USER'S GUIDE

MegaRAID® 1078-based SAS RAID Controllers

September 2007

80-00157-01 Rev. B

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Preface

This document is the primary reference and user's guide for the LSI MegaRAID® Serial Attached SCSI/SATA II RAID Controllers based on the LSISAS1078, which is a SAS/SATA RAID On-a-Chip device. It contains complete installation instructions for these RAID controllers and includes specifications for them.

The MegaRAID 1078-based Serial Attached SCSI (SAS) RAID controller family consists of the following controllers:

- MegaRAID SAS 8704ELP PCI Express Low-Profile Serial-Attached SCSI/SATA II Disk Array Controller with Internal Connectors
- MegaRAID SAS 8708ELP PCI Express Low-Profile Serial-Attached SCSI/SATA II Disk Array Controller with Internal Connectors
- MegaRAID SAS 8708EM2 PCI Express Serial-Attached SCSI/SATA II Disk Array Controller with Internal Connectors
- MegaRAID SAS 8880EM2 PCI Express Serial-Attached SCSI/SATA II Disk Array Controller with External Connectors
- MegaRAID SAS 8888ELP PCI Express Low-Profile Serial-Attached SCSI/SATA II Disk Array Controller with External Connectors and Internal Connectors

For details on how to configure the RAID controllers, refer to the *MegaRAID SAS Software User's Guide*. For information about the operating system drivers, refer to the *MegaRAID SAS Device Driver Installation User's Guide*.

Audience

This document assumes that you have some familiarity with RAID controllers and related support devices. The people who benefit from this book are:

- Engineers who are designing a system that will include a MegaRAID 1078-based SAS RAID controller
- Anyone who is installing a MegaRAID 1078-based SAS RAID controller in a RAID system

Organization

This document contains the following chapters and appendix:

- Chapter 1, **Overview**, provides an overview of the MegaRAID 1078-based SAS RAID controllers.
- Chapter 2, **MegaRAID SAS Hardware Installation**, describes the procedures for installing the MegaRAID 1078-based SAS RAID controllers.
- Chapter 3, **MegaRAID SAS RAID Controller Characteristics**, provides the characteristics and technical specifications for the MegaRAID 1078-based SAS RAID controllers.
- Appendix A, **Glossary of Terms and Abbreviations**, lists and defines the terms and abbreviations used in this document.

Related Publications

MegaRAID SAS Device Driver Installation User's Guide

Document Number: *80-00163-01 Rev. B*

This document describes how to install the MegaRAID device driver for your operating system. The information in this document is independent of the back-end bus and applies to the MegaRAID SAS RAID controllers.

MegaRAID SAS Software User's Guide

Document Number: 80-00156-01 Rev. C

This document describes how to use the MegaRAID Storage Manager, WebBIOS, and command line interface (CLI) utilities to configure, monitor, and maintain MegaRAID SAS RAID controllers and the storage-related devices connected to them.

Intelligent Battery Backup Units for 1078-based MegaRAID Products User's Guide

Document Number: 80-00162-01 Rev. B

This document describes how to install and use the LSI battery backup units for MegaRAID 1078-based SAS RAID controllers. The 1078-based SAS boards use the LSI intelligent Battery Backup Unit 01 (LSIiBBU01), LSI intelligent Battery Backup Unit 05 (LSIiBBU05), LSI intelligent Battery Backup Unit 06 (LSIiBBU06), LSI intelligent Battery Backup Unit 07 (LSIiBBU07), and the LSI intelligent Transportable Battery Backup Unit 03 (LSIiTBBU03).

Conventions

The following table describes how the user interacts with the product::

Notation	Example	Meaning and Use
Courier typeface	`.nwk` file	Names of commands, files, and directories, as well as code and screen messages, are shown in Courier.
Bold typeface	**fd1sp**	In a command line, keywords are shown in bold, non-italic typeface. Enter them exactly as shown.
Italics	*module*	In command lines and names, italics indicate user variables. Replace italicized text with appropriate user-specified items. Enter items of the type called for, using lowercase.
Initial capital letters	Undo Edit Apply	Names of menu commands, options, check buttons, text buttons, options buttons, text boxes, list boxes, and so on., are shown in text with Initial Capital lettering to avoid misreading. These elements might appear on your screen in all lowercase.
Semicolon, and other punctuation		Use as shown in the text.

Note: Notes contain supplementary information that can affect system performance.

Caution: Cautions are notifications that an action has the potential to adversely affect equipment operation, system performance, or data integrity.

Revision History

Document Number	Date/Version	Remarks
80-00157-01 Rev. B	September 2007	Added the SAS 8708EM2 RAID controller, and the SAS 8880EM2 RAID controller
80-00157-01 Rev. A	February 2007	Initial release of the document.

Safety Instructions

Use the following safety guidelines to help protect your computer system from potential damage and to ensure your own personal safety.

Note: Use the MegaRAID 1078-based SAS RAID controllers with UL-listed Information Technology Equipment (ITE) products only.

When Using Your Computer System – As you use your computer system, observe the following safety guidelines:

Caution: Do not operate your computer system with any covers (such as computer covers, bezels, filler brackets, and front-panel inserts) removed.

- To avoid damaging your computer, make sure that the voltage selection switch on the power supply is set to match the alternating current (AC) power available at your location:
  - 115 volts (V)/60 hertz (Hz) in most of North American and South American countries, and some Far Eastern countries, such as Japan, South Korea, and Taiwan.
  - 230 V/50 Hz in most of Europe, the Middle East, and the Far East. Also make sure that your monitor and attached peripherals are electrically rated to operate with the AC power available in your location.
- To avoid possible damage to the system board, wait 5 seconds after you turn off the system before you remove a component from the system board or disconnect a peripheral device from the computer.

- To prevent electric shock, connect the computer and peripheral power cords into correctly grounded power sources. These cords are equipped with three-prong plugs to ensure correct grounding.
- Do not use adapter plugs or remove the grounding prong from a cable. If you must use an extension cable, use a three-wire cable with correctly grounded plugs.
- To protect your computer system from sudden, transient increases and decreases in electrical power, use a surge suppressor, line conditioner, or uninterruptible power supply (UPS).
- Make sure that equipment does not rest on your computer system cables and that the cables are not located where they can be stepped on or tripped over.
- Do not spill food or liquids on your computer. If the computer gets wet, consult the documentation that came with it.
- Do not push any objects into the openings of your computer. Doing so can cause fire or electric shock by shorting out interior components.
- Keep your computer away from radiators and heat sources. Also, do not block cooling vents. Avoid placing loose papers underneath your computer; do not place your computer in a closed-in wall unit or on a rug.

When Working Inside Your Computer –

Caution: Do not attempt to service the computer system yourself, except as explained in this document and elsewhere in LSI Logic documentation. Always follow installation and service instructions closely.

1. Turn off your computer and any peripherals.
2. Disconnect your computer and peripherals from their power sources. Also disconnect any telephone or telecommunications lines from the computer.

   Performing these actions reduces the potential for personal injury or shock.

Also note these safety guidelines:

- When you disconnect a cable, pull on its connector or on its strain-relief loop, not on the cable itself. Some cables have a

connector with locking tabs. If you are disconnecting this type of cable, press in on the locking tabs before you disconnect the cable. As you pull connectors apart, keep them evenly aligned to avoid bending any connector pins. Also, before you connect a cable, make sure that both connectors are correctly oriented and aligned.

- Handle components and cards with care. Do not touch the components or contacts on a card. Hold a card by its edges or by its metal mounting bracket. Hold a component, such as a microprocessor chip, by its edges, not by its pins.

Protecting Against Electrostatic Discharge – Static electricity can harm delicate components inside your computer. To prevent static damage, discharge static electricity from your body before you touch any of your computer's electronic components, such as the microprocessor. To discharge static electricity, touch an unpainted metal surface, such as the metal around the card-slot openings at the back of the computer.

As you continue to work inside the computer, periodically touch an unpainted metal surface to remove any static charge your body may have accumulated. In addition to the preceding precautions, you can also take the following steps to prevent damage from electrostatic discharge:

- When unpacking a static-sensitive component from its shipping carton, do not remove the component from the antistatic packing material until you are ready to install the component in your computer. Just before unwrapping the antistatic packaging, be sure to discharge static electricity from your body.
- When transporting a sensitive component, first place it in an antistatic container or packaging.
- Handle all sensitive components in a static-safe area. If possible, use antistatic floor pads and workbench pads.

Contents

Figures

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Chapter 1
Overview

This chapter provides an overview of the MegaRAID 1078-based Serial Attached SCSI/Serial ATA II controllers with RAID control capabilities. It consists of the following sections:

1.1 Overview

The MegaRAID 1078-based SAS RAID controllers are high-performance intelligent PCI Express-to-SCSI/Serial ATA II adapters with RAID control capabilities. MegaRAID 1078-based SAS RAID controllers provide reliability, high performance, and fault-tolerant disk subsystem management. They are an ideal RAID solution for the internal storage of workgroup, departmental, and enterprise systems. MegaRAID 1078-based SAS RAID controllers offer a cost-effective way to implement RAID in a server.

SAS technology brings a wealth of options and flexibility with the use of SAS and Serial ATA (SATA) II devices within the same storage infrastructure. However, SAS and SATA devices bring individual characteristics that make each one a more suitable choice depending on your storage needs. MegaRAID gives you the flexibility to combine these

two similar technologies on the same controller, within the same enclosure, and in the same virtual disk.

Note: LSI recommends that you carefully assess any decision to mix SAS and SATA drives within the same *virtual disks*. Although you can mix drives, LSI strongly discourages the practice.

The MegaRAID 1078-based SAS RAID controllers are based on the LSI first-to-market SAS IC technology and proven MegaRAID technology. As second-generation PCI Express RAID controllers, the MegaRAID SAS RAID controllers address the growing demand for increased data throughput and scalability requirements across midrange and enterprise-class server platforms. LSI offers a family of MegaRAID SAS RAID controllers addressing the needs for both internal and external solutions.

The following battery backup units provide cached data protection and allow system builders to protect cached data even during the most catastrophic system failures:

- LSI intelligent Battery Backup Unit 01 (LSIiBBU-01)
- LSI intelligent Battery Backup Unit 05 (LSIiBBU-05)
- LSI intelligent Battery Backup Unit 06 (LSIiBBU-06)
- LSI intelligent Battery Backup Unit 07 (LSIiBBU-07)
- LSI intelligent Transportable Battery Backup Unit 03 (LSIiTBBU-03)

Refer to the *MegaRAID Battery Backup Unit User's Guide* on the *MegaRAID Universal Software Suite* CD for more information about these batteries.

The SAS controllers support the ANSI *Serial Attached SCSI standard, version 1.1*. In addition, the controller supports the SATA II protocol defined by the *Serial ATA specification, version 1.0a*. Supporting both the SAS and SATA II interfaces, the SAS controller is a versatile controller that provides the backbone of both server and high-end workstation environments.

