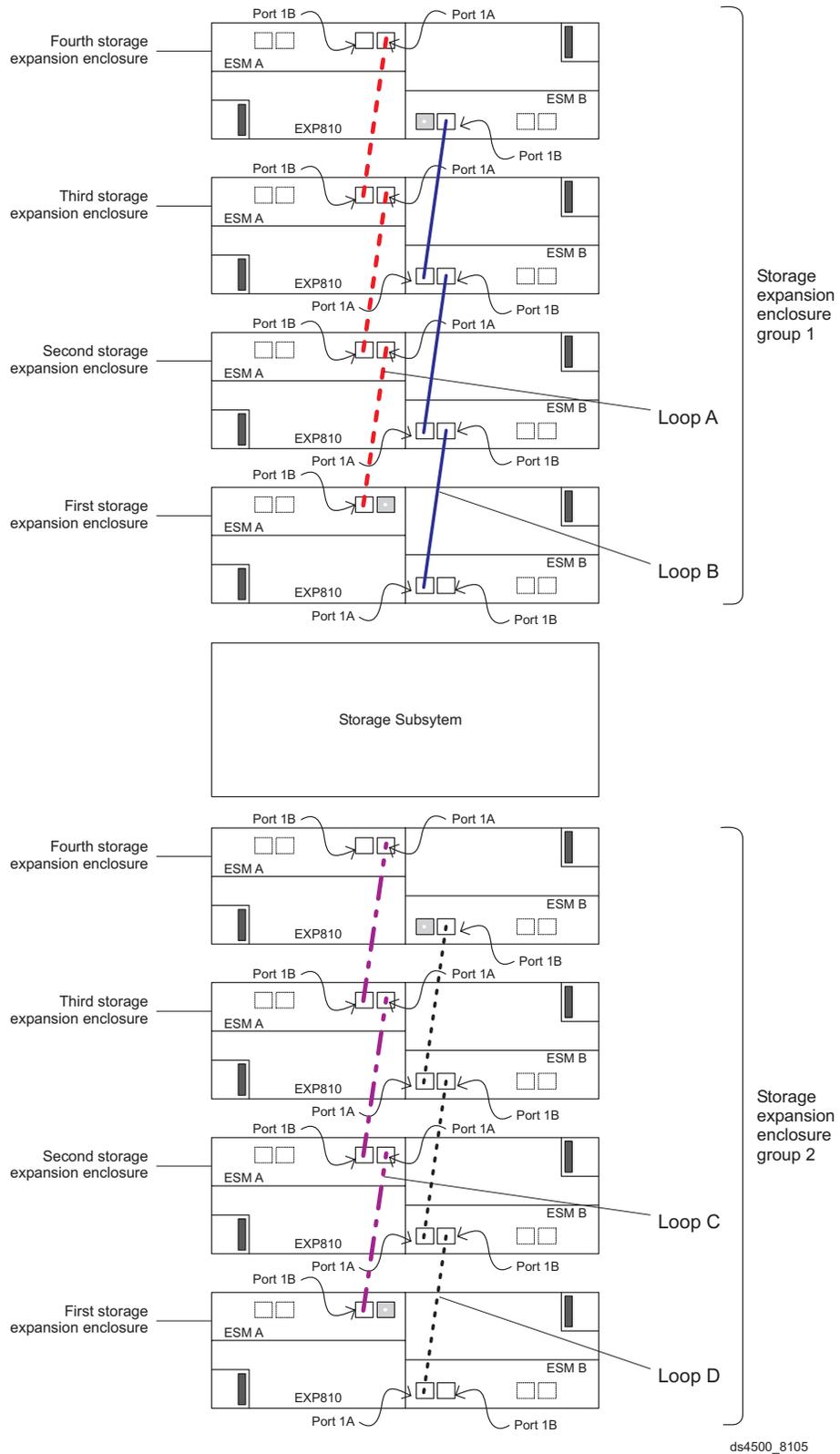


Figure 70. Connecting additional EXP810 storage expansion enclosures to drive loops A and B

If you want to connect a second storage expansion enclosure group, repeat Step 1 on page 90 through Step 3 on page 91. Otherwise, go to “Connecting the redundant EXP810 drive loop to the DS4500” on page 93. Figure 71 on page 93 shows a second redundant storage expansion enclosure group (loop C and loop D on storage expansion enclosure group 2).



ds4500_8105

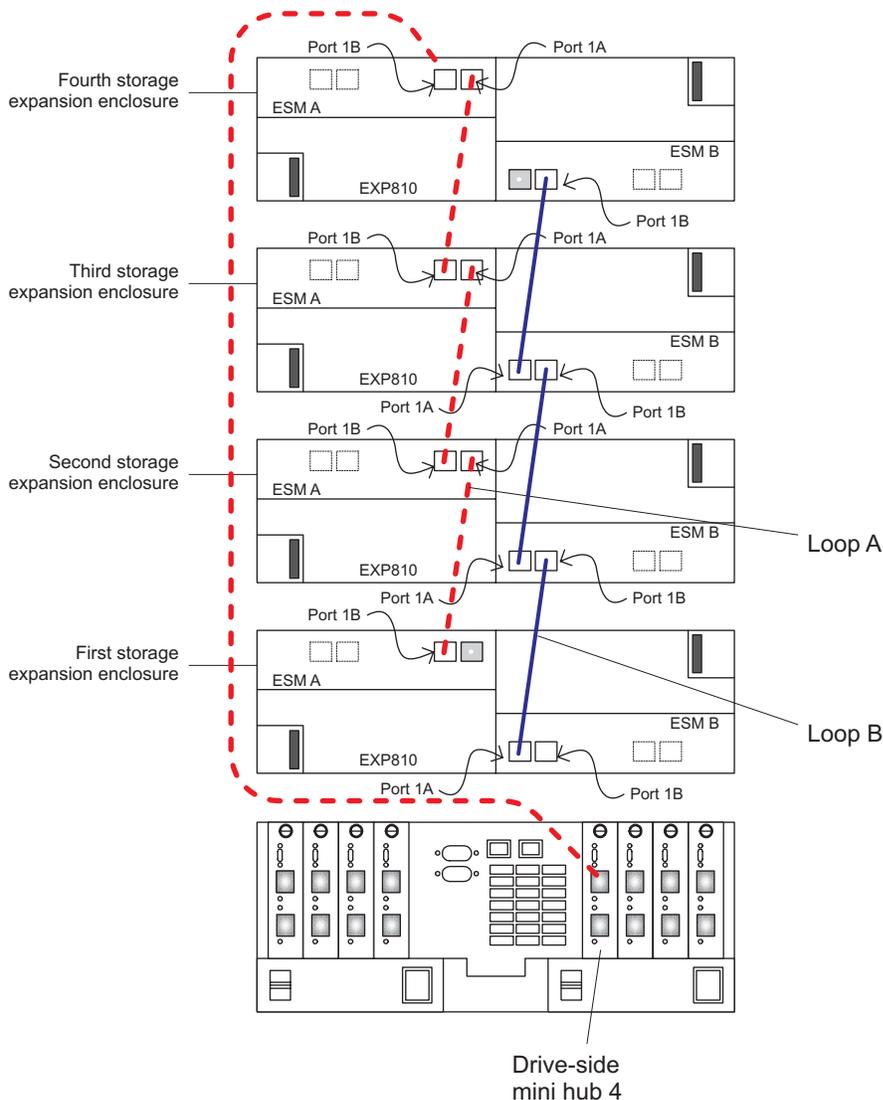
Figure 71. Connecting a second redundant EXP810 storage expansion enclosure group (loops C and D)

Connecting the redundant EXP810 drive loop to the DS4500: After you configure the redundant drive loop using the EXP810 storage expansion

enclosures, use the following procedure to connect a redundant drive loop to the DS4500 Storage Subsystem. You will need two fiber-optic cables for each redundant pair of loops (for example, loop A and loop B) that you are connecting to the DS4500 Storage Subsystem.

1. Connect drive loop A to the DS4500 Storage Subsystem, as shown in Figure 72. Starting with the last (fourth) storage expansion enclosure in loop A, connect port 1B on the ESM A board to the Out (upper) port on drive mini hub 4 on the DS4500 Storage Subsystem.

Leave port 1A on the ESM A board on the first storage expansion enclosure and the In (lower) port on drive mini hub 4 unoccupied.



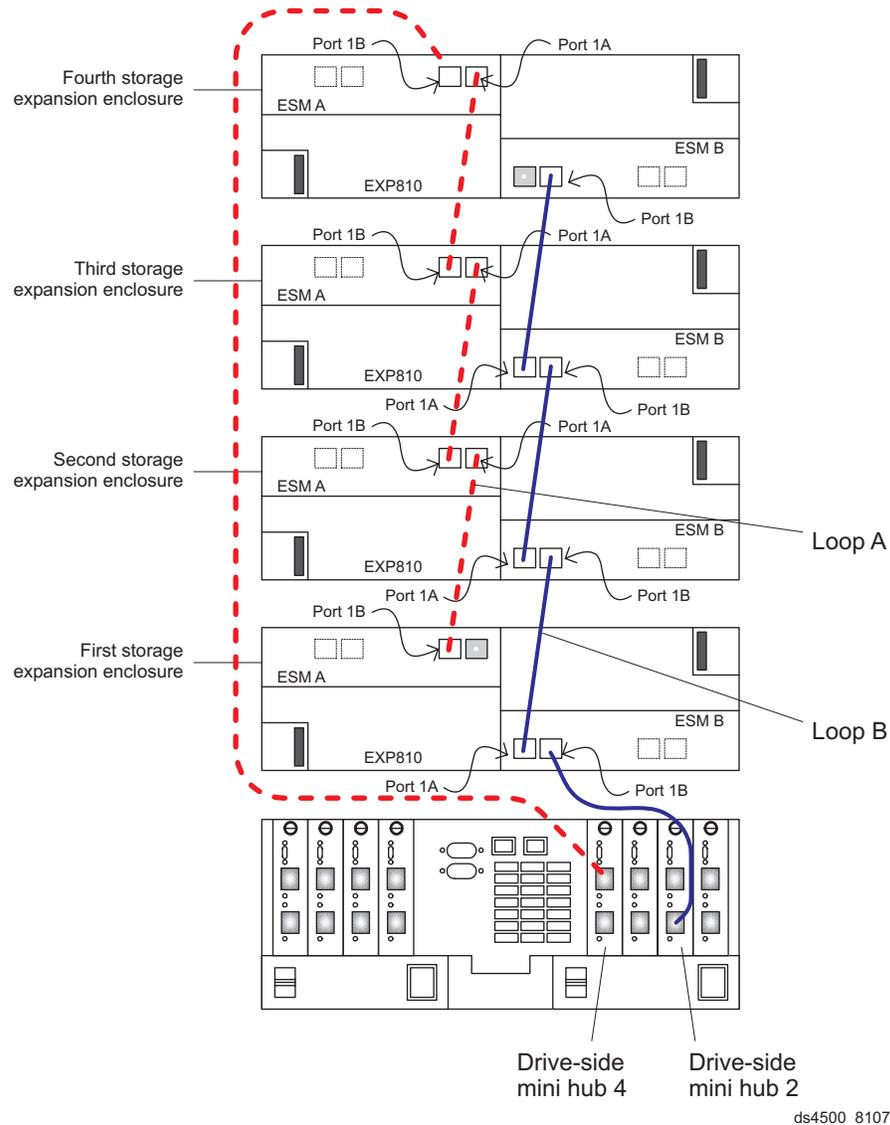
ds4500_8106

Figure 72. Connecting EXP810 drive loop A to the DS4500

2. Connect drive loop B to the DS4500 Storage Subsystem, as shown in Figure 73 on page 95.

Starting with the first storage expansion enclosure in the loop, connect port 1B on the ESM B board to the In (lower) port on drive mini hub 2.

Leave port 1A on the ESM B board on the last (fourth) storage expansion enclosure and the Out (upper) port on drive mini hub 2 unoccupied.



ds4500_8107

Figure 73. Connecting redundant EXP810 drive loops to the DS4500

To connect a second redundant storage expansion enclosure group to the DS4500 Storage Subsystem, continue with Step 3.

3. Connect drive loop C to the DS4500 Storage Subsystem, as shown in Figure 74 on page 97.

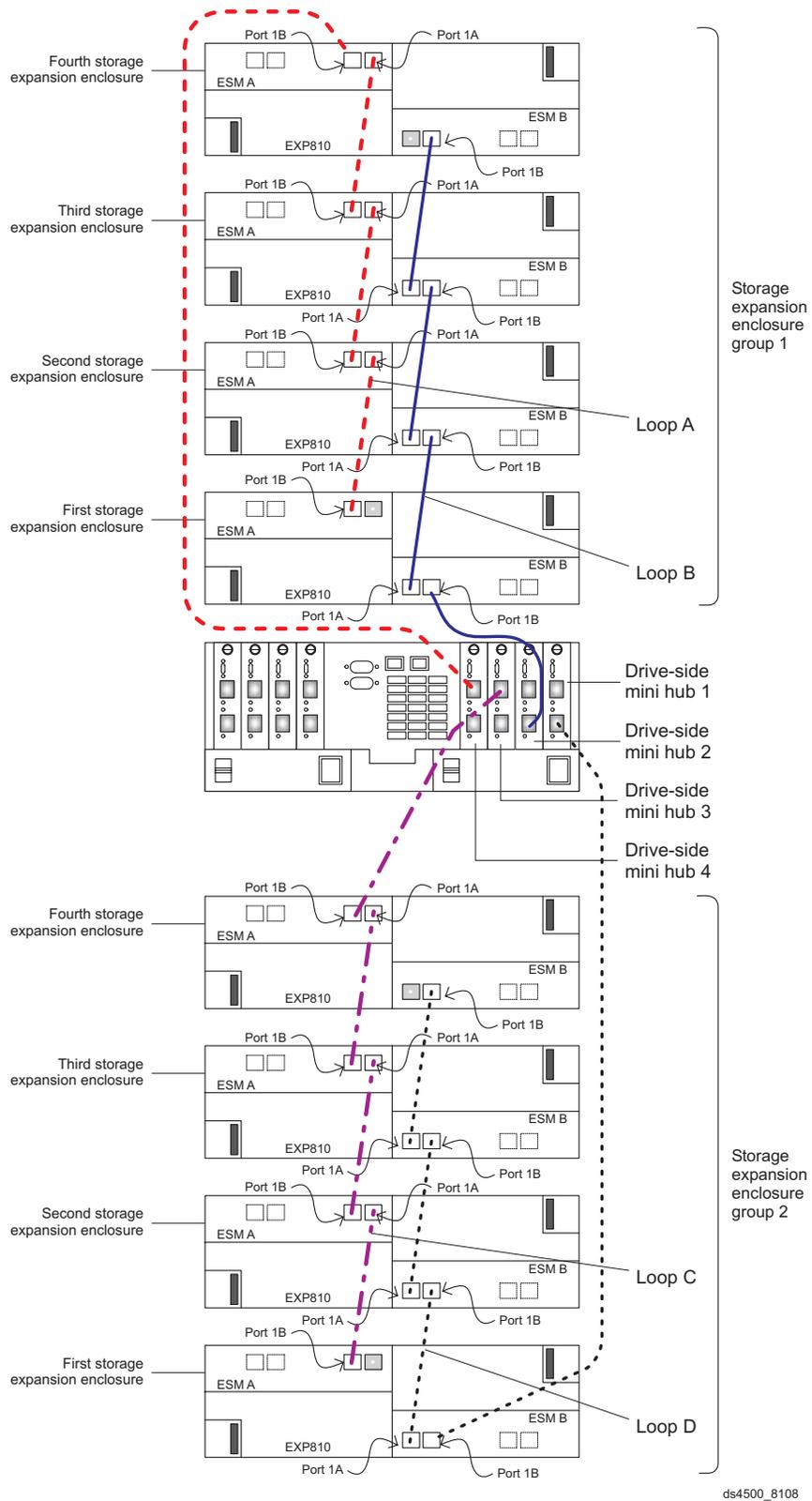
Starting with the first storage expansion enclosure in group 2, connect port 1B on the ESM A board to the Out (upper) port on drive mini hub 3.

Leave port 1A on the ESM A board on the last (fourth) storage expansion enclosure in group 2 and the In (lower) port on the drive mini hub 3 unoccupied.

4. Connect drive loop D to the DS4500 Storage Subsystem, as shown in Figure 74 on page 97.

Starting with the last storage expansion enclosure in group 2, connect port 1B on the right ESM B board to the In (lower) port on mini hub 1.

Leave port 1A on the ESM B board on the first storage expansion enclosure in group 2 and the Out (upper) port on drive mini hub 1 unoccupied.



ds4500_8108

Figure 74. Connecting two redundant EXP810 storage expansion enclosure groups

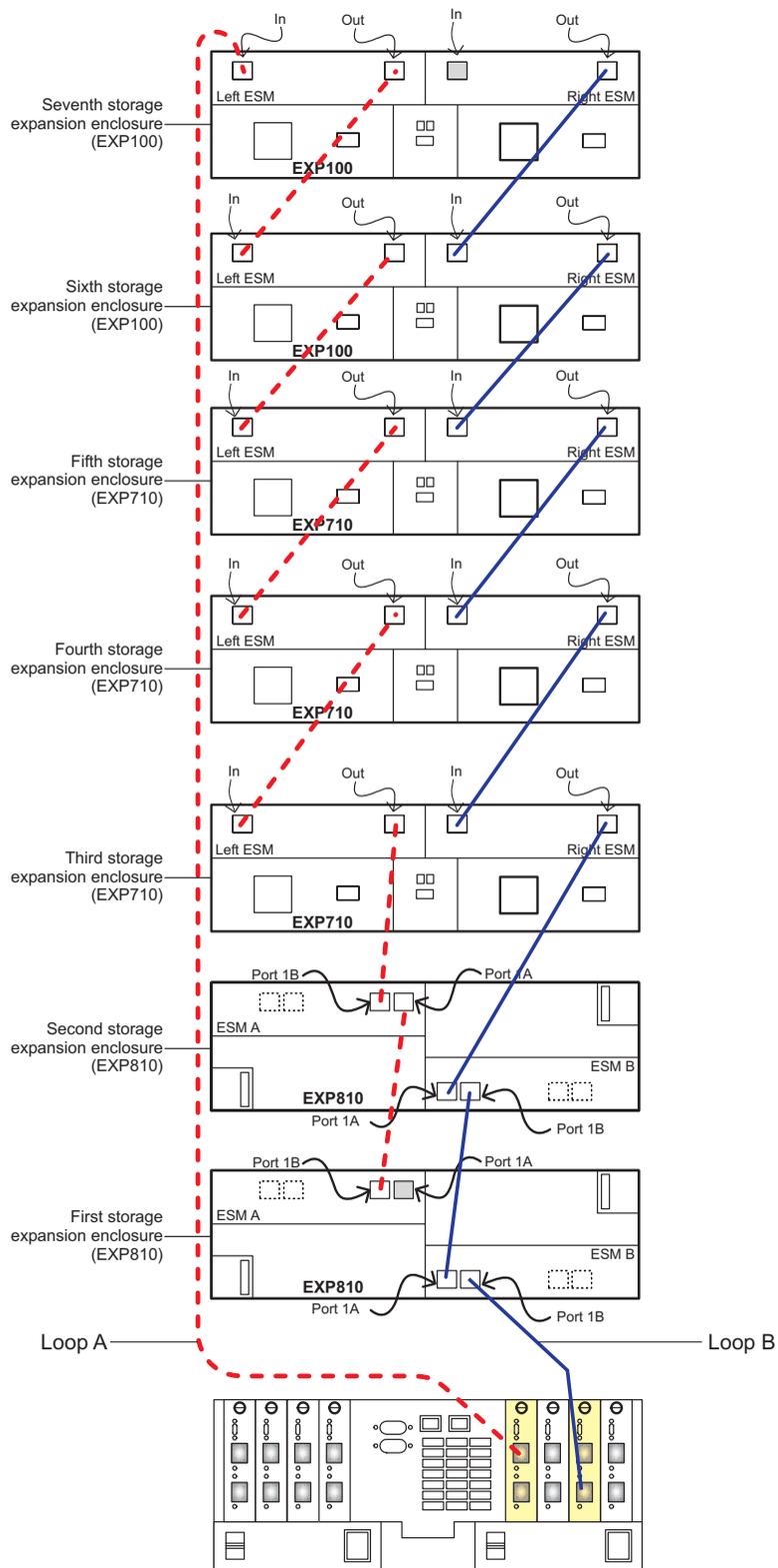
One DS4500 and two or more storage expansion enclosure types in a mixed configuration

Note: Not all of the EXP500, EXP100, EXP700, EXP710 or EXP810 enclosures can be cabled together. For information on supported combinations, see “Supported storage expansion enclosure configurations and intermix combinations” on page 62.

When you plan to cable the DS4500 Storage Subsystem to storage expansion enclosure types that are in a mixed configuration, it is recommended that you cable the same type of enclosures together. Since the EXP810s and EXP710s are generally considered as the same type (enclosures with switched-ESMs type), these two enclosure models must be grouped together if they are contained within a drive loop. (For detailed information, see “Overview: Connecting storage expansion enclosures to a storage subsystem” on page 65.) If a storage expansion type with non Switched-ESMs, such as EXP100, is cabled between the EXP710s and EXP810s, a *"drive enclosure not cabled correctly"* error will be displayed in the DS4000 Storage Manager Recovery Guru.

In addition, it is strongly recommended, for such reasons as easier maintenance and minimizing cabling errors, that you not only cable the same type of enclosures together, but that you also cable the enclosures within groups of the same model. For example, cable the EXP710s together, followed by all of the EXP810s, then followed by all of the EXP100s, and so on.

Figure 75 on page 99 and Figure 76 on page 101 show two examples of recommended cabling schemes of mixed enclosure types behind a DS4500 Storage Subsystem using EXP100s, EXP710s, and EXP810s storage expansion enclosures. Figure 76 on page 101 also shows the IBM-preferred method of cabling enclosures when mixing EXP100, EXP710 and EXP810 enclosures in the same redundant drive loop pair: a group of EXP100s, followed by a group of EXP810s followed by a group of EXP710s. The EXP810s are sandwiched between the EXP100s and EXP710s.



ds4500_mix1

Figure 75. Example 1: One DS4500 and two or more storage expansion enclosures in a mixed environment — Recommended cabling

Perform the following steps to create the recommended cabling scheme shown in Figure 75.

1. Connect the storage expansion enclosures to drive loop A as follows:
 - a. Starting with the first storage expansion enclosure, connect a fiber-optic cable from port 1B on the ESM A board to port 1A on the ESM A board in the second enclosure.
Leave port 1A on the ESM A board in the first enclosure unoccupied.
 - b. Connect port 1B on the ESM A board in the second enclosure to the Out port on the left ESM in the third enclosure.
 - c. Connect the In port on the left ESM in the third enclosure to the Out port on the left ESM in the fourth enclosure.
 - d. Connect the In port on the left ESM in the fourth enclosure to the Out port on the left ESM in the fifth enclosure.
 - e. Connect the In port on the left ESM in the fifth enclosure to the Out port on the left ESM in the sixth enclosure.
 - f. Connect the In port on the left ESM in the sixth enclosure to the Out port on the left ESM in the seventh enclosure.
2. Connect the storage expansion enclosures to drive loop B as follows:
 - a. Starting with the first storage expansion enclosure, connect a fiber-optic cable from port 1A on the ESM B board to port 1B on the ESM B board in the second enclosure.
 - b. Connect port 1A on the ESM B board in the second enclosure to the Out port on the right ESM in the third enclosure.
 - c. Connect the In port on the right ESM in the third enclosure to the Out port on the right ESM in the fourth enclosure.
 - d. Connect the In port on the right ESM in the fourth enclosure to the Out port on the right ESM in the fifth enclosure.
 - e. Connect the In port on the right ESM in the fifth enclosure to the Out port on the right ESM in the sixth enclosure.
 - f. Connect the In port on the right ESM in the sixth enclosure to the Out port on the right ESM in the seventh enclosure.
Leave In port on the right ESM in the seventh enclosure unoccupied.
3. Connect drive loop A to the DS4500 Storage Subsystem as follows:
 - Connect the In port on the left ESM in the seventh enclosure to the Out (upper) port on drive mini hub 4 on the DS4500.
Leave the In (lower) port on drive mini hub 4 unoccupied.
4. Connect drive loop B to the DS4500 Storage Subsystem as follows:
 - Connect port 1B on the ESM B board in the first enclosure to the In (lower) port on drive mini hub 2 on the DS4500.
Leave the Out (upper) port on drive mini hub 2 unoccupied.

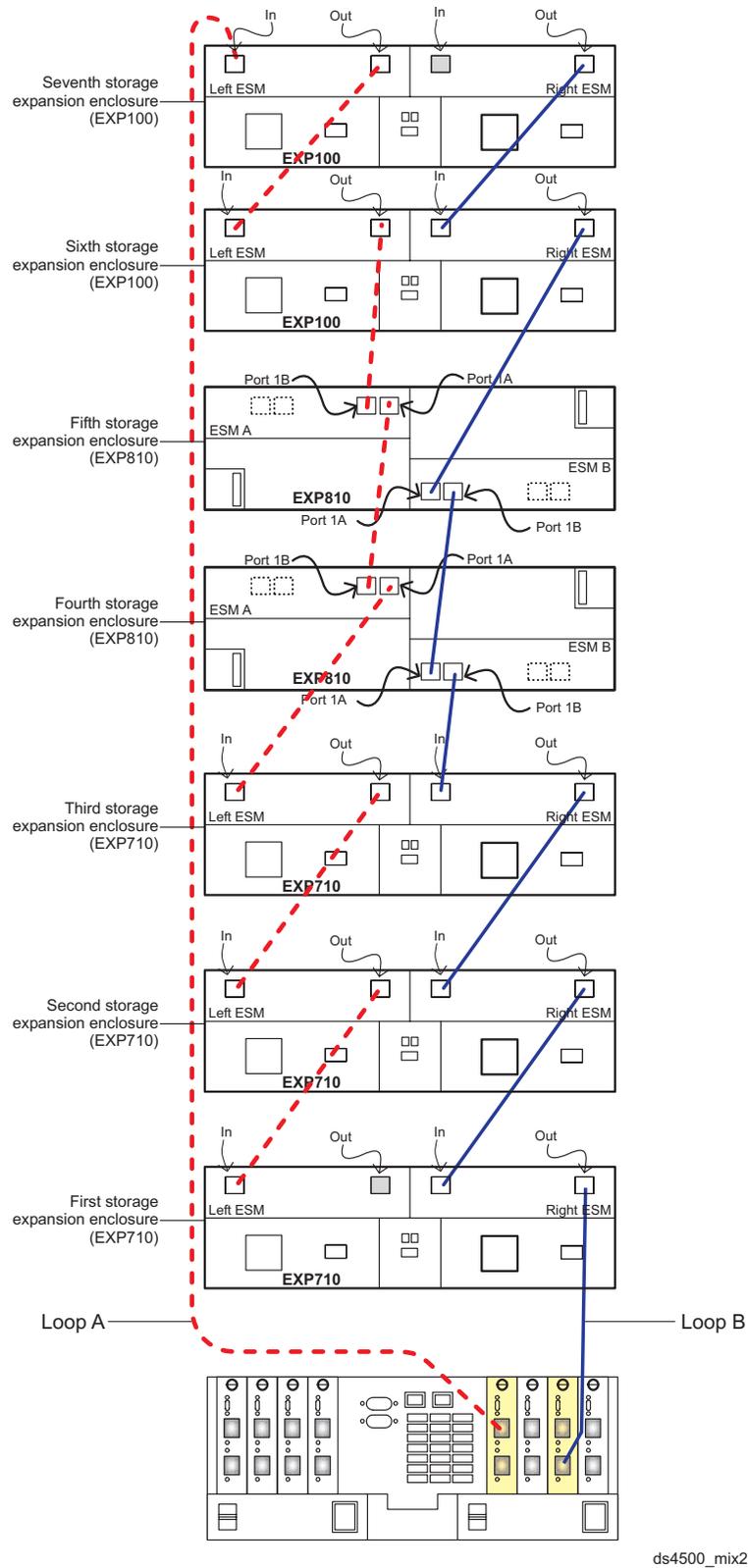


Figure 76. Example 2: One DS4500 and two or more storage expansion enclosures in a mixed environment — Recommended cabling

Perform the following steps to create the recommended cabling scheme shown in Figure 76.

1. Connect the storage expansion enclosures to drive loop A as follows:
 - a. Starting with the first storage expansion enclosure, connect a fiber-optic cable from the In port on the left ESM to the Out port on the left ESM in the second enclosure.
Leave the Out port on the left ESM in the first enclosure unoccupied.
 - b. Connect the In port on the left ESM in the second enclosure to the Out port on the left ESM in the third enclosure.
 - c. Connect the In port on the left ESM in the third enclosure to port 1A on the ESM A in the fourth enclosure.
 - d. Connect port 1B on the ESM A in the fourth enclosure to port 1A on the ESM A in the fifth enclosure.
 - e. Connect port 1B on the ESM A in the fifth enclosure to the Out port on the left ESM in the sixth enclosure.
 - f. Connect the In port on the left ESM in the sixth enclosure to the Out port on the left ESM in the seventh enclosure.
2. Connect the storage expansion enclosures to drive loop B as follows:
 - a. Starting with the first storage expansion enclosure, connect a fiber-optic cable from the In port on the right ESM to the Out port on the right ESM in the second enclosure.
 - b. Connect the In port on the right ESM in the second enclosure to the Out port on the right ESM in the third enclosure.
 - c. Connect the In port on the right ESM in the third enclosure to port 1B on the ESM B in the fourth enclosure.
 - d. Connect port 1A on the ESM B in the fourth enclosure to port 1B on the ESM B in the fifth enclosure.
 - e. Connect port 1A on the ESM B in the fifth enclosure to the Out port on the right ESM in the sixth enclosure.
 - f. Connect the In port on the right ESM in the sixth enclosure to the Out port on the right ESM in the seventh enclosure.
Leave the In port on the right ESM in the last enclosure unoccupied.
3. Connect drive loop A to the DS4500 Storage Subsystem as follows:
 - Connect the In port on the left ESM in the seventh enclosure to the Out (upper) port on drive mini hub 4 on the DS4500.
Leave the In (lower) port on drive mini hub 4 unoccupied.
4. Connect drive loop B to the DS4500 Storage Subsystem as follows:
 - Connect the Out port on the right ESM in the first enclosure to the In (lower) port on drive mini hub 2 on the DS4500.
Leave the Out (upper) port on drive mini hub 2 unoccupied.