Each port on the SAS RAID controller supports SAS devices, SATA II devices, or both, using the following protocols:

- SAS Serial SCSI Protocol (SSP), which enables communication with other SAS devices

- SATA II, which enables communication with other SATA II devices
- Serial Management Protocol (SMP), which communicates topology management information directly with an attached SAS expander device
- Serial Tunneling Protocol (STP), which enables communication with a SATA II device through an attached expander

1.2 SAS Controller Descriptions

The 1078-based SAS RAID controllers are described as follows:

- The MegaRAID SAS 8704ELP PCI Express 1078-based Low-Profile Serial-Attached SCSI/SATA II Disk Array Controller controls four internal SAS/SATA ports through one Mini SAS 4i internal connector.
- The MegaRAID SAS 8708ELP PCI Express 1078-based Low-Profile Serial-Attached SCSI/SATA II Disk Array Controller controls eight internal SAS/SATA ports through two Mini SAS 4i internal connectors
- The MegaRAID SAS 8708EM2 PCI Express 1078-based Serial-Attached SCSI/SATA II Disk Array Controller controls eight internal SAS/SATA ports through two SFF-8087 Mini SAS 4i internal connectors
- The MegaRAID SAS 8880EM2 PCI Express 1078-based Serial-Attached SCSI/SATA II Disk Array Controller controls eight external SAS/SATA ports through two SFF-8088 Mini SAS 4x external connectors
- The MegaRAID SAS 8888ELP PCI Express 1078-based Low-Profile Disk Array RAID Controller has one I/O processor. This processor controls eight ports through two (x4 SAS Port) SFF-8088 Mini SAS 4x external connectors and two (x4 SAS Port) SFF-8087 Mini SAS 4i internal connectors, configurable through a SAS mux.

1.3 General Description

The MegaRAID 1078-based SAS RAID controllers bring 3.0 Gbit/s Serial Attached SCSI and 3.0 Gbit/s SATA II performance to host adapter, workstation, and server designs. The controllers support internal and

external storage devices, which allow you to use a system that supports enterprise-class SAS drives and desktop-class SATA II drives. Each MegaRAID 1078-based SAS RAID controller can connect to drives directly and can use expanders to connect to additional drives. Simplified cabling between devices is an additional benefit.

These SAS controllers are based on the LSISAS1078 RAID On-a-Chip (ROC) device. This device is compliant with the Fusion-MPT™ architecture and provides a PCI Express x4 or x8 interface.

Note: The MegaRAID SAS 8704ELP RAID controller and the MegaRAID SAS 8704ELP RAID controller provide an x4 PCI Express interface. The MegaRAID SAS 8708EM2, the MegaRAID SAS 8880EM2, and the MegaRAID SAS 8888ELP RAID controllers provide an x8 PCI Express interface.

The LSISAS1078 ROC device provides an eight-lane, 2.5-Gbit/s PCI Express host interface, eight 3.0 Gbit/s SAS or SATA ports, and a full-featured, hardware-based RAID implementation. The LSISAS1078 ROC device integrates a high-speed DDR/DDR2 SDRAM interface with a hardware RAID assist engine for parity calculations. The LSISAS1078 ROC device provides the maximum benefits of a RAID system and enables you to configure the system to satisfy your system requirements.

The LSISAS1078 ROC device increases system performance and provides fault-tolerant data storage. The LSISAS1078 supports data striping across multiple disks, which reduces disk access time because multiple disks simultaneously read or write data. The LSISAS1078 ROC device backs up data with either data mirroring or a parity block. Either backup method enables you to recover lost data in the event of a disk failure. You can select the data backup method that best suits your needs. A hardware RAID assist exclusive-OR (XOR) engine speeds parity generation and checking and reduces system-access times.

The SAS RAID controllers integrate eight high-performance SAS/SATA II PHYs and a PCI Express bus master DMA core. Each of the eight PHYs is capable of 3.0 Gbit/s SAS link rates and 3.0 Gbit/s SATA II link rates.

The LSISAS1078 ROC device adheres to the *PCI Express Specification, Revision 1.0a.* The PCI Express software is backward compatible with previous revisions of the PCI bus and PCI-X bus.

The SAS RAID controllers support the SAS protocol as described in the *Serial Attached SCSI Standard*, *version 1.1*. The controllers also support the Serial ATA II (SATA II) protocol defined by the *Serial ATA Specification, Version 1.0a* and the *Serial ATAII; Extension to the Serial ATA Specification, Version 1.1*. SATA II is an extension to SATA 1.0a. In addition, the SAS RAID controllers support the following SATA II features:

- 3 Gbit/s SATA II
- Staggered spin-up
- Hot plug
- Native command queuing
- Activity and fault indicators for each PHY
- Port selector (for dual-port drives)

Each port on the SAS controllers supports SAS devices, SATA II devices, or both using SSP, SMP, STP, and SATA II. SSP enables communication with other SAS devices. SATA II enables the SAS controllers to communicate with other SATA II devices.

1.4 Configuration Scenarios

There are three main scenarios in which you can use the SAS RAID controllers:

- **Low-end, internal SATA II configurations:** In this configuration, use the RAID controller as a high-end SATA II compatible controller that connects up to eight disks either directly or through a port expander. This configuration is mostly for low-end or entry servers. Enclosure management is provided through out-of-band I^2C bus. Side bands of both types of internal SAS connectors support the SFF-8485 (SGPIO) interface.
- **Midrange internal SAS configurations:** This is like the internal SATA II configurations, but with high-end disks. This is more suitable for low-range to midrange servers.
- **High-end external SAS/SATA II configurations:** This configuration is for both internal and external connectivity, using SATA II drives, SAS drives, or both. External enclosure management is supported

through in-band, SCSI-enclosed storage. The configuration must support STP and SMP.

Figure 1.1 shows a direct-connect configuration. The Inter-IC (I^2C) interface communicates with peripherals. The external memory bus provides a 32-bit memory bus, parity checking, and chip select signals for pipelined synchronous burst static random access memory (PSBRAM), nonvolatile static random access memory (NVSRAM), and Flash ROM.

Note: The external memory bus is 32-bit for the SAS 8704ELP and the SAS 8708ELP, and 64-bit for the SAS 8708EM2, the SAS 8880EM2, and the SAS 8888ELP.

Figure 1.1 Example of an LSI SAS Direct-Connect Application

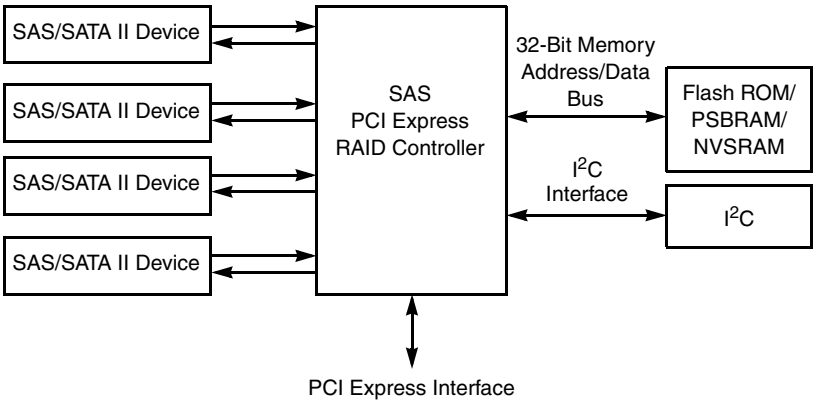
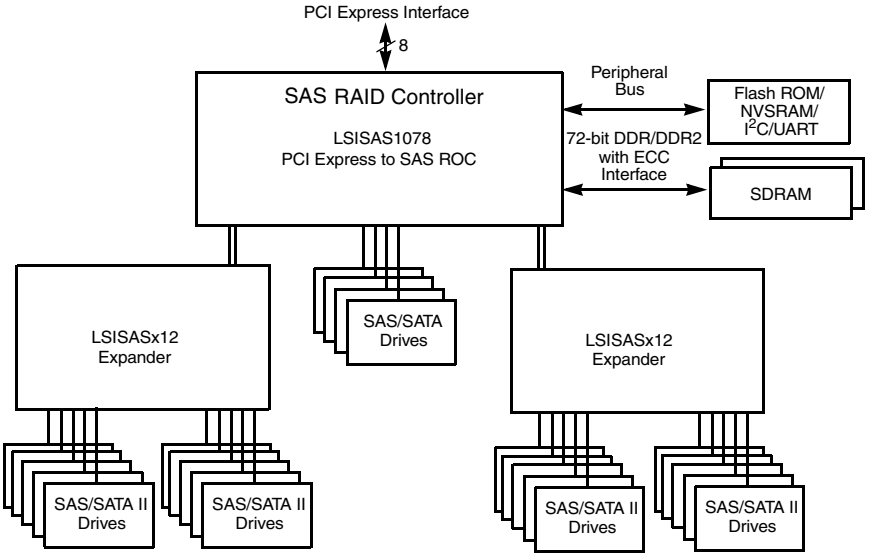


Figure 1.2 shows an example of a SAS RAID controller configured with an LSISASx12 expander that is connected to SAS disks, SATA II disks, or both.

Figure 1.2 Example of an LSI SAS RAID Controller Configured with an LSISASx12 Expander



1.5 Benefits of the SAS Interface

SAS is a serial, point-to-point, enterprise-level device interface that leverages the proven SCSI protocol set. SAS is a convergence of the advantages of SATA II, SCSI, and Fibre Channel, and is the future mainstay of the enterprise and high-end workstation storage markets. SAS offers a higher bandwidth per pin than parallel SCSI, and it improves signal and data integrity.

The SAS interface uses the proven SCSI command set to ensure reliable data transfers, while providing the connectivity and flexibility of point-to-point serial data transfers. The serial transmission of SCSI commands eliminates clock-skew challenges. The SAS interface provides improved performance, simplified cabling, smaller connectors, lower pin count, and lower power requirements when compared to parallel SCSI.

SAS controllers leverage a common electrical and physical connection interface that is compatible with Serial ATA technology. The SAS and SATA II protocols use a thin, 7-wire connector instead of the 68-wire

SCSI cable or 26-wire ATA cable. The SAS/SATA II connector and cable are easier to manipulate, allow connections to smaller devices, and do not inhibit airflow. The point-to-point SATA II architecture eliminates inherent difficulties created by the legacy ATA master-slave architecture, while maintaining compatibility with existing ATA firmware.

1.5.1 PCI Express Architecture

PCI Express is a local bus system designed to increase data transfers without slowing down the central processing unit (CPU). You can install MegaRAID PCI Express RAID controllers in PCI Express computer systems with a standard bracket type. With these adapters in your system, you can connect SCSI and SATA II devices over the bus.

PCI Express goes beyond the PCI specification in that it is intended as a unifying I/O architecture for various systems: desktops, workstations, mobile, server, communications, and embedded devices.

1.5.2 Operating System Support

The MegaRAID 1078-based SAS RAID controllers supports the following operating systems:

- Windows 2000, Windows Server 2003, and Windows XP
- Red Hat Linux
- SUSE Linux
- Novell NetWare
- SCO OpenServer
- SCO UnixWare
- FreeBSD

To download the latest operating system drivers, you can access http://www.lsi.com/cm/DownloadSearch.do.

The MegaRAID 1078-based SAS RAID controllers use Fusion-MPT™ architecture for all major operating systems, thinner drivers, and better performance.

1.6 Summary of SAS RAID Controller Characteristics

This section provides a summary of the features and benefits of the SAS RAID controller. It contains information on SAS features, SATA II features, PCI performance, integration, usability, and flexibility.

The MegaRAID 1078-based SAS RAID controllers include the following features:

- PCI Express x4 lane width for the SAS 8704ELP RAID controller and the SAS 8708ELP RAID controller (with support for x8 and x16 connections)
- PCI Express x8 lane width for the SAS 8708EM2 RAID controller, the SAS 8880EM2 RAID controller, and the SAS 8888ELP RAID controller (with support for x16 connections)
- PCI Express performance up to 2.5 Gbits/s per lane
- Support for 128-, 256-, or 512-Mbyte DDR2 667 MHz on-board SDRAM intelligent battery-backed module (SAS 8704ELP, SAS 8708ELP, and SAS 8880EM2 RAID controllers)
- Support for 128- or 256-Mbyte DDR2 667 MHz on-board SDRAM intelligent battery-backed module (SAS 8708EM2 RAID controller)
- Support for 256- and 512-Mbyte DDR2 667 MHz on-board SDRAM intelligent transportable battery-backed MiniDIMM module (SAS 8888ELP RAID controller)
- One internal connector for the SAS 8704ELP RAID controller
- Two internal connectors for the SAS 8708ELP RAID controller and the SAS 8708EM2 RAID controller
- Two external connectors for the SAS 8880ELP RAID controller
- Two external connectors and two internal connectors for the SAS 8888ELP RAID controller
- Support for RAID levels 0, 1, 5, 6, 10, 50, and 60
- Advanced array configuration and management utilities
- Online RAID level migration
- Drive migration
- Drive roaming

- Patrol read
- No reboot necessary after expansion
- More than 200 Qtags per array
- Hardware clustering support on the board
- User-specified rebuild rate
- 32-Kbyte nonvolatile random access memory (NVRAM) for storing RAID system configuration information; the MegaRAID SAS firmware is stored in flash ROM for easy upgrade.

1.6.1 SAS Features

The following list describes the SAS features of the RAID controllers:

- Provides eight fully independent PHYs
- Supports 3.0 Gbit/s SAS data transfers per PHY
- Supports SSP to enable communication with other SAS devices
- Supports SMP to communicate topology management information
- Provides a serial, point-to-point, enterprise-level storage interface
- Simplifies cabling between devices
- Provides a scalable interface that supports up to 122 devices through the use of expanders

  Note: The number of devices varies depending on the MegaRAID product. Check the LSI web site (http://www.lsi.com) for specific details about your product.
- Supports wide ports consisting of 2, 3, or 4 PHYs within a single quad port
- Supports narrow ports consisting of a single PHY
- Transfers data using SCSI information units

1.6.2 SAS Array Limitations

This section describes the array limitations of the MegaRAID 1078-based SAS RAID controllers. These include limitations such as the number of physical disks supported, the maximum number of disks per controller, and the maximum number of virtual disks allowed per controller.

Table 1.1 lists the array limitations for the 1078-based SAS RAID controllers.

Table 1.1 SAS RAID Controller Array Limitations

Specification	SAS 8704ELP RAID Controller	SAS 8708ELP RAID Controller	SAS 8708EM2 RAID Controller	SAS 8880EM2 RAID Controller	SAS 8888ELP RAID Controller
Maximum virtual disks per controller	64	64	64	64	64
Maximum arrays per controller	8	16	16	128	128
Maximum virtual disks per array	16	16	16	16	16
Maximum physical devices per array	8	16	16	32	32
Maximum physical devices per controller	8	16	16	240	240
Maximum hot spares per controller	8	16	16	240	240
Maximum spans per virtual disk	4	8	8	8	8
Maximum enclosures per port*	3	3	3	16	16
Maximum ports	1	2	2	2	2**

* - Assumes one Storage Enclosure Processor (SEP) per enclosure.

** - Although the MegaRAID SAS 8888ELP RAID controller has two internal and two external ports, only two ports can be used at one time.

The maximum numbers in Table 1.1 depend on how many physical devices you have connected to the RAID controller. For example, the maximum number of arrays is equal to the number of physical disks supported by the controller, up to a limit of 128 arrays per controller. Thus, for the SAS 8704ELP RAID controller, the maximum number of arrays per controller, eight, is based on the maximum number of physical devices that can be connected. The SAS 8704ELP RAID controller

supports up to 240 physical disks, but the maximum number of arrays is limited to 128.

In addition, though you can have up to eight virtual disks per array, and up to 16 arrays per controller for the SAS 8704ELP, there is a limit of 64 virtual disks per controller. Because of this constraint, the 16 arrays cannot all contain eight virtual disks at the same time.

Note: The maximum number of hot spares per controller is equal to the maximum number of drives per controller.

These RAID controllers support 64-bit logical block addressing (LBA), which makes it possible to connect a large number of drives to the RAID controller, directly and through expanders. However, the actual number of drives that you can attach depends on the limits listed in Table 1.1 rather than by actual RAID volume capacity.

1.6.3 SATA II Features

The following list describes the SATA II features of the RAID controllers:

- Supports SATA II data transfers of 3.0 Gbits/s
- Supports STP data transfers of 3.0 Gbits/s
- Provides a serial, point-to-point storage interface
- Simplifies cabling between devices
- Eliminates the master-slave construction used in parallel ATA
- Allows addressing of multiple SATA II targets through an expander
- Allows multiple initiators to address a single target (in a fail-over configuration) through an expander

1.6.4 PCI Express Performance

The following list describes the PCI Express performance features of the RAID controllers:

- Provides a PCI Express interface that:
  - Supports a dedicated PCI Express bus
  - Supports x4, x8, or x16 lane configuration
  - Supports transfer rates of up to 2.5 Gbits/s per lane

  - Complies with the *PCI Express Specification*, *Revision 1.0a*
- Provides unequaled performance through the Fusion-MPT architecture
- Provides high throughput and low CPU utilization to offload the host processor

1.6.5 Usability Features

The following list describes the usability features of the RAID controllers:

- Simplifies cabling with point-to-point, serial architecture
- Supports smaller, thinner cables that do not restrict airflow
- Provides drive spin-up sequencing control
- Provides up to two LED signals for each PHY to indicate link activity and faults
- Provides an I^2C interface for enclosure management
- Supports the internal SAS Sideband signal SFF-8485 (SGPIO) interface

1.6.6 Flexibility Features

These features increase the flexibility of the RAID controllers:

- Supports a Flash ROM interface, a nonvolatile static RAM (NVSRAM) interface, and a pipelined synchronous burst SRAM (PSBRAM) interface
- Offers a flexible programming interface to tune I/O performance
- Allows mixed connections to SAS or SATA II targets
- Leverages compatible connectors for SAS and SATA II connections
- Allows grouping of up to four PHYs in a single quad port to form a wide port
- Allows programming of the World Wide Name

1.6.7 Drive Roaming

Drive roaming occurs when the physical disks are changed to different ports on the same controller. When the drives are placed on different channels, the controller detects the RAID configuration from the configuration data on the drives.

Note: In a clustering environment, drive roaming is supported within the same channel only.

Configuration data is saved in both the NVRAM on the RAID controller and on the hard drives attached to the controller. This action maintains the integrity of the data on each drive, even if the drives have changed their target ID.

Note: If you move a drive that is being rebuilt, the rebuild operation will restart, not resume.

Follow these steps to use drive roaming:

Step 1. Turn off all power to the server and all hard drives, enclosures, and system components. Disconnect the power cords from the system.

Step 2. Open the host system by following the instructions in the host system technical documentation.

Step 3. Move the drives to different positions on the backplane to change the targets.

Step 4. Determine the SAS target requirements.

Step 5. Perform a safety check.

a. Make sure that the drives are inserted correctly.

b. Close the cabinet of the host system.

Step 6. Reconnect the power cords to the system.

Step 7. Turn on the power to the system.

The controller then detects the RAID configuration from the configuration data on the drives.

1.6.8 Drive Migration

Drive migration is the transfer of a set of hard drives in an existing configuration from one controller to another. The drives must remain on the same channel and must be reinstalled in the same order as in the original configuration. The controller to which you migrate the drives cannot have an existing configuration.

Note: Only complete configurations can be migrated; individual virtual disks cannot be migrated.

Note: Drive roaming and drive migration cannot be supported at the same time.

Follow these steps to migrate drives:

Step 1. Make sure that you clear the configuration on the system to which you migrate the drives, to prevent a configuration data mismatch between the hard drives and the NVRAM.

Note: When you migrate drives, move only the disks that make up the virtual disk (not all of the physical disks in an array), so you do not see an NVRAM mismatch error (providing a configuration is on the destination controller). The NVRAM mismatch error appears only if you move all of the physical drives to the other controller.

Step 2. Turn off all power to the server and all hard drives, enclosures, and system components. Disconnect the power cords from the systems.

Step 3. Open the host system by following the instructions in the host system technical documentation.

Step 4. Either remove the SAS cable connectors from the internal drives, or remove the shielded cables from the external drives that you want to migrate.

a. Make sure that pin 1 on the cable matches pin 1 on the connector.

b. Make sure that the SAS cables conform to all SAS specifications.

Step 5. Remove the hard drives from the first system, and insert them into drive bays on the second system.

Step 6. Connect the SAS cables to the hard drives in the second system.

Step 7. Determine the SAS target requirements.

Step 8. Perform a safety check.

a. Make sure that all of the cables are attached correctly.

b. Make sure that the RAID controller is installed correctly.

c. Close the cabinet of the host system.

Step 9. Reconnect the power cords to the system.

Step 10. Turn on the power to the system.

The controller detects the RAID configuration from the configuration data on the drives.

1.7 Hardware Specifications

You can install the MegaRAID 1078-based SAS RAID controllers in a computer with a mainboard that has a PCI Express slot. Table 1.2 describes the hardware configuration features for the MegaRAID 1078-based SAS RAID controllers.

Table 1.2 MegaRAID 1078-based SAS RAID Controller Comparisons

Specification	MegaRAID SAS 8704ELP, MegaRAID SAS 8708ELP, MegaRAID SAS 8708EM2, and MegaRAID SAS 8880EM2, and MegaRAID SAS 8888ELP RAID Controllers
RAID levels	0, 1, 5, 6, 10, 50, and 60
Devices supported per port	Up to 15 SAS or SATA II devices (such as hard drives and expanders)
Number of ports	• MegaRAID SAS 8704ELP RAID controller – Four internal • MegaRAID SAS 8708ELP RAID controller – Eight internal • MegaRAID SAS 8708EM2 RAID controller – Eight internal • MegaRAID SAS 8880EM2 RAID controller – Eight external • MegaRAID SAS 8888ELP RAID controller – Eight internal, eight external

Table 1.2 MegaRAID 1078-based SAS RAID Controller Comparisons (Cont.)

Specification	MegaRAID SAS 8704ELP, MegaRAID SAS 8708ELP, MegaRAID SAS 8708EM2, and MegaRAID SAS 8880EM2, and MegaRAID SAS 8888ELP RAID Controllers
Data transfer rate	Up to 3 Gbits/s per PHY
Bus	PCI Express 1.0a
Cache function	Write-back, write-through, adaptive read ahead, non-read ahead, read ahead, cache I/O, direct I/O
Multiple virtual disks or arrays per controller	Up to 40 virtual disks per controller or per logical array (this value is dependent on the firmware)
Online capacity expansion	Yes
Dedicated and global hot spares	Yes
Hot-swap devices supported	Yes
Non-disk devices supported	Yes
Mixed capacity physical disks supported	Yes
Number of external connectors	MegaRAID SAS 8880EM2 – Two (x4 SAS Port) SFF-8088 Mini SAS 4x connectors MegaRAID SAS 8888ELP – Two (x4 SAS Port) SFF-8088 Mini SAS 4x connectors
Number of internal connectors	• MegaRAID SAS 8704ELP RAID controller – One (x4 SAS Port) Mini SAS 4i connector • MegaRAID SAS 8708ELP RAID controller – Two (x4 SAS Port) Mini SAS 4i connectors • MegaRAID SAS 8708EM2 RAID controller – Two (x4 SAS Port) SFF-8087 Mini SAS 4i connectors • MegaRAID SAS 8888ELP RAID controller – Two (x4 SAS Port) SFF-8087 Mini SAS 4i connectors
Hardware exclusive OR (XOR) assistance	Yes
Direct I/O	Yes
Architecture	Fusion-MPT

1.8 Technical Support

For assistance installing, configuring, or running your MegaRAID 1078-based SAS RAID controller, contact LSI Technical Support:

Phone Support:

1-800-633-4545 (North America)

Web Site:

http://www.lsi.com/support/technical_support/index.html

Chapter 2
MegaRAID SAS
Hardware Installation

This chapter describes the procedures used to install the MegaRAID 1078-based Serial Attached SCSI/Serial ATA II RAID controllers with internal and external connectors. It consists of the following sections:

2.1 Requirements

The following items are required to install a MegaRAID SAS 1078-based RAID controller:

- A MegaRAID SAS 87xx or 88xx RAID controller
- A host system with an available PCI Express slot
- The *MegaRAID Universal Software Suite* CD, which contains the drivers and documentation
- The necessary internal cables, external cables, or both
- SAS physical disks or SATA II physical disks

Note: LSI strongly recommends using an uninterruptible power supply (UPS).