Storage expansion enclosure ID settings

This section provides information about storage expansion enclosure settings. For additional detail, refer to the *Installation, User's, and Maintenance Guide* for your storage expansion enclosure.

Fibre channel loop and ID settings

When you install a hard disk drive in the storage expansion enclosure, the drive tray plugs into a printed circuit board called the *midplane*. The midplane sets the fibre channel loop ID automatically, based on the enclosure ID switch setting and the physical location (bay) of the hard disk drive.

DS4000 storage expansion enclosure ID settings

Some DS4000 storage expansion enclosures, such as the EXP710/EXP700/EXP100/EXP500, have an enclosure ID switch that is used to identify the DS4000 storage expansion enclosure on a fibre channel loop. The enclosure ID switch is located on the back of the unit. Other DS4000 storage expansion enclosures, such as the EXP810, do not have an enclosure ID switch because the controller automatically sets the enclosure ID number.

If required, use a small screwdriver or the tip of a pen to push the small buttons above and below each enclosure ID digit to change the enclosure ID setting. Press the button located above the digit to lower the digit by one. Press the button located below the digit to raise the digit by one.

Note: Some DS4000 storage expansion enclosures ship with a panel installed over the enclosure ID switch to prevent the enclosure ID from being changed accidentally. If your DS4000 storage expansion enclosure has a protective panel over the ID switch, use a pencil or a small screwdriver to change the enclosure ID.

Each storage expansion enclosure in a DS4000 Storage Subsystem drive loop must have a unique enclosure ID. DS4000 controllers use a combination of the enclosure ID and the number of the physical slot that a hard drive occupies to create a unique fibre channel loop address or arbitrated loop physical address (AL_PA) for each drive in a fibre channel drive loop. The enclosure ID consists of two digits, a tens digit (x10) and ones digit (x1).

Attention: When connecting storage expansion enclosures, you must use the tens digit (x10) enclosure ID setting to distinguish different redundant drive loop pairs and use the ones digit (x1) enclosure ID setting to distinguish storage expansion enclosures IDs within a redundant drive loop pair. For example, in a DS4500 configuration with sixteen EXP710 storage expansion enclosures distributed equally across one redundant drive loop pair, the recommended enclosure ID settings for the enclosures are shown in Table 16 on page 67. EXP810 storage expansion enclosures automatically set their enclosure IDs to be unique in a drive loop pair.

Give each storage expansion enclosure in a redundant drive loop pair a unique ones digit (x1) ID. This setting will enforce hard AL_PAs (unchangeable between fibre channel Loop Initializations [LIPs]) for the drives and facilitate drive loop problem troubleshooting in the event of an error. If the one's digits are not unique, two or more devices will have the same hard AL_PA. In such a case, the DS4500 controller will use soft AL_PAs for the devices that have identical hard AL_PAs.

The problem with soft AL_PAs addressing is that addresses may change between LIPs. This possibility increases the difficulty of troubleshooting drive loop problems, since one cannot easily ascertain whether the same device with a different address or different device may be causing a problem. In addition, drive loop errors might be randomly posted in the DS4500 subsystem Major Event Log (MEL) when intermixing EXP100s, EXP710 and EXP810s in the same redundant drive loop pair with a soft AL_PA addressing scheme.

Connecting secondary interface cables

This section is applicable to (direct) out-of-band management configurations only. If your configuration uses host-agent (in-band) management, skip this section.

Use the Ethernet interface ports on the back of the storage subsystem to connect the controllers for direct management of the storage subsystems (see “Direct (out-of-band) management method” on page 105).

Important:

1. To minimize security risks, do not connect the DS4500 in a public LAN or public subnet. Use a local private network for the DS4500 and the management station Ethernet ports.
2. To ensure proper EMI shielding, always use quality braided and shielded serial cables.

Connect a pair of Ethernet cables from the storage-management station to the Ethernet ports for controller A (located on the top) and controller B (located on the bottom) on the back of the storage subsystem. For the location of the ports on the DS4500 Storage Subsystem, see “Ethernet interface ports” on page 50. Only one Ethernet port connection from each controller is required to establish a direct (out-of-band) management connection to the DS4500 Storage Subsystem.

Configuring the storage subsystem

You must configure the storage subsystem configuration after you install the storage subsystem in a rack cabinet. Use the information in the following sections to configure your storage subsystem configuration.

Storage subsystem management methods

Before you configure the storage subsystem, determine which method of storage subsystem management you want to use. You can manage the storage subsystems in either of two ways: host-agent (in-band) management or direct (out-of-band) management.

For more information on setting up in-band or out-of-band management connections, refer to the *DS4000 Storage Manager Installation and Support Guide* for the operating system of the host computer that will be used to manage the DS4500 Storage Subsystem.

Important: If the operating system of the host server that the storage subsystem logical drives are mapped to is not Microsoft Windows 2000 or Server 2003, then you have to make a direct (out-of-band) management connection to the storage subsystem to set the correct host type first. Then, the server will be able to recognize the storage subsystem correctly for host-agent (in-band) management.

Host-agent (in-band) management method

This method, shown in Figure 77 on page 105, requires host-agent software that you install on the host server. The host-agent software allows the DS4000 Storage Manager client program to manage the DS4000 storage subsystem using the same fibre channel connections between the host server and the storage subsystem. You must install at least one management station and a software agent host. The management station can be the host or a workstation on the Ethernet network. A management station will have the client software installed.

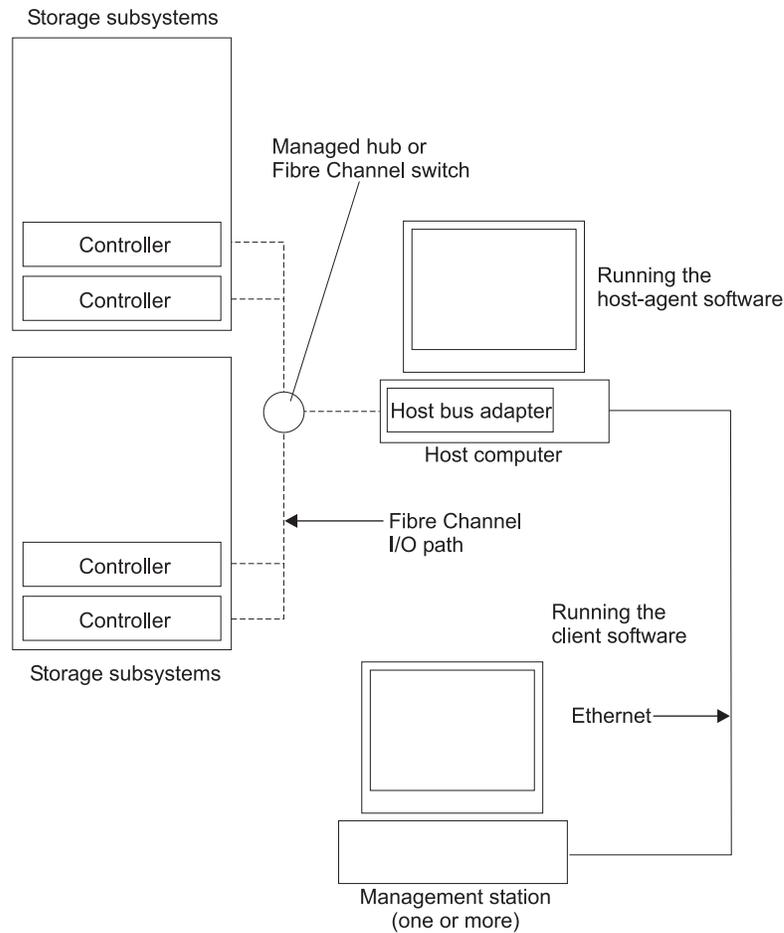


Figure 77. Host-agent (in-band) managed storage subsystems

Direct (out-of-band) management method

This method, shown in Figure 78 on page 106, uses Ethernet connections from a management station to each controller. You must install at least one management station. The management station can be the host or a workstation on the Ethernet network. A management station will have the client software installed. Attach Ethernet cables to each management station (one pair per storage subsystem). You will connect the cables to each storage subsystem controller later when you install the storage subsystem. Figure 78 on page 106 shows the direct (out-of-band) management method.

Note: Do not connect the DS4500 Storage Subsystem Ethernet ports to a public network or public subnet. It is strongly recommended that you create a private network between the DS4500 Storage Subsystem and the management station.

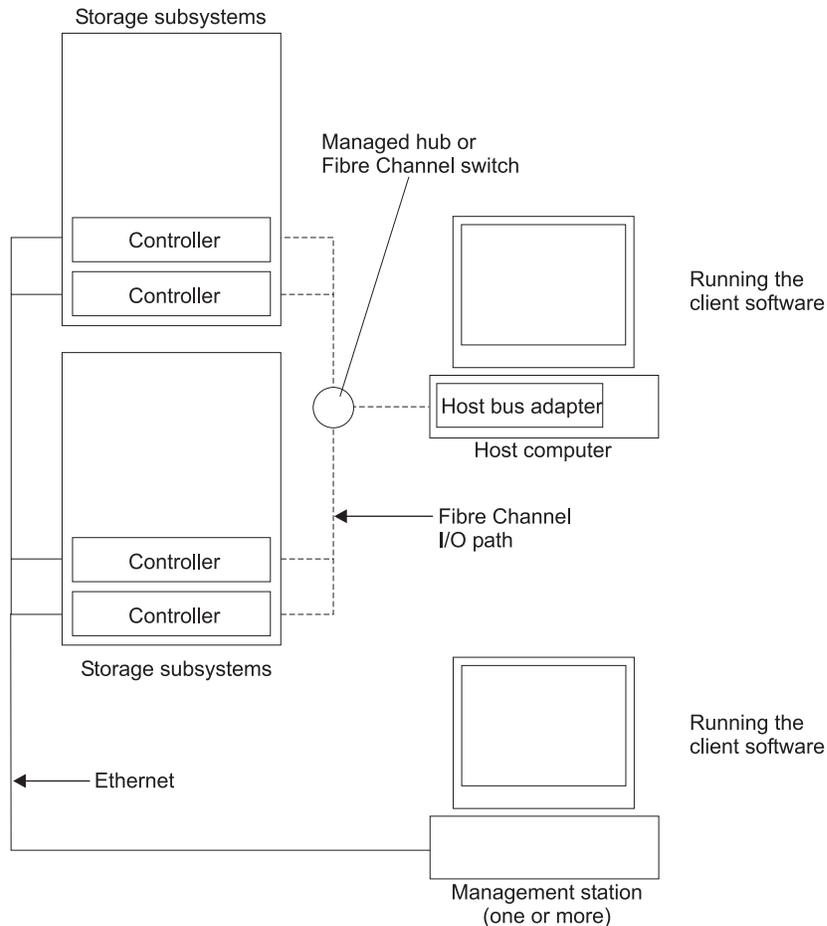


Figure 78. Direct (out-of-band) managed storage subsystems

Connecting hosts to the DS4500

The DS4500 supports direct attached connections to up to four hosts or supports connection to five or more hosts using external devices.

For examples of redundant, partially-redundant, and non-redundant host and drive loop configurations, see “Configuring the drive loops with storage expansion enclosures” on page 77.

Connecting hosts directly

This section provides instructions for connecting up to four hosts, with two host adapters each, directly to the DS4500 Storage Subsystem.

Before proceeding, make sure that you connect fiber-optic cables to all host adapters that you are connecting to the DS4500 Storage Subsystem.

Important: Host mini hub 1 and mini hub 3 correspond to Controller A (top) and mini hub 2 and mini hub 4 correspond to Controller B (bottom). To ensure redundancy, connect each host to both controllers. You can use either the upper or lower ports on either mini hub.

The example in the following procedure uses the upper ports for Hosts 1 and 4 and the lower ports for Hosts 2 and 3.

1. Connect the first host (Host 1) to the DS4500 Storage Subsystem, as shown in Figure 79.
 Connect Host Adapter 1 (HA1) from Host 1 to a port on host mini hub 1.
 Connect HA2 from Host 1 to mini hub 2.
 To connect a second host, continue with Step 2. Otherwise, go to “Setting the Link Rate Interface switch” on page 113.
2. Connect a second host (Host 2) to the DS4500 Storage Subsystem, as shown in Figure 79.
 Attach HA1 from Host 2 to the unoccupied port on mini hub 1. Attach HA2 from Host 2 to the unoccupied port on mini hub 2.
 To connect a third host, continue with Step 3. Otherwise, go to “Setting the Link Rate Interface switch” on page 113.
3. Connect a third host (Host 3) to the DS4500 Storage Subsystem, as shown in Figure 79.
 Attach HA1 from Host 3 to mini hub 3. Attach HA2 from Host 3 to mini hub 4.
 To connect a fourth host, continue with Step 4. Otherwise, go to “Setting the Link Rate Interface switch” on page 113.
4. Connect a fourth host (Host 4) to the DS4500 Storage Subsystem, as shown in Figure 79.
 Attach HA1 and HA2 from Host 4 to the two unoccupied ports on mini hub 3 and mini hub 4.

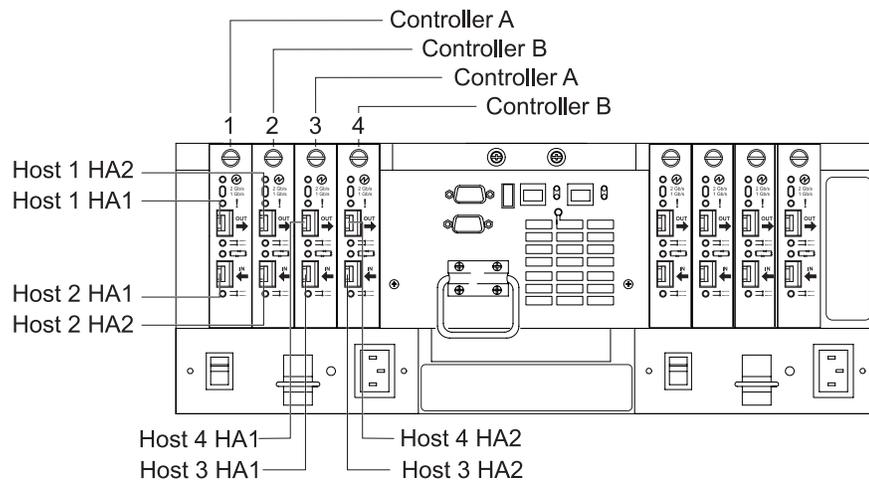


Figure 79. Connecting hosts directly to the controller

5. Go to “Setting the Link Rate Interface switch” on page 113.

Connecting hosts by using external devices

This section provides instructions for connecting five or more hosts to the DS4500 Storage Subsystem. When you use external fibre channel switches, the DS4500 Storage Subsystem supports up to 64 hosts (128 host adapters, 64 host adapters per controller) and two host adapters for each host.

Important: Host mini hub 1 and host mini hub 3 correspond to Controller A (top). Mini hub 2 and mini hub 4 correspond to Controller B (bottom). To ensure redundancy, connect each host to both controllers. You can use either the upper or lower connectors on either mini hub.

You connect additional hosts to the DS4500 Storage Subsystem by adding host-side mini hubs and fibre channel switches (one fibre channel switch for each mini hub).

Figure 80 shows an example of dual path configuration using fibre channel switches. Host 1 contains two host bus adapters that are connected to host mini hubs. To configure a host with dual path redundancy, connect the first host bus adapter (HA1) to SW1 and connect the second host bus adapter (HA2) to SW2. Then, connect SW1 to host mini hub 1 and SW2 to host mini hub 2.

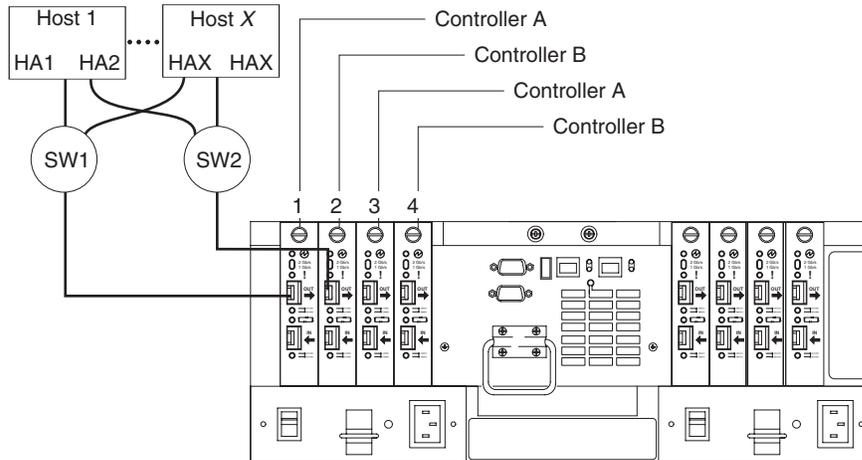


Figure 80. Using two fibre channel switches to connect a host

You can directly attach up to four fibre channel switches (one per mini hub) to a DS4500 Storage Subsystem. Figure 81 shows an example of attaching four fibre channel switches.

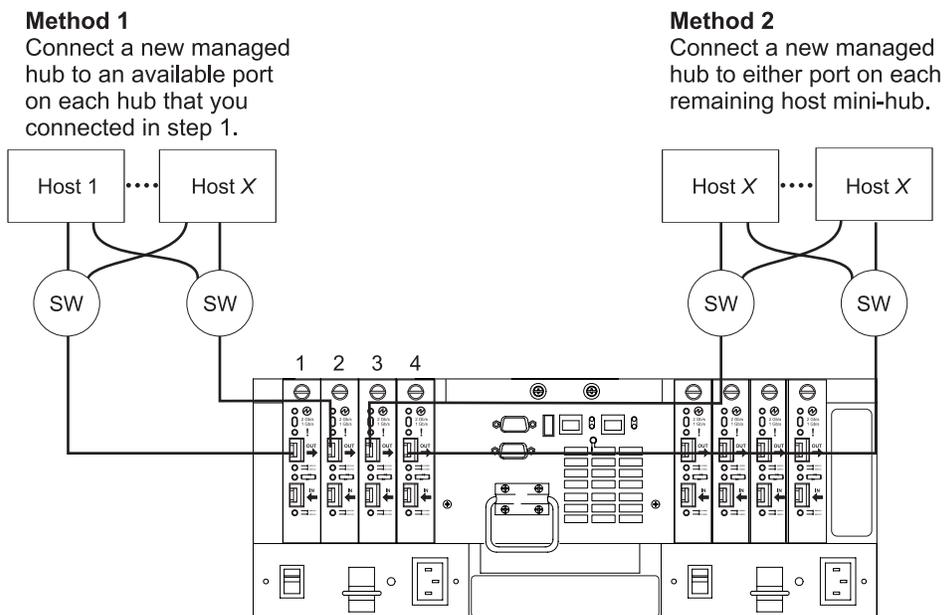


Figure 81. Using four fibre channel switches to connect multiple hosts

Most fibre channel switches support eight to 16 hosts. If the configuration requires more hosts than four fibre channel switches can support, you must add cascading switches, as shown in Figure 82.

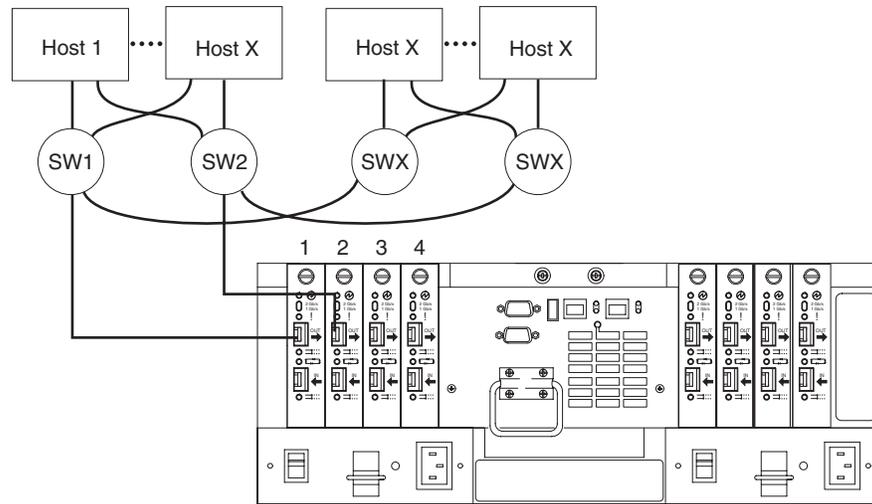


Figure 82. Adding hosts by using cascading switches

Cluster servers

If the fibre channel network environment into which you are installing the storage subsystem is configured for cluster servers, you must install two host bus adapters per cluster node. For complete information about installing host bus adapters, refer to the *IBM TotalStorage DS4000 FC2-133 Dual Port Host Bus Adapter Installation and User's Guide*.

Figure 83 on page 110 shows fibre channel connections using a dual-path configuration for fully redundant environments.

Note: The interlink is used as the clustering heartbeat path.

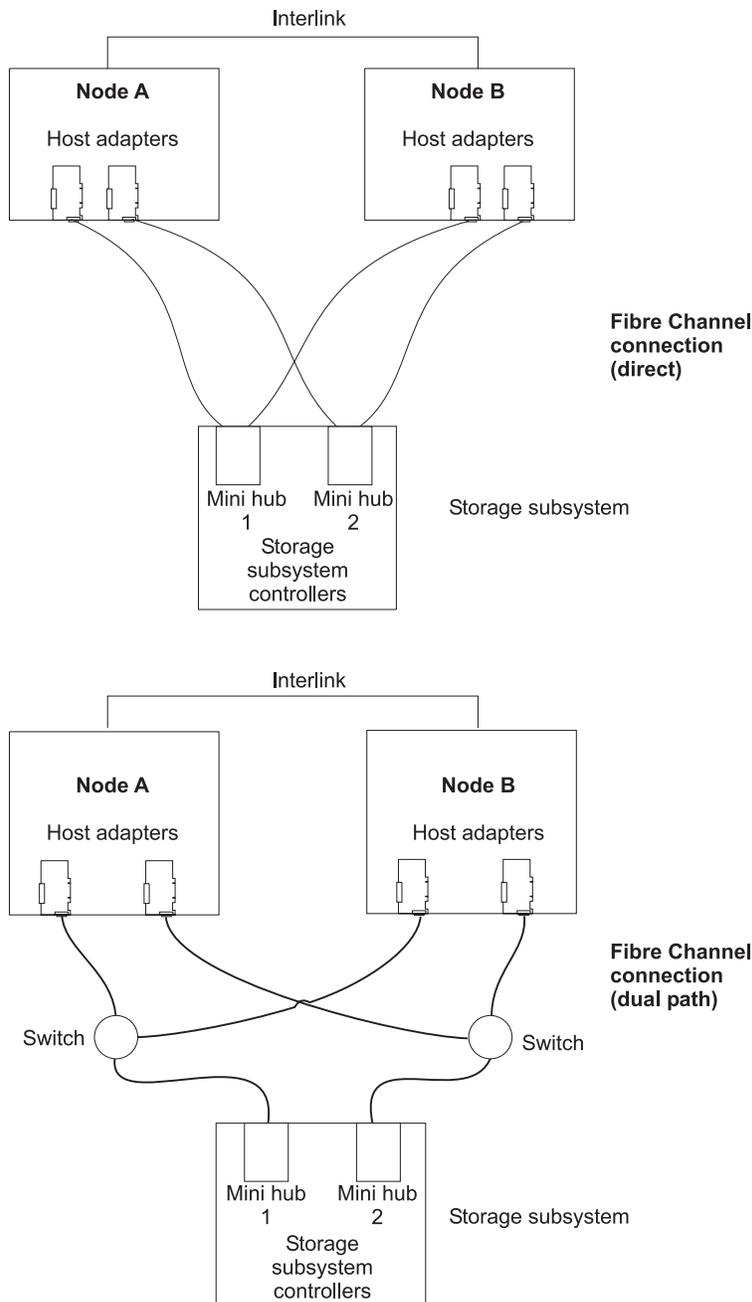


Figure 83. Host adapters in storage subsystems on a fibre channel network

Before you install the host adapters, note the following reminders about the cluster server fibre channel network environment:

- When using a dual-path configuration, each node has two paths to the storage subsystem providing greater redundancy protection if a connection problem occurs. Install two single-channel host adapters in each node.
- Use the correct host adapter device driver. Refer to the Storage Manager Installation Guide that is appropriate for your operating system and refer to the readme file for information on supported host adapters and device drivers. You can find this information on the Storage Manager installation CD or at the

following Web site: www.ibm.com/servers/storage/support/disk/. Make sure each host adapter and controller has a unique fibre channel ID. This is the value set in the adapter Hard Loop ID field.

After you install the cluster server hardware, if you have storage expansion enclosures, see “Connecting storage expansion enclosures to the DS4500” on page 61.

Installing the storage subsystem configuration

Using the information gathered in the previous sections, install the host systems and host adapters.

Notes:

1. See the documentation provided with your host adapters for installation requirements and procedures.
2. Use the correct host adapter driver. For the latest supported host adapters and drivers, go to the following Web site:

www.ibm.com/servers/storage/support/disk/

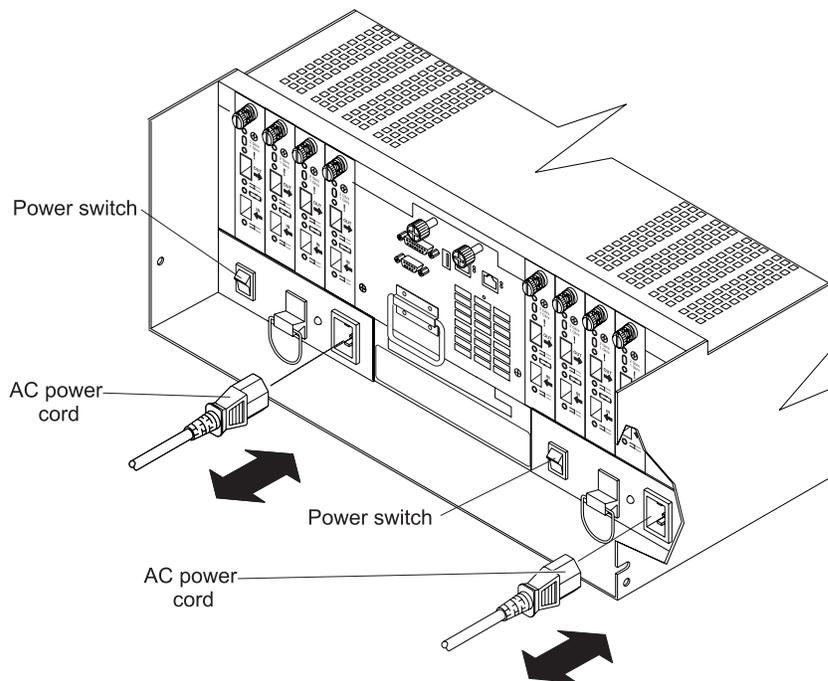
Attach fiber-optic interface cables to each host adapter. You will connect the other end of the cables to the controller later in the installation process. For more information about handling fiber-optic cables, see “Handling fiber-optic cables” on page 50.

Cabling the power supply

The DS4500 uses two standard power cords. You can connect the power cords to a primary power unit inside the rack cabinet, such as a properly grounded ac distribution unit, or to an external source, such as a properly grounded electrical outlet.

The DS4500 Storage Subsystem does not ship with power cords. Refer to Appendix C, “Power cords,” on page 175 for the list of IBM-approved power cords for your region. The DS4500 Storage Subsystem ships with two line cord jumpers for connecting the DS4500 power supplies to an IBM-approved rack power distribution unit.

If you have not already done so, attach the power cords by using Figure 84 on page 112 for the location of the component parts.



d3nu4033

Figure 84. Connecting the power cords

Perform the following to cable the power cords:

1. Connect the power cord to the power supply.
2. Remove the nut that holds the power cable strain-relief clamp, and then remove the strain-relief clamp.
3. Wrap the strain-relief clamp around the power cord approximately 20 cm (8 in.) from the power supply connection end. Leave some slack between the clamp and the power-supply end of the power cord.
4. Replace the power cable strain-relief clamp, and tighten it securely with the nut.
5. Plug the power cord into a properly grounded electrical outlet.

Note: To maintain power redundancy, plug the storage subsystem's right and left power supplies into two independent external power circuits through ac distribution units inside a rack cabinet or directly into external receptacles. Similarly, the right and left power supplies of the DS4000 storage expansion enclosures attached to the DS4500 should be plugged into the same two independent external power circuits as the DS4500.

It is recommended that you determine the maximum surge current possible when all devices in the power circuit are started at the same time. Based on the total number of devices on a power circuit, find the maximum (worst-case) specification value in order to prevent the circuit from tripping. When both power supplies are connected and the storage subsystem is powered on, each power supply unit will handle approximately one-half of the current load. If there is only one power supply unit, it will handle all of the current load. To ensure maximum protection against power loss due to power supply unit failure or a power circuit tripping, both power supply units must be connected and powered on. See "Electrical requirements" on page 16 for the DS4500 AC power requirements.

See Figure 85 for an example of redundant power cabling.