2.2 Quick Installation

The following steps are for quick MegaRAID SAS RAID controller installation. These steps are for experienced computer users or installers. Section 2.3, "Detailed Installation," contains the steps for all others to follow.

Step 1. Turn off the power to the system, all physical disks, enclosures, and system components, and disconnect the PC power cord.

Step 2. Open the cabinet of the host system by following the instructions in the host system technical documentation.

Step 3. Check the jumper settings and the memory module to make sure that they are in the desired position. The jumpers are set at the factory, and you usually do not need to change them.

Note: See Chapter 3, "MegaRAID SAS RAID Controller Characteristics" for detailed information about the jumpers and the connectors.

Step 4. Install the MegaRAID SAS RAID controller in the server, and connect SAS or SATA II devices to it. Make sure that the cables you use conform to all specifications.

Step 5. Perform a safety check.

a. Make sure that all cables are attached correctly.

b. Make sure that the MegaRAID SAS RAID controller is installed correctly.

c. Close the cabinet of the host system

Step 6. Reconnect the power cords to the system.

Step 7. Turn on the power to the system.

2.3 Detailed Installation

This section provides detailed instructions for installing a MegaRAID SAS RAID controller.

Step 1. Unpack the RAID Controller

Unpack and remove the MegaRAID SAS RAID controller. Inspect it for damage. If it appears damaged, or if any of the following items are missing, contact your LSI support representative. The MegaRAID SAS RAID controller is shipped with the following items:

- A CD containing MegaRAID drivers for supported operating systems, an electronic version of this *User's Guide*, and other related documentation
- A license agreement
- Warranty information

Step 2. Turn off the Power to the System

Turn off the power to the computer, and disconnect the AC power cord. Remove the computer cover. Refer to the system documentation for instructions. Before you install the controller, make sure that the computer is disconnected from the power and from any networks.

Step 3. Review the MegaRAID Controller Jumpers and Controllers

The jumpers are set at the factory, and you usually do not need to change them. See Chapter 3, "MegaRAID SAS RAID Controller Characteristics" for diagrams of the MegaRAID SAS RAID controllers with their jumpers and connectors.

Step 4. Check the Memory Module

Make sure that the memory module is present and seated firmly in the dual-inline memory module (DIMM) socket.

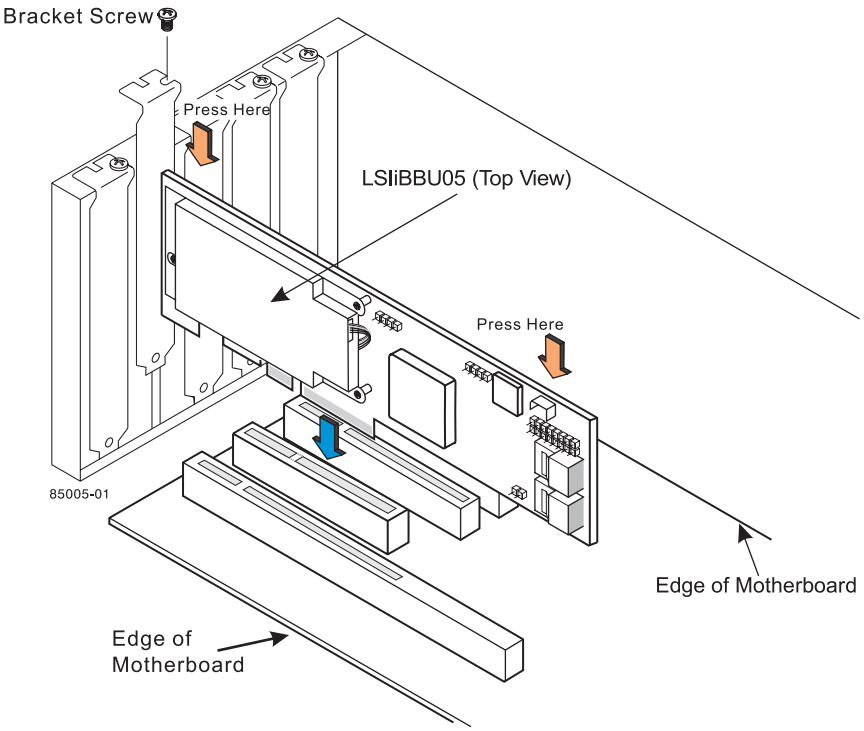
Note: The SAS 8704ELP, SAS 8708ELP, SAS 8708EM2, and SAS 8880EM2 RAID controllers have on-board DDR2 memory. The SAS 8888ELP RAID controller has a mini-DIMM socket for memory.

Step 5. Install the MegaRAID SAS RAID Controller

Select a PCI Express slot, and align the controller's PCI Express bus connector to the slot. Press down gently, but firmly, to make sure that the card is seated correctly in the slot. Secure the bracket to the computer chassis with the bracket screw.

Figure 2.1 shows the installation of a MegaRAID SAS PCI-Express RAID controller in a PCI Express slot.

Figure 2.1 Example of the MegaRAID SAS 8708ELP Board Installation in a PCI Express Slot



Step 6. Configure and Install the SAS Devices, SATA II Devices, or Both in the Host Computer Case

Refer to the documentation for the devices for any preinstallation configuration requirements.

Step 7. Connect the RAID Controller to the Devices

Use SAS cables to connect SAS devices, SATA II devices, or both to the MegaRAID SAS RAID controller. See Section 2.4, "SAS Device Cables" for SAS cable information. See Section 2.4.1, "Connecting the SAS RAID Controller with External Connectors to Drive Boxes and Drive Enclosures," on page 2-9 for details on connecting the controller to physical disks and expanders.

The maximum cable length is 6 meters (236.22 in.). You can connect one device per SAS PHY unless you use an expander.

System throughput problems can occur if the SAS cables are not the correct type. To minimize the potential for problems, use the following guidelines:

a. Use cables no longer than 6 meters (236.22 in.) (LSI recommends using shorter cables, if possible).

b. Use cables that meet the SAS specification.

c. Route the SAS cables carefully.

Step 8. Turn on the Power to the System

Reinstall the computer cover, and reconnect the AC power cords. Turn power on to the host computer. Make sure that the power is turned on to the SAS devices, SATA II devices, or both before or at the same time that the power is turned on to the host computer. If the computer is powered up before these devices, the devices might not be recognized.

During boot, a BIOS message appears. The firmware takes several seconds to initialize. The configuration utility prompt times out after several seconds. The second portion of the BIOS message displays the MegaRAID SAS RAID controller number, firmware version, and cache SDRAM size. The numbering of the controllers follows the PCI slot scanning order used by the host mainboard.

Step 9. Run the WebBIOS Configuration Utility

Run the WebBIOS Configuration Utility to configure the physical arrays and the logical drives. When the message `Press CTRL+H for WebBIOS` appears on the screen, immediately press CTRL+H to run the utility.

Step 10. Install the Operating System Driver

The SAS RAID controllers can operate under various operating systems. To operate under these operating systems, you must install the software drivers. The *MegaRAID Universal Software Suite* CD includes software drivers for the supported operating systems, along with documentation. You can view the supported operating systems and download the latest drivers for RAID adapters on the LSI web site at: http://www.lsi.com/cm/DownloadSearch.do.

For details on installing the driver, refer to the *MegaRAID SAS Device Driver Installation User's Guide* on the *MegaRAID Universal Software Suite* CD. Be sure to use the latest service packs provided by the operating system manufacturer and to review the `readme` file that accompanies the driver.

2.4 SAS Device Cables

This section describes the cables used on the SAS controllers and provides step-by-step instructions for connecting SAS physical disks, SATA II physical disks, or both to the SAS RAID controller. The SAS and SATA II protocols use a thin, 7-wire connector instead of the 68-wire SCSI cable or 40-wire ATA cable.

Note: Use only straight SAS cables, not crossover SAS cables.

Figure 2.2 displays the SAS cable that connects the internal connectors on a SAS RAID controller to SAS drives.

Figure 2.2 Internal SAS Cable for Connection to SAS Physical Disks, SATA II Physical Disks, or Both

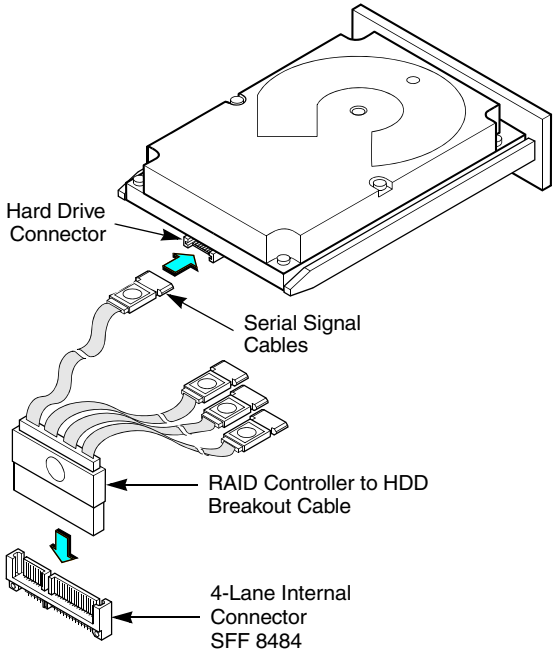


Figure 2.3 displays the SATA II device plug connector that connects a SAS RAID controller with internal connectors to the host receptable connector on a backplane. A SATA II connector consists of a signal connector and a power connector.