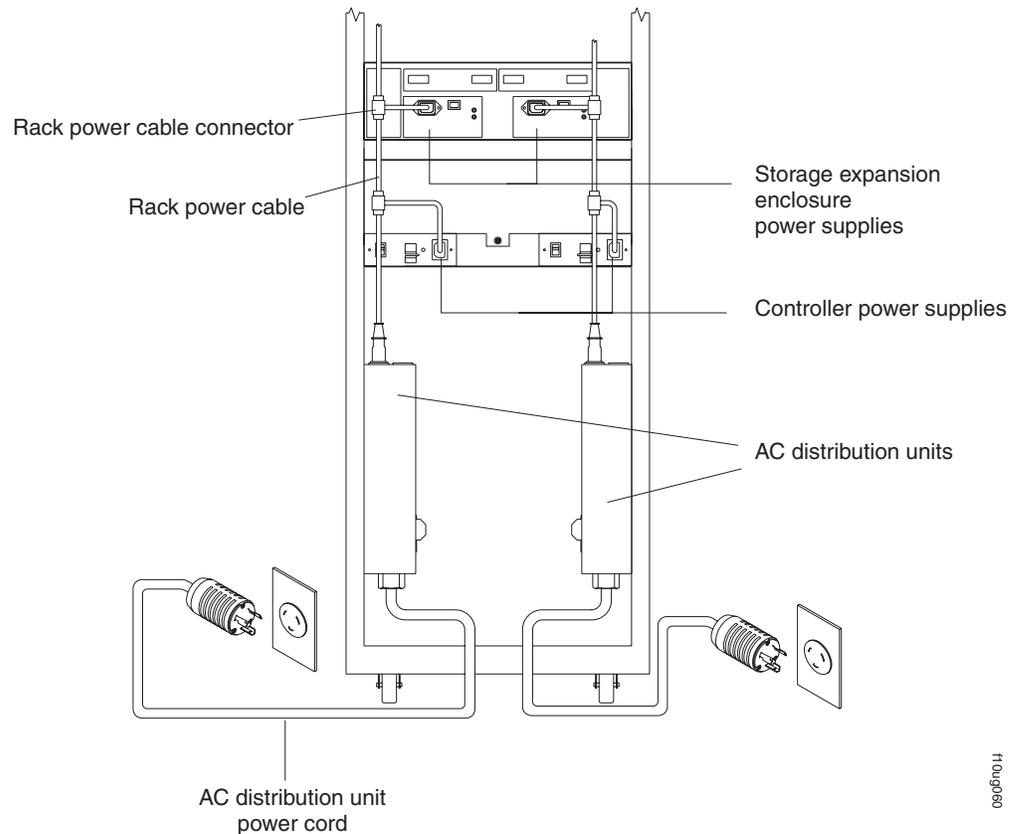


Figure 85. Redundant AC power connections to controllers and storage expansion enclosures

- Go to “Powering on the storage subsystem” on page 119 for the initial startup of the storage subsystem.

Attention: Before you power on the storage subsystem, any storage expansion enclosures should be completely connected to the storage subsystem.

Setting the Link Rate Interface switch

Each DS4500 Storage Subsystem mini hub has a Link Rate Interface switch that is used to select the host-side or drive-side mini-hub data transfer rates. The switch settings are labeled 2 Gb per second and 1 Gb per second. Use a device with a point such as a small flat-blade screwdriver or ballpoint pen to set the host-side or drive-side mini hub Link Rate Interface switch. See Figure 86 on page 114.

The Speed LED is green when the data transfer rate of the fibre channel loop is 2 Gbps. The Speed LED is off when the data transfer rate is 1 Gbps. Figure 86 on page 114 shows the location of the Link Rate switch and LED.

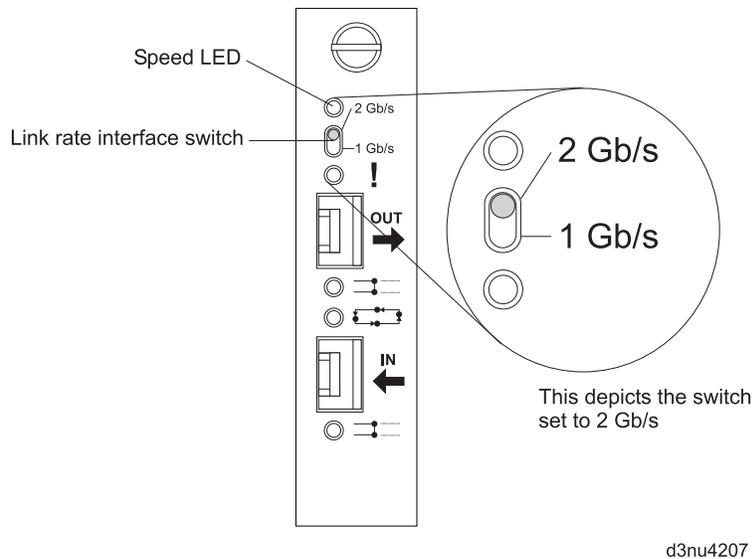


Figure 86. Mini hub Link Rate Interface switch and Speed LED

Setting data transfer rates on host-side mini hubs

To set the Link Rate Interface switch on the host-side mini hubs, complete the following steps.

Note: Host-side mini hub ports must be connected to devices that have the same data transfer rate.

1. Verify the data transfer rate of the devices on the loop or the fibre channel switch port.
2. Set the data transfer rate on the host bus adapter based on the data transfer rate of the devices on the loop or the fibre channel switch port.
3. Set the Link Rate Interface switch to match the data transfer rate of the host bus adapter.

Setting data transfer rates on drive-side mini hubs

On the drive-side mini hubs, set the Link Rate Interface switch to 2 Gbps or 1 Gbps based on the data transfer rate of the storage expansion enclosures.

Note: All storage expansion enclosures on the loop and drive-side mini-hub ports must be connected to devices that have the same data transfer rate.

To set the data transfer rate on drive-side mini hubs, perform the following steps:

1. Verify the data transfer rate of the storage expansion enclosure on the loop.
2. Set the link rate interface switch to match the data rate of the storage expansion enclosure.

Note: The data transfer rate of all drives mini hubs must be set to operate at either 1 Gbps or 2 Gbps. If you have one set of drive loops using EXP500 storage expansion enclosures (data transfer speed of 1 Gbps) and the other set of drive loops using EXP700 storage expansion enclosures (data transfer speed of 2 Gbps), the speed of all drive mini hubs must be set to 1 Gbps. Not doing so will result in drive channel mini hub data rate mismatch errors.

Attention: You cannot mix the DS4000 EXP100/EXP710/EXP810 with FAStT EXP500s in a DS4500 Storage Subsystem configuration. If a DS4000 EXP100/EXP710/EXP810 is included in one drive loop, no FAStT EXP500s can be present in the other drive loop (because the storage subsystem does not support mixed drive loop speeds).

For full details about intermixing DS4000 storage expansion enclosures, refer to the *IBM TotalStorage DS4000 Hard Drive and Storage Expansion Enclosure Installation and Migration Guide*.

Chapter 4. Operating the storage subsystem

This chapter describes operating procedures for the DS4500 Storage Subsystem.

To ensure optimal operation of your system, see “Best practices guidelines” on page 5.

Performing the DS4000 Health Check process

The DS4000 Health Check process is a sequence of suggested actions developed by IBM to help users verify and maintain the optimal performance of their DS4000 storage configurations. The information that you collect in these steps also helps provide IBM Service with important information needed for problem troubleshooting during IBM Service calls.

Perform the following Health Check tasks after the initial configuration of your DS4000 Storage Subsystem, and after all configuration sessions. It is also recommended that you set a regular schedule of periodic Health Check evaluations to keep your DS4000 code current and to preserve optimal data access and performance.

Note: The following process is applicable for storage subsystems operating with controller firmware 6.12.xx.xx or higher.

1. Monitor the Recovery Guru in the Storage Manager client for any obvious storage subsystem errors or problem conditions.
2. Gather and save the following DS4000 storage subsystem event logs for review by IBM Service. These event logs should be gathered periodically for regular Health Check monitoring regardless of the state of the Recovery Guru. (You can collect all these logs at once and zip them into a single file by clicking **Advanced ► Troubleshooting ► Collect All Support Data** in the DS4000 Storage Manager Subsystem Management window.)
 - DS4000 storage subsystem management event log (MEL)
 - Storage Subsystem Profile or DS4000 Profile
 - Read-Link Status (RLS) data

In addition, you should also collect event logs for the host servers that have mapped logical drives from the storage subsystem.

Attention: Save these event log files to a server disk that will remain accessible in the event of a DS4000 storage configuration failure. Do not save these event log files only to a LUN in the DS4000 Storage Subsystem.

3. Use the Storage Subsystem Profile or DS4000 Profile to verify that the following firmware levels are at the latest versions supported for your DS4000 storage subsystem:
 - Controller firmware
 - ESM firmware
 - Drive firmware

If you discover your firmware is not up-to-date, upgrade the firmware and software to the latest level appropriate to your DS4000 storage configuration. See “Web pages” on page 118 for information about where to find the latest firmware and software.

Attention: You must resolve Recovery Guru errors or problems before upgrading firmware.

Save the storage subsystem profile before performing any controller or ESM firmware upgrades. Save the storage subsystem profile and all *.cfg files to a server disk that will remain accessible in the event of a DS4000 storage configuration failure.

Note: When you upgrade firmware, you must upgrade all client package components to the same release level. For example, if you are upgrading your controller firmware from version 5.x to version 6.x, you must also upgrade your Storage Manager client to version 9.x or higher. If your host system uses RDAC, upgrading controller firmware from version 5.x to version 6.x might also require host software updates, such as RDAC updates and HBA driver updates. Refer to the IBM DS4000 Web site for detailed instructions.

4. Use the Storage Subsystem Profile or DS4000 Profile to verify that the following functions are enabled:
 - For all DS4000 models, Media Scan should be enabled both at the controller level and at the LUN level.
 - For all DS4000 models, the read/write cache should be enabled. In addition, use the Storage Subsystem Profile to verify that cache is matched between the controllers.

Web pages

IBM maintains pages on the World Wide Web where you can get the latest technical information and download device drivers and updates.

For DS4000 information, go to the following Web site:

www.ibm.com/servers/storage/support/disk/

For the latest information about operating system and HBA support, clustering support, SAN fabric support, and Storage Manager feature support, see the TotalStorage DS4000 Interoperability Matrix at the following Web site:

www.ibm.com/servers/storage/disk/ds4000/interop-matrix.html

Hardware responsibilities

In addition to the Health Check steps described above, regular hardware inspection and maintenance helps to support the optimal performance of your DS4000 storage configuration. You should periodically inspect the fibre channel components of your DS4000 storage configuration.

The following guidelines are suggested:

- Maintain an up-to-date storage subsystem profile for your DS4000 storage configuration. Save the profile to a server disk that will remain accessible in case of a DS4000 storage configuration failure. Do not save the profile only to a LUN in the DS4000 Storage Subsystem.
- Develop a Change Management plan. The plan should include schedules for updating subsystem firmware and server host software.

Note: Some updates might require storage subsystem downtime.

- Use IBM-approved fibre channel cables for all situations. Note in your configuration documentation whether any cables are not IBM-approved.

- Create and maintain a cabling diagram of the current SAN configuration. Keep this diagram updated as you make configuration changes, and keep the cabling diagram available for review.
- Create and maintain a list of other components that are being used within the cabling diagram (such as the host system, fibre channel switches, and other SAN attachments).
- Ensure that all ESMs are properly seated.
- Ensure that all drives are properly seated.
- Ensure that all SFP modules are properly seated.
- Confirm fibre channel cable loop size. (IBM specifications call for at least 3-inch cable loops, but it is recommended that you use 6-inch cable loops or longer.)
- Ensure proper fibre channel cable management.
- Ensure proper air flow and temperature for all components in your EXP810 storage configuration.

Note: You can find details on many of these inspection and maintenance responsibilities in the appropriate sections of this document.

In addition to these inspection and maintenance responsibilities, IBM also strongly recommends DS4000 training for staff that supports DS4000 storage configurations. Although training is not a part of the Health Check process, DS4000 training reduces the potential for configuration problems and contributes to the overall health of the system.

Powering on the storage subsystem

This section contains instructions for turning the storage subsystem on under normal and emergency situations. When you turn on and turn off the DS4500, be sure to use the startup sequence in this section. If you are turning on the storage subsystem after an emergency shutdown or power outage, see “Restoring power after an unexpected shutdown” on page 138.

Turning on the storage subsystem

The following procedure covers two situations:

- The entire storage subsystem has been shut down. (The main circuit breakers for the cabinet are off.)
- Some storage expansion enclosures are being powered on while others remain online. (The main circuit breakers for the cabinet are on.) You might encounter this if you are adding an additional storage expansion enclosure to increase storage capacity.

Attention:

1. **Potential damage to drives** - Repeatedly turning the power off and on without waiting for the drives to spin down can damage the storage expansion enclosure drives. Always wait at least 70 seconds from when you turn off the power until you turn it on again.
 2. If you are connecting a power cord to a DS4500 Storage Subsystem or storage expansion enclosure, turn off both of its power switches first. If the main circuit breaker is off, be sure both power switches are off on each storage expansion enclosure in the cabinet before turning on the main circuit breakers.
1. Are the main circuit breakers turned on?

- **Yes** - Turn off **both** power switches on each enclosure that you intend to connect to the power.
 - **No** - Turn off **both** power switches on **all** enclosures in the storage subsystem.
2. Ensure that all power cords are connected.

Note: If the power cords are not connected, turn off both power switches on all modules in the configuration before connecting power cords or turning on the main circuit breakers.

3. If the main circuit breakers are turned off, turn them on.
4. Verify that the link rate setting on the drive-side mini hubs matches the lowest operating fibre channel speed on the attached drive expansion enclosures.

Attention: You must turn on power to each attached storage expansion enclosure before turning on power to the DS4500 Storage Subsystem to ensure that the controllers recognize all drives in the configuration during the startup process.

5. Turn on both power switches on the back of each storage expansion enclosure attached to the storage subsystem. While each storage expansion enclosure powers up, the green and amber LEDs on the front and back of the storage expansion enclosure turn on and off intermittently. Depending on your configuration, it can take several minutes for each storage expansion enclosure to power up.

Check the LEDs on the front and back of all the storage expansion enclosures. Verify that no Fault or enclosure ID LEDs light on any of the storage expansion enclosures. To verify the fibre channel connections between the drive expansion enclosures, make sure that no Port Bypass LEDs for connections to other storage expansion enclosures are lit. Only the Port Bypass LED of the ESM port that connects directly to the storage subsystem drive port should be lit.

Note: The drive activity LEDs will flash slowly (once every 2 seconds) until the drive is started by the DS4500 controller.

6. Turn on both AC power switches on the back of each power supply in the storage subsystem. Figure 84 on page 112 shows the location of the AC power switches on the power supplies.

Depending on the number of storage expansion enclosures in the configuration, the storage subsystem might take several minutes to power up. The battery self-test might take an additional 15 minutes. The LEDs will blink intermittently until the storage subsystem powers up and completes the battery self-test. Before attempting any operations, wait at least five minutes for the storage subsystem to completely power up. A storage subsystem can take up to 10 minutes to power on and up to 15 more minutes to complete its controller battery self-test. During this time, the indicator lights on the front and back of the module blink intermittently.

7. Determine the status of all storage subsystems and components in the configuration by completing the following steps:
 - a. Check all LEDs on each component in the storage expansion enclosures. Ensure that all the LEDs show normal status. For more information on LED status for storage expansion enclosures, see the Installation, User's, and Maintenance Guide for your DS4000 storage expansion enclosure.
 - b. Check all LEDs on each component in the storage subsystem. Ensure that all the LEDs show normal status. For information about LED status, see "Checking the LEDs" on page 127.

- c. Open the DS4000 Storage Manager Subsystem Management window, and display the Physical View for the configuration.
The status for each component will be either Optimal or Fault.
 - d. Review the status of the configuration components shown in the Subsystem Management window by selecting the appropriate component button for each storage subsystem.
8. Are the LEDs indicating normal operation, and is the status Optimal on all the configuration components?
 - Yes — End of procedure.
 - No — Go to step 9.
 9. Diagnose and correct the fault by completing the following steps:
 - a. Run the DS4000 Storage Manager Recovery Guru by selecting the Recovery Guru toolbar button in the Subsystem Management window.
 - b. Complete the recovery procedure.
If the Recovery Guru directs you to replace a failed component, use the individual LEDs on the storage subsystem to locate the specific failed component. For troubleshooting procedures, see “Troubleshooting the storage subsystem” on page 126.
 - c. When the recovery procedure is completed, select Recheck in the Recovery Guru. This action reruns the Recovery Guru to ensure that the problem has been corrected.
 - d. If the problem persists, contact your IBM service representative.

Turning on the DS4500 Storage Subsystem alarm

The DS4500 Storage Subsystem has an audible alarm. This alarm is controlled by a switch that is located on the storage subsystem fan. You can enable this alarm by removing the bezel (see “Removing the front bezel” on page 32) and setting the switch in the up position, as shown in Figure 87.

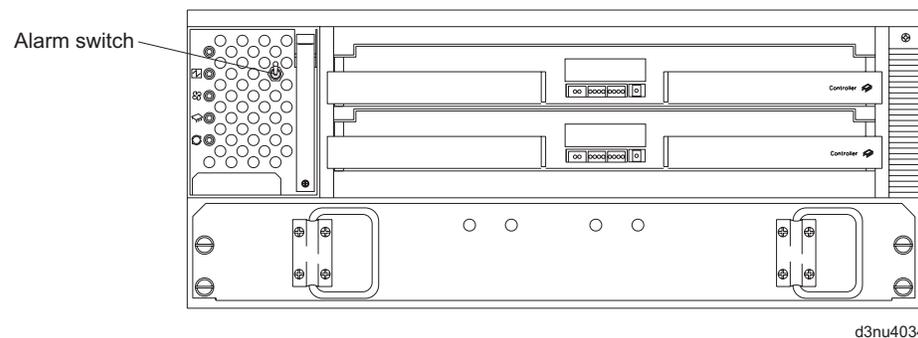


Figure 87. DS4500 Storage Subsystem alarm switch

Installing the DS4000 Storage Manager client

Refer to the *IBM System Storage DS4000 Storage Manager 9.19 Installation and Support Guide* for the appropriate operating system for instructions on how to install the Storage Manager software. Use that document and the online help to configure the logical drives, partitions, and so on for the RAID controllers. Use your operating system documentation to make the new logical drives accessible to the operating system. Do not proceed with the configuration setup until you have completed the DS4000 Storage Manager installation.

Assemble any additional items in preparation for software installation. These items might include the following:

- HBA drivers
- Controller firmware version 06.19.xx.xx
- IP addresses for RAID controllers (for in-band management only)
- Additional documentation for switches and HBAs, if needed
- Appropriate host software kit for your operating system.

The standard DS4500 ships with the Microsoft Windows, Linux, Netware host software attachment kits. The host software kit grants you permission to attach host servers using the appropriate operating system to the DS4500. Additional operating system host attachment kits can be purchased separately. For supported operating systems, see “Operating system support” on page 2.

For the latest controller firmware and the DS4500 Storage Manager host software, check the IBM support Web site for DS4000 storage products:

www.ibm.com/servers/storage/support/disk/

Before any planned system shutdown or after any system additions, removals, or modifications (including firmware updates, logical drive creations, storage partitioning definitions, hardware changes, and so on), save the storage subsystem profile as explained in the DS4000 Storage Manager guide for your operating system. Save the profile in a location other than the logical drives created for the DS4500.

Always refer to the readme that is included with the DS4500 Storage Subsystem firmware package (whether the firmware is accessed by the Web or CD) for any special requirements or restrictions that apply to that particular firmware version.

Note: Make sure that you install the DS4000 Storage Manager event monitoring service to enable continuous monitoring of the status of the storage subsystem. For more information about the importance of this information, see “Monitoring status through software” on page 124.

Setting up IP addresses for DS4000 storage controllers

After you install DS4000 Storage Manager (as described in the DS4000 Storage Manager Installation and Support Guide for your host operating system), complete one of the following procedures to set up IP addresses:

- “Steps for setting up the DHCP/BOOTP server and network”
- “Steps for assigning static TCP/IP addresses to the DS4000 controllers” on page 123

Steps for setting up the DHCP/BOOTP server and network

To complete this procedure, you must have the following components:

- A DHCP or BOOTP server
- A network management station (NMS) for Simple Network Management Protocol (SNMP) traps
- A host that is connected to a storage subsystem through a fibre-channel I/O path
- A management station that is connected by an Ethernet cable to the storage subsystem controllers

Note: You can avoid DHCP/BOOTP server and network tasks either by using the default controller IP addresses, or by assigning static IP addresses to the controller, as described in the next section.

Complete the following steps to set up the DHCP/BOOTP server and network:

1. Get the MAC address from each controller blade.
2. Complete whichever of the following steps is appropriate for your server:
 - On a DHCP server, create a DHCP record for each of the MAC addresses. Set the lease duration to the longest time possible.
 - On a BOOTP server, edit the bootptab file to add in the entries that associate the MAC address tab with the TCP/IP address.
3. Connect the DS4000 storage subsystem Ethernet ports to the network.
4. Boot the DS4000 storage subsystem.

The DHCP server automatically assigns new IP addresses to the controller Ethernet port.

Steps for assigning static TCP/IP addresses to the DS4000 controllers

To complete this procedure, you must have the following components:

- A host that is connected to a storage subsystem through a fibre-channel I/O path
- A management station that is connected by an Ethernet cable to the storage subsystem controllers

Complete the following steps to assign static TCP/IP addresses to the DS4000 storage subsystem controllers, using default TCP/IP addresses that are assigned to the DS4000 storage subsystem controllers during manufacturing:

1. Make a direct management connection to the DS4000 storage subsystem, using the default TCP/IP addresses:
 - **Controller A:** 192.168.128.101
 - **Controller B:** 192.168.128.102
 - **Subnet Mask:** 255.255.255.0

Note: For a DS4000 subsystem that has two Ethernet ports per controller, such as the DS4200, DS4700 and DS4800, use the Ethernet port that is labeled #1.

2. Start the DS4000 Storage Manager client software. The Enterprise Management window opens.
3. Add the DS4000 subsystem to the DS4000 Enterprise Management domain using the default IP addresses.
4. In the Enterprise Management window, click on the name of the default storage subsystem. The Subsystem Management window opens.
5. In the Subsystem Management window, right-click the controller icon and select **Change** → **Network Configuration** in the pull-down menu. The Change Network Configuration window opens.
6. In the Change Network Configuration window, click on the Controller A and Controller B tabs and type the new TCP/IP addresses in their appropriate fields. Click **OK**.
7. Close the Subsystem Management window, wait at least five minutes, then delete the default DS4000 storage subsystem entry in the Enterprise Management window. The default DS4000 storage subsystem entry still displays, but shows an “unresponsive” icon.

8. If applicable, change the IP address of the Ethernet port in the management station to a value that is on the same TCP/IP subnet as the controller Ethernet port IP addresses that you just assigned. Exit DS4000 Storage Manager, then restart.
9. Add a new storage subsystem entry in the Enterprise Management window, using the new assigned IP addresses.

Note: To manage storage subsystems through a firewall, configure the firewall to open port 2463 to TCP data.

Monitoring status through software

Use the DS4000 Storage Manager client to monitor the status of the storage subsystem. Run the software constantly, and check it frequently.

Notes:

1. You can only monitor storage subsystems that are within the management domain of the storage-management software.
2. If you have not installed the DS4000 Storage Manager Event Monitor service as part of the storage-management software installation, the DS4000 Storage Manager Enterprise Management window must remain open. (If you close the window, you will not receive any alert notifications from the managed storage subsystems.)

For more information, see the Enterprise Management online Help.

Important: Refer to the *IBM System Storage DS4000 Storage Manager 9.19 Installation and Support Guide* for the appropriate operating system for instructions on how to install the DS4000 Storage Manager 9.19 host software.

In addition, to download the latest version of the DS4000 Storage Manager host software, the DS4500 Storage Subsystem controller firmware and NVSRAM, and the latest DS4000 ESM firmware, go to the following Web site:

www.ibm.com/servers/storage/support/disk/

The DS4000 Storage Manager client provides the best way to diagnose and repair storage-server failures. The software can help you do the following:

- Determine the nature of the failure
- Locate the failed component
- Determine the recovery procedures to repair the failure

Although the storage subsystem has Fault LEDs, these LEDs do not necessarily indicate which component has failed or needs to be replaced, or which type of recovery procedure you must perform. In some cases (such as in the case of a hard disk drive exceeding its PFAs), the Fault LED does not turn on. Only the DS4000 Storage Manager client can detect the failure.

For example, the recovery procedure for a Predictive Failure Analysis[®] (PFA) flag (impending drive failure) on a drive varies depending on the drive status (hot spare, unassigned, RAID level, current logical drive status, and so on). Depending on the circumstances, a PFA flag on a drive can indicate a high risk of data loss (if the

drive is in a RAID 0 volume) or a minimal risk (if the drive is unassigned). Only the DS4000 Storage Manager client can identify the risk level and provide the necessary recovery procedures.

Note: For PFA flags, the General-system-error LED and Drive Fault LEDs do not turn on, so checking the LEDs will not notify you of the failure, even if the risk of data loss is high.

Recovering from a storage-server failure might require you to perform procedures other than replacing the component (such as backing up the logical drive). The DS4000 Storage Manager client gives these procedures.

Attention: Not following the software-recovery procedures can result in data loss. In addition, always replace a failing component as soon as possible to minimize additional failures that might occur, causing loss of data access.

Firmware updates

Attention: Save the storage subsystem profile before performing any controller or ESM firmware upgrades. Save the DS4500 storage subsystem profile and all configuration (*.cfg) files to a server disk that will remain accessible in the event of a DS4000 storage configuration failure. Do not save these files only to a LUN in the DS4000 Storage Subsystem.

To ensure the optimal operation of the DS4500 and its attached storage expansion enclosures, the storage expansion enclosure ESM firmware, the DS4500 controller firmware, the hard drive firmware, and the NVSRAM (for controllers only) must be up to date. Go to the following Web site to get the latest updates:

www.ibm.com/servers/storage/support/disk/

Always check the readme files that are included with the firmware packages for the most up-to-date information about firmware prerequisites, firmware update instructions, and host I/O restrictions, if any. Apply the necessary updates before configuring the storage subsystem arrays and logical drives. Subscribe to My Support for automatic notifications of firmware or Storage Manager software updates or any important information about your DS4000 subsystems (see “Product updates” on page 4).

Attention: Read the readme file that is included in each firmware or DS4000 Storage Manager software package for any limitations, subsystem firmware prerequisites, or download-sequence information. For example, the controller firmware code might require the storage expansion enclosure ESM firmware to be upgraded first to a particular version, or the controller firmware download might require the halting of I/Os to the DS4500's logical drives. Failure to observe the limitations, prerequisites, and dependencies in the readme file might result in a loss of data access.

Unless the readme file contains special requirements for the sequence in which you upgrade firmware, you should perform firmware upgrades in the following sequence:

1. ESM firmware for the storage expansion enclosures
2. Controller NVSRAM
3. Controller firmware
4. Drive firmware

Troubleshooting the storage subsystem

The DS4000 Storage Manager is the best way to monitor the storage subsystem, diagnose a problem, and recover from a hardware failure. You should run the DS4000 Storage Manager continuously, and frequently check the configuration status.

Use the following procedure to check the status of and identify a problem with the storage subsystem. If a problem has occurred, use the DS4000 Storage Manager client software and the LEDs on the storage subsystem to help locate a failed component.

1. Open the Subsystem Management window.
2. Select the component button for each storage expansion enclosure in this storage subsystem, and view the status of each of the components.
The status for each component is either Optimal or Fault.
3. Does any component have a Fault status?
 - **Yes** - Go to step 4.
 - **No** - All components are Optimal. Go to step 6.
4. Select the Recovery Guru toolbar button. Perform the procedure in the Recovery Guru to correct the problem. The Recovery Guru might direct you to replace the failed component. If so, go to step 5.

Attention: If the fault requires you to power off an attached storage expansion enclosure, you might need to cycle the power on the DS4000 storage subsystem and all remaining storage expansion enclosures in the storage subsystem. Contact IBM Customer and Technical Support before powering off any attached storage expansion enclosures.

5. Mute the alarm, if needed.
6. Check the indicator LEDs on the front and the back of the storage expansion enclosure.
A green LED denotes a normal status; an amber LED denotes a hardware fault.
7. Is an amber LED on?
 - **Yes** - Locate and troubleshoot the failed components. See "Checking the LEDs" on page 127.
 - **No** - You are finished with this procedure. If you are still experiencing a problem with this storage subsystem, create, save, and print a storage subsystem profile. This information might be helpful when troubleshooting.

Contact IBM Customer and Technical Support for assistance. When the recovery procedure is completed, select **Recheck** in the Recovery Guru to rerun the Recovery Guru and to ensure that the problem has been corrected.

Checking the LEDs

The LEDs display the status of the storage subsystem and components. Green LEDs indicate a normal operating status; amber LEDs (Fault) indicate a possible failure.

It is important to check all the LEDs on the front and back of the storage subsystem when you turn on the power. During power up, the indicator LEDs blink intermittently as the storage subsystem and components complete the power-up process. It can take up to 15 minutes for the battery to complete its self-test and up to 24 hours to fully charge, particularly after an unexpected power loss of more than a few minutes.

Front Bezel LEDs

The DS4500 Storage Subsystem has five LEDs on the front bezel, as shown in Figure 88. To view these LEDs, you do not have to remove the DS4500 bezel.

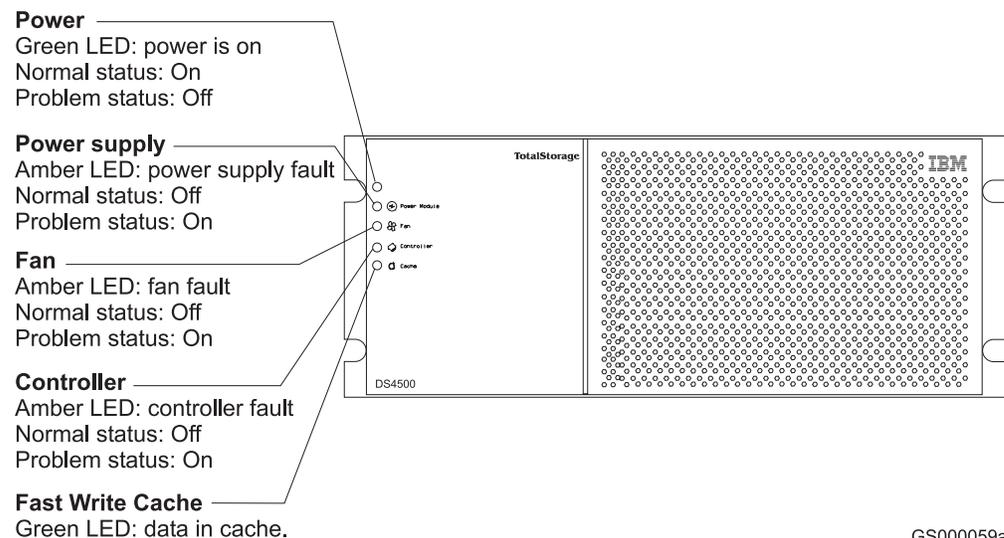


Figure 88. DS4500 Storage Subsystem front LEDs

Table 17 describes the front LEDs.

Table 17. DS4500 Storage Subsystem LEDs

LED	Color	Normal status	Problem status	Possible conditions indicated by the problem status ¹
Power	Green	On	Off	<ul style="list-style-type: none"> The DS4500 has no power. The power supply cables are loose or the switches are off. Both power supplies are turned off, have power cable problems, or have failed. The temperature of the DS4500 is too high. The AC power circuit tripped.

Table 17. DS4500 Storage Subsystem LEDs (continued)

LED	Color	Normal status	Problem status	Possible conditions indicated by the problem status ¹
Power supply fault	Amber	Off	On	<ul style="list-style-type: none"> One of the redundant power supplies has failed or the power supply is turned off, has power cable problems, or is not fully seated in the DS4500. The temperature of the DS4500 is too high. If both power supplies have failed, are turned off, or are disconnected, all of the LEDs will not be off.
Storage subsystem fan fault	Amber	Off	On	<ul style="list-style-type: none"> The storage subsystem fan has failed. The fan and communications module is missing, unplugged, or has failed. The storage subsystem fan circuitry has failed. The temperature of the DS4500 is too high.
Controller fault	Amber	Off	On	<ul style="list-style-type: none"> The RAID controller is restarting. The RAID controller has failed. One or more controller memory modules have failed. One or more controller is idle. There are not any I/Os.
Cache active (Fast write cache)	Green	Steady or blinking ²	Software dependent ¹	<p>During normal operation, the indicator light is not lit in the following conditions:</p> <ul style="list-style-type: none"> The RAID controller cache is not enabled. The battery is not ready.

¹ Always use the storage-management software to identify the failure.

² The Cache active LED is on when there is data in the cache and blinks during a write operation.

Controller LEDs

Each RAID controller has ten LEDs: one power, one fault, and eight status, as shown in Figure 89 on page 129.

Note: To view the controller LEDs, remove the DS4500 bezel (see “Removing the front bezel” on page 32).

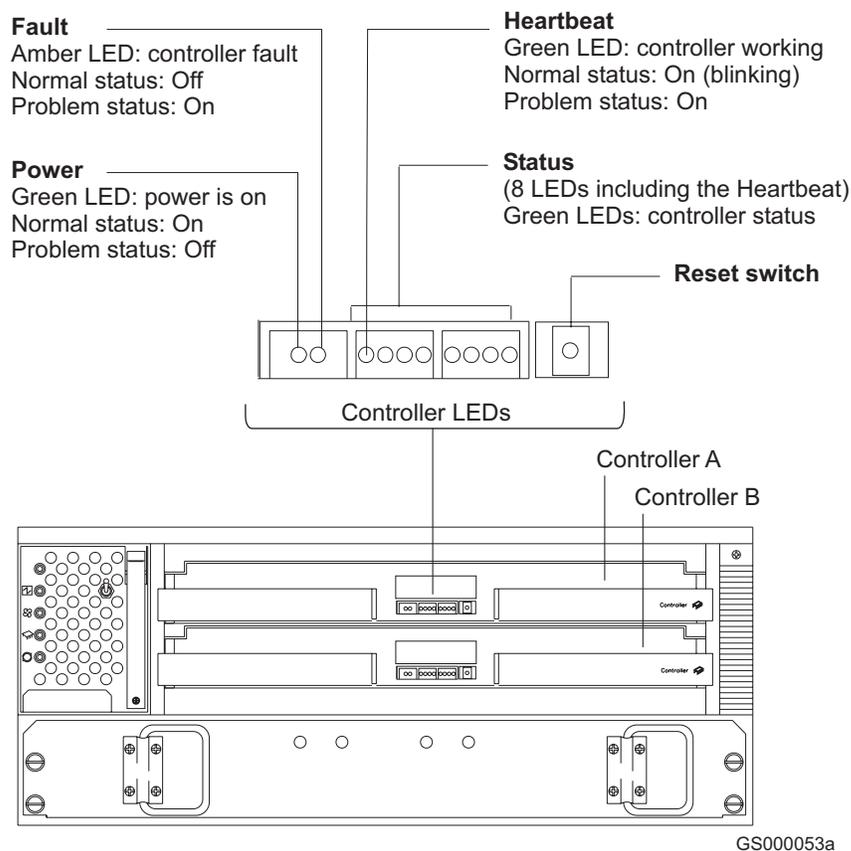


Figure 89. Controller LEDs

Table 18 describes the DS4500 Controller LEDs.

Table 18. Controller LEDs

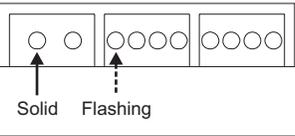
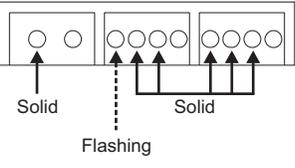
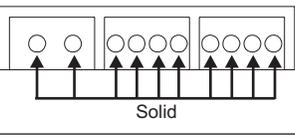
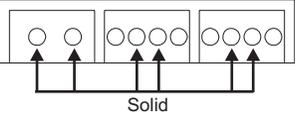
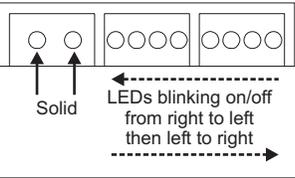
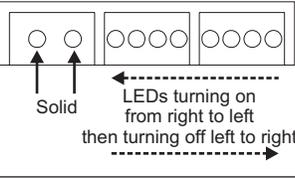
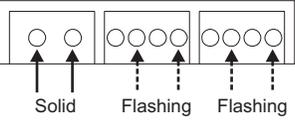
LED	Color	Normal status	Problem status	Possible conditions indicated by the problem status ¹
Power	Green	On	Off	<ul style="list-style-type: none"> There is no power to the storage subsystem. The cables are loose or the switches are off. The power supply has failed, is missing, or is not fully seated. The temperature of the DS4500 is too high.
Fault ³	Amber	Off	On	Controller failure
Heartbeat	Green	Blinking	Not blinking	No controller activity
Status (seven ³ LEDs not including Heartbeat)	Green	All LEDs are off except the heartbeat ²	Various patterns depending on the condition ²	If any status LEDs are lit and the controller is not offline, there is a memory fault indicating that the controller CRU has failed.

¹ Always use the storage-management software to identify the failure.

² There are eight LEDs (the Heartbeat and seven others); the seven others are lit in various patterns, depending on the controller status. For details on these common patterns, see Table 19 on page 130.

³If the controller is offline, all of the LEDs will be lit. This does not indicate failure.

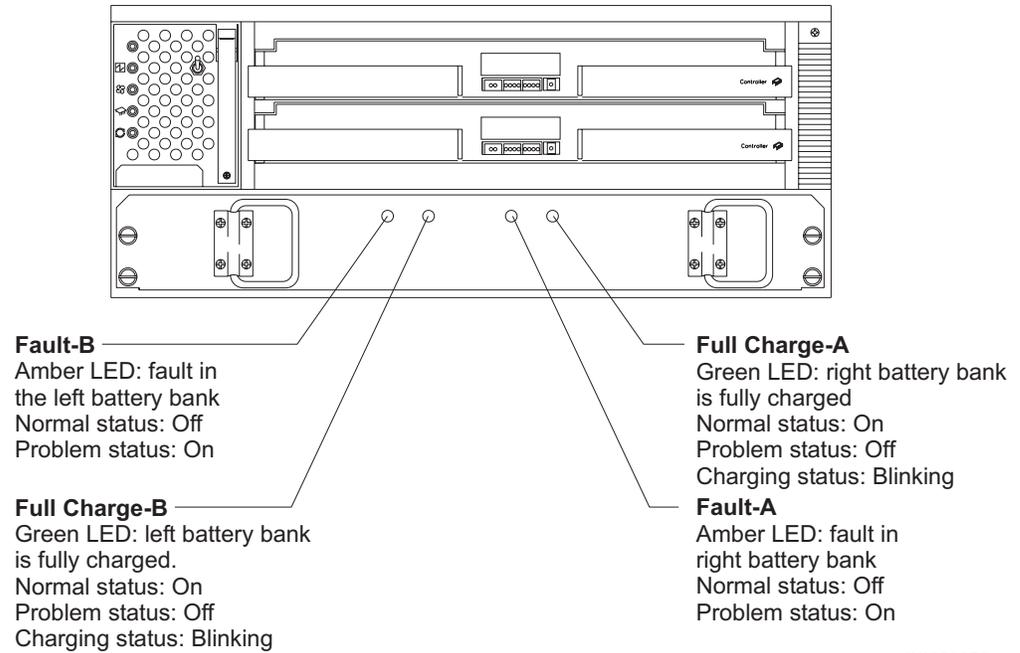
Table 19. Common Controller LEDs patterns

LED pattern	Status
 <p>Solid Flashing</p>	Active and no fault - Status LEDs = 0x00 blinking 0x80
 <p>Solid Flashing Solid</p>	Passive and no fault - Status LEDs = 0x6E blinking 0xEE
 <p>Solid</p>	Held in reset - Status LEDs = 0xFF (no blinking) and fault LED lit
 <p>Solid</p>	Memory error - Status LEDs = 0x66 (no blinking) and fault LED lit
 <p>Solid LEDs blinking on/off from right to left then left to right</p>	Boot menu - Fault LED lit and status LEDs are + single cycling LED (LSB-MSB)
 <p>Solid LEDs turning on from right to left then turning off left to right</p>	Firmware download - Fault LED lit and status LEDs are one to all cycling
 <p>Solid Flashing Flashing</p>	Controller fails self test/start of day - Flashing code (Contact IBM support for help in troubleshooting the problem)

Battery unit LEDs

The battery unit has four LEDs, as shown in Figure 90.

Note: To view the battery LED, remove the DS4500 bezel (see “Removing the front bezel” on page 32).



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Figure 90. Battery unit LEDs

Table 20 describes the battery unit LEDs.

Table 20. Battery unit LEDs

LED	Color	Normal status	Problem status	Possible conditions indicated by the problem status ¹
Fault-A or Fault-B	Amber	Off	On	<ul style="list-style-type: none"> The left or right battery bank has failed. The battery is either discharged or defective.
Full Charge-A or Full Charge-B	Green	On ²	Off	The left or right battery bank has failed.

¹ Always use the storage-management software to identify the failure.

² If the Full Charge-A or Full Charge-B LED is blinking, the battery is in the process of charging.

Fan and communications module LED

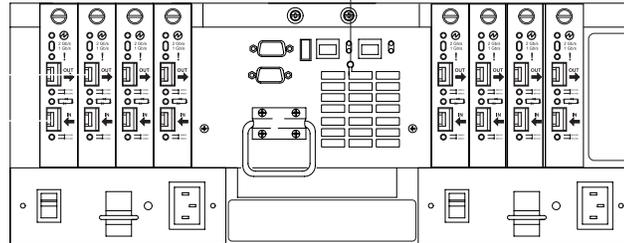
The fan and communications module has one LED, as shown in Figure 91.

Fault

Amber LED: fault in the fan and communications module

Normal status: Off

Problem status: On



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Figure 91. Fan and communications module LED

Table 21 describes the fan and communications module LED.

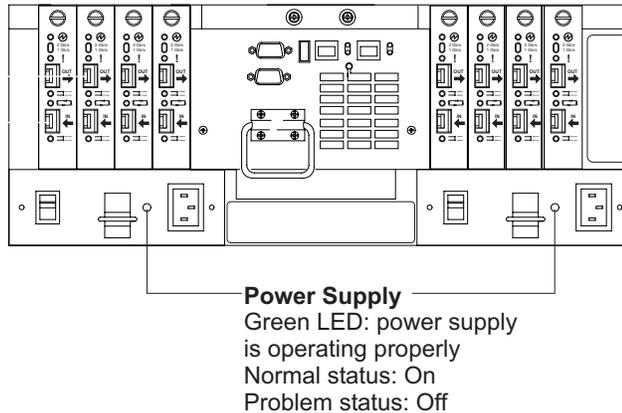
Table 21. Fan and communications module LED

LED	Color	Normal status	Problem status	Possible conditions indicated by the problem status ¹
Fan and communications fault	Amber	Off	On	<ul style="list-style-type: none"> The fan and communications module has failed or is installed incorrectly. The temperature of the DS4500 is too high.

¹ Always use the storage-management software to identify the failure.

Power supply LED

Each power supply has one LED, viewable from the back side of the DS4500, as shown in Figure 92.



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Figure 92. Fan and communications module LED

Table 22 describes the power supply LED.

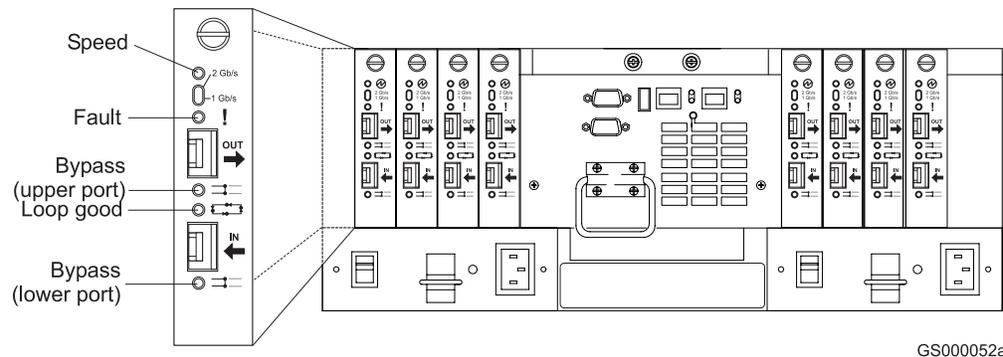
Table 22. Power supply LED

LED	Color	Normal status	Problem status	Possible conditions indicated by the problem status ¹
Power supply	Green	On	Off	<ul style="list-style-type: none"> The power supply has failed or is turned off. The temperature of the DS4500 is too high.

¹ Always use the storage-management software to identify the failure.

Mini hub LEDs

There are five LEDs on each mini hub. Figure 93 shows the host-side LEDs. The drive-side LEDs are the same; however, the possible conditions indicated by the problem status (described in Table 23) might be different.



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Figure 93. Mini hub LEDs

Table 23 describes the LED status when there are Fibre Channel connections to devices between host-side and drive-side mini hubs.

Table 23. Host-side and drive-side mini hub LEDs

Icon	LED	Color	Normal status	Problem status	Possible condition indicated by the problem status
None	Speed	Green	On for 2 GB Off for 1 GB	N/A	Lit LED indicates data transfer rate of 2 Gbps. LED off indicates data transfer rate of 1 Gbps.
!	Fault	Amber	Off	On	Mini hub has failed. Note: If a host-side mini hub is not connected to a controller, this fault LED is always lit.
⏏	Bypass (upper port)	Amber	Off	On	<ul style="list-style-type: none"> Upper mini hub port is bypassed. Mini hub port or SFP module has failed or is loose. Fiber-optic cables are damaged. <p>Note: When two functioning SFP modules are installed into the mini-hub ports and no Fibre Channel cables are connected to them, the bypass LED is lit.</p> <p>If only one functioning SFP module is installed in a host-side mini hub port and no Fibre Channel cables are connected to it, the LED will not be lit.</p> <p>However, the drive-side mini hub bypass LED will be lit when one SFP module is installed in the mini hub and the mini hub has no Fibre Channel cable connection.</p>

Table 23. Host-side and drive-side mini hub LEDs (continued)

Icon	LED	Color	Normal status	Problem status	Possible condition indicated by the problem status
	Loop good	Green	On	Off	<ul style="list-style-type: none"> The loop is not operational, so no devices are connected. Mini hub has failed or a faulty device is connected to the mini hub. If no SFP module is installed, the LED will be lit. If one functioning SFP module is installed in the host-side mini hub port and no Fibre Channel cable is connected to it, the loop good LED will not be lit. <p>If one functioning SFP module is installed in the drive-side mini hub port and no Fibre Channel cable is connected to it, the loop good LED will be lit.</p> <ul style="list-style-type: none"> Storage expansion enclosure has failed (drive-side mini hub only).
	Bypass (lower port)	Amber	Off	On	<ul style="list-style-type: none"> Lower mini hub port is bypassed; no devices are connected. Mini hub port or SFP module has failed or is loose. Fiber-optic cables are damaged. <p>Note: When two functioning SFP modules are installed into the mini hub port and no Fibre Channel cables are connected to them, the bypass LED is lit.</p> <p>If only one functioning SFP module is installed in a host-side mini hub port and no Fibre Channel cables are connected to it, the LED is not lit.</p> <p>However, the drive-side mini hub bypass LED will be lit when one functioning SFP module is installed in the mini hub port and the mini hub has no Fibre Channel cables connected to it.</p>

Powering off the storage subsystem

The DS4500 is designed to run continuously. After you turn it on, do not turn it off. Turn off the power only in the following situations:

- Instructions in a hardware or software procedure require that you turn off the power.
- An IBM technical support representative instructs you to turn off the power.
- A power outage or emergency situation occurs, see “Restoring power after an unexpected shutdown” on page 138.

Turning off the storage subsystem

Use the following procedure to turn off the power for the DS4500. Figure 84 on page 112 shows the location of the power switches on a storage subsystem.

Attention: Except in an emergency, never turn off the power if any Fault LEDs are on. Correct the fault before you turn off the power. Use the DS4000 Storage Manager client and the Fault LEDs to check the overall status of the DS4500. All LEDs should be green on the front of the storage subsystem. If they are not, use the DS4000 Storage Manager client to diagnose the problem. This ensures that the DS4500 will power up correctly later.

Statement 5:



CAUTION:

The power control button on the device and the power switch on the power supply do not turn off the electrical current supplied to the device. The device also might have more than one power cord. To remove all electrical current from the device, ensure that all power cords are disconnected from the power source.



Attention: Turning off and turning on power without waiting for the storage expansion enclosure disk drives to spin down can damage the drives and might cause data loss. Always let at least 70 seconds elapse from when you turn off the power until you turn on the power again.

Power-off overview

Review the following information before you continue with the power-off procedure.

Turn off the power to each device based on the following shutdown sequence:

1. Turn off power to the host before the storage subsystem. If the host must stay powered on to support an existing network, see the operating system documentation for information about disconnecting the storage subsystem logical drives from the host before the storage subsystem is powered off.
2. Turn off power to the storage subsystem before you turn off power to the storage expansion enclosures. Turn off both power supply switches on the back of the storage subsystem.
3. Turn off power to other supporting devices (for example, management stations, fibre-channel switches, or Ethernet switches).

Note: You do not need to perform step 3 if you are servicing only the storage subsystem.

Use the following procedure to turn off power to one or more storage subsystems for a planned shutdown. To turn off power for an unplanned shutdown, see “Restoring power after an unexpected shutdown” on page 138.

Before proceeding, use the Storage Manager client to determine the status of the system components and special instructions. The operating system software might require you to perform other procedures before you turn off the power.

1. Stop all I/O activity to each storage subsystem.
2. Remove the front bezel from the storage subsystem (see “Removing the front bezel” on page 32).
3. Determine the status of all storage subsystems and components in the configuration by completing the following steps:
 - a. Check all LEDs on each component in each storage expansion enclosure. Ensure that all the LEDs show normal status.
 - b. Check all LEDs on each component in the storage subsystem. Ensure that all the LEDs show normal status.
 - c. Open the Subsystem Management window for the configuration and display the Physical View for the configuration.
 - d. Review the status of the configuration components shown in the Subsystem Management window by selecting the appropriate component button for each storage subsystem.

The status for each component will be either Optimal or Fault.

4. Are the LEDs indicating normal operation, and is the status Optimal on all configuration components?
 - **Yes** - Go to step 6 on page 138.
 - **No** - Go to step 5.
5. To diagnose and correct the fault, complete the following steps:
 - a. Run the Recovery Guru by selecting the Recovery Guru toolbar button in the Subsystem Management window.
 - b. Complete the recovery procedure.

- If the Recovery Guru directs you to replace a failed component, use the individual LEDs to locate the failed component.
- c. When the recovery procedure is completed, select **Recheck** in the Recovery Guru. This action reruns the Recovery Guru to ensure that the problem has been fixed.
 - d. If the problem has not been fixed, contact your IBM service representative. Do not turn off power until all problems are corrected.
6. Check the Cache Active LED, and verify that it is off.
If the Cache Active LED is on steady, the cache contains data. Wait for the data to clear from cache memory before turning off the power.
 7. Check the LEDs on the storage expansion enclosures to verify that all Drive Active LEDs are on steady (not blinking).
If one or more LEDs are blinking, data is being written to or from the drives. Wait for all Active LEDs to stop blinking.
 8. Turn off the AC power switch on the back of each power supply in the storage subsystem.
 9. Turn off both power switches on the back of each storage expansion enclosure in the configuration.
 10. After you perform the necessary maintenance procedures, turn on the power using the procedure in “Turning on the storage subsystem” on page 119.

Performing an emergency shutdown

Attention: Emergency situations might include fire, flood, extreme weather conditions, or other hazardous circumstances. If a power outage or emergency situation occurs, always turn off all power switches on all computing equipment. This helps to safeguard your equipment from potential damage due to electrical surges when power is restored. If the storage subsystem loses power unexpectedly, it might be due to a hardware failure in the power system or in the midplane.

Complete the following steps to shut down the system during an emergency:

1. If you have time, stop all I/O activity to the storage subsystem by shutting down the host or disconnecting the storage subsystem logical drives through the host.
2. Check the LEDs. Make note of any Fault LEDs that are on so you can correct the problem when you turn on the power again.
3. Turn off all power supply switches, starting with the DS4500 Storage Subsystem first, and followed by the storage expansion enclosures. Then, unplug the power cables from the storage subsystem.

Restoring power after an unexpected shutdown

Use the following procedure to restore power to the storage subsystem in a configuration after an unplanned shutdown.

Risk of severe electrical shock – Never turn on the power to any equipment if there is evidence of fire, water, or structural damage. Doing so might cause severe electrical shock.

1. After the emergency situation is over or power is restored, visually check the storage subsystem for damage. Is there evidence of damage to any of the storage subsystem components, cables, or equipment attached to the storage subsystem?

- Yes – Do not continue with this procedure. Contact your IBM service representative for assistance. Depending on the current service agreements, you might need to return the equipment to the factory or local service center for repair.
- No – Go to step 2.

Potential data loss – Before resetting circuit breakers in the cabinet, ensure that the storage subsystem and storage expansion enclosures power switches are turned off. Resetting circuit breakers after an emergency situation while the storage subsystem and storage expansion enclosure power switches are turned on can cause potential data loss because the configuration components might not be powered on in the correct sequence. See “Turning on the storage subsystem” on page 119 for details about the correct power-on sequence.

2. After you check the storage subsystem for damage, ensure that the power switches are in the off position; then plug in the DS4500 power cables, if required.
3. Check the system documentation of the hardware devices that you want to turn on and determine the proper startup sequence.

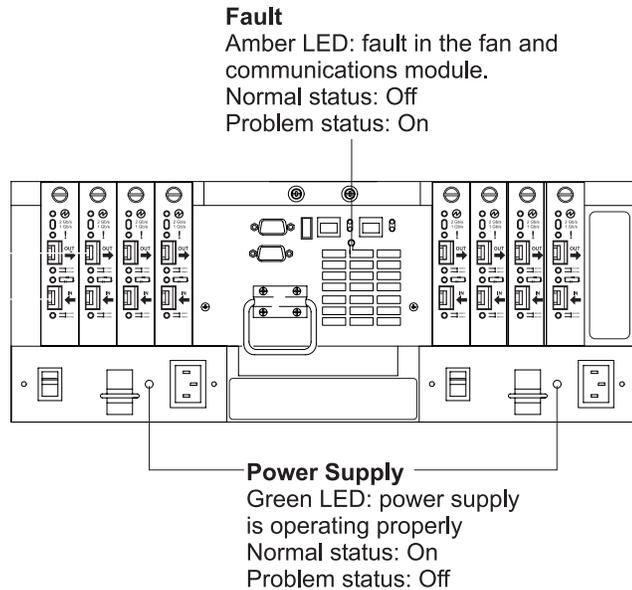
Note: Be sure to turn on all of the storage expansion enclosures and verify that there are not any ESM, power supply, or fan and communications module fault LEDs lit before you turn on the DS4500.

In addition, consider the following items:

- The storage subsystem supports simultaneous power-up of the system components; however, you should always follow the power-up sequence listed in the “Turning on the storage subsystem section” of the appropriate *DS4000 Storage Subsystem Installation, User’s, and Maintenance Guide* during any attended power-up procedure.
 - A storage subsystem in an optimal state should recover automatically from an unexpected shutdown and unattended simultaneous restoration of power to system components. After power is restored, contact IBM technical support if any of the following conditions occur:
 - The storage subsystem logical drives and subsystems do not display in the Storage Manager graphical user interface (GUI).
 - The storage subsystem logical drives and subsystems do not come online.
 - The storage subsystem logical drives and subsystems seem to be degraded.
4. Turn on the power to each device, based on the startup sequence.
 5. Turn on both of the power supply switches on the DS4500. The green LEDs on the front and the back of the DS4500 should remain lit. If other amber Fault LEDs light, see the appropriate section for the DS4500 in the *IBM TotalStorage DS4000 Hardware Maintenance Manual*.

Recovering from an overtemperature condition and power supply shutdown

If the fan and communications module fails or is unable to maintain an internal temperature below 70° C (158° F), one or both of the power supplies in the DS4500 Storage Subsystem might shut down (see Figure 94 on page 140). If both power supplies shut down, the DS4500 Storage Subsystem is not operational.



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Figure 94. Fan and communications and power supply fault LEDs

The storage-management software causes the fan and communications module fault LED and storage subsystem fan LED to light before the temperature has risen sufficiently to shut down the power supplies. The storage subsystem fan LED, shown in Figure 95, is lit when the DS4500 Storage Subsystem temperature exceeds 45° C (113° F). The DS4500 Storage Subsystem shuts down if the temperature rises to 70° C (158° F). If both power supplies shut down, the fault LED cannot light.

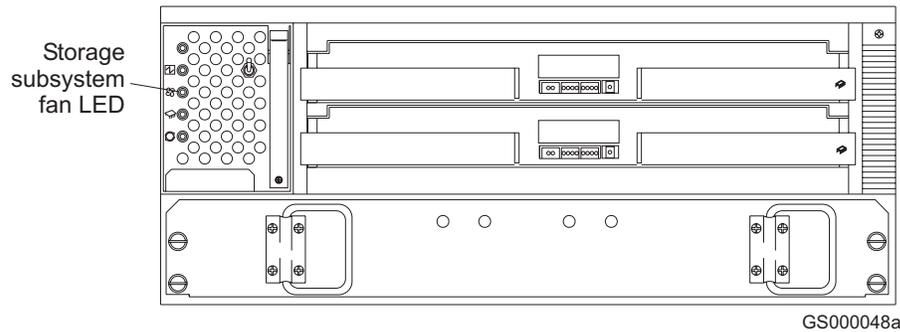


Figure 95. Storage subsystem fan LED

Turning on the power after an overtemperature shutdown

If your DS4500 Storage Subsystem shuts down unexpectedly and you received a "Maximum temperature exceeded" alert from the storage subsystem before it shutdown, take the following precautions to cool it before you power on the unit:

1. Turn off the power switches to allow the DS4500 Storage Subsystem to cool.
2. When the room temperature is below the upper operating temperature of 35° C (95° F), turn on the power switches.

3. Check the DS4500 Storage Subsystem for faults or damage. Use the storage-management software to check the overall status of the DS4500 Storage Subsystem and its components. Correct any problems indicated.
4. Turn on the circuit breakers in the rack cabinet, and turn on the power switches on all storage expansion enclosures attached to the DS4500 Storage Subsystem.

Important: You must turn on the storage expansion enclosures *before* you turn on the DS4500 Storage Subsystem. The controllers might not recognize the correct configuration if the attached drives are powered up after the DS4500 Storage Subsystem. For instructions on how to power up the storage expansion enclosures, refer to the storage expansion enclosure documentation.

5. Turn on both power switches on the back of the DS4500 Storage Subsystem. For the location of the power switches, see Figure 84 on page 112.
6. Check the status of the DS4500 Storage Subsystem and other devices. Make sure all fault indicator lights are off on the front and back of the DS4500 Storage Subsystem. For more information, see “Checking the LEDs” on page 127.
7. When all the devices are powered up, check the overall system status by using the storage-management software.

Checking the battery service date

Note: Replace the battery unit whenever it fails to hold a charge or when the DS4000 Storage Manager displays the battery age exceeded event message. Operating the DS4500 Storage Subsystem in a hot environment (above 35° C or 95° F) lowers the battery life expectancy.

To check the battery service date, perform the following steps:

1. Remove the DS4500 Storage Subsystem bezel (see “Removing the front bezel” on page 32).
2. Check the Battery Support Information label, as shown in Figure 96.

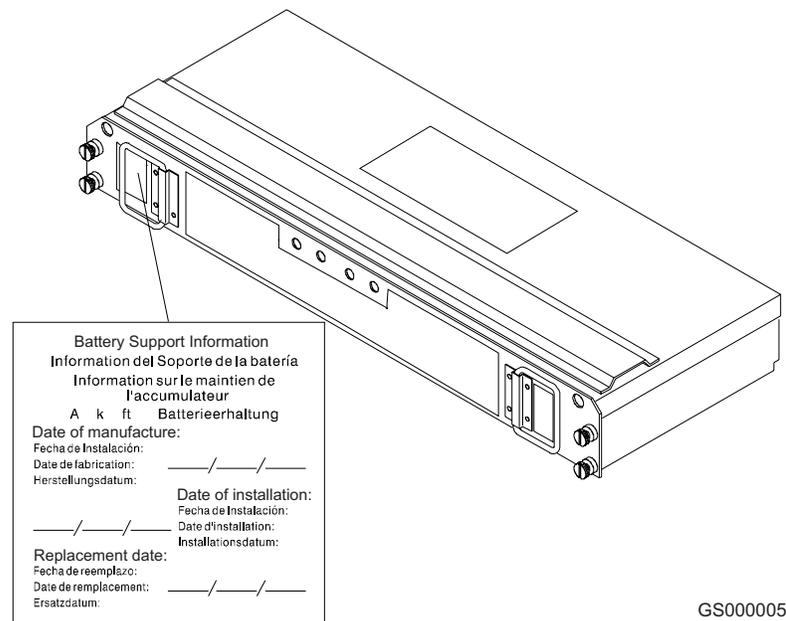


Figure 96. Checking the battery service date

The Battery Support Information label on the front of the battery has three dates:

- **Date of Manufacture** - Date the battery was built at the factory
- **Date of Installation** - Date the battery was installed in the DS4500 Storage Subsystem
- **Replacement Date** - Battery replacement date (see 141)

3. Perform one of the following tasks:

- If it is time to replace the battery, install a new battery using the procedure described in “Replacing a battery unit” on page 147.
- If it is not time to replace the battery, replace the DS4500 Storage Subsystem bezel (see “Replacing the front bezel” on page 44).