Figure 2.3 SATA II Connectors

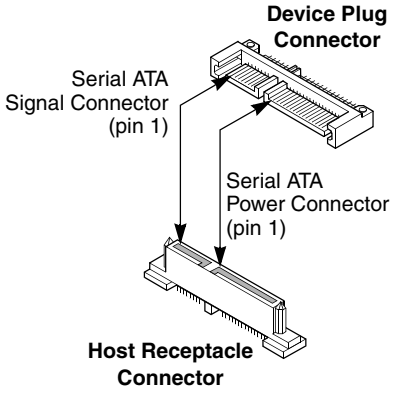
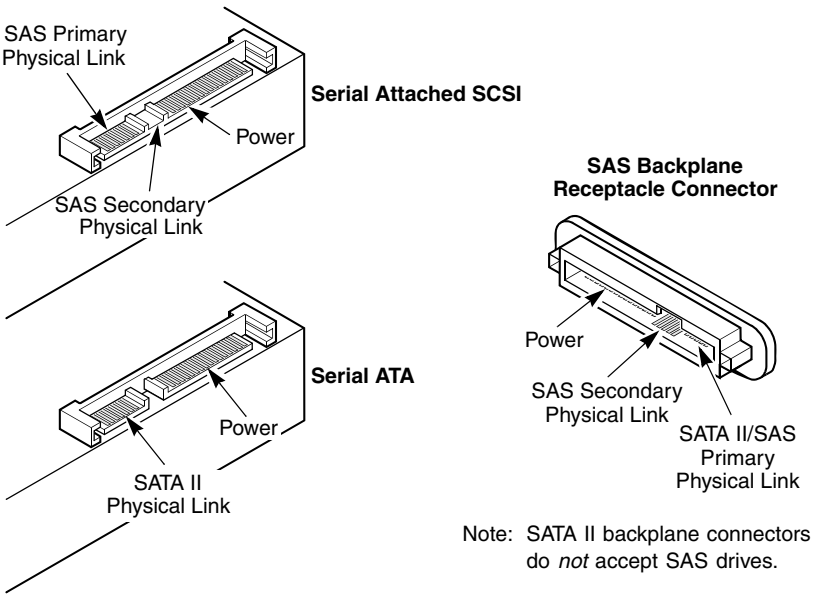


Figure 2.4 shows SAS and SATA II connectors on SAS and SATA II physical disks, respectively. Cables connect internal connectors on the RAID controllers to connectors on SAS drives, SATA II drives, or both. Both SAS and/or SATA II physical disks can connect to SAS backplane receptable connectors. The difference between the SAS connector and SATA II connector is the bridge between the SAS primary physical link and power connector on the SAS controller, which the SATA II connector does not have.

Note: SAS backplane connectors can accept SAS or SATA II physical disks, but SATA II backplane connectors *cannot* accept SAS drives.

Figure 2.4 SAS and SATA II Plugs and SAS Backplane Receptacle Connector



The following subsections provide step-by-step instructions for connecting the SAS RAID controllers to SAS physical disks and SATA II physical disks, either directly or through an expander. Figure 2.5 through Figure 2.6 show the MegaRAID SAS 8408E RAID controller and the MegaRAID SAS 8480E RAID controller connected to physical disks and to expanders, which then connect to physical disks.

2.4.1 Connecting the SAS RAID Controller with External Connectors to Drive Boxes and Drive Enclosures

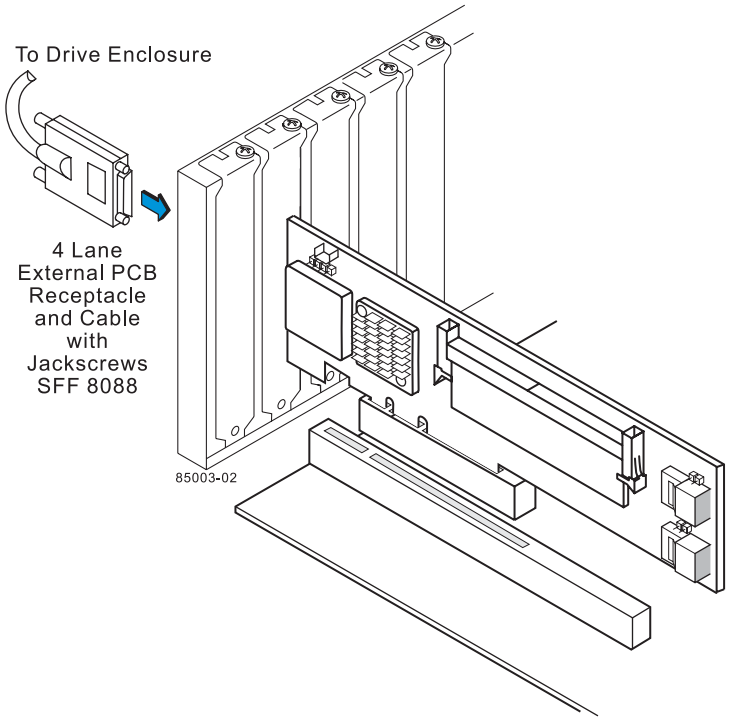
Figure 2.5 shows how to connect the external SAS cable from the SAS RAID controller that has external connectors to drive boxes or drive enclosures.

Follow these steps to connect a SAS RAID controller with external connectors to a drive box or a drive enclosure.

Step 1. Connect the 4-lane external PCB receptacle plug on the external cable to the external connector on your SAS RAID controller.

Step 2. Connect the plug on the other end of the SAS cable to the connector on the drive box or the drive enclosure.

Figure 2.5 Connecting the SAS 8888E RAID Controller with External Connectors to a Drive Box or Drive Enclosure



2.4.2 Connecting the SAS RAID Controller with Internal Connectors to Physical Disks

Figure 2.6 shows how to connect the internal SAS cable from internal connectors on the SAS 8708ELP RAID controller to SAS and SATA II drives.

Follow these steps to connect a SAS RAID controller with internal connectors directly to SAS physical disks, SATA II physical disks, or both.

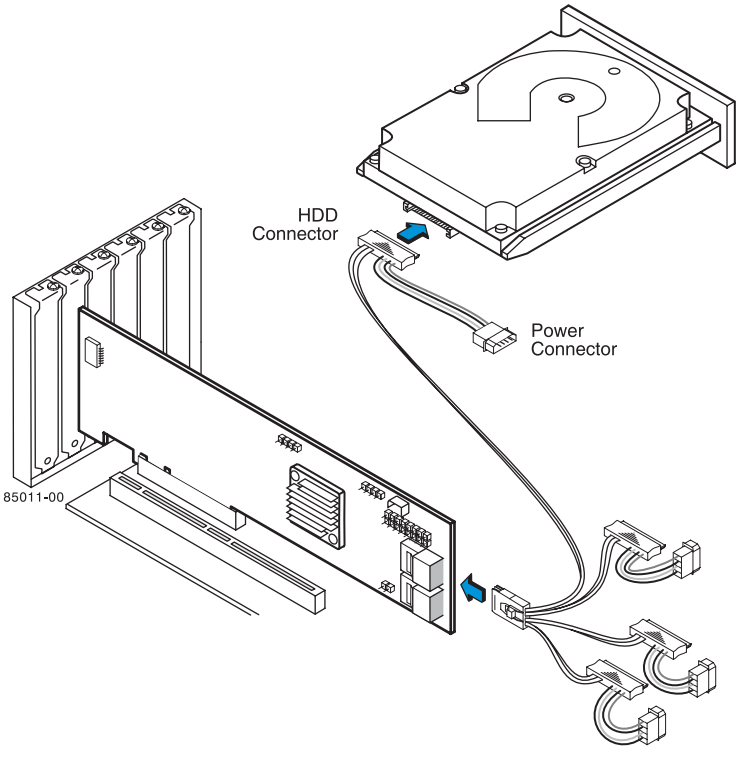
Step 1. Plug the connector on the internal cable into the internal connector on the SAS RAID controller.

Step 2. Plug the connector on the other end of the internal cable into the connector on the SAS physical disk or the SATA II physical disk.

Step 3. If you have another physical disk, connect it to another plug on the internal cable.

You can connect other devices if the cable has more connectors.

Figure 2.6 Connecting a SAS 8708ELP RAID Controller with Internal Connectors to Physical Disks



2.5 Replacing a Failed Controller Containing Data in the LSIiTBBU03

The MegaRAID intelligent Transportable Battery Backup Module 03 (LSIiTBBU03) is a cache memory module with an integrated battery pack. The module provides an uninterrupted power source to the module if power is unexpectedly interrupted while cached data is still present. If the power failure is the result of the MegaRAID SAS RAID controller itself failing, then the LSIiTBBU03 can be moved to a new controller and the data can be recovered. The replacement controller must have a cleared configuration.

Follow these steps to replace a failed controller with data in the transportable battery backup unit.

Step 1. Turn off the power to the system and to the drives.

Step 2. Remove the failed controller from the system.

Step 3. Remove the LSIiTBBU03 from the failed controller.

Step 4. Insert the LSIiTBBU03 into the replacement controller.

Step 5. Insert the replacement controller into the system.

Step 6. Turn off the power to the system and to the drives.

The controller then reads the disk configuration into NVRAM and flushes cache data to the virtual disks.

Note: Refer to the *MegaRAID 1078 Battery Backup Unit User's Guide* for installation instructions for the LSIiTBBU03.

2.6 After Installing the RAID Controller

After MegaRAID SAS RAID controller installation, you must configure the MegaRAID SAS RAID controller and install the operating system driver. The *MegaRAID SAS Software User's Guide* instructs you on the configuration options and how to set them on your MegaRAID SAS RAID controller. The *MegaRAID SAS Device Driver Installation User's Guide* provides detailed installation instructions for operating system drivers.

Chapter 3
MegaRAID SAS RAID Controller Characteristics

This chapter describes the characteristics of the LSI MegaRAID Serial Attached SCSI/Serial ATA II 1078-based RAID controllers. It consists of the following sections:

- Section 3.1, “MegaRAID 1078-based SAS RAID Controller Family”
- Section 3.2, “MegaRAID SAS 1078-based RAID Controller Characteristics”
- Section 3.3, “Technical Specifications”

3.1 MegaRAID 1078-based SAS RAID Controller Family

The MegaRAID 1078-based SAS RAID controllers are dual PHY, SAS PCI Express RAID controllers and are used in a system with a PCI Express slot. PCI Express goes beyond the PCI specification in that it is intended as a unifying I/O architecture for various systems: desktops, workstations, mobile, server, communications, and embedded devices.

The following subsections provide graphics and connector information for the SAS RAID controllers.

3.1.1 MegaRAID SAS 8704ELP/8708ELP RAID Controllers

The MegaRAID SAS 8704ELP PCI Express Low-Profile Disk Array RAID Controller controls four internal SAS/SATA ports through one (x4 SAS Port) SFF-8087 Mini SAS 4i internal connector.

The MegaRAID SAS 8708ELP PCI Express Low-Profile Disk Array RAID Controller controls eight internal SAS/SATA ports through two (x4 SAS Port) SFF-8087 Mini SAS 4i internal connectors.

Note: The only difference between the SAS 8704ELP RAID controller and the SAS 8708ELP RAID controller is that the SAS 8704ELP does not contain the J9 connector, which supports ports 4–7.

This subsection provides the board layout, and connector and jumper information for the SAS RAID controller. Figure 3.1 shows the jumpers and connectors on the SAS 8708ELP RAID controller, and Table 3.1 describes them.