Cache battery and cache memory

Each RAID controller in the DS4500 Storage Subsystem contains 1 GB of cache memory to store read and write operations. The battery unit in each controller can maintain the data in the RAID controller caches for up to three days in the event that the DS4500 Storage Subsystem loses power.

Cache memory is memory on the RAID controller that is used for intermediate storage of read and write data on the DS4500 RAID controllers. Using cache memory can increase system performance. The data for a read operation from the host might be in the cache memory from a previous operation (thus eliminating the need to access the drive itself), and a write operation is completed when it is written to the cache, rather than to the drives.

The RAID controller has a Cache Active (Fast Write Cache) LED, located on the front of the DS4500 bezel or the storage subsystem fan, displays the current status of the cache. The LED is on if there is data in the cache, blinks during a write operation, and is off if there is no data in the cache, the cache is not enabled, or the battery is not ready.

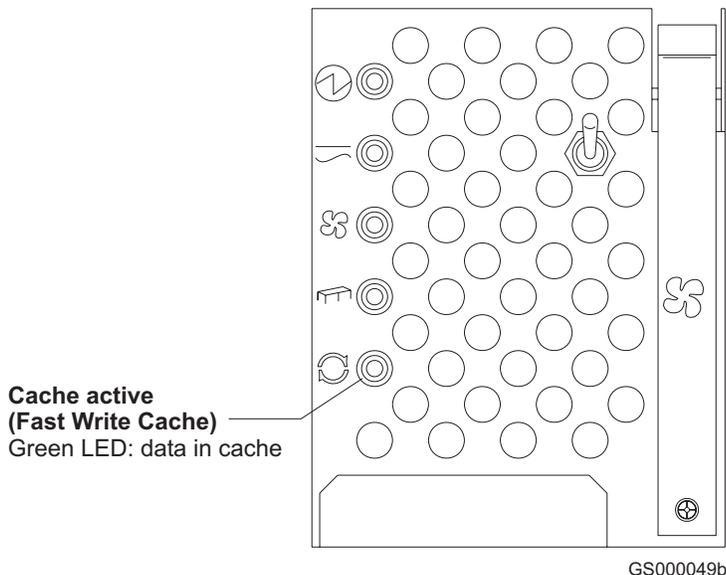


Figure 97. Location of Cache Active (Fast Write Cache)

Moving or relocating the DS4500 Storage Subsystem

Notes:

1. Remove each CRU before you move the DS4500 Storage Subsystem to a new location or before you remove the chassis from its rack cabinet. This precaution helps safeguard the equipment and ensures a smoother transition to the new environment.
2. If you are moving the DS4500 Storage Subsystem a short distance, and you have sufficient assistance or equipment, you might be able to move the DS4500 Storage Subsystem without removing each component CRU. If you do not have sufficient assistance or equipment, use the following procedure to safely move the equipment to its new location.
3. If you are moving the DS4500 Storage Subsystem a significant distance, be sure to pack it in its original shipping container.

Use the following procedure to remove all component CRUs before you move or relocate the DS4500 Storage Subsystem.

1. Turn off the DS4500 Storage Subsystem (see “Turning off the storage subsystem” on page 136).
2. Label the host Fibre Channel and interface cables and disconnect them.
Attention: Handle and install fiber-optic cables properly to avoid degraded performance or loss of communications with devices. When working with fiber-optic cables, do not pinch them, step on them, or locate them in aisles or walkways. Do not bend the cables to a radius of less than 38 mm (1.5 in.).
3. Disconnect all remaining cables from the DS4500 Storage Subsystem and label them so that you can correctly reconnect them later.
Attention: When you handle static-sensitive devices, take precautions to avoid damage from static electricity. For details about handling static-sensitive devices, see “Handling static-sensitive devices” on page 24.
4. Remove all CRUs from the DS4500 Storage Subsystem (see “Removing the CRUs” on page 31).
5. Remove the two screws from the inside rear of the DS4500 Storage Subsystem; then, remove the two screws from the inside front of the DS4500 Storage Subsystem. Save the screws for later. For detailed information, see the *Rack Mounting Instructions* that come with the storage subsystem.
Attention: Do not remove the black hex head screws. These secure the rails that support your DS4500 Storage Subsystem.

Statement 4:



≥ 18 kg (39.7 lb)	≥ 32 kg (70.5 lb)	≥ 55 kg (121.2 lb)

CAUTION:**Use safe practices when lifting.**

6. Slide the DS4500 Storage Subsystem out of the rack cabinet and set it on a level, dry surface.
7. Perform one of the following tasks:
 - If you are shipping the DS4500 Storage Subsystem to another location, replace all CRUs in the DS4500 Storage Subsystem. Carefully pack the unit in its original shipping container. You are finished with this procedure.
 - If you are moving the DS4500 Storage Subsystem to another rack cabinet, remove the support rails and power cords from the old rack cabinet and install them in the new one.
8. To install the DS4500 Storage Subsystem into a rack cabinet in the new location, perform the following steps:
 - a. Slide the DS4500 Storage Subsystem into the rack cabinet.
 - b. Insert and tighten two of the screws that you removed in Step 5 on the inside front of the DS4500 Storage Subsystem.
 - c. Insert and tighten the remaining two screws that you removed in Step 5 on the inside rear of the DS4500 Storage Subsystem.
9. Replace all CRUs in the DS4500 Storage Subsystem.
10. Connect the interface cables and host Fibre Channel cables that you labeled in Step 3 on page 143.
11. Connect the remaining cables to the DS4500 Storage Subsystem.
12. Turn on power to the DS4500 Storage Subsystem. Use the procedure in “Powering on the storage subsystem” on page 119.
13. Replace the DS4500 Storage Subsystem bezel (see “Replacing the front bezel” on page 44).

Chapter 5. Replacing components

The DS4500 Storage Subsystem contains two RAID controllers, a cooling system that contain four fans (the storage subsystem fan and the fan and communications module), mini hubs, SFP modules, and a power system. This chapter includes detailed instructions on how to replace these components.

Attention: Always replace a failed component as soon as possible. The Recovery Guru menu function in the DS4500 Storage Subsystem identifies failed components.

When performing replacement procedures for each component, take precautions to avoid damage from static electricity. For details about handling static-sensitive devices, see “Handling static-sensitive devices” on page 24.

Replacing a controller

Attention: Before you replace a controller, consider the following factors:

- You can hot swap or replace a failed controller while the DS4500 Storage Subsystem is in operation as long as the host has a Fibre Channel connection to the functioning controller and is in a “passive” or “offline” status in the storage-management software.
- If cache mirroring is enabled in redundant controllers and one controller fails, the second controller assumes processing functions without data loss. However, some or all data might be lost if cache mirroring is disabled and a failure occurs before data is written from cache memory to disk.
- Removing a controller that is operating normally (not failed) can result in data loss. Only remove a controller that:
 - has a fault LED that is lit, indicating that it has failed (see “Controller LEDs” on page 128)
 - Is marked as “Failed” (offline) through the storage-management software
- The two controllers are automatically synchronized when you replace a failed controller. The storage-management software automatically synchronizes the firmware between the existing controller and the new controller.
- If you are replacing an optimal controller, first make sure that the other controller is optimal and that the fibre channel path from the hosts to the other controller is also optimal.
- If you replace the controller CRU and still experience problems, the DS4500 Storage Subsystem might have other defective components or connections. Check the storage-management software for indications of other component failures.

When instructed by the storage-management software, replace a controller CRU by using the following procedure:

Attention: After replacing a controller, always use the storage-management software to verify the firmware levels.

1. Remove the DS4500 bezel (see “Removing the front bezel” on page 32).
2. Remove the failed controller, as shown in Figure 98 on page 146.
 - a. Using your thumbs, squeeze the two center tabs and pull both controller handles outward with your fingers.

- b. Using both handles, pull out on the controller to remove it.

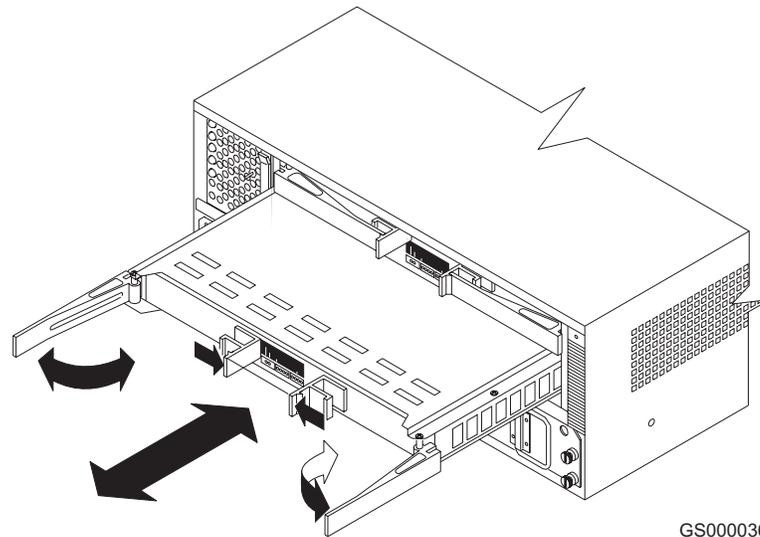


Figure 98. Removing and replacing a failed controller CRU

3. Unpack the new controller. Using the proper handling precautions, remove the new controller from the packing material.
Check the shipping invoice and the controller to make sure that it has the same memory size as the controller that you just removed.
4. Install the new controller, as shown in Figure 98.
 - a. Using your thumbs, squeeze the two center tabs and pull both controller handles outward with your fingers.
 - b. Using the handles, slide the controller into the slot until the back edge of both handles hooks onto the frame.
 - c. Close both handles and snap into place.
5. Check the controller LEDs, as shown in Figure 99.

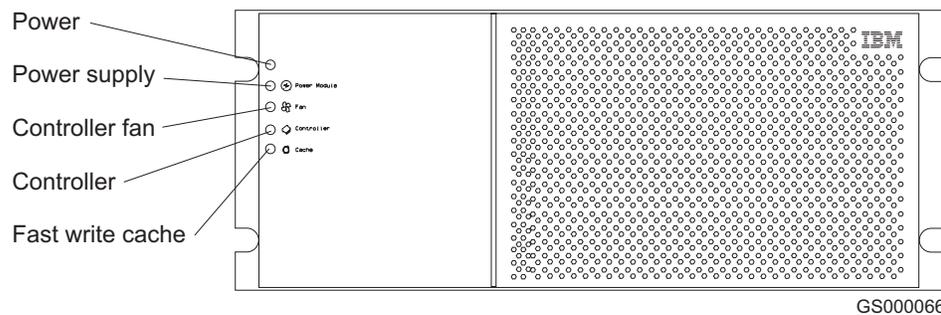


Figure 99. LEDs on the DS4500 Storage Subsystem bezel

- If the green power LED is lit and the amber fault LED is off, go to Step 8 on page 147.
- If the green power LED remains off or the fault LED is on after a few seconds, make sure that the controller CRU is locked into place. If the fault LED remains on, go to Step 6.

6. Use the storage-management software to check the status of both controllers. If applicable, perform the recovery procedures required by the software. If this corrects the fault and the DS4500 Storage Subsystem is operating without error, go to Step 8. If not, go to Step 7.
7. Reinsert the controller CRU. Then, if there are no error messages or controller faults, go to Step 8. If there is still a problem, call for service.
8. Replace the DS4500 Storage Subsystem bezel (see “Replacing the front bezel” on page 44).

Replacing a battery unit

Attention: Before you replace a battery unit, consider the following factors:

- The battery has a three-year life expectancy. Replace the battery when the DS4000 Storage Manager displays the battery age exceeded event message or whenever it fails to hold a charge. Operating the DS4500 Storage Subsystem in an unsupported environment (above 35° C or 95° F) lowers the life expectancy of the battery.
- The service label on the battery provides a blank line for recording the date on which the battery was last serviced (see Figure 101 on page 150). Check this label to determine when to replace the battery. For information about using the software to track battery age, refer to the IBM DS4000 Storage Manager online help.
- When a battery fails, the fault LED on the battery is lit (see “Battery unit LEDs” on page 131).
- If you replace the battery and still experience battery problems (for example, loss of battery power to the controllers or batteries not charging properly), the DS4500 Storage Subsystem might have defective components or connections. Check the storage-management software for indications of other component failures.

When instructed by the storage-management software, replace the battery unit by using the following procedure:

Attention: Because the battery is a sealed unit, you must replace the entire CRU (not just the batteries) to keep the battery backup system in working order. Opening the battery CRU voids your warranty.

1. Use the storage-management software to disable caching. Caching is disabled when the Cache active (Fast write cache) LED is off. Data in cache is unprotected if a power outage occurs while the battery unit is out of operation.

Statement 8:



CAUTION:

Never remove the cover on a power supply or any part that has the following label attached.



Hazardous voltage, current, and energy levels are present inside any component that has this label attached. There are no serviceable parts inside these components. If you suspect a problem with one of these parts, contact a service technician.

2. Remove the DS4500 bezel (see “Removing the front bezel” on page 32).
Attention: Be careful when you remove the battery unit. The battery weighs approximately 9.7 kg (21.4 lb).
3. Remove the battery, as shown in Figure 100 on page 149.
 - a. Loosen the four captive screws on the battery. If necessary, use a flat blade screwdriver to loosen the screws.
 - b. Using both pull handles, slide out the battery about 5 cm (2 in.).
 - c. Grasp the sides of the unit with both hands and pull it out of the chassis.
 - d. Place the battery unit on a level surface.

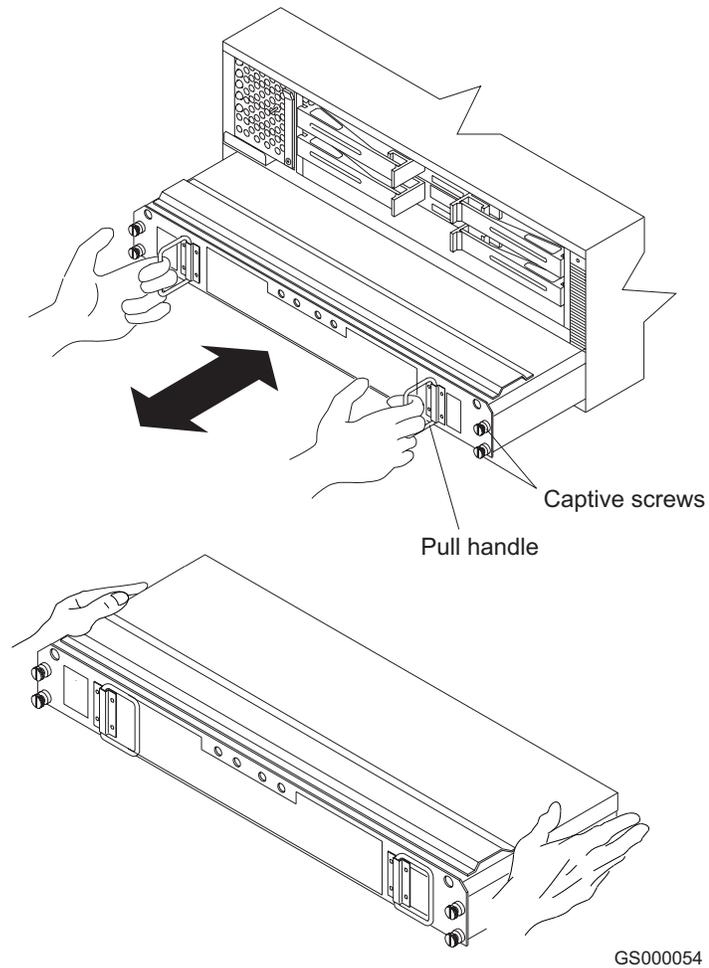
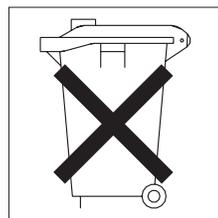


Figure 100. Removing and installing a battery unit

4. Prepare and unpack the new battery unit. Save the packing material for shipping the used failed battery unit to a disposal facility.



Pb

CONTAINS
SEALED LEAD
BATTERY.
BATTERY
MUST BE
RECYCLED.

CAUTION:

This product contains a sealed lead acid battery. The battery must be recycled or disposed of properly. In the United States, IBM has established a collection process for reuse, recycling, or proper disposal of used IBM sealed lead acid batteries. For information on proper disposal of these batteries, please contact IBM at 1-800-426-4333 or contact your IBM representative. For information on disposal of sealed lead acid batteries outside the United States, go to <http://www.ibm.com/ibm/environment/products/batteryrecycle.shtml> or contact your local waste disposal facility. If the battery CRU is physically damaged or leaking electrolyte gel, *do not* ship it to a recycling center. The battery contains sealed lead-acid batteries that might be considered hazardous material. You must handle this unit in accordance with all applicable local and federal regulations.

5. Find the “Battery Support Information” label on the front of the new battery unit, as shown in Figure 101.

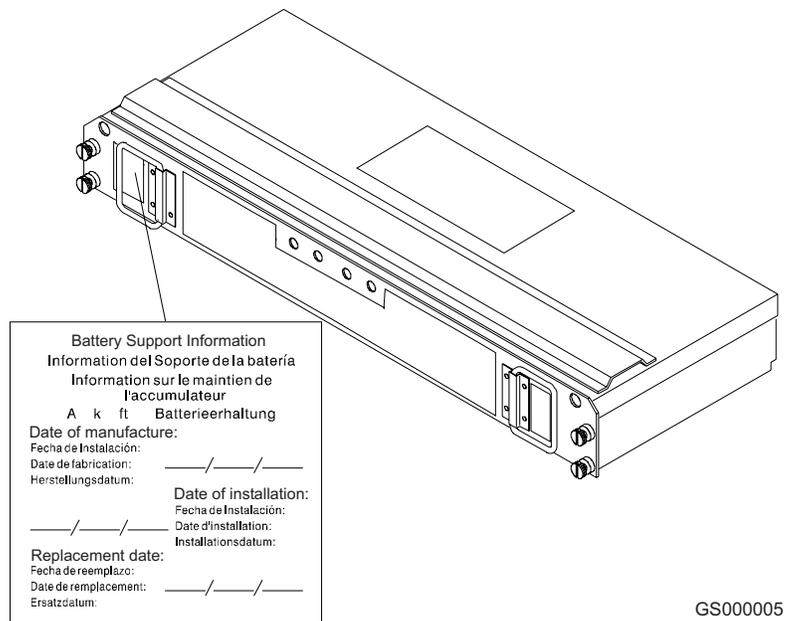


Figure 101. Recording the battery support information

Fill in the following information:

- Date of Installation - Record today's date on the blank line
- Replacement Date - Record the expiration date (three years from today's date) on the blank line

6. Install the new battery.
 - a. Grasp the battery unit with both hands and slide the unit into the slot about 5 cm (2 in.).
 - b. Slowly push the battery completely into the slot.
 - c. Using a flat-blade screwdriver, tighten the four captive screws.
7. Replace the DS4500 bezel (see “Replacing the front bezel” on page 44).
8. Run the system for at least 24 hours to properly charge the batteries. The battery might take up to 15 minutes to complete its self-test and up to 24 hours to fully charge, even after a power loss of only a few minutes. When properly charged, both full-charge LEDs on the front of the battery are lit.

9. Check the battery LEDs (see “Battery unit LEDs” on page 131).

Note: If the Full Charge-A and the Full Charge-B LEDs are blinking, the battery is in the process of charging.

10. After your battery has completed the self test, reset the battery installation date using the storage-management software. The software continues to issue battery-related errors if the installation date is not reset.

Replacing a storage subsystem fan

Attention: Before you replace a storage subsystem fan, consider the following factors:

- The storage subsystem fan and the fan and communications module cooling system failing simultaneously in the storage subsystem is unlikely. Such a failure will cause either one or both controllers to overheat. Under these circumstances, the amber controller LED on the front panel might be lit. If this occurs, shut down the DS4500 Storage Subsystem immediately and let the unit cool to room temperature and then replace the storage subsystem fan.
- You can hot swap, or replace, the storage subsystem fan, as long as you complete the exchange within 15 minutes. The time limit applies to the total time that the fan is out of the chassis. The time begins when you remove the failed storage subsystem fan and ends when you install the new one. This does not include the time it takes to perform the entire procedure (for example, checking the LEDs).
- When a storage subsystem fan fails, the fault LED on the storage subsystem fan is lit. For more information about LEDs, see “Front Bezel LEDs” on page 127.
- If you replace the storage subsystem fan and still experience problems, the DS4500 Storage Subsystem might have defective components or connections. Check the storage-management software for indications of other component failures.
- The storage subsystem fan LED is also used to indicate a fan and communications module failure. Be sure to check both the storage subsystem fan and the fan and communications module before you call for service.

When instructed by the storage-management software, replace the storage subsystem fan by using the following procedure:

1. Remove the DS4500 bezel (see “Removing the front bezel” on page 32).

Attention: To prevent damage to the DS4500 components, do not operate the DS4500 without adequate ventilation to the controllers. If it will take longer than 15 minutes to replace the storage subsystem fan, you must shut down the DS4500 to prevent it from overheating. The time limit applies to the total time that the fan is out of the chassis. For more information, see “Turning off the storage subsystem” on page 136.

2. Remove the failed storage subsystem fan, as shown in Figure 102 on page 152.
 - a. Lift the storage subsystem fan lever to its open position (so that the lever is horizontal and 90°); then, grasp the fan handle and pull out firmly to remove the fan.
 - b. Slowly pull the lever away from the chassis to remove the storage subsystem fan from the bay.
 - c. Place the storage subsystem fan on a level surface.

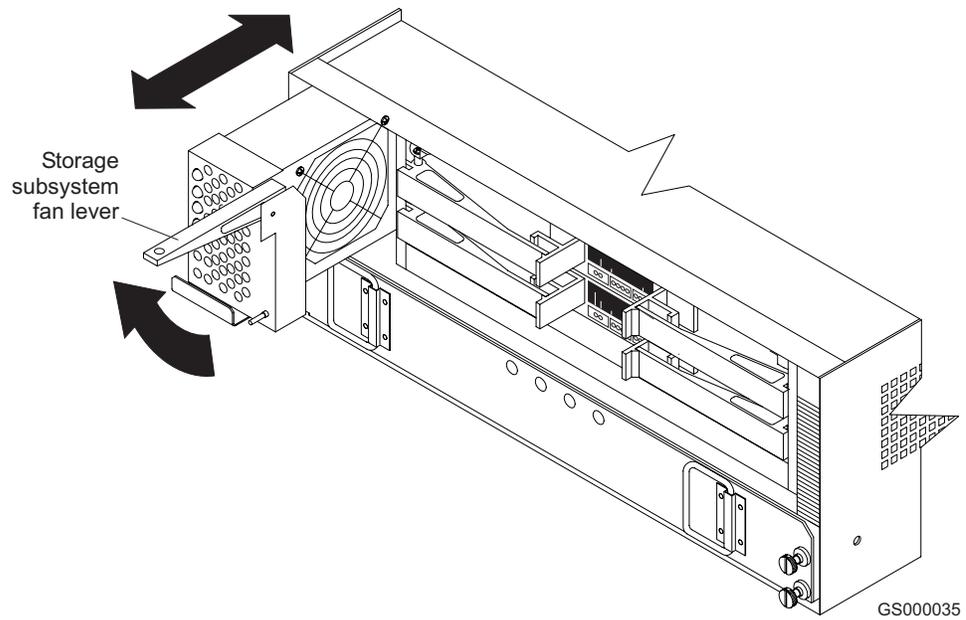


Figure 102. Removing and installing the storage subsystem fan

3. Unpack the new storage subsystem fan.
4. Install the new storage subsystem fan:
 - a. Slide the new storage subsystem fan all the way into the slot.
Attention: Be sure that the lever is pulled straight out (in a horizontal position) as you slide the unit into the storage subsystem.
 - b. Press down on the lever and snap the lever into place.
5. Check the Fan LED, located on the storage subsystem front bezel, as shown in Figure 103 on page 153.

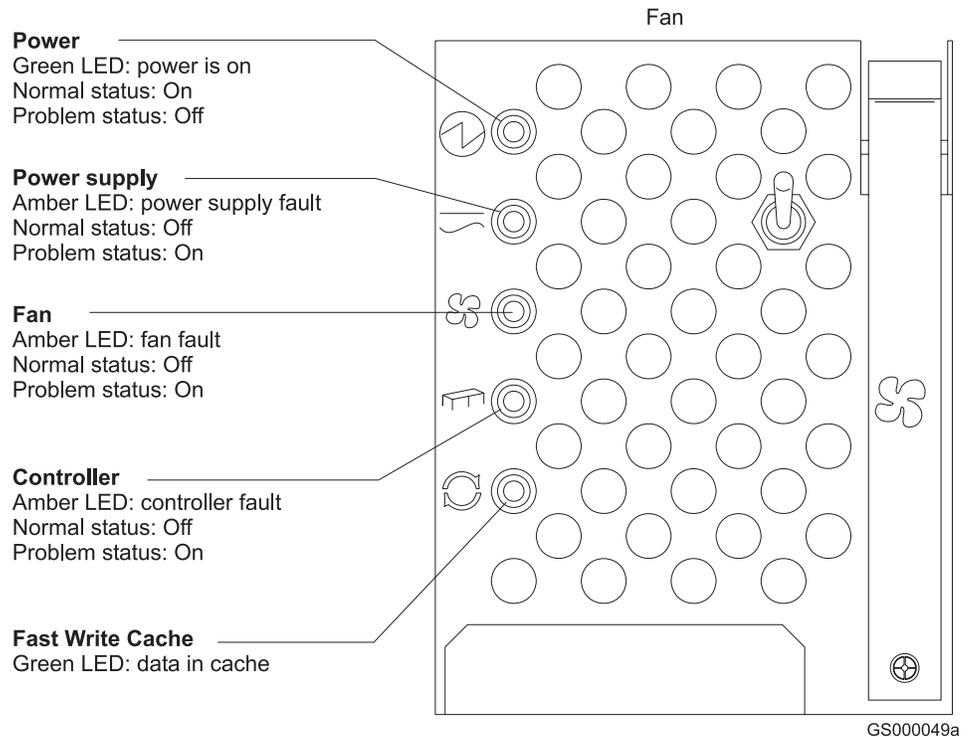


Figure 103. Storage subsystem LEDs

The storage subsystem fan LED will indicate one of the following conditions:

- If the amber fan LED is off and the green Power LED is lit, the storage subsystem fan is operating properly.
 - If the amber fan LED is lit or the green Power LED remains off, make sure that the storage subsystem fan is seated securely in the slot and that the lever is snapped into place. Check the storage subsystem fan or the fan and communications module status.
 - If the storage subsystem fan LED remains on, it might indicate a problem with the new storage subsystem fan or the fan and communications module (both components share the same LED). Replace the storage subsystem fan with a spare, if available. Otherwise, turn off the DS4500 Storage Subsystem to prevent it from overheating until you can replace the fan.
6. Replace the DS4500 bezel (see “Replacing the front bezel” on page 44).

Replacing a fan and communications module

Attention: Before you replace a fan and communications module, consider the following factors:

- The fan and communications module contains two Ethernet connections used for direct network-management.
- You can hot swap the fan and communications module as long as you complete the exchange within 15 minutes from when you remove the failed unit until you install the new one.
- It is unlikely that the storage subsystem fan and the fan and communications module cooling system will fail simultaneously. Such a failure will cause one or both power supplies to overheat. In these circumstances, the amber power supply LED on the bezel is lit and the overheated power supply automatically shuts down (the green power LED on the power supply turns off). Once the ambient air temperature cools below 70° C (158° F), the power supply automatically turns on. Replace the failed fan and communications module. Then, check the power supply LEDs (fault LED on the front and power LED on the back). If the power supply fault LED remains on, replace the power supply. For more information, see “Checking the LEDs” on page 127.
- If you replace the fan and communications module and still experience problems, the DS4500 might have defective components or connections. Check the storage-management software for indications of other component failures.

When instructed by the storage-management or diagnostic software, replace the fan and communications module by using the following procedure:

Attention: To prevent damage to the DS4500 Storage Subsystem circuitry, do not operate the DS4500 without adequate ventilation to the power supplies and mini hubs. If it will take longer than 15 minutes to replace this module, you must shut down the DS4500 to prevent it from overheating. The time limit applies only to the total time that the fan and communications module is out of the chassis. The time begins when you remove the failed module and ends when you install the new one. This does not include the time it takes you to perform this entire procedure (for example, checking the LEDs).

1. Disconnect all Ethernet interface cables from the failed fan and communications module (see Figure 104 for locations of the ports).

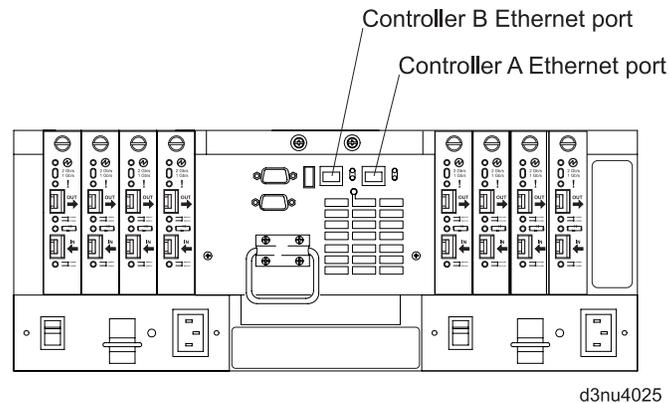


Figure 104. Fan and communications module ports

2. Remove the failed fan and communications module, as shown in Figure 105.

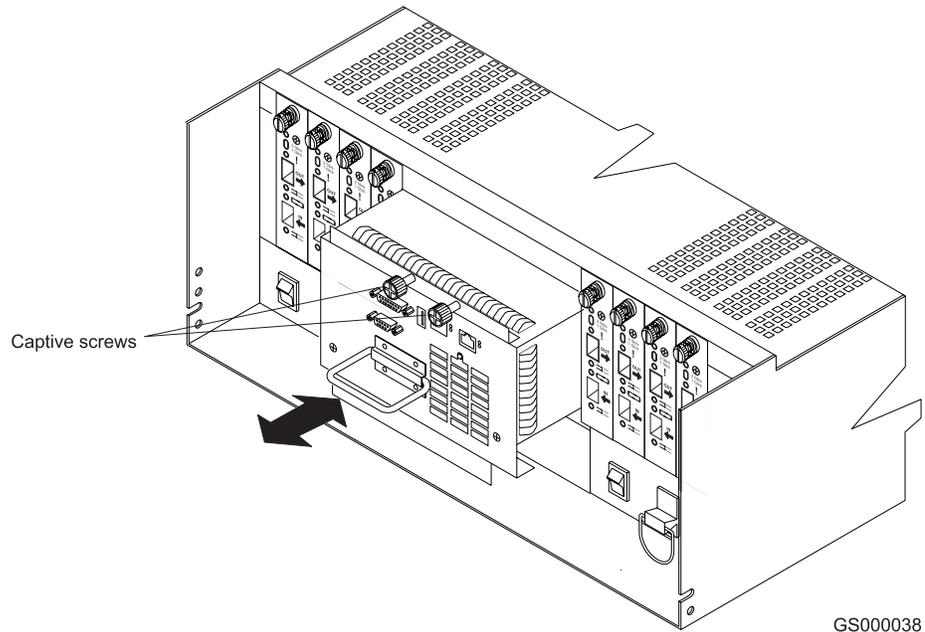


Figure 105. Removing and installing a fan and communications module

- a. Using a flat-blade screwdriver, loosen the two captive screws on the fan and communications module.
 - b. Lift up and pull out on the pull handle to slide the module out of the slot a few inches.
 - c. Grasp the sides of the module with both hands and pull it from the chassis.
 - d. Place the module on a level surface.
3. Unpack the new fan and communications module.
 4. Install the new fan and communications module:
 - a. Push the new fan and communications module all the way into its chassis slot.
 - b. Use a flat-blade screwdriver to tighten the two captive screws on the new module, securing it into place.
 5. Check the fan and communications module LED (see “Front Bezel LEDs” on page 127).
 - If the amber fault LED is on, make sure that the fan and communications module is inserted all the way into the chassis and secured in place.
 - If the fault LED remains on, one or both fans inside the fan and communications module might be malfunctioning. Replace the failed fan and communications module with a spare, if available. Otherwise, shut down the DS4500 until you can replace the failed fan and communications module with a new one.
 6. Reconnect the Ethernet interface cables that you disconnected in Step 1 on page 154 to the new fan and communications module.

Replacing a power supply

Attention: Before you replace a power supply, consider the following factors:

- Each power supply has a built-in sensor that detects the following conditions:
 - Overvoltage
 - Overcurrent
 - Overtemperature

If any of these conditions occur, one or both power supplies enter shutdown mode. All power remains off until one of the following events occurs:

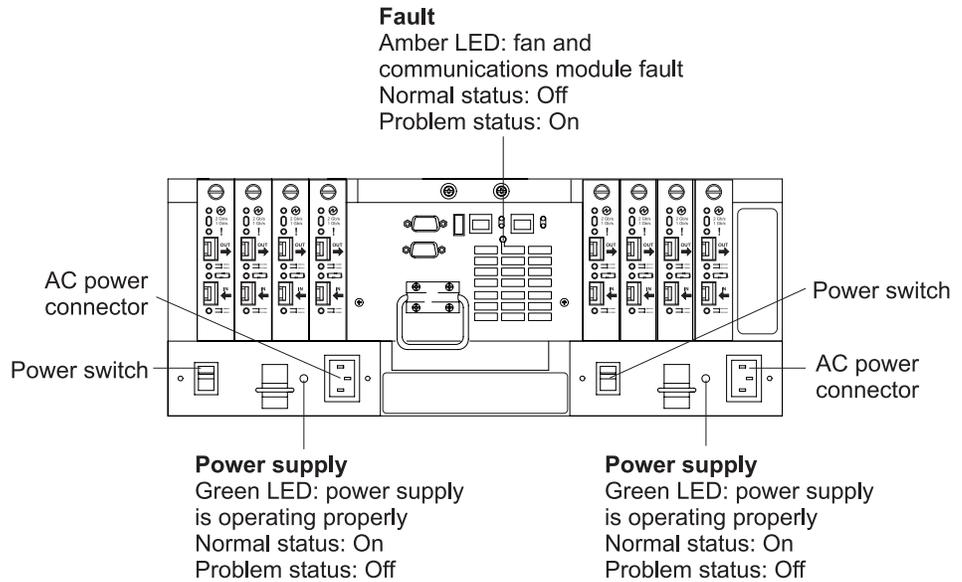
- You cycle the power switches (turn off the power switches, wait at least 30 seconds, then turn on the power switches). For more information, see “Recovering from an overtemperature condition and power supply shutdown” on page 139.
 - The power supplies automatically resume operation when the ambient air temperature cools to below 70° C (158° F). When the power supplies automatically resume operation, the DS4500 Storage Subsystem also resumes operation.
- You can hot swap (replace) a power supply because the two power supplies provide redundancy.
 - Both power supplies have built-in temperature sensors designed to prevent the power supplies from overheating. If a temperature sensor detects an ambient air temperature greater than 70° C (158° F), the “overheated” power supply automatically shuts down. The second power supply remains on as long as its temperature remains below 70° C (158° F). If the second power supply overheats, it turns off all power to the DS4500 Storage Subsystem.

Note: There is a serious problem if the air temperature inside the rack cabinet is hot enough to cause the power supplies to shut down.

- The DS4500 Storage Subsystem is capable of power-up recovery without operator intervention. Once the air temperature cools to below 70° C (158° F), the power supplies automatically restart. An automatic restart resets the controllers, attempts to restart the hard disk drives, which has no effect on the hard disk drives if they are already running, and returns the DS4500 to normal operation.
- When a power supply fails, the green power LED on the power supply goes off and the amber power supply fault LED is lit on the front of the DS4500 Storage Subsystem. For more information, see “Power supply LED” on page 133 and “Front Bezel LEDs” on page 127.
- If you replace the power supply CRU and still experience problems, the DS4500 Storage Subsystem might have defective components or connections. Check the storage-management software for indications of other component failures.

When instructed by the storage-management software, replace a power supply by using the following procedure:

1. Check the power supply LED on the back of the DS4500 Storage Subsystem, as shown in Figure 106 on page 157. Be sure that the green power indicator light on the failed power supply is off.



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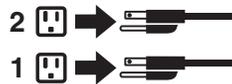
Figure 106. Power supply switch, AC power connectors, and indicator lights

Statement 5:



CAUTION:

The power control button on the device and the power switch on the power supply do not turn off the electrical current supplied to the device. The device also might have more than one power cord. To remove all electrical current from the device, ensure that all power cords are disconnected from the power source.



2. Turn off the power switch and unplug the power cord from the failed power supply (see Figure 106).

Statement 8:



CAUTION:

Never remove the cover on a power supply or any part that has the following label attached.



Hazardous voltage, current, and energy levels are present inside any component that has this label attached. There are no serviceable parts inside these components. If you suspect a problem with one of these parts, contact a service technician.

3. Remove the failed power supply, as shown in Figure 107.

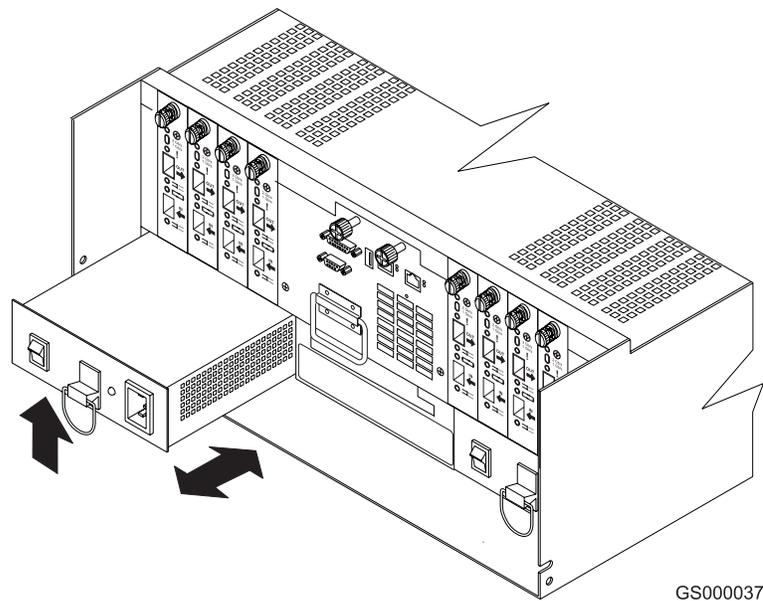


Figure 107. Removing and installing a power supply

- a. Lift up and pull out on the pull handle to release the power supply.
 - b. Slide the power supply out of the chassis.
 - c. Grasp the sides of the unit with both hands and pull it from the chassis.
 - d. Place the power supply on a level surface.
4. Unpack the new power supply.
 5. Install the new power supply:
 - a. Grasp the power supply with both hands and slide the module into the chassis slot, as shown in Figure 25 on page 43.
 - b. Gently push the front of the power supply to ensure that it is fully seated.
 6. Plug in the power cord and turn on the power switch on the power supply.
 7. Check the new power supply and other DS4500 Storage Subsystem LEDs for faults. For more information, see “Checking the LEDs” on page 127.

Replacing a mini hub

Attention: Before you replace a mini hub, consider the following factors:

- You can hot swap (replace) a failed mini hub while the DS4500 Storage Subsystem is in operation.
- There are four LEDs that provide status information. If a mini hub fails, the interface fault and the bypass LEDs on the mini hub are lit and the loop good LED is off. For more information about LEDs, see “Mini hub LEDs” on page 134.
- If you replace the mini hub and its SFP modules and still experience problems, the DS4500 might have defective components or connections. Check the storage-management software for indications of other component failures.

For more information, see “Redundant drive loop cabling overview” on page 76 and “Types of interface ports” on page 48.

When instructed by the storage-management software, replace a failed mini hub (host-side and drive-side) by using the following procedure:

Attention: To prevent possible data loss, do not remove cables from a mini hub that has not failed.

Note: You *must* remove the fiber-optic cable from the SFP module before you can remove the SFP module from the mini-hub port.

1. On the mini hub that has failed, remove the fiber-optic cables from the SFP modules, as shown in Figure 108.

For proper handling of fiber-optic cables, see “Handling fiber-optic cables” on page 50.

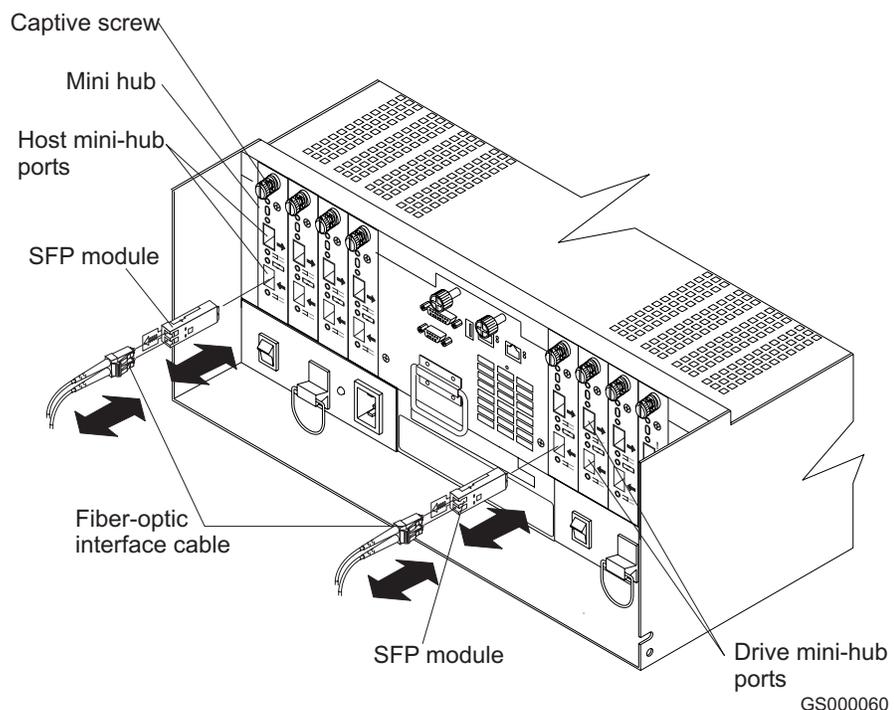
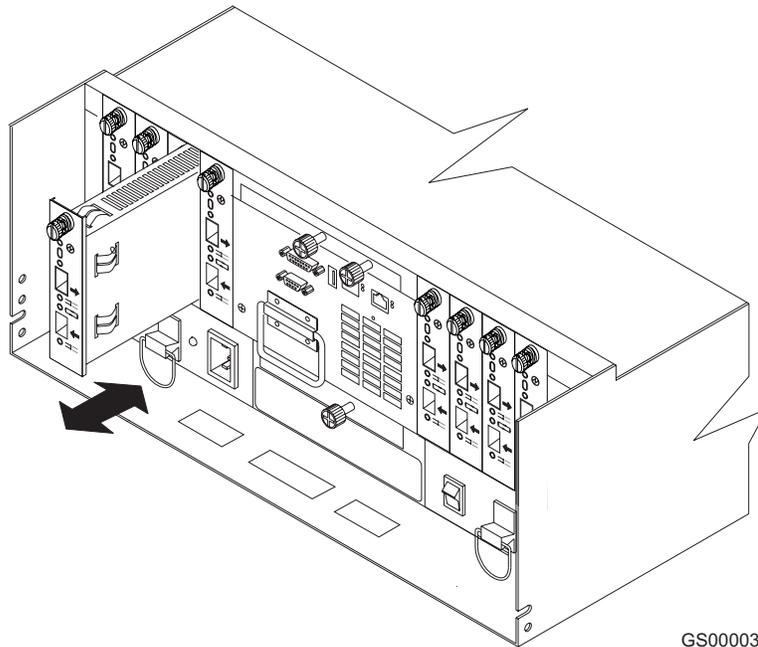


Figure 108. Removing the fiber-optic cable from the SFP module

2. Replace the protective caps on the cables.
3. Remove the SFP modules from the mini hub as follows:
 - a. Unlock the SFP module latch by pulling the plastic tab outward 10° and slide the SFP module out of the mini-hub port.
 - b. Replace the protective cap on the SFP module.
 - c. Place the SFP modules into their static-protective packages.
4. Loosen the captive screw on the mini hub. Then, grasp the screw and remove the mini hub from the chassis, as shown in Figure 109.



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Figure 109. Removing and installing a mini hub

5. Unpack the new mini hub and slide it into the appropriate slot. Then, tighten the captive screw.
6. Install the SFP modules that you removed as follows:
 - a. Remove the SFP modules from their static-protective packages.
 - b. Remove the protective caps from the SFP modules.
 - c. Slide the SFP modules into the mini-hub ports.
7. Replace the fiber-optic cables that you removed in Step 1 on page 159.
8. Check the indicator lights on the mini hub.

When the mini hub is operating properly, the green loop good light is lit and the fault light is off. If the mini-hub port is active, the amber port bypass light is not lit. For more information see “Mini hub LEDs” on page 134. If a problem is indicated, use the storage-management software to check the DS4500 Storage Subsystem status.

Replacing an SFP module

The maximum operating speed of the fibre channel port is determined by two factors: the speed of the SFP module that is installed and the speed of the fibre channel connection. For example, a 2-Gbps SFP that is plugged into a 4-Gbps-capable port will limit the speed of that port to a maximum of 2 Gbps.

Conversely, a 4-Gbps SFP that is plugged into a 2-Gbps-capable port will be limited by the speed of the port to a maximum of 2 Gbps.

Attention: Refer to the FRU option P/N on the SFP to identify the maximum operating speed of the SFP and to request the correct FRU replacement.

Use the following procedure to replace a SFP module on the storage subsystem. The SFP module shown in this procedure might look different from those you are using, but the difference will not affect functionality. Figure 110 on page 162 illustrates installing an SFP module.

Electrostatic discharge can damage sensitive components. To prevent electrostatic discharge damage to the storage subsystem, use proper antistatic protection when handling components.

To replace an SFP module, perform the following steps:

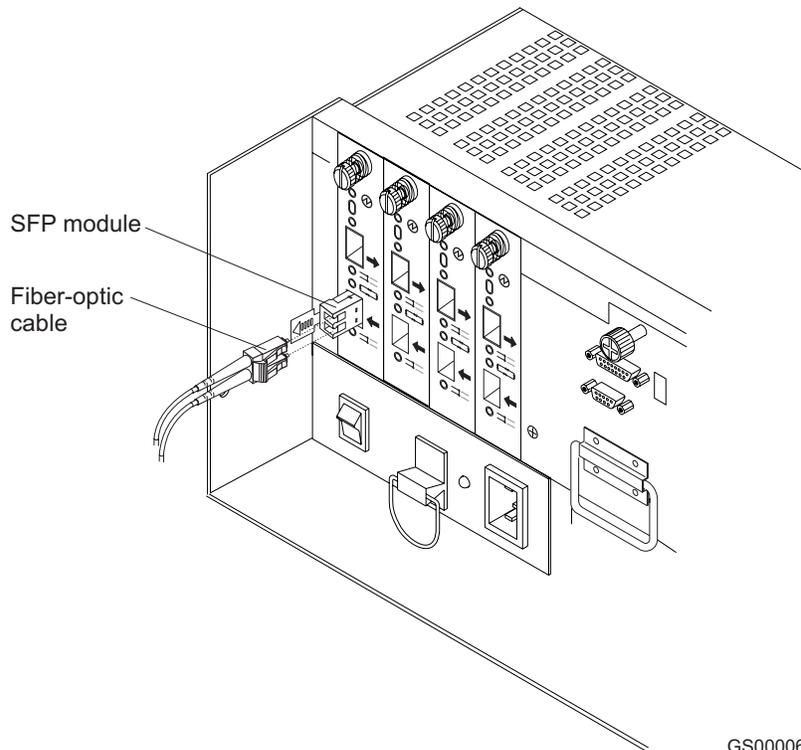
1. Use the DS4000 Storage Manager client software to print a new storage subsystem profile.
2. Using the Recovery Guru, identify the failed component that needs to be replaced.
3. Check the Fault LEDs to locate the failed SFP module. If a fault is detected, the amber Fault LED is on.

Attention: Potential loss of data access - To prevent loss of access to data, remove only the SFP module that has a failed status in the storage management software and has Port Bypass LED lit.

4. Put on antistatic protection.
5. Unpack the new SFP module. Verify that it is the same type of module you are replacing. If it is not, contact IBM Customer and Technical Support.

Attention: Handle and install fiber-optic cables properly to avoid degraded performance or loss of communications with devices. When working with fiber-optic cables, do not pinch them, step on them, or locate them in aisles or walkways. Do not overtighten the cable straps or bend the cables to a radius smaller than 38 mm (1.5 inches).

6. Disconnect the interface cables from the SFP module.
7. Remove the failed SFP module from the controller.
8. Install the new SFP module into the controller.
9. Reconnect the interface cable.



GS000069

Figure 110. Replacing an SFP module

10. Check the Bypass and Fault LEDs for the new SFP module.
11. Based on the status of the Bypass and Fault LEDs, choose one of the following steps:
 - **Bypass LED or Fault LED is on** - Reinstall the SFP module and cables, and verify that the SFP module and cables are securely connected. Use the fibre channel loopback and the LC-LC connector to perform path diagnostics to ensure that the FC cable is good and the SFP on the other end of the fibre channel connection is working properly. When finished, go to step 12.
 - **Bypass LED and Fault LED are off** - Go to step 12.
12. Is the problem corrected?
 - **Yes** - Go to step 13.
 - **No** - Contact IBM Support.
13. Complete any remaining Recovery Guru procedures, if needed.
14. Use the DS4000 Storage Manager Subsystem Management window to check the status the status of all components in the storage subsystem.
15. Remove the antistatic protection.
16. Does any component have a Fault status?
 - **Yes** - Select the Recovery Guru toolbar button in the Subsystem Management window, and complete the recovery procedure. If the problem persists, contact IBM Support.
 - **No** - Go to step 17.
17. Use the DS4000 Storage Manager client software to print a new storage subsystem profile.

Chapter 6. Hardware maintenance

This chapter contains information to help you solve some of the simpler problems that you might have with your storage subsystem. It contains the problem indicators and error messages along with suggested actions to take to resolve the problem.

For instructions on how to obtain service and technical assistance for your storage subsystem and other IBM products, see “Getting information, help, and service” on page xxiii.

General checkout

Use the LEDs, the diagnostics and test information, and the Symptom-to-FRU index to diagnose problems.

The PD maps found in the *IBM TotalStorage DS4000 Problem Determination Guide* provide you with additional diagnostic aids.

Using the diagnostic hardware

The DS4500 Storage Subsystem comes with a wrap-plug adapter and LC coupler. The wrap-plug adapter and LC coupler are used to identify fibre path problems. The loopback and sendEcho tests are described in the *IBM TotalStorage DS4000 Problem Determination Guide*.

Solving problems

This section contains information to help you solve some of the problems you might have with your storage subsystem. Table 24 contains the problem symptoms and error messages, along with suggested actions to take to resolve problems.

Always use the DS4000 Storage Manager client to diagnose storage subsystem problems and component failures and find solutions to problems that have definite symptoms.

You can use Table 24, which contains the problem symptoms, along with suggested actions as a guide for troubleshooting problems in addition to the DS4000 Storage Manager Recovery Guru in the Subsystem Management window. Do not depend solely Table 24 for a FRU replacement decision.

Note: Before any planned system shutdown or after any system additions, removals, or modifications, save the storage subsystem profile as explained in the DS4000 Storage Manager guide for your operating system. Save the profile in a location other than in the logical drives created for the DS4500.

Table 24. Symptom-to-FRU index for DS4500

Problem	Action/FRU
Controller LED (front cover) is on.	<ol style="list-style-type: none">1. Reseat Controller CRU.2. If in passive mode, place Controller online using DS4000 Storage Manager GUI.3. Controller CRU

Table 24. Symptom-to-FRU index for DS4500 (continued)

Problem	Action/FRU
Software issued a controller error message.	<ol style="list-style-type: none"> 1. Check Controller Fan. 2. Controller CRU 3. Check Fibre path/SFP, HBA, FC switches, if the LUNs are not on preferred path error reported.
Software errors occur when attempting to access controllers or drives.	<ol style="list-style-type: none"> 1. Check appropriate software and documentation to make sure the system is set up correctly and the proper command was run. 2. Power to the Controller 3. Interface cables 4. ID settings 5. Controller 6. Drive 7. Controller backpanel
Fan LED (front cover) is on.	<ol style="list-style-type: none"> 1. Power supply fan CRU 2. Controller fan CRU
Controller and Fan fault LEDs (front cover) are on.	<ol style="list-style-type: none"> 1. Check both Fan and Controller CRUs for fault LED and replace faulty CRU.
Fault-A or Fault-B LED (battery CRU) is on.	<ol style="list-style-type: none"> 1. Battery CRU
Full Charge-A or Full Charge-B LED (battery CRU) is off.	<ol style="list-style-type: none"> 1. Power-on Controller and allow batteries to charge for 24 hours until the Full Charge LEDs are on. 2. Battery CRU 3. Both power supplies
No power to controller (all power LEDs off).	<ol style="list-style-type: none"> 1. Check power switches and power cords. 2. Power supplies
Power Supply LED is off.	<ol style="list-style-type: none"> 1. Check and reseal power supply. 2. Check for overheating. Wait ten minutes for the power supply CRU to cool down. 3. Power supply CRU
Power Supply CRUs LED are on, but all other CRU LEDs are off.	<ol style="list-style-type: none"> 1. DC power harness.

Table 24. Symptom-to-FRU index for DS4500 (continued)

Problem	Action/FRU
The Storage Manager client Enterprise Management window sees each storage subsystem controller as an independent storage subsystem.	<p>No drives are present in the storage expansion enclosures or there are not any storage expansion enclosures attached to the DS4500 subsystem. Ensure that at least one drive is present in the storage subsystem so that it can be configured properly.</p> <p>One controller was replaced incorrectly. The controller firmware versions probably failed to synchronize correctly. To recover, perform the following steps:</p> <ol style="list-style-type: none"> 1. Remove and reinsert the controller blade. 2. Wait 5 minutes. 3. Delete the controller entry with the incorrect firmware version from the DS4000 Storage Manager Enterprise Management window. 4. Add the controller back to the DS4000 Storage Manager Enterprise Management window using the Add Device menu option in the Enterprise Management window. 5. If the Storage Manager client Enterprise Management window still shows each storage subsystem controller as an independent storage subsystem or a partially managed device, repeat this procedure. If the problem still persists, contact IBM support.

Parts listing

Figure 111 and the following table provide a parts listing for the DS4500 Storage Subsystem.

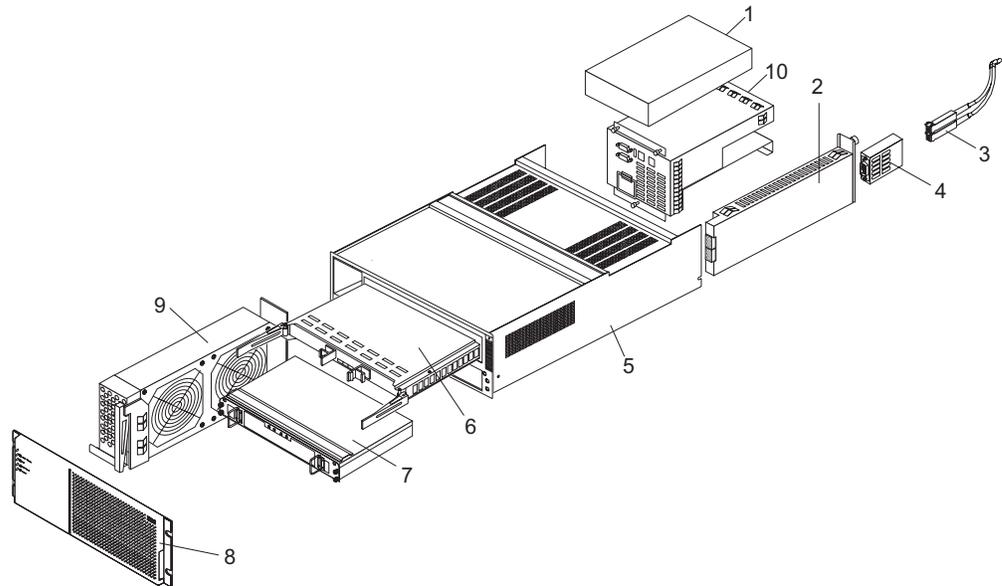


Figure 111. DS4500 Storage Subsystem parts listing

Index	DS4500 storage subsystem	FRU
1	175-Watt Power Supply	01K6743

Index	DS4500 storage subsystem	FRU
2	Mini hub Card Assembly	19K1270
3	Optical Cable - 1 Meter	19K1265
3	Optical Cable - 5 Meters	19K1266
3	Optical Cable - 25 Meters	19K1267
	LC-SC Adapter Cable	19K1268
4	Short Wave SFP Module	19K1280
4	Long Wave SFP Module	19K1281
5	Frame Assembly with Midplane	71P8142
6	RAID Card	71P8144
7	Battery Backup Assembly	24P0953
8	Bezel Assembly	71P8141
9	Front Fan Assembly (Controller CRU Fan)	37L0094
10	Rear Fan Assembly	37L0102
	Battery Cable	03K9285
	Blank Mini Hub Canister	37L0100
	Line Cord Jumper, High Voltage	36L8886
	Power Cable	37L0101
	Miscellaneous Hardware Kit	24P0954
	Rail Kit	37L0085
	Line Cord, US	6952300
	LC Wrap Plug ASM	24P0950

Figure 85 on page 113 lists required power cords for the DS4000 storage components discussed in this document by country and region.

Appendix A. Records

Whenever you add options to your DS4500, be sure to update the information in this appendix. Accurate, up-to-date records make it easier to add other options and provide needed data whenever you contact your IBM technical support representative.

Identification numbers

Record and retain the following information.

Product name:	IBM TotalStorage DS4500 Storage Subsystem
Machine type:	
Model number:	
Serial number:	

The serial number, machine type, and model number are located on the rear lip at the back of the unit.

Sample information record

Table 26 shows a sample information record. This network contains storage subsystems that are managed by using both the direct-management and host-agent-management method.

Table 26. Sample information record

Storage subsystem name	Management method	Controllers-Ethernet and IP addresses, and host name		Host-IP address and host name
		Controller A	Controller B	
Finance	Direct	Hardware Ethernet address = 00a0b8020420	Hardware Ethernet address = 00a0b80000d8	
		IP address = 192.168.128.101	IP address = 192.168.128.102	
		Host = Denver_a	Host = Denver_b	
Engineering	Host-agent			IP address = 192.168.2.22
				Host = Atlanta

Appendix B. Rack mounting template

This appendix provides duplicate copies of the rack mounting templates. If you want to tear out the templates from this document for easier use, use these copies rather than those provided in “Installing the support rails” on page 27.

Use the following templates (Figure 112 on page 172 and Figure 113 on page 173) to identify the proper locations for inserting M6 screws when mounting the support rails and DS4500 to a rack. The locations for the M6 screws are highlighted in the templates.

The DS4500 is 4 U high. Align the template with the rack at a U boundary. U boundaries are shown as horizontal dashed lines in the rack mounting templates.

Note: The mounting holes that are shown in the following templates are square. The holes in your rack might be round or square.