Figure 3.1 Card Layout for the MegaRAID SAS 8708ELP RAID Controller

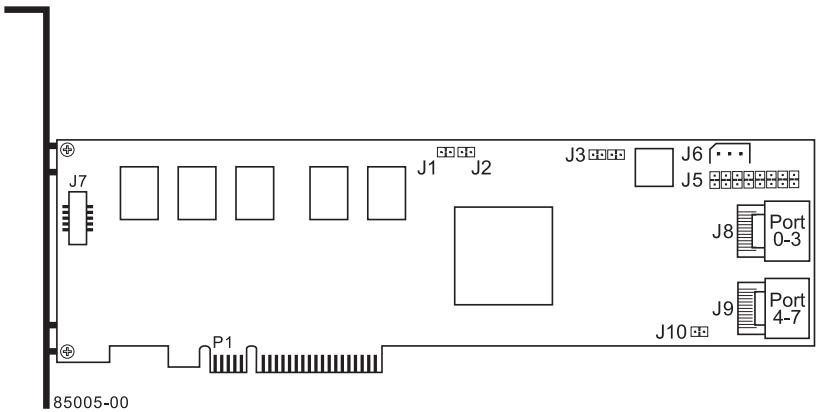


Table 3.1 SAS 8708ELP RAID Controller – Jumpers and Connectors

Jumper	Type	Description
J1	Cache Write Pending LEDx	2-pin connector. Connector for the enclosure LED. Provides a signal that indicates when the on-board cache contains data and a write from the cache to the hard drives is pending. Optional.
J2	On-board BIOS Enable	2-pin shielded header. The optional BIOS function is enabled or disabled in software depending on the status of this jumper. No jumper: BIOS is enabled (default). Jumper: BIOS is disabled.
J3	Universal Asynchronous Receiver/Transmitter (UART) debugging	4-pin connector. Reserved for LSI use.
J5	Individual Fault LED header for eight ports	16-pin connector. Indicates hard drive faults. There is one LED per port. When lit, each LED indicates the corresponding hard drive has failed or is in the Unconfigured-Bad state. Refer to the *MegaRAID SAS Software User's Guide* for more information about drive states. Note: The LEDs function in a direct-attach configuration (there are no SAS expanders). Direct attach is defined as a maximum of one hard drive connected directly to each port. See Figure 2.6 for an example.
J6	IPMI-style SMBus (System Management)/I^2C header	3-pin shielded header. Provides enclosure management support.
J7	Board-to-board connector for battery backup unit daughter card	20-pin connector. Provides the interface to the daughter card that contains the battery backup unit.

Jumper	Type	Description
J8	x4 SAS Ports 0–3	The x4 SAS connectors connect the cables from the adapter to SAS or SATA II physical drives, or to a SAS expander
J9	x4 SAS Ports 4–7 Note: The SAS 8704ELP does not support the J9 connector.	The x4 SAS connectors connect the cables from the adapter to SAS or SATA II physical drives, or to a SAS expander
J10	Default Boot Strap Controller	2-pin connector. Loads the defaults in case the boot strap controller (the serial ROM that controls the memory and processor speeds) becomes corrupt.

3.1.2 MegaRAID SAS 8708EM2 RAID Controllers

The MegaRAID SAS 8708EM2 PCI Express Disk Array RAID Controller controls eight internal SAS/SATA ports through two (x4 SAS Port) SFF-8087 Mini SAS 4i internal connectors.

This subsection provides the board layout, and connector and jumper information for the SAS 8708ELP RAID controller. Figure 3.1 shows the jumpers and connectors on the RAID controller, and Table 3.1 describes them.

Figure 3.2 Card Layout for the MegaRAID SAS 8708EM2 RAID Controller

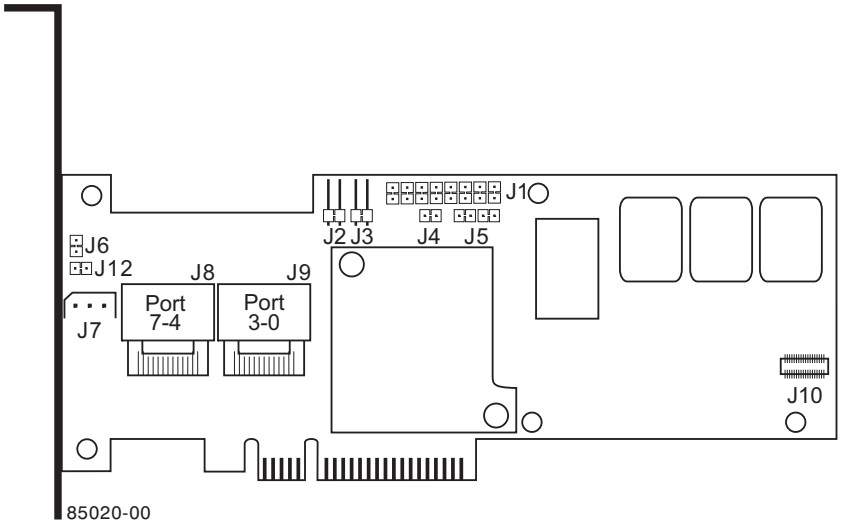


Table 3.2 SAS 8708EM2 RAID Controller – Jumpers and Connectors

Jumper	Type	Description
J1	Individual Fault LED header for eight ports	16-pin connector. Indicates hard drive faults. There is one LED per port. When lit, each LED indicates the corresponding hard drive has failed or is in the Unconfigured-Bad state. Refer to the *MegaRAID SAS Software User's Guide* for more information about drive states. The LEDs function in a direct-attach configuration (there are no SAS expanders). Direct attach is defined as a maximum of one hard drive connected directly to each port.
J2	Cache Write Pending LED	2-pin connector. The connector for the enclosure LED. It provides a signal that indicates when the on-board cache contains data and a write from the cache to the hard drives is pending. Optional.

Jumper	Type	Description
J3	Combined Activity header	2-pin connector. Provides an LED interface that indicates activity on individual drives attached to the card.
J4	BRK Debug connector	2-pin connector. Reserved for LSI use.
J5	Universal Asynchronous Receiver/Transmitter (UART) debugging	4-pin connector. Reserved for LSI use.
J6	Mode Select header	2-pin header. Reserved for LSI use.
J7	IPMI-style SMBus (System Management)/I^2C header	3-pin shielded header. Provides enclosure management support.
J8	x8 SAS Ports 4–7	The x4 SAS connectors connect the cables from the RAID controller to SAS or SATA II physical drives or to a SAS expander.
J9	x8 SAS Ports 0–3	The x4 SAS connectors connect the cables from the RAID controller to SAS or SATA II physical drives or to a SAS expander.

3.1.3 MegaRAID SAS 8880EM2 RAID Controller

The MegaRAID SAS 8880EM2 PCI Express Disk Array RAID Controller has one I/O processor. This processor controls eight ports through two (x4 SAS Port) SFF-8088 Mini SAS 4x external connectors. You can configure the connectors through a SAS mux.

This subsection provides the board layout, and connector and jumper information for the SAS 8880EM2 RAID controller, which has eight external SAS or SATA port connectors. Figure 3.4 shows the jumpers and connectors on the controller, and Table 3.4 describes them.

Figure 3.3 Card Layout for the MegaRAID SAS 8880EM2 RAID Controller

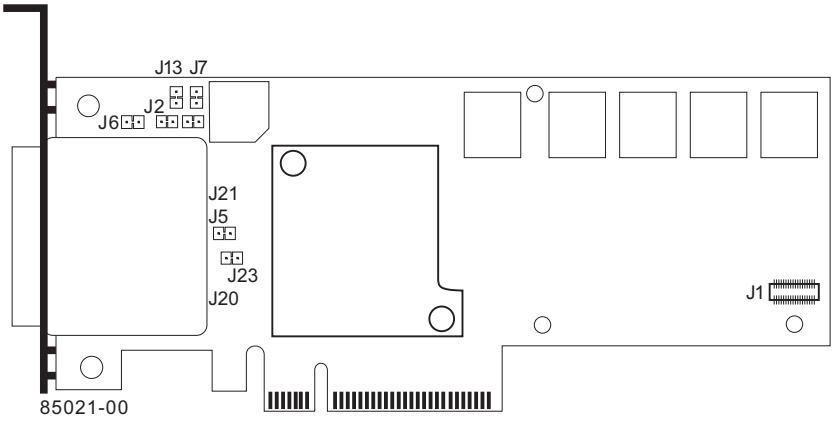


Table 3.3 SAS 8880EM2 RAID Controller – Jumpers and Connectors

Jumper	Type	Description
J1	Battery Backup Connector	20-pin connector Provides the interface to the battery backup unit. The SAS 8880EM2 RAID controller connects directly to the LSIiBBU07.
J2	Universal Asynchronous Receiver/Transmitter debugging	4-pin connector Reserved for LSI use. Note: This connector uses 3.3V LVTTL levels and will be damaged if connected to standard transceiver levels.
J5	BIOS Disable	2-pin connector Reserved for LSI use.
J6	Board Default Debug	2-pin connector Reserved for LSI use (default jumper).
J7	Cache Write Pending LED	2-pin connector The connector for the enclosure LED. It provides a signal that indicates when the on-board cache contains data and a write from the cache to the hard drives is pending. Optional.
J13	Global Drive Activity header	2-pin connector Indicates activity on the physical drives. Operates at approximately 10mA at 3.3V.
J20	x4 SAS PORT B (Lanes 0-3)	The x4 SAS connectors connect the cables from the RAID controller to SAS or SATA II physical drives or to a SAS expander.
J21	x4 SAS PORT A (Lanes 4-7)	The x4 SAS connectors connect the cables from the RAID controller to SAS or SATA II physical drives or to a SAS expander.
J23	Debug connector	Reserved for LSI use.

3.1.4 MegaRAID SAS 8888ELP RAID Controller

The MegaRAID SAS 8888ELP PCI Express Low-Profile Disk Array RAID Controller has one I/O processor. This processor controls eight ports through two (x4 SAS Port) SFF-8088 Mini SAS 4x external connectors and two (x4 SAS Port) SFF-8087 Mini SAS 4i internal connectors. You can configure the connectors through a SAS mux.

This subsection provides the board layout, and connector and jumper information for the SAS 8888ELP RAID controller, which has eight internal and eight external SAS or SATA port connectors. Figure 3.4 shows the jumpers and connectors on the controller, and Table 3.4 describes them.

Figure 3.4 Card Layout for the MegaRAID SAS 8888ELP RAID Controller

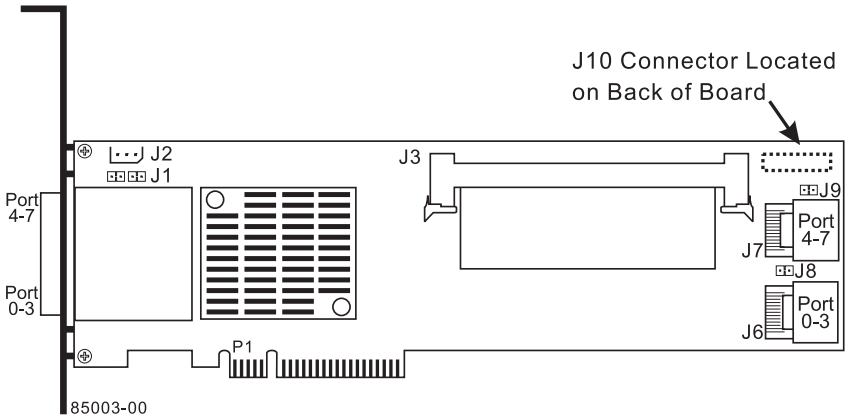


Table 3.4 SAS 8888ELP RAID Controller – Jumpers and Connectors

Jumper	Type	Description
J1	Serial header for debug use	4-pin jumper. Reserved for LSI use.
J2	IPMI-style SMBus (System Management) /I^2C header	3-pin (shielded) header. Provides enclosure management support.
J3	MiniDIMM bracket	Holds the cache memory module. The SAS 8888ELP RAID controller supports the following battery-backed cache configurations: - 256 MB – 72b arrangement (3) 64Mx16, Double Data Rate II @ 667 MHz SDRAM intelligent transportable battery-backed MiniDIMM module - 512 MB – 72b arrangement (3) 128Mx16, Double Data Rate II @ 667 MHz SDRAM intelligent transportable battery-backed MiniDIMM module Using unapproved memory modules can void your limited warranty.
J6	SAS 8888ELP Ports	Ports 4–7. The ports connect the cables from the adapter to SAS or SATA II physical drives, or a port multiplier.
J7	SAS 8888ELP Ports	Ports 0–3. The ports connect the cables from the adapter to SAS or SATA II physical drives, or a port multiplier.