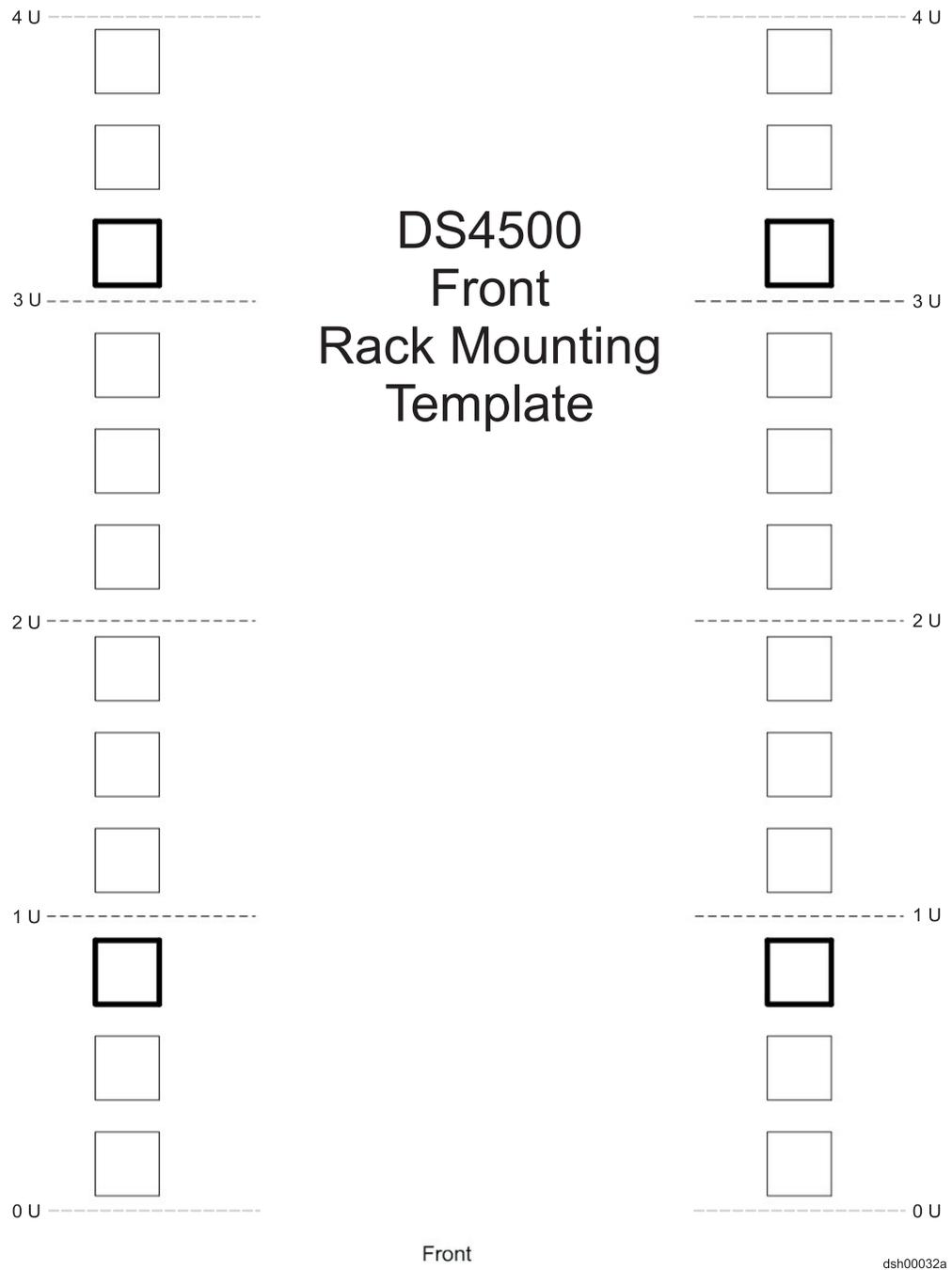


Figure 112. Front rack mounting template

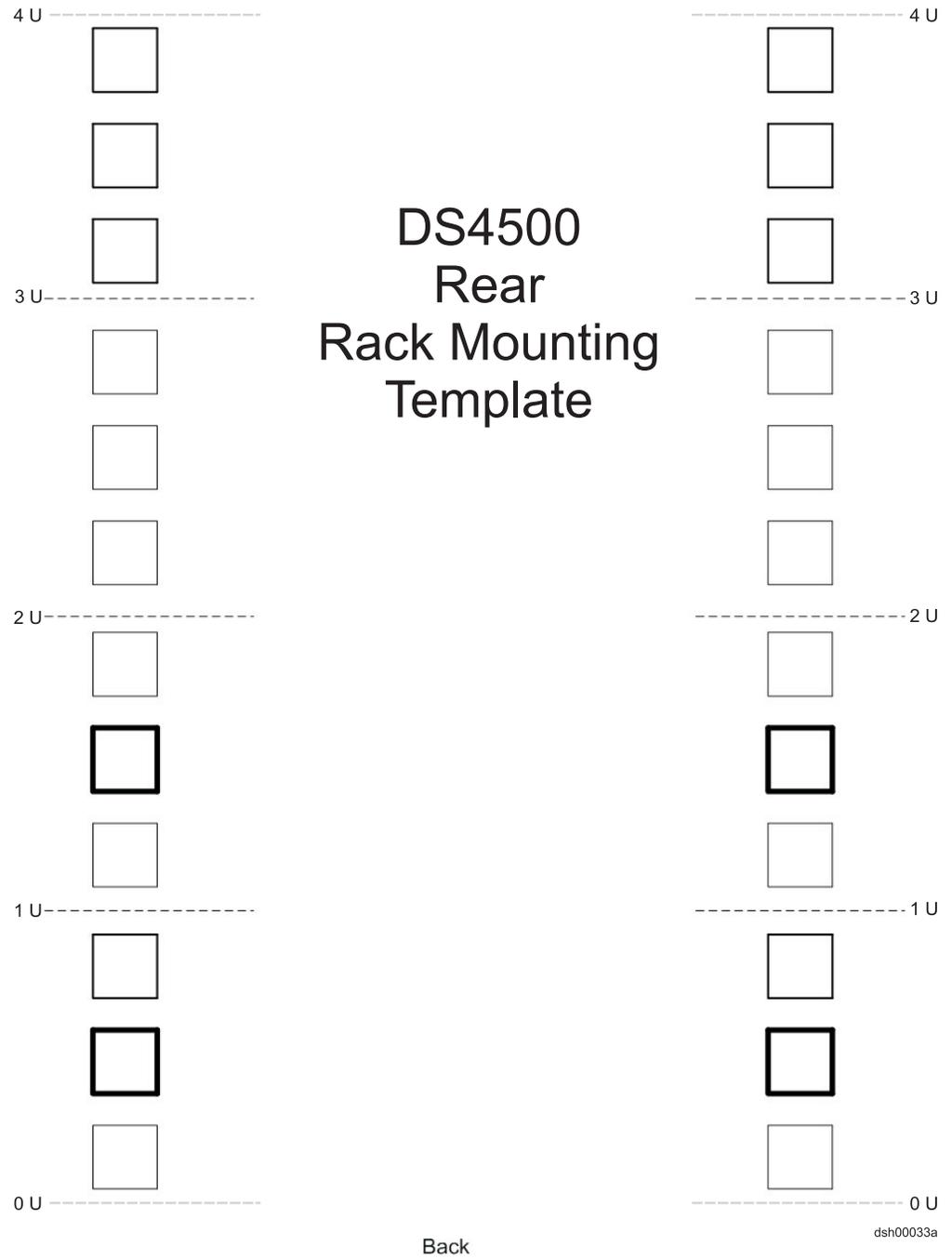


Figure 113. Rear rack mounting template

Appendix C. Power cords

For your safety, IBM provides a power cord with a grounded attachment plug to use with this IBM product. To avoid electrical shock, always use the power cord and plug with a properly grounded outlet.

IBM power cords used in the United States and Canada are listed by Underwriter's Laboratories (UL) and certified by the Canadian Standards Association (CSA).

For units intended to be operated at 115 volts: Use a UL-listed and CSA-certified cord set consisting of a minimum 18 AWG, Type SVT or SJT, three-conductor cord, a maximum of 15 feet in length and a parallel blade, grounding-type attachment plug rated 15 amperes, 125 volts.

For units intended to be operated at 230 volts (U.S. use): Use a UL-listed and CSA-certified cord set consisting of a minimum 18 AWG, Type SVT or SJT, three-conductor cord, a maximum of 15 feet in length and a tandem blade, grounding-type attachment plug rated 15 amperes, 250 volts.

For units intended to be operated at 230 volts (outside the U.S.): Use a cord set with a grounding-type attachment plug. The cord set should have the appropriate safety approvals for the country in which the equipment will be installed.

IBM power cords for a specific country or region are usually available only in that country or region.

Table 27. IBM power cords

IBM power cord part number	Feature code	Description	Used in these countries or regions
39Y7931	9800	Power Cord (125v, 10A, 4.3m)	Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Cayman Islands, Costa Rica, Columbia, Cuba, Dominican Republic, Ecuador, El Salvador, Guam, Guatemala, Haiti, Honduras, Jamaica, Mexico, Micronesia (Federal States of), Netherlands Antilles, Nicaragua, Panama, Peru, Philippines, Saudi Arabia, Thailand, Turks and Caicos Islands, United States, Venezuela

Table 27. IBM power cords (continued)

IBM power cord part number	Feature code	Description	Used in these countries or regions
39Y7917	9820	Power Cord (250v, 10A, 2.8m)	Afghanistan, Albania, Algeria, Andorra, Angola, Armenia, Austria, Azerbaijan, Belarus, Belgium, Benin, Bosnia and Herzegovina, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo (Democratic Republic of), Congo (Republic of), Cote D'Ivoire (Ivory Coast), Croatia (Republic of), Czech Rep, Dahomey, Djibouti, Egypt, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Finland, France, French Guyana, French Polynesia, Gabon, Georgia, Germany, Greece, Guadeloupe, Guinea, Guinea Bissau, Hungary, Iceland, Indonesia, Iran, Kazakhstan, Kyrgyzstan, Laos (Peoples Democratic Republic of), Latvia, Lebanon, Lithuania, Luxembourg, Macedonia (former Yugoslav Republic of), Madagascar, Mali, Martinique, Mauritania, Mauritius, Mayotte, Moldova (Republic of), Monaco, Mongolia, Morocco, Mozambique, Netherlands, New Caledonia, Niger, Norway, Poland, Portugal, Reunion, Romania, Russian Federation Rwanda, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Slovakia, Slovenia (Republic of), Somalia, Spain, Suriname, Sweden, Syrian Arab Republic, Tajikistan, Tahiti, Togo, Tunisia, Turkey, Turkmenistan, Ukraine, Upper Volta, Uzbekistan, Vanuatu, Vietnam, Wallis and Futuna, Yugoslavia (Federal Republic of), Zaire
39Y7918	9821	Power Cord (250v, 10A, 2.8m)	Denmark

Table 27. IBM power cords (continued)

IBM power cord part number	Feature code	Description	Used in these countries or regions
39Y7923	9825	Power Cord (250v, 10A, 2.8m)	Abu Dhabi, Bahrain, Botswana, Brunei Darussalam, Channel Islands, Cyprus, Dominica, Gambia, Ghana, Grenada, Guyana, Hong Kong, Iraq, Ireland, Jordan, Kenya, Kuwait, Liberia, Malawi, Malaysia, Malta, Myanmar (Burma), Nigeria, Oman, Qatar, Saint Kitts & Nevis, Saint Lucia, Saint Vincent and the Grenadines, Seychelles, Sierra Leone, Singapore, Sudan, Tanzania (United Republic of), Trinidad & Tobago, United Arab Emirates (Dubai), United Kingdom, Yemen, Zambia, Zimbabwe
39Y7920	9827	Power Cord (250v, 10A, 2.8m)	Israel
39Y7919	9828	Power Cord (250v, 10A, 2.8m)	Liechtenstein, Switzerland
39Y7922	9829	Power Cord (250v, 10A, 2.8m)	Bangladesh, Lesotho, Maceo, Maldives, Namibia, Nepal, Pakistan, Samoa, South Africa, Sri Lanka, Swaziland, Uganda
39Y7925	9845	Power Cord (250v, 12A, 2.8m)	Korea (Democratic Peoples Republic of)
39Y7921	9830	Power Cord (250v, 10A, 2.8m)	Chile, Italy, Libyan Arab Jamahiriya
39M7924	9831	Power Cord (250v, 10A, 2.8m)	Australia, Fiji, Kiribati, Nauru, New Zealand, Papua New Guinea
39Y7930	9834	Power Cord (250v, 10A, 2.8m)	Argentina, Paraguay, Uruguay
39Y7928	9840	Power Cord (250v, 10A, 2.8m)	China
39M2830	9841	Power Cord 1.8m long	Taiwan
39Y7929	9842	Power Cord (125v, 10A, 2.8m)	Brazil
39Y7927	9843	Power Cord (250v, 10A, 2.8m)	India
39Y7926	9844	Power Cord (125v, 10A, 4.3m)	Japan
N/A	9986	Power Cord (125v, 10A, 1.8m) - US/Chicago	

Appendix D. Additional DS4000 documentation

The following tables present an overview of the IBM System Storage DS4000 Storage Manager, Storage Subsystem, and Storage Expansion Enclosure product libraries, as well as other related documents. Each table lists documents that are included in the libraries and what common tasks they address.

You can access the documents listed in these tables at both of the following Web sites:

www.ibm.com/servers/storage/support/disk/

www.ibm.com/shop/publications/order/

DS4000 Storage Manager Version 9 library

Table 28 associates each document in the DS4000 Storage Manager Version 9 library with its related common user tasks.

Table 28. DS4000 Storage Manager Version 9 titles by user tasks

Title	User tasks					
	Planning	Hardware installation	Software installation	Configuration	Operation and administration	Diagnosis and maintenance
<i>IBM System Storage DS4000 Storage Manager Version 9 Installation and Support Guide for Windows 2000/Server 2003, NetWare, ESX Server, and Linux</i>	✓		✓	✓		
<i>IBM System Storage DS4000 Storage Manager Version 9 Installation and Support Guide for AIX, UNIX®, Solaris and Linux on POWER</i>	✓		✓	✓		
<i>IBM System Storage DS4000 Storage Manager Version 9 Copy Services User's Guide</i>	✓		✓	✓	✓	
<i>IBM TotalStorage DS4000 Storage Manager Version 9 Concepts Guide</i>	✓	✓	✓	✓	✓	✓

Table 28. DS4000 Storage Manager Version 9 titles by user tasks (continued)

Title	User tasks					
	Planning	Hardware installation	Software installation	Configuration	Operation and administration	Diagnosis and maintenance
<i>IBM System Storage DS4000 Fibre Channel and Serial ATA Intermix Premium Feature Installation Overview</i>	✓	✓	✓	✓		

DS4800 Storage Subsystem library

Table 29 associates each document in the DS4800 Storage Subsystem library with its related common user tasks.

Table 29. DS4800 Storage Subsystem document titles by user tasks

Title	User Tasks					
	Planning	Hardware Installation	Software Installation	Configuration	Operation and Administration	Diagnosis and Maintenance
<i>IBM System Storage DS4800 Storage Subsystem Installation, User's and Maintenance Guide</i>	✓	✓		✓	✓	✓
<i>IBM System Storage DS4800 Storage Subsystem Installation and Cabling Overview</i>		✓				
<i>IBM TotalStorage DS4800 Controller Cache Upgrade Kit Instructions</i>	✓	✓		✓		

DS4700 Storage Subsystem library

Table 30 associates each document in the DS4700 Storage Subsystem library with its related common user tasks.

Table 30. DS4700 Storage Subsystem document titles by user tasks

Title	User Tasks					
	Planning	Hardware Installation	Software Installation	Configuration	Operation and Administration	Diagnosis and Maintenance
<i>IBM System Storage DS4700 Storage Subsystem Installation, User's and Maintenance Guide</i>	✓	✓		✓	✓	✓
<i>IBM System Storage DS4700 Storage Subsystem Fibre Channel Cabling Guide</i>		✓				

DS4500 Storage Subsystem library

Table 31 associates each document in the DS4500 (previously FAStT900) Storage Subsystem library with its related common user tasks.

Table 31. DS4500 Storage Subsystem document titles by user tasks

Title	User Tasks					
	Planning	Hardware Installation	Software Installation	Configuration	Operation and Administration	Diagnosis and Maintenance
<i>IBM TotalStorage DS4500 Storage Subsystem Installation, User's, and Maintenance Guide</i>	✓	✓		✓	✓	✓
<i>IBM TotalStorage DS4500 Storage Subsystem Cabling Instructions</i>	✓	✓				
<i>IBM TotalStorage DS4500 Rack Mounting Instructions</i>	✓	✓				

DS4400 Storage Subsystem library

Table 32 associates each document in the DS4400 (previously FAStT700) Storage Subsystem library with its related common user tasks.

Table 32. DS4400 Storage Subsystem document titles by user tasks

Title	User Tasks					
	Planning	Hardware Installation	Software Installation	Configuration	Operation and Administration	Diagnosis and Maintenance
<i>IBM TotalStorage DS4400 Fibre Channel Storage Server User's Guide</i>	✓	✓		✓	✓	✓
<i>IBM TotalStorage DS4400 Fibre Channel Storage Server Installation and Support Guide</i>	✓	✓		✓	✓	
<i>IBM TotalStorage DS4400 Fibre Channel Cabling Instructions</i>	✓	✓				

DS4300 Storage Subsystem library

Table 33 associates each document in the DS4300 (previously FAStT600) Storage Subsystem library with its related common user tasks.

Table 33. DS4300 Storage Subsystem document titles by user tasks

Title	User Tasks					
	Planning	Hardware Installation	Software Installation	Configuration	Operation and Administration	Diagnosis and Maintenance
<i>IBM TotalStorage DS4300 Storage Subsystem Installation, User's, and Maintenance Guide</i>	✓	✓		✓	✓	✓
<i>IBM TotalStorage DS4300 Rack Mounting Instructions</i>	✓	✓				
<i>IBM TotalStorage DS4300 Storage Subsystem Cabling Instructions</i>	✓	✓				
<i>IBM TotalStorage DS4300 SCU Base Upgrade Kit</i>		✓	✓			
<i>IBM TotalStorage DS4300 SCU Turbo Upgrade Kit</i>		✓	✓			
<i>IBM TotalStorage DS4300 Turbo Models 6LU/6LX Upgrade Kit</i>		✓	✓			

DS4200 Express Storage Subsystem library

Table 34 associates each document in the DS4200 Express Storage Subsystem library with its related common user tasks.

Table 34. DS4200 Express Storage Subsystem document titles by user tasks

Title	User Tasks					
	Planning	Hardware Installation	Software Installation	Configuration	Operation and Administration	Diagnosis and Maintenance
<i>IBM System Storage DS4200 Express Storage Subsystem Installation, User's and Maintenance Guide</i>	✓	✓		✓	✓	✓
<i>IBM System Storage DS4200 Express Storage Subsystem Cabling Guide</i>		✓				

DS4100 Storage Subsystem library

Table 35 associates each document in the DS4100 (previously FAStT100) Storage Subsystem library with its related common user tasks.

Table 35. DS4100 Storage Subsystem document titles by user tasks

Title	User Tasks					
	Planning	Hardware Installation	Software Installation	Configuration	Operation and Administration	Diagnosis and Maintenance
<i>IBM TotalStorage DS4100 Storage Server Installation, User's and Maintenance Guide</i>	✓	✓		✓	✓	✓
<i>IBM TotalStorage DS4100 Storage Server Cabling Guide</i>		✓				

DS4000 Storage Expansion Enclosure documents

Table 36 associates each of the following documents with its related common user tasks.

Table 36. DS4000 Storage Expansion Enclosure document titles by user tasks

Title	User Tasks					
	Planning	Hardware Installation	Software Installation	Configuration	Operation and Administration	Diagnosis and Maintenance
<i>IBM System Storage DS4000 EXP810 Storage Expansion Enclosure Installation, User's, and Maintenance Guide</i>	✓	✓		✓	✓	✓
<i>IBM TotalStorage DS4000 EXP700 and EXP710 Storage Expansion Enclosures Installation, User's, and Maintenance Guide</i>	✓	✓		✓	✓	✓
<i>IBM DS4000 EXP500 Installation and User's Guide</i>	✓	✓		✓	✓	✓
<i>IBM System Storage DS4000 EXP420 Storage Expansion Enclosure Installation, User's, and Maintenance Guide</i>	✓	✓		✓	✓	✓
<i>IBM System Storage DS4000 Hard Drive and Storage Expansion Enclosures Installation and Migration Guide</i>	✓	✓				

Other DS4000 and DS4000-related documents

Table 37 associates each of the following documents with its related common user tasks.

Table 37. DS4000 and DS4000–related document titles by user tasks

Title	User Tasks					
	Planning	Hardware Installation	Software Installation	Configuration	Operation and Administration	Diagnosis and Maintenance
<i>IBM Safety Information</i>					✓	
<i>IBM TotalStorage DS4000 Quick Start Guide</i>	✓	✓				
<i>IBM TotalStorage DS4000 Hardware Maintenance Manual</i> ¹						✓
<i>IBM System Storage DS4000 Problem Determination Guide</i>						✓
<i>IBM Fibre Channel Planning and Integration: User's Guide and Service Information</i>	✓	✓			✓	✓
<i>IBM TotalStorage DS4000 FC2-133 Host Bus Adapter Installation and User's Guide</i>		✓			✓	
<i>IBM TotalStorage DS4000 FC2-133 Dual Port Host Bus Adapter Installation and User's Guide</i>		✓			✓	
<i>IBM Netfinity® Fibre Channel Cabling Instructions</i>		✓				
<i>IBM Fibre Channel SAN Configuration Setup Guide</i>	✓		✓	✓	✓	

Notes:

1. The *IBM TotalStorage DS4000 Hardware Maintenance Manual* does not contain maintenance information for the IBM System Storage DS4200, DS4300, DS4500, DS4700, or DS4800 storage subsystems. You can find maintenance information for these products in the *IBM System Storage DSx000 Storage Subsystem Installation, User's, and Maintenance Guide* for the particular subsystem.

Appendix E. Accessibility

This section provides information about alternate keyboard navigation, which is a DS4000 Storage Manager accessibility feature. Accessibility features help a user who has a physical disability, such as restricted mobility or limited vision, to use software products successfully.

By using the alternate keyboard operations that are described in this section, you can use keys or key combinations to perform Storage Manager tasks and initiate many menu actions that can also be done with a mouse.

Note: In addition to the keyboard operations that are described in this section, the DS4000 Storage Manager 9.14, 9.15, and 9.16 software installation packages for Windows include a screen reader software interface. To enable the screen reader, select Custom Installation when using the installation wizard to install Storage Manager 9.14, 9.15, or 9.16 on a Windows host/management station. Then, in the Select Product Features window, select Java™ Access Bridge in addition to the other required host software components.

Table 38 defines the keyboard operations that enable you to navigate, select, or activate user interface components. The following terms are used in the table:

- *Navigate* means to move the input focus from one user interface component to another.
- *Select* means to choose one or more components, typically for a subsequent action.
- *Activate* means to carry out the action of a particular component.

Note: In general, navigation between components requires the following keys:

- **Tab** - Moves keyboard focus to the next component or to the first member of the next group of components
- **Shift-Tab** - Moves keyboard focus to the previous component or to the first component in the previous group of components
- **Arrow keys** - Move keyboard focus within the individual components of a group of components

Table 38. DS4000 Storage Manager alternate keyboard operations

Short cut	Action
F1	Open the Help.
F10	Move keyboard focus to main menu bar and post first menu; use the arrow keys to navigate through the available options.
Alt+F4	Close the management window.
Alt+F6	Move keyboard focus between dialogs (non-modal) and between management windows.

Table 38. DS4000 Storage Manager alternate keyboard operations (continued)

Short cut	Action
Alt+ underlined letter	<p>Access menu items, buttons, and other interface components by using the keys associated with the underlined letters.</p> <p>For the menu options, select the Alt + underlined letter combination to access a main menu, and then select the underlined letter to access the individual menu item.</p> <p>For other interface components, use the Alt + underlined letter combination.</p>
Ctrl+F1	Display or conceal a tool tip when keyboard focus is on the toolbar.
Spacebar	Select an item or activate a hyperlink.
Ctrl+Spacebar (Contiguous/Non-contiguous) AMW Logical/Physical View	<p>Select multiple drives in the Physical View.</p> <p>To select multiple drives, select one drive by pressing Spacebar, and then press Tab to switch focus to the next drive you want to select; press Ctrl+Spacebar to select the drive.</p> <p>If you press Spacebar alone when multiple drives are selected then all selections are removed.</p> <p>Use the Ctrl+Spacebar combination to deselect a drive when multiple drives are selected.</p> <p>This behavior is the same for contiguous and non-contiguous selection of drives.</p>
End, Page Down	Move keyboard focus to the last item in the list.
Esc	Close the current dialog (does not require keyboard focus).
Home, Page Up	Move keyboard focus to the first item in the list.
Shift+Tab	Move keyboard focus through components in the reverse direction.
Ctrl+Tab	Move keyboard focus from a table to the next user interface component.
Tab	Navigate keyboard focus between components or select a hyperlink.
Down arrow	Move keyboard focus down one item in the list.
Left arrow	Move keyboard focus to the left.
Right arrow	Move keyboard focus to the right.
Up arrow	Move keyboard focus up one item in the list.

Appendix F. Product Recycling and Disposal

This unit must be recycled or discarded according to applicable local and national regulations. IBM encourages owners of information technology (IT) equipment to responsibly recycle their equipment when it is no longer needed. IBM offers a variety of product return programs and services in several countries to assist equipment owners in recycling their IT products. Information on IBM product recycling offerings can be found on IBM's Internet site at www.ibm.com/ibm/environment/products/prp.shtml.

Esta unidad debe reciclarse o desecharse de acuerdo con lo establecido en la normativa nacional o local aplicable. IBM recomienda a los propietarios de equipos de tecnología de la información (TI) que reciclen responsablemente sus equipos cuando éstos ya no les sean útiles. IBM dispone de una serie de programas y servicios de devolución de productos en varios países, a fin de ayudar a los propietarios de equipos a reciclar sus productos de TI. Se puede encontrar información sobre las ofertas de reciclado de productos de IBM en el sitio web de IBM www.ibm.com/ibm/environment/products/prp.shtml.



Notice: This mark applies only to countries within the European Union (EU) and Norway.

Appliances are labeled in accordance with European Directive 2002/96/EC concerning waste electrical and electronic equipment (WEEE). The Directive determines the framework for the return and recycling of used appliances as applicable throughout the European Union. This label is applied to various products to indicate that the product is not to be thrown away, but rather reclaimed upon end of life per this Directive.

In accordance with the European WEEE Directive, electrical and electronic equipment (EEE) is to be collected separately and to be reused, recycled, or recovered at end of life. Users of EEE with the WEEE marking per Annex IV of the WEEE Directive, as shown above, must not dispose of end of life EEE as unsorted municipal waste, but use the collection framework available to customers for the return, recycling and recovery of WEEE. Customer participation is important to minimize any potential effects of EEE on the environment and human health due to the potential presence of hazardous substances in EEE. For proper collection and treatment, contact your local IBM representative.

Appendix G. Battery Return Program

This product may contain sealed lead acid, nickel cadmium, nickel metal hydride, lithium, or a lithium ion battery. Consult your user manual or service manual for specific battery information. The battery must be recycled or disposed of properly. Recycling facilities may not be available in your area. For information on disposal of batteries outside the United States, go to www.ibm.com/ibm/environment/products/batteryrecycle.shtml or contact your local waste disposal facility.

In the United States, IBM has established a return process for reuse, recycling, or proper disposal of used IBM sealed lead acid, nickel cadmium, nickel metal hydride, and other battery packs from IBM Equipment. For information on proper disposal of these batteries, contact IBM at 1-800-426-4333. Please have the IBM part number listed on the battery available prior to your call.

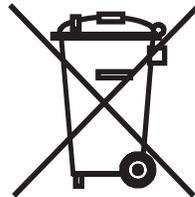
For Taiwan:



Please recycle batteries

廢電池請回收 svc00066

For the European Union:



For California:

Perchlorate Material - special handling may apply. See www.dtsc.ca.gov/hazardouswaste/perchlorate.

The foregoing notice is provided in accordance with California Code of Regulations Title 22, Division 4.5 Chapter 33. Best Management Practices for Perchlorate Materials. This product/part may include a lithium manganese dioxide battery which contains a perchlorate substance.

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Processor speeds indicate the internal clock speed of the microprocessor; other factors also affect application performance.

CD-ROM drive speeds list the variable read rate. Actual speeds vary and are often less than the maximum possible.

When referring to processor storage, real and virtual storage, or channel volume, KB stands for approximately 1000 bytes, MB stands for approximately 1 000 000 bytes, and GB stands for approximately 1 000 000 000 bytes.

When referring to hard disk drive capacity or communications volume, MB stands for 1 000 000 bytes, and GB stands for 1 000 000 000 bytes. Total user-accessible capacity may vary depending on operating environments.

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This section gives the electronic emission notices or statements for the United States and other countries or regions.

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Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio

communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

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Attention: This is a class A statement. In a domestic environment, this product might cause radio interference in which case the user might be required to take adequate measures.

中华人民共和国“A类”警告声明

声 明

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Avis de conformité à la réglementation d'Industrie Canada

Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.

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United Kingdom telecommunications safety requirement

Notice to Customers

This apparatus is approved under approval number NS/G/1234/J/100003 for indirect connection to public telecommunication systems in the United Kingdom.

European Union EMC Directive conformance statement

This product is in conformity with the protection requirements of EU Council Directive 89/336/EEC on the approximation of the laws of the Member States relating to electromagnetic compatibility. IBM cannot accept responsibility for any failure to satisfy the protection requirements resulting from a nonrecommended modification of the product, including the fitting of non-IBM option cards.

This product has been tested and found to comply with the limits for Class A Information Technology Equipment according to CISPR 22/European Standard EN 55022. The limits for Class A equipment were derived for commercial and industrial environments to provide reasonable protection against interference with licensed communication equipment.

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Glossary

This glossary provides definitions for the terminology and abbreviations used in IBM TotalStorage DS4000 publications.

If you do not find the term you are looking for, see the *IBM Glossary of Computing Terms* located at the following Web site:

www.ibm.com/ibm/terminology

This glossary also includes terms and definitions from:

- *Information Technology Vocabulary* by Subcommittee 1, Joint Technical Committee 1, of the International Organization for Standardization and the International Electrotechnical Commission (ISO/IEC JTC1/SC1). Definitions are identified by the symbol (I) after the definition; definitions taken from draft international standards, committee drafts, and working papers by ISO/IEC JTC1/SC1 are identified by the symbol (T) after the definition, indicating that final agreement has not yet been reached among the participating National Bodies of SC1.
- *IBM Glossary of Computing Terms*. New York: McGraw-Hill, 1994.

The following cross-reference conventions are used in this glossary:

See Refers you to (a) a term that is the expanded form of an abbreviation or acronym, or (b) a synonym or more preferred term.

See also

Refers you to a related term.

Abstract Windowing Toolkit (AWT). A Java graphical user interface (GUI).

accelerated graphics port (AGP). A bus specification that gives low-cost 3D graphics cards faster access to main memory on personal computers than the usual peripheral component interconnect (PCI) bus. AGP reduces the overall cost of creating high-end graphics subsystems by using existing system memory.

access volume. A special logical drive that allows the host-agent to communicate with the controllers in the storage subsystem.

adapter. A printed circuit assembly that transmits user data input/output (I/O) between the internal bus of the

host system and the external fibre-channel (FC) link and vice versa. Also called an I/O adapter, host adapter, or FC adapter.

advanced technology (AT) bus architecture. A bus standard for IBM compatibles. It extends the XT bus architecture to 16 bits and also allows for bus mastering, although only the first 16 MB of main memory are available for direct access.

agent. A server program that receives virtual connections from the network manager (the client program) in a Simple Network Management Protocol-Transmission Control Protocol/Internet Protocol (SNMP-TCP/IP) network-managing environment.