Table 3.4 SAS 8888ELP RAID Controller – Jumpers and Connectors

Jumper	Type	Description
J8	Serial Bootstrap EEPROM connector	2-pin connector. Reserved for LSI use.
J9	Cache Write Pending LED	2-pin connector. Connector for an LED mounted on the system enclosure. The LED indicates that the data in the cache has yet to be written to the storage devices.
J10	Battery Backup Connector (located on the rear of the connector)	20-pin connector. Provides the interface to the remote battery pack.

3.2 MegaRAID SAS 1078-based RAID Controller Characteristics

Table 3.5 shows the general characteristics for all MegaRAID 1078-based SAS RAID controllers.

Table 3.5 MegaRAID 1078-based SAS RAID Controller Characteristics

Flash ROM[1]	Serial EEPROM[2]	SAS Data Transfers	SCSI Features	SCSI Termination
Yes	Yes	Up to 3 Gbits/s per port	Plug and Play Scatter/Gather Activity LED	Active

1. For boot code and firmware.
2. For BIOS configuration storage.

Each MegaRAID 1078-based SAS RAID controller ensures data integrity by intelligently validating the compatibility of the SAS domain. The MegaRAID 1078-based SAS RAID controllers use Fusion-MPT architecture, which allows for thinner drivers and better performance.

3.3 Technical Specifications

The design and implementation of the MegaRAID 1078-based SAS RAID controllers minimize electromagnetic emissions, susceptibility to radio frequency energy, and the effects of electrostatic discharge. The MegaRAID 1078-based SAS RAID controllers show the following marks and certifications:

- CE mark
- C-Tick mark
- FCC Self-Certification logo
- Canadian Compliance Statement
- Korean MIC
- Taiwan BSMI
- Japan VCCI
- CISPR Class B

The following hardware is compliant with CSA C22.2 No. 60950-1, UL 60950-1 First Edition-listed accessory, UL file number E257743:

- MegaRAID SAS 8704ELP RAID controller (model 01116)
- MegaRAID SAS 8708ELP RAID controller (model 01116)
- MegaRAID SAS 8708EM2 RAID controller (model 01144)
- MegaRAID SAS 8880EM2 RAID controller (model 25039)
- MegaRAID SAS 8888ELP RAID controller (model 01119)
- LSIiBBU01 battery backup unit (model 01058)
- LSIiBBU05 intelligent battery backup unit (model 01117)
- LSIiBBU06 intelligent battery backup unit (model 29707)
- LSIiBBU07 intelligent battery backup unit (model 31503)
- LSIiTBBU03 intelligent transportable battery backup unit (model 01126)

3.3.1 RAID Controller Specifications

Table 3.6 lists the specifications for the MegaRAID 1078-based SAS RAID controllers.

Table 3.6 RAID Controller Specifications

Specification	MegaRAID SAS 8704ELP, MegaRAID SAS 8708ELP, MegaRAID SAS 8708EM2, MegaRAID SAS 8880EM2, and MegaRAID SAS 8888ELP RAID Controllers
Processor (PCI Express host controller to PCI secondary I/O controller)	LSISAS1078 ROC device with Integrated PowerPC processor
Part number	• SAS 8704ELP RAID controller: 01116 • SAS 8708ELP RAID controller: 01116 • SAS 8708EM2 RAID controller: 01144 • SAS 8880EM2 RAID controller: 25039 • SAS 8888ELP RAID controller: 01119 • LSIiBBU01 intelligent Battery Backup Unit 01: 01058 • LSIiBBU05 intelligent Battery Backup Unit 05: 01117 • LSIiBBU06 intelligent Battery Backup Unit 05: 29707 • LSIiBBU07 intelligent Battery Backup Unit 05: 31503 • LSIiTBBU03 intelligent Transportable Battery Backup Unit 03: 01126
Operating voltage	+3.3 V, +12 V
Card size	• SAS 8704ELP RAID controller: Low-profile PCI Express adapter card size (167.64 mm x 68.91 mm) • SAS 8708ELP RAID controller: Low-profile PCI Express adapter card size (167.64 mm x 68.91 mm) • SAS 8708EM2 RAID controller: Low-profile PCI Express adapter card size (167.64 mm x 68.91 mm) • SAS 8880EM2 RAID controller: Low-profile PCI Express adapter card size (167.64 mm x 68.91 mm) • SAS 8888ELP RAID controller: Extended Length Low-profile PCI Express adapter card size (167.64 mm x 64.39 mm)
Array interface to the host	PCI Express Rev. 1.0a

Table 3.6 RAID Controller Specifications (Cont.)

Specification	MegaRAID SAS 8704ELP, MegaRAID SAS 8708ELP, MegaRAID SAS 8708EM2, MegaRAID SAS 8880EM2, and MegaRAID SAS 8888ELP RAID Controllers
PCI Express bus data transfer rate	• Up to 2.5 Gbits/s per lane • x4 lane width (SAS 8704ELP, SAS 8708EM2, and SAS 8708ELP RAID controllers • x8 lane width (SAS 8880EM2 and SAS 8888ELP RAID controller) • Up to 2 Gbytes/s per direction for SAS 8888ELP x8 cards (4 Gbytes/s total)
Serial port	3-pin RS232-compatible connector (for manufacturing use only)
SAS controller	One LSISAS1078 Single SAS controller
SAS bus speed	3 Gbits/s
SAS ports	SAS connectors with four SAS ports each

Table 3.6 RAID Controller Specifications (Cont.)

Specification	MegaRAID SAS 8704ELP, MegaRAID SAS 8708ELP, MegaRAID SAS 8708EM2, MegaRAID SAS 8880EM2, and MegaRAID SAS 8888ELP RAID Controllers
Cache configuration	The SAS 8704ELP, SAS 8708ELP, and SAS 8880EM2 RAID controllers support the following battery-backed cache configurations: • 128 MB – 40b arrangement (3) 32Mx16, Double Data Rate II @ 667 MHz battery-backed module • 256 MB – 40b arrangement (3) 64Mx16, Double Data Rate II @ 667 MHz battery-backed module • 256 MB – 72b arrangement (5) 32Mx16, Double Data Rate II @ 667 MHz battery-backed module • 512 MB – 72b arrangement (5) 64Mx16, Double Data Rate II @ 667 MHz battery-backed module The SAS 8708EM2 RAID controller supports the following battery-backed cache configurations: • 128 MB – 40b arrangement (3) 32Mx16, Double Data Rate II @ 667 MHz battery-backed module • 256 MB – 40b arrangement (3) 64Mx16, Double Data Rate II @ 667 MHz battery-backed module The SAS 8888ELP RAID controller supports the following battery-backed cache configurations: • 256 MB – 72b arrangement (5) 64Mx16, Double Data Rate II @ 667 MHz SDRAM intelligent transportable battery-backed MiniDIMM module • 512 MB – 72b arrangement (5) 128Mx16, Double Data Rate II @ 667 MHz SDRAM intelligent transportable battery-backed MiniDIMM module
Size of flash ROM for firmware	4 Mbytes
Nonvolatile random access memory (NVRAM)	32 Kbytes for storing RAID configurations

3.3.2 Array Performance Features

Table 3.7 shows the array performance features for the MegaRAID 1078-based SAS RAID controllers.

Table 3.7 Array Performance Features

Specification	MegaRAID SAS 8704ELP, MegaRAID SAS 8708ELP, and MegaRAID SAS 8888ELP RAID Controllers
PCI Express host data transfer rate	2.5 Gbits/s per lane
Drive data transfer rate	3.0 Gbits/s per lane
Maximum scatters and gathers	26 elements
Maximum size of I/O requests	6.4 Mbytes in 64-Kbyte stripes
Maximum queue tags per drive	As many as the drive can accept
Stripe sizes	8 Kbytes, 16 Kbytes, 32 Kbytes, 64 Kbytes, 128 Kbytes, 256 Kbytes, 512 Kbytes, or 1 Mbyte
Maximum number of concurrent commands	255
Support for multiple initiators	Yes

3.3.3 Fault Tolerance

Table 3.8 lists the fault tolerance features for the MegaRAID 1078-based SAS RAID controllers.

Table 3.8 Fault Tolerance Features

Specification	MegaRAID SAS 8704ELP, MegaRAID SAS 8708ELP, MegaRAID SAS 8708EM2, MegaRAID SAS 8880EM2, and MegaRAID SAS 8888ELP
Support for SMART[1]	Yes
Optional battery backup for cache memory	MegaRAID SAS 8704ELP RAID controller and MegaRAID SAS 8708ELP RAID controller: - LSIiBBU05 battery backup. <3.6V/880mAH battery pack; up to 72 hours of data retention for 128 Mbytes MegaRAID SAS 8708EM2 RAID controller: - LSIiBBU06 battery backup. <3.7V/790mAH battery pack; up to 72 hours of data retention for 256 Mbytes MegaRAID SAS 8880EM2 RAID controller: - LSIiBBU07 battery backup. <3.7V/1350mAH battery pack; up to 72 hours of data retention for 512 Mbytes MegaRAID SAS 8888ELP RAID controller: - LSIiBBU01 battery backup. <3.6V/880mAH battery pack; up to 72 hours of data retention for 128 Mbytes - LSIiBBU05 battery backup. <3.6V/880mAH battery pack; up to 72 hours of data retention for 128 Mbytes - LSIiTBBU03 battery backup. 3.7V/1350mAH battery pack; up to 72 hours of data retention for 512 Mbytes
Drive failure detection	Automatic
Drive rebuild using hot spares	Automatic
Parity generation and checking	Yes

1. The Self Monitoring Analysis and Reporting Technology (SMART) detects up to 70 percent of all predictable disk drive failures. In addition, SMART monitors the internal performance of all motors, heads, and drive electronics.

3.3.4 Electrical Characteristics

This subsection provides the power supply requirements for the MegaRAID 1078-based SAS RAID controllers.

3.3.4.1 Power Supply Requirements for the SAS 8704ELP and SAS 8708ELP RAID Controllers

All power is supplied to the SAS 8704ELP and the SAS 8708ELP RAID controllers through the PCI Express 3.3V rails and the 12V rail. Onboard switching regulator circuitry operating from the 3.3V rails and the 12V rail provide the necessary voltages. The following states determine the typical current consumption of the controller:

- State 1: During a hard reset
- State 2: During a disk stress test
- State 3: While sitting idle at the DOS prompt

The supply voltages are 12V ± 8 percent (from PCI edge connector only) and 3.3V ± - 9 percent (from PCI edge connector only). Table 3.9 lists the power supply for the RAID controller for each of the three states at the different voltages.

Table 3.9 Power Supply for the SAS 8704ELP and the SAS 8708ELP RAID Controllers

PCI Edge Connector	State 1	State 2	State 3
3.3V supply	330mA	330mA	330mA
+12V supply	1.00A	1.81A	1.53A
3.3V auxiliary supply	30mA	30mA	30mA

Note: +12V is used in the charging circuitry for the battery pack on the optional iBBU battery-backed daughter card. If the BBU daughter card is mounted, the following power consumption figures apply:

– During trickle charging of the battery pack: N/A (no trickle charge for Li-ION)

– During fast charging of the battery pack: 230mA in +12V current

3.3.4.2 Power Supply Requirements for the SAS 8708EM2 RAID Controller

All power is supplied to the SAS 8708EM2 RAID controller through the PCI Express 3.3V rails and the 12V rail. Onboard switching regulator circuitry operating from the 3.3V rails and the 12V rail provide the necessary voltages. The following states determine the typical current consumption of the controller:

- State 1: During a hard reset
- State 2: During a disk stress test
- State 3: While sitting idle at the DOS prompt

The supply voltages are 12V ± 8 percent (from PCI edge connector only) and 3.3V ± - 9 percent (from PCI edge connector only). Table 3.9 lists the power supply for the RAID controller for each of the three states at the different voltages.