AGP. See *accelerated graphics port*.

AL_PA. See *arbitrated loop physical address*.

arbitrated loop. One of three existing fibre-channel topologies, in which 2 - 126 ports are interconnected serially in a single loop circuit. Access to the Fibre Channel-Arbitrated Loop (FC-AL) is controlled by an arbitration scheme. The FC-AL topology supports all classes of service and guarantees in-order delivery of FC frames when the originator and responder are on the same FC-AL. The default topology for the disk array is arbitrated loop. An arbitrated loop is sometimes referred to as a Stealth Mode.

arbitrated loop physical address (AL_PA). An 8-bit value that is used to uniquely identify an individual port within a loop. A loop can have one or more AL_PAs.

array. A collection of fibre-channel or SATA hard drives that are logically grouped together. All the drives in the array are assigned the same RAID level. An array is sometimes referred to as a "RAID set." See also *redundant array of independent disks (RAID)*, *RAID level*.

asynchronous write mode. In remote mirroring, an option that allows the primary controller to return a write I/O request completion to the host server before data has been successfully written by the secondary controller. See also *synchronous write mode*, *remote mirroring*, *Global Copy*, *Global Mirroring*.

AT. See *advanced technology (AT) bus architecture*.

ATA. See *AT-attached*.

AT-attached. Peripheral devices that are compatible with the original IBM AT computer standard in which signals on a 40-pin AT-attached (ATA) ribbon cable followed the timings and constraints of the Industry Standard Architecture (ISA) system bus on the IBM PC AT computer. Equivalent to integrated drive electronics (IDE).

auto-volume transfer/auto-disk transfer (AVT/ADT).

A function that provides automatic failover in case of controller failure on a storage subsystem.

AVT/ADT. See *auto-volume transfer/auto-disk transfer*.

AWT. See *Abstract Windowing Toolkit*.

basic input/output system (BIOS). The personal computer code that controls basic hardware operations, such as interactions with diskette drives, hard disk drives, and the keyboard.

BIOS. See *basic input/output system*.

BOOTP. See *bootstrap protocol*.

bootstrap protocol (BOOTP). In Transmission Control Protocol/Internet Protocol (TCP/IP) networking, an alternative protocol by which a diskless machine can obtain its Internet Protocol (IP) address and such configuration information as IP addresses of various servers from a BOOTP server.

bridge. A storage area network (SAN) device that provides physical and transport conversion, such as Fibre Channel to small computer system interface (SCSI) bridge.

bridge group. A bridge and the collection of devices connected to it.

broadcast. The simultaneous transmission of data to more than one destination.

cathode ray tube (CRT). A display device in which controlled electron beams are used to display alphanumeric or graphical data on an electroluminescent screen.

client. A computer system or process that requests a service of another computer system or process that is typically referred to as a server. Multiple clients can share access to a common server.

command. A statement used to initiate an action or start a service. A command consists of the command name abbreviation, and its parameters and flags if applicable. A command can be issued by typing it on a command line or selecting it from a menu.

community string. The name of a community contained in each Simple Network Management Protocol (SNMP) message.

concurrent download. A method of downloading and installing firmware that does not require the user to stop I/O to the controllers during the process.

CRC. See *cyclic redundancy check*.

CRT. See *cathode ray tube*.

CRU. See *customer replaceable unit*.

customer replaceable unit (CRU). An assembly or part that a customer can replace in its entirety when any of its components fail. Contrast with *field replaceable unit (FRU)*.

cyclic redundancy check (CRC). (1) A redundancy check in which the check key is generated by a cyclic algorithm. (2) An error detection technique performed at both the sending and receiving stations.

dac. See *disk array controller*.

dar. See *disk array router*.

DASD. See *direct access storage device*.

data striping. See *striping*.

default host group. A logical collection of discovered host ports, defined host computers, and defined host groups in the storage-partition topology that fulfill the following requirements:

- Are not involved in specific logical drive-to-LUN mappings
- Share access to logical drives with default logical drive-to-LUN mappings

device type. Identifier used to place devices in the physical map, such as the switch, hub, or storage.

DHCP. See *Dynamic Host Configuration Protocol*.

direct access storage device (DASD). A device in which access time is effectively independent of the location of the data. Information is entered and retrieved without reference to previously accessed data. (For example, a disk drive is a DASD, in contrast with a tape drive, which stores data as a linear sequence.) DASDs include both fixed and removable storage devices.

direct memory access (DMA). The transfer of data between memory and an input/output (I/O) device without processor intervention.

disk array controller (dac). A disk array controller device that represents the two controllers of an array. See also *disk array router*.

disk array router (dar). A disk array router that represents an entire array, including current and deferred paths to all logical unit numbers (LUNs) (hdisks on AIX). See also *disk array controller*.

DMA. See *direct memory access*.

domain. The most significant byte in the node port (N_port) identifier for the fibre-channel (FC) device. It is not used in the Fibre Channel-small computer system interface (FC-SCSI) hardware path ID. It is required to be the same for all SCSI targets logically connected to an FC adapter.

drive channels. The DS4200, DS4700, and DS4800 subsystems use dual-port drive channels that, from the physical point of view, are connected in the same way as two drive loops. However, from the point of view of the number of drives and enclosures, they are treated as a single drive loop instead of two different drive loops. A group of storage expansion enclosures are connected to the DS4000 storage subsystems using a drive channel from each controller. This pair of drive channels is referred to as a redundant drive channel pair.

drive loops. A drive loop consists of one channel from each controller combined to form one pair of redundant drive channels or a redundant drive loop. Each drive loop is associated with two ports. (There are two drive channels and four associated ports per controller.) For the DS4800, drive loops are more commonly referred to as drive channels. See *drive channels*.

DRAM. See *dynamic random access memory*.

Dynamic Host Configuration Protocol (DHCP). A protocol defined by the Internet Engineering Task Force that is used for dynamically assigning Internet Protocol (IP) addresses to computers in a network.

dynamic random access memory (DRAM). A storage in which the cells require repetitive application of control signals to retain stored data.

ECC. See *error correction coding*.

EEPROM. See *electrically erasable programmable read-only memory*.

EISA. See *Extended Industry Standard Architecture*.

electrically erasable programmable read-only memory (EEPROM). A type of memory chip which can retain its contents without consistent electrical power. Unlike the PROM which can be programmed only once, the EEPROM can be erased electrically. Because it can only be reprogrammed a limited number of times before it wears out, it is appropriate for storing small amounts of data that are changed infrequently.

electrostatic discharge (ESD). The flow of current that results when objects that have a static charge come into close enough proximity to discharge.

environmental service module (ESM) canister. A component in a storage expansion enclosure that monitors the environmental condition of the components in that enclosure. Not all storage subsystems have ESM canisters.

E_port. See *expansion port*.

error correction coding (ECC). A method for encoding data so that transmission errors can be detected and corrected by examining the data on the

receiving end. Most ECCs are characterized by the maximum number of errors they can detect and correct.

ESD. See *electrostatic discharge*.

ESM canister. See *environmental service module canister*.

automatic ESM firmware synchronization. When you install a new ESM into an existing storage expansion enclosure in a DS4000 storage subsystem that supports automatic ESM firmware synchronization, the firmware in the new ESM is automatically synchronized with the firmware in the existing ESM.

EXP. See *storage expansion enclosure*.

expansion port (E_port). A port that connects the switches for two fabrics.

Extended Industry Standard Architecture (EISA). A bus standard for IBM compatibles that extends the Industry Standard Architecture (ISA) bus architecture to 32 bits and allows more than one central processing unit (CPU) to share the bus. See also *Industry Standard Architecture*.

fabric. A Fibre Channel entity which interconnects and facilitates logins of N_ports attached to it. The fabric is responsible for routing frames between source and destination N_ports using address information in the frame header. A fabric can be as simple as a point-to-point channel between two N_ports, or as complex as a frame-routing switch that provides multiple and redundant internal pathways within the fabric between F_ports.

fabric port (F_port). In a fabric, an access point for connecting a user's N_port. An F_port facilitates N_port logins to the fabric from nodes connected to the fabric. An F_port is addressable by the N_port connected to it. See also *fabric*.

FC. See *Fibre Channel*.

FC-AL. See *arbitrated loop*.

feature enable identifier. A unique identifier for the storage subsystem, which is used in the process of generating a premium feature key. See also *premium feature key*.

Fibre Channel (FC). A set of standards for a serial input/output (I/O) bus capable of transferring data between two ports at up to 100 Mbps, with standards proposals to go to higher speeds. FC supports point-to-point, arbitrated loop, and switched topologies.

Fibre Channel-Arbitrated Loop (FC-AL). See *arbitrated loop*.

Fibre Channel Protocol (FCP) for small computer system interface (SCSI). A high-level fibre-channel mapping layer (FC-4) that uses lower-level fibre-channel

(FC-PH) services to transmit SCSI commands, data, and status information between a SCSI initiator and a SCSI target across the FC link by using FC frame and sequence formats.

field replaceable unit (FRU). An assembly that is replaced in its entirety when any one of its components fails. In some cases, a field replaceable unit might contain other field replaceable units. Contrast with *customer replaceable unit (CRU)*.

FlashCopy®. A premium feature for DS4000 that can make an instantaneous copy of the data in a volume.

F_port. See *fabric port*.

FRU. See *field replaceable unit*.

GBIC. See *gigabit interface converter*

gigabit interface converter (GBIC). A transceiver that performs serial, optical-to-electrical, and electrical-to-optical signal conversions for high-speed networking. A GBIC can be hot swapped. See also *small form-factor pluggable*.

Global Copy. Refers to a remote logical drive mirror pair that is set up using asynchronous write mode without the write consistency group option. This is also referred to as "Asynchronous Mirroring without Consistency Group." Global Copy does not ensure that write requests to multiple primary logical drives are carried out in the same order on the secondary logical drives as they are on the primary logical drives. If it is critical that writes to the primary logical drives are carried out in the same order in the appropriate secondary logical drives, Global Mirroring should be used instead of Global Copy. See also *asynchronous write mode*, *Global Mirroring*, *remote mirroring*, *Metro Mirroring*.

Global Mirroring. Refers to a remote logical drive mirror pair that is set up using asynchronous write mode with the write consistency group option. This is also referred to as "Asynchronous Mirroring with Consistency Group." Global Mirroring ensures that write requests to multiple primary logical drives are carried out in the same order on the secondary logical drives as they are on the primary logical drives, preventing data on the secondary logical drives from becoming inconsistent with the data on the primary logical drives. See also *asynchronous write mode*, *Global Copy*, *remote mirroring*, *Metro Mirroring*.

graphical user interface (GUI). A type of computer interface that presents a visual metaphor of a real-world scene, often of a desktop, by combining high-resolution graphics, pointing devices, menu bars and other menus, overlapping windows, icons, and the object-action relationship.

GUI. See *graphical user interface*.

HBA. See *host bus adapter*.

hdisk. An AIX term representing a logical unit number (LUN) on an array.

heterogeneous host environment. A host system in which multiple host servers, which use different operating systems with their own unique disk storage subsystem settings, connect to the same DS4000 storage subsystem at the same time. See also *host*.

host. A system that is directly attached to the storage subsystem through a fibre-channel input/output (I/O) path. This system is used to serve data (typically in the form of files) from the storage subsystem. A system can be both a storage management station and a host simultaneously.

host bus adapter (HBA). An interface between the fibre-channel network and a workstation or server.

host computer. See *host*.

host group. An entity in the storage partition topology that defines a logical collection of host computers that require shared access to one or more logical drives.

host port. Ports that physically reside on the host adapters and are automatically discovered by the DS4000 Storage Manager software. To give a host computer access to a partition, its associated host ports must be defined.

hot swap. To replace a hardware component without turning off the system.

hub. In a network, a point at which circuits are either connected or switched. For example, in a star network, the hub is the central node; in a star/ring network, it is the location of wiring concentrators.

IBMSAN driver. The device driver that is used in a Novell NetWare environment to provide multipath input/output (I/O) support to the storage controller.

IC. See *integrated circuit*.

IDE. See *integrated drive electronics*.

in-band. Transmission of management protocol over the fibre-channel transport.

Industry Standard Architecture (ISA). Unofficial name for the bus architecture of the IBM PC/XT personal computer. This bus design included expansion slots for plugging in various adapter boards. Early versions had an 8-bit data path, later expanded to 16 bits. The "Extended Industry Standard Architecture" (EISA) further expanded the data path to 32 bits. See also *Extended Industry Standard Architecture*.

initial program load (IPL). The initialization procedure that causes an operating system to commence operation. Also referred to as a system restart, system startup, and boot.

integrated circuit (IC). A microelectronic semiconductor device that consists of many interconnected transistors and other components. ICs are constructed on a small rectangle cut from a silicon crystal or other semiconductor material. The small size of these circuits allows high speed, low power dissipation, and reduced manufacturing cost compared with board-level integration. Also known as a *chip*.

integrated drive electronics (IDE). A disk drive interface based on the 16-bit IBM personal computer Industry Standard Architecture (ISA) in which the controller electronics reside on the drive itself, eliminating the need for a separate adapter card. Also known as an Advanced Technology Attachment Interface (ATA).

Internet Protocol (IP). A protocol that routes data through a network or interconnected networks. IP acts as an intermediary between the higher protocol layers and the physical network.

Internet Protocol (IP) address. The unique 32-bit address that specifies the location of each device or workstation on the Internet. For example, 9.67.97.103 is an IP address.

interrupt request (IRQ). A type of input found on many processors that causes the processor to suspend normal processing temporarily and start running an interrupt handler routine. Some processors have several interrupt request inputs that allow different priority interrupts.

IP. See *Internet Protocol*.

IPL. See *initial program load*.

IRQ. See *interrupt request*.

ISA. See *Industry Standard Architecture*.

Java Runtime Environment (JRE). A subset of the Java Development Kit (JDK) for end users and developers who want to redistribute the Java Runtime Environment (JRE). The JRE consists of the Java virtual machine, the Java Core Classes, and supporting files.

JRE. See *Java Runtime Environment*.

label. A discovered or user entered property value that is displayed underneath each device in the Physical and Data Path maps.

LAN. See *local area network*.

LBA. See *logical block address*.

local area network (LAN). A computer network located on a user's premises within a limited geographic area.

logical block address (LBA). The address of a logical block. Logical block addresses are typically used in hosts' I/O commands. The SCSI disk command protocol, for example, uses logical block addresses.

logical partition (LPAR). (1) A subset of a single system that contains resources (processors, memory, and input/output devices). A logical partition operates as an independent system. If hardware requirements are met, multiple logical partitions can exist within a system. (2) A fixed-size portion of a logical volume. A logical partition is the same size as the physical partitions in its volume group. Unless the logical volume of which it is a part is mirrored, each logical partition corresponds to, and its contents are stored on, a single physical partition. (3) One to three physical partitions (copies). The number of logical partitions within a logical volume is variable.

logical unit number (LUN). An identifier used on a small computer system interface (SCSI) bus to distinguish among up to eight devices (logical units) with the same SCSI ID.

loop address. The unique ID of a node in fibre-channel loop topology sometimes referred to as a loop ID.

loop group. A collection of storage area network (SAN) devices that are interconnected serially in a single loop circuit.

loop port. A node port (N_port) or fabric port (F_port) that supports arbitrated loop functions associated with an arbitrated loop topology.

LPAR. See *logical partition*.

LUN. See *logical unit number*.

MAC. See *medium access control*.

management information base (MIB). The information that is on an agent. It is an abstraction of configuration and status information.

man pages. In UNIX-based operating systems, online documentation for operating system commands, subroutines, system calls, file formats, special files, stand-alone utilities, and miscellaneous facilities. Invoked by the **man** command.

MCA. See *micro channel architecture*.

media scan. A media scan is a background process that runs on all logical drives in the storage subsystem for which it has been enabled, providing error detection on the drive media. The media scan process scans all

logical drive data to verify that it can be accessed, and optionally scans the logical drive redundancy information.

medium access control (MAC). In local area networks (LANs), the sublayer of the data link control layer that supports medium-dependent functions and uses the services of the physical layer to provide services to the logical link control sublayer. The MAC sublayer includes the method of determining when a device has access to the transmission medium.

Metro Mirroring. This term is used to refer to a remote logical drive mirror pair which is set up with synchronous write mode. See also *remote mirroring*, *Global Mirroring*.

MIB. See *management information base*.

micro channel architecture (MCA). Hardware that is used for PS/2 Model 50 computers and above to provide better growth potential and performance characteristics when compared with the original personal computer design.

Microsoft Cluster Server (MSCS). MSCS, a feature of Windows NT® Server (Enterprise Edition), supports the connection of two servers into a cluster for higher availability and easier manageability. MSCS can automatically detect and recover from server or application failures. It can also be used to balance server workload and provide for planned maintenance.

mini hub. An interface card or port device that receives short-wave fiber channel GBICs or SFPs. These devices enable redundant Fibre Channel connections from the host computers, either directly or through a Fibre Channel switch or managed hub, over optical fiber cables to the DS4000 Storage Server controllers. Each DS4000 controller is responsible for two mini hubs. Each mini hub has two ports. Four host ports (two on each controller) provide a cluster solution without use of a switch. Two host-side mini hubs are shipped as standard. See also *host port*, *gigabit interface converter (GBIC)*, *small form-factor pluggable (SFP)*.

mirroring. A fault-tolerance technique in which information on a hard disk is duplicated on additional hard disks. See also *remote mirroring*.

model. The model identification that is assigned to a device by its manufacturer.

MSCS. See *Microsoft Cluster Server*.

network management station (NMS). In the Simple Network Management Protocol (SNMP), a station that runs management application programs that monitor and control network elements.

NMI. See *non-maskable interrupt*.

NMS. See *network management station*.

non-maskable interrupt (NMI). A hardware interrupt that another service request cannot overrule (mask). An NMI bypasses and takes priority over interrupt requests generated by software, the keyboard, and other such devices and is issued to the microprocessor only in disastrous circumstances, such as severe memory errors or impending power failures.

node. A physical device that allows for the transmission of data within a network.

node port (N_port). A fibre-channel defined hardware entity that performs data communications over the fibre-channel link. It is identifiable by a unique worldwide name. It can act as an originator or a responder.

nonvolatile storage (NVS). A storage device whose contents are not lost when power is cut off.

N_port. See *node port*.

NVS. See *nonvolatile storage*.

NVSRAM. Nonvolatile storage random access memory. See *nonvolatile storage*.

Object Data Manager (ODM). An AIX proprietary storage mechanism for ASCII stanza files that are edited as part of configuring a drive into the kernel.

ODM. See *Object Data Manager*.

out-of-band. Transmission of management protocols outside of the fibre-channel network, typically over Ethernet.

partitioning. See *storage partition*.

parity check. (1) A test to determine whether the number of ones (or zeros) in an array of binary digits is odd or even. (2) A mathematical operation on the numerical representation of the information communicated between two pieces. For example, if parity is odd, any character represented by an even number has a bit added to it, making it odd, and an information receiver checks that each unit of information has an odd value.

PCI local bus. See *peripheral component interconnect local bus*.

PDF. See *portable document format*.

performance events. Events related to thresholds set on storage area network (SAN) performance.

peripheral component interconnect local bus (PCI local bus). A local bus for PCs, from Intel, that provides a high-speed data path between the CPU and up to 10 peripherals (video, disk, network, and so on). The PCI bus coexists in the PC with the Industry Standard Architecture (ISA) or Extended Industry

Standard Architecture (EISA) bus. ISA and EISA boards plug into an IA or EISA slot, while high-speed PCI controllers plug into a PCI slot. See also *Industry Standard Architecture, Extended Industry Standard Architecture*.

polling delay. The time in seconds between successive discovery processes during which discovery is inactive.

port. A part of the system unit or remote controller to which cables for external devices (such as display stations, terminals, printers, switches, or external storage units) are attached. The port is an access point for data entry or exit. A device can contain one or more ports.

portable document format (PDF). A standard specified by Adobe Systems, Incorporated, for the electronic distribution of documents. PDF files are compact; can be distributed globally by e-mail, the Web, intranets, or CD-ROM; and can be viewed with the Acrobat Reader, which is software from Adobe Systems that can be downloaded at no cost from the Adobe Systems home page.

premium feature key. A file that the storage subsystem controller uses to enable an authorized premium feature. The file contains the feature enable identifier of the storage subsystem for which the premium feature is authorized, and data about the premium feature. See also *feature enable identifier*.

private loop. A freestanding arbitrated loop with no fabric attachment. See also *arbitrated loop*.

program temporary fix (PTF). A temporary solution or bypass of a problem diagnosed by IBM in a current unaltered release of the program.

PTF. See *program temporary fix*.

RAID. See *redundant array of independent disks (RAID)*.

RAID level. An array's RAID level is a number that refers to the method used to achieve redundancy and fault tolerance in the array. See also *array, redundant array of independent disks (RAID)*.

RAID set. See *array*.

RAM. See *random-access memory*.

random-access memory (RAM). A temporary storage location in which the central processing unit (CPU) stores and executes its processes. Contrast with *DASD*.

RDAC. See *redundant disk array controller*.

read-only memory (ROM). Memory in which stored data cannot be changed by the user except under special conditions.

recoverable virtual shared disk (RVSD). A virtual shared disk on a server node configured to provide continuous access to data and file systems in a cluster.

redundant array of independent disks (RAID). A collection of disk drives (*array*) that appears as a single volume to the server, which is fault tolerant through an assigned method of data striping, mirroring, or parity checking. Each array is assigned a RAID level, which is a specific number that refers to the method used to achieve redundancy and fault tolerance. See also *array, parity check, mirroring, RAID level, striping*.

redundant disk array controller (RDAC). (1) In hardware, a redundant set of controllers (either active/passive or active/active). (2) In software, a layer that manages the input/output (I/O) through the active controller during normal operation and transparently reroutes I/Os to the other controller in the redundant set if a controller or I/O path fails.

remote mirroring. Online, real-time replication of data between storage subsystems that are maintained on separate media. The Enhanced Remote Mirror Option is a DS4000 premium feature that provides support for remote mirroring. See also *Global Mirroring, Metro Mirroring*.

ROM. See *read-only memory*.

router. A computer that determines the path of network traffic flow. The path selection is made from several paths based on information obtained from specific protocols, algorithms that attempt to identify the shortest or best path, and other criteria such as metrics or protocol-specific destination addresses.

RVSD. See *recoverable virtual shared disk*.

SAI. See *Storage Array Identifier*.

SA Identifier. See *Storage Array Identifier*.

SAN. See *storage area network*.

SATA. See *serial ATA*.

scope. Defines a group of controllers by their Internet Protocol (IP) addresses. A scope must be created and defined so that dynamic IP addresses can be assigned to controllers on the network.

SCSI. See *small computer system interface*.

segmented loop port (SL_port). A port that allows division of a fibre-channel private loop into multiple segments. Each segment can pass frames around as an independent loop and can connect through the fabric to other segments of the same loop.

sense data. (1) Data sent with a negative response, indicating the reason for the response. (2) Data describing an I/O error. Sense data is presented to a host system in response to a sense request command.

serial ATA. The standard for a high-speed alternative to small computer system interface (SCSI) hard drives. The SATA-1 standard is equivalent in performance to a 10 000 RPM SCSI drive.

serial storage architecture (SSA). An interface specification from IBM in which devices are arranged in a ring topology. SSA, which is compatible with small computer system interface (SCSI) devices, allows full-duplex packet multiplexed serial data transfers at rates of 20 Mbps in each direction.

server. A functional hardware and software unit that delivers shared resources to workstation client units on a computer network.

server/device events. Events that occur on the server or a designated device that meet criteria that the user sets.

SFP. See *small form-factor pluggable*.

Simple Network Management Protocol (SNMP). In the Internet suite of protocols, a network management protocol that is used to monitor routers and attached networks. SNMP is an application layer protocol. Information on devices managed is defined and stored in the application's Management Information Base (MIB).

SL_port. See *segmented loop port*.

SMagent. The DS4000 Storage Manager optional Java-based host-agent software, which can be used on Microsoft Windows, Novell NetWare, AIX, HP-UX, Solaris, and Linux on POWER host systems to manage storage subsystems through the host fibre-channel connection.

SMclient. The DS4000 Storage Manager client software, which is a Java-based graphical user interface (GUI) that is used to configure, manage, and troubleshoot storage servers and storage expansion enclosures in a DS4000 storage subsystem. SMclient can be used on a host system or on a storage management station.

SMruntime. A Java compiler for the SMclient.

SMutil. The DS4000 Storage Manager utility software that is used on Microsoft Windows, AIX, HP-UX, Solaris, and Linux on POWER host systems to register and map new logical drives to the operating system. In Microsoft Windows, it also contains a utility to flush the cached data of the operating system for a particular drive before creating a FlashCopy.

small computer system interface (SCSI). A standard hardware interface that enables a variety of peripheral devices to communicate with one another.

small form-factor pluggable (SFP). An optical transceiver that is used to convert signals between

optical fiber cables and switches. An SFP is smaller than a gigabit interface converter (GBIC). See also *gigabit interface converter*.

SNMP. See *Simple Network Management Protocol and SNMPv1*.

SNMP trap event. (1) (2) An event notification sent by the SNMP agent that identifies conditions, such as thresholds, that exceed a predetermined value. See also *Simple Network Management Protocol*.

SNMPv1. The original standard for SNMP is now referred to as SNMPv1, as opposed to SNMPv2, a revision of SNMP. See also *Simple Network Management Protocol*.

SRAM. See *static random access memory*.

SSA. See *serial storage architecture*.

static random access memory (SRAM). Random access memory based on the logic circuit known as flip-flop. It is called static because it retains a value as long as power is supplied, unlike dynamic random access memory (DRAM), which must be regularly refreshed. It is however, still volatile, meaning that it can lose its contents when the power is turned off.

storage area network (SAN). A dedicated storage network tailored to a specific environment, combining servers, storage products, networking products, software, and services. See also *fabric*.

Storage Array Identifier (SAI or SA Identifier). The Storage Array Identifier is the identification value used by the DS4000 Storage Manager host software (SMClient) to uniquely identify each managed storage server. The DS4000 Storage Manager SMClient program maintains Storage Array Identifier records of previously-discovered storage servers in the host resident file, which allows it to retain discovery information in a persistent fashion.

storage expansion enclosure (EXP). A feature that can be connected to a system unit to provide additional storage and processing capacity.

storage management station. A system that is used to manage the storage subsystem. A storage management station does not need to be attached to the storage subsystem through the fibre-channel input/output (I/O) path.

storage partition. Storage subsystem logical drives that are visible to a host computer or are shared among host computers that are part of a host group.

storage partition topology. In the DS4000 Storage Manager client, the Topology view of the Mappings window displays the default host group, the defined host group, the host computer, and host-port nodes. The host port, host computer, and host group topological

elements must be defined to grant access to host computers and host groups using logical drive-to-LUN mappings.

striping. Splitting data to be written into equal blocks and writing blocks simultaneously to separate disk drives. Striping maximizes performance to the disks. Reading the data back is also scheduled in parallel, with a block being read concurrently from each disk then reassembled at the host.

subnet. An interconnected but independent segment of a network that is identified by its Internet Protocol (IP) address.

sweep method. A method of sending Simple Network Management Protocol (SNMP) requests for information to all the devices on a subnet by sending the request to every device in the network.

switch. A fibre-channel device that provides full bandwidth per port and high-speed routing of data by using link-level addressing.

switch group. A switch and the collection of devices connected to it that are not in other groups.

switch zoning. See *zoning*.

synchronous write mode. In remote mirroring, an option that requires the primary controller to wait for the acknowledgment of a write operation from the secondary controller before returning a write I/O request completion to the host. See also *asynchronous write mode*, *remote mirroring*, *Metro Mirroring*.

system name. Device name assigned by the vendor's third-party software.

TCP. See *Transmission Control Protocol*.

TCP/IP. See *Transmission Control Protocol/Internet Protocol*.

terminate and stay resident program (TSR program). A program that installs part of itself as an extension of DOS when it is executed.

topology. The physical or logical arrangement of devices on a network. The three fibre-channel topologies are fabric, arbitrated loop, and point-to-point. The default topology for the disk array is arbitrated loop.

TL_port. See *translated loop port*.

transceiver. A device that is used to transmit and receive data. Transceiver is an abbreviation of transmitter-receiver.

translated loop port (TL_port). A port that connects to a private loop and allows connectivity between the private loop devices and off loop devices (devices not connected to that particular TL_port).

Transmission Control Protocol (TCP). A communication protocol used in the Internet and in any network that follows the Internet Engineering Task Force (IETF) standards for internetwork protocol. TCP provides a reliable host-to-host protocol between hosts in packed-switched communication networks and in interconnected systems of such networks. It uses the Internet Protocol (IP) as the underlying protocol.

Transmission Control Protocol/Internet Protocol (TCP/IP). A set of communication protocols that provide peer-to-peer connectivity functions for both local and wide-area networks.

trap. In the Simple Network Management Protocol (SNMP), a message sent by a managed node (agent function) to a management station to report an exception condition.

trap recipient. Receiver of a forwarded Simple Network Management Protocol (SNMP) trap. Specifically, a trap receiver is defined by an Internet Protocol (IP) address and port to which traps are sent. Presumably, the actual recipient is a software application running at the IP address and listening to the port.

TSR program. See *terminate and stay resident program*.

uninterruptible power supply. A source of power from a battery that is installed between a computer system and its power source. The uninterruptible power supply keeps the system running if a commercial power failure occurs, until an orderly shutdown of the system can be performed.

user action events. Actions that the user takes, such as changes in the storage area network (SAN), changed settings, and so on.

worldwide port name (WWPN). A unique identifier for a switch on local and global networks.

worldwide name (WWN). A globally unique 64-bit identifier assigned to each Fibre Channel port.

WORM. See *write-once read-many*.

write-once read many (WORM). Any type of storage medium to which data can be written only a single time, but can be read from any number of times. After the data is recorded, it cannot be altered.

WWN. See *worldwide name*.

zoning. (1) In Fibre Channel environments, the grouping of multiple ports to form a virtual, private, storage network. Ports that are members of a zone can communicate with each other, but are isolated from ports in other zones. (2) A function that allows segmentation of nodes by address, name, or physical port and is provided by fabric switches or hubs.



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