Table 3.10 Power Supply for the SAS 8708EM2 RAID Controllers

PCI Edge Connector	State 1	State 2	State 3
3.3V supply	250mA	330mA	312mA
+12V supply	1.00A	1.15A	1.00A
3.3V auxiliary supply	30mA	30mA	30mA

Note: +12V is used in the charging circuitry for the battery pack on the optional iBBU battery-backed daughter card. If the BBU daughter card is mounted, the following power consumption figures apply:

– During trickle charging of the battery pack: N/A (no trickle charge for Li-ION)

– During fast charging of the battery pack: 230mA in +12V current

3.3.4.3 Power Supply Requirements for the SAS 8880EM2 RAID Controllers

All power is supplied to the SAS 8880EM2 RAID controller through the PCI Express 3.3V rails and the 12V rail. Onboard switching regulator circuitry operating from the 3.3V rails and the 12V rail provide the necessary voltages. The following states determine the typical current consumption of the controller:

- State 1: During a hard reset
- State 2: During a disk stress test
- State 3: While sitting idle at the DOS prompt

The supply voltages are 12V ± 8 percent (from PCI edge connector only) and 3.3V ± - 9 percent (from PCI edge connector only). Table 3.9 lists the power supply for the RAID controller for each of the three states at the different voltages.

Table 3.11 Power Supply for the SAS 8880EM2 RAID Controller

PCI Edge Connector	State 1	State 2	State 3
3.3V supply	330mA	330mA	330mA
+12V supply	1.00A	1.81A	1.53A
3.3V auxiliary supply	30mA	30mA	30mA

Note: +12V is used in the charging circuitry for the battery pack on the optional iBBU battery-backed daughter card. If the BBU daughter card is mounted, the following power consumption figures apply:

- During trickle charging of the battery pack: N/A (no trickle charge for Li-ION)
- During fast charging of the battery pack: 230mA in +12V current

3.3.4.4 Power Supply Requirements for the SAS 8888ELP RAID Controller

All power is supplied to the SAS 8888ELP RAID controller through the PCI Express 3.3V rails and the 12V rail. Necessary voltages are provided by onboard switching regulator circuitry operating from the 3.3V rails and the 12V rail. The following states determine the typical current consumption of the controller:

- State 1: No BBU, eight SAS ports active
- State 2: Eight SAS ports active, remote iBBU charging
- State 3: Eight SAS ports active, both remote iBBU and iTBBU charging

The supply voltages are 12V ± 8 percent (from the PCI edge connector only) and 3.3V ± 9 percent (from PCI edge connector only). The 3.3V auxiliary supply measurement is for the board powered down in the BBU mode with an iTBBU installed. Table 3.12 lists the power supply for the RAID controller for each of the three states at the different voltages.

Table 3.12 Power States for the SAS 8888ELP RAID Controller

PCI Edge Connector	State 1	State 2	State 3
3.3V supply	330mA	330mA	330mA
+12V supply	1.30A	1.50A	1.80A
3.3V auxiliary supply	20mA	20mA	20mA

3.3.5 Operating and Non-operating Conditions

For the MegaRAID 1078-based SAS RAID controllers, the operating (thermal and atmospheric) conditions are:

- Relative humidity range is 5 percent to 90 percent noncondensing (20 percent to 80 percent noncondensing for the RAID controllers)
- Airflow must be at least 200 linear feet per minute (LFPM) to avoid operating the processor above the maximum ambient temperature

The parameters for the non-operating (such as storage and transit) environment for the MegaRAID 1078-based SAS RAID controllers are:

- Temperature range: -30° C to +80° C without the battery backup unit
- Temperature range: 0° C to +45° C with the battery backup unit

3.3.6 Safety Characteristics

All MegaRAID 1078-based SAS RAID controllers meet or exceed the requirements of UL flammability rating 94 V0. Each bare board is also marked with the supplier name or trademark, type, and UL flammability rating. For the boards installed in a PCI Express bus slot, all voltages are lower than the SELV 42.4V limit.

Appendix A
Glossary of Terms and Abbreviations

active termination	The electrical connection required at each end of the SCSI bus, composed of active voltage regulation and a set of termination resistors.
array	A group of disk drives that combines the storage space on the disk drives into a single segment of storage space. A hot spare drive does not actively participate in an array.
BIOS	Acronym for Basic Input/Output System. Software that provides basic read/write capability. Usually kept as firmware (ROM-based). The system BIOS on the mainboard of a computer boots and controls the system. The BIOS on your host adapter acts as an extension of the system BIOS.
configuration	Refers to the way a computer is set up, the combined hardware components (computer, monitor, keyboard, and peripheral devices) that make up a computer system, or the software settings that allow the hardware components to communicate with each other.
device driver	A program that allows a microprocessor (through the operating system) to direct the operation of a peripheral device.
domain validation	A software procedure in which a host queries a device to determine its ability to communicate at the negotiated data rate.
EEPROM	Acronym for Electronically Erasable Programmable Read-Only Memory. It is a memory chip that typically stores configuration information, as it provides stable storage for long periods without electricity and can be reprogrammed. Refer to NVRAM.
external SAS device	A SAS device installed outside the computer cabinet. These devices are connected using specific types of shielded cables.
Fusion-MPT architecture	An acronym for Fusion-Message Passing Technology architecture. Fusion-MPT consists of several main elements: Fusion-MPT firmware, the Fibre Channel and SCSI hardware, and the operating system level

drivers that support these architectures. Fusion-MPT architecture offers a single binary, operating system driver that supports both Fibre Channel and SCSI devices.

host The computer system in which a RAID controller is installed. It uses the RAID controller to transfer information to and from devices attached to the SCSI bus.

host adapter board A circuit board or integrated circuit that provides a device connection to the computer system.

hot spare An idle, powered on, standby drive that is ready for immediate use in case of disk failure. A hot spare does not contain any user data. A hot spare can be dedicated to a single redundant array or it can be part of the global hot-spare pool for all arrays managed by the controller.

When a disk fails, the controller firmware automatically replaces and rebuilds the data from the failed drive to the hot spare. Data can be rebuilt only from virtual disks with redundancy (RAID levels 1, 5, 6, 10, 50, and 60; not RAID level 0), and the hot spare must have sufficient capacity.

internal SAS device A SAS device installed inside the computer cabinet. These devices are connected by using a shielded cable.

main memory The part of computer memory that is directly accessible by the CPU (usually synonymous with RAM).

NVRAM Acronym for nonvolatile random access memory. An EEPROM (electronically erasable read-only memory) chip that stores configuration information. Refer to EEPROM.

PCI Acronym for peripheral component interconnect. A high-performance, local bus specification that allows the connection of devices directly to computer memory. The PCI Local Bus allows transparent upgrades from 32-bit data path at 33 MHz to 64-bit data path at 33 MHz, and from 32-bit data path at 66 MHz to 64-bit data path at 66 MHz.

PCI Express Acronym for peripheral component interconnect Express. A high-performance, local bus specification that allows the connection of devices directly to computer memory. PCI Express is a two-way, serial connection that transfers data on two pairs of point-to-point data lines. PCI Express goes beyond the PCI specification in that it is intended as

a unifying I/O architecture for various systems: desktops, workstations, mobile, server, communications, and embedded devices.

peripheral devices A piece of hardware (such as a video monitor, disk drive, printer, or CD-ROM) used with a computer and under the control of the computer. SCSI peripherals are controlled through a SAS MegaRAID SAS RAID controller (host adapter).

PHY The interface required to transmit and receive data packets transferred across the serial bus.

Each PHY can form one side of the physical link in a connection with a PHY on a different SATA device. The physical link contains four wires that form two differential signal pairs. One differential pair transmits signals, while the other differential pair receives signals. Both differential pairs operate simultaneously and allow concurrent data transmission in both the receive and the transmit directions.

RAID Acronym for Redundant Array of Independent Disks (originally Redundant Array of Inexpensive Disks). An array of multiple independent physical disks managed together to yield higher reliability, performance, or both exceeding that of a single physical disk. The RAID array appears to the controller as a single storage unit. I/O is expedited because several disks can be accessed simultaneously. Redundant RAID levels (RAID levels 1, 5, 6, 10, 50, and 60) provide data protection.

RAID levels A set of techniques applied to disk groups to deliver higher data availability, performance characteristics, or both to host environments. Each virtual disk must have a RAID level assigned to it.

SAS Acronym for Serial Attached SCSI. A serial, point-to-point, enterprise-level device interface that leverages the proven SCSI protocol set. The SAS interface provides improved performance, simplified cabling, smaller connections, lower pin count, and lower power requirements when compared to parallel SCSI. SAS controllers leverage a common electrical and physical connection interface that is compatible with Serial ATA. The SAS controllers support the ANSI *Serial Attached SCSI Standard, Version 1.0*. In addition, the controller supports the Serial ATA II (SATA II) protocol defined by the *Serial ATA Specification, Version 1.0a*. Supporting both the SAS and SATA II interfaces, the SAS controller is a versatile controller that provides the backbone of both

server and high-end workstation environments. Each port on the SAS RAID controller supports SAS devices, SATA II devices, or both.

SAS device Any device that conforms to the SAS standard and is attached to the SAS bus by a SAS cable. This includes SAS RAID controllers (host adapters) and SAS peripherals.

SATA Acronym for Serial Advanced Technology Attachment. A physical storage interface standard, SATA is a serial link that provides point-to-point connections between devices. The thinner serial cables allow for better airflow within the system and permit smaller chassis designs.

SMP Acronym for Serial Management Protocol. SMP enables communicates topology management information directly with an attached SAS expander device. Each PHY on the controller can function as an SMP initiator.

SSP Acronym for Serial SCSI Protocol. SSP enables communication with other SAS devices. Each PHY on the SAS controller can function as an SSP initiator or SSP target.

STP Acronym for Serial Tunneling Protocol. STP enables communication with a SATA II device through an attached expander. Each PHY on the SAS controller can function as an STP initiator.

stripe size The total disk space consumed by a stripe not including a parity disk. For example, consider a stripe that contains 64 Kbytes of disk space and has 16 Kbytes of data residing on each disk in the stripe. In this case, the stripe size is 64 Kbytes and the stripe element size is 16 Kbytes. The stripe depth is four (four physical disks in the stripe). You can specify stripe sizes of 8 Kbytes, 16 Kbytes, 32 Kbytes, 64 Kbytes, 128 Kbytes, 256 Kbytes, 512 Kbytes, or 1 Mbyte for each virtual disk. A larger stripe size produces improved read performance, especially if most of the reads are sequential. For mostly random reads, select a smaller stripe size.

striping Disk striping writes data across two or more disks. Each stripe spans two or more disks but consumes only a portion of each disk. Each disk, therefore, may have several stripes. The amount of space consumed by a stripe is the same on each disk that is included in the stripe. The portion of a stripe that resides on a single disk is a stripe element. Striping by itself does not provide data redundancy; striping in combination with parity provides data redundancy.

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