Broadcom® MegaRAID® and HBA Tri-Mode
Storage Adapters

User Guide
Version 1.4

Table of Contents

Chapter 1: Broadcom MegaRAID and HBA Tri-Mode Storage Adapters

This document is the primary reference and user guide for the Broadcom® MegaRAID® Tri-Mode storage adapters and Broadcom HBA Tri-Mode storage adapters, based on the Broadcom Tri-Mode controller devices. This document contains the complete installation instructions and specifications for the following Tri-Mode storage adapters:

- MegaRAID 9460-16i (model number 50011)
- MegaRAID 9460-8i (model number 50011)
- MegaRAID 9480-8i8e (model number 50031)
- MegaRAID 9440-8i (model number 50008)
- HBA 9400-16i (model number 50008)
- HBA 9400-8i (model number 50008)
- HBA 9400-8i8e (model number 50031)
- HBA 9400-16e (model number 50013)
- HBA 9400-8e (model number 50013)
- HBA 9405W-16i (model number 50047)
- HBA 9405W-16e (model number 50044)

1.1 Overview

The MegaRAID storage adapters and the HBAs, based on the SAS3616W, SAS3516, SAS3508, SAS3416, or SAS3408 Tri-mode controller, are high-performance PCIe-to-SATA/SAS/PCIe (Tri-Mode) storage adapters. Broadcom Tri-Mode SerDes technology enables operation of SAS, SATA, or PCIe (NVMe) storage devices in a single drive bay. A single controller can operate in all three modes concurrently: SAS, SATA, or PCIe/NVMe.

The Tri-Mode storage adapters provide the following storage interface data transfer rates:

- SAS data transfer rates of 12Gb/s, 6Gb/s, and 3Gb/s per lane
- SATA transfer rates at 6Gb/s and 3Gb/s per lane
- PCIe (NVMe) data transfer rates of 8 GT/s, 5 GT/s, and 2.5 GT/s per lane

The adapters negotiate between the speeds and the protocols to recognize and concurrently interface with these three storage devices types. The following table summarizes many key features of the MegaRAID Tri-Mode storage adapters.

Table 1 MegaRAID Tri-Mode Storage Adapters

Adapter	9460-16i	9460-8i	9480-8i8e	9440-8i
Ports	16 internal	8 internal	8 internal, 8 external	8 internal
I/O Processor	SAS3516	SAS3508	SAS3516	SAS3408
Form Factor	LP-MD2	LP-MD2	LP-MD2	LP-MD2
Storage Interface Connectors	Four SFF-8643 x4	Two SFF-8643 x4	Two SFF-8643 x4, Two SFF-8644 x4	Two SFF-8643 x4
Host Interface	x8 PCIe 3.1	x8 PCIe 3.1	x8 PCIe 3.1	x8 PCIe 3.1
Storage Interface	SAS, SATA, and PCIe (NVMe)	SAS, SATA, and PCIe (NVMe)	SAS, SATA, and PCIe (NVMe)[a]	SAS, SATA, and PCIe (NVMe)
Cache Memory	4 GB, 2133 MHz, DDR4 SDRAM	2 GB, 2133 MHz, DDR4 SDRAM	4 GB, 2133 MHz, DDR4 SDRAM	N/A

Table 1 MegaRAID Tri-Mode Storage Adapters (Continued)

Adapter	9460-16i	9460-8i	9480-8i8e	9440-8i
Cache Protection	Yes	Yes	Yes	N/A
Super Capacitor	CVPM05 module	CVPM05 module	CVPM05 module	N/A

    a. NVMe is supported for internal connection only.

The following table summarizes many key features of the HBA Tri-Mode storage adapters.

Table 2 HBA Tri-Mode Storage Adapters

Adapter	9400-16i	9400-8i	9400-16e	9400-8e	9400-8i8e	9405W-16e	9405W-16i
Ports	16 internal	8 internal	16 external	8 external	8 external, 8 internal	16 external	16 internal
I/O Processor	SAS3416	SAS3408	SAS3416	SAS3408	SAS3516	SAS3616W	SAS3616W
Form Factor	LP-MD2	LP-MD2	LP-MD2	LP-MD2	LP-MD2	LP-MD2	LP-MD2
Storage Interface Connectors	Four SFF-8643 x4	Two SFF-8643 x4	Four SFF-8644 x4	Two SFF-8644 x4	Two SFF-8643 x4, Two SFF-8644 x4	Four SFF-8644 x4	Four SFF-8643 x4
Host Interface	x8 PCIe 3.1	x8 PCIe 3.1	x8 PCIe 3.1	x8 PCIe 3.1	x8 PCIe 3.1	x16 PCIe 3.1	x16 PCIe 3.1
Storage Interface	SAS, SATA, and PCIe (NVMe)	SAS, SATA, and PCIe (NVMe)	SAS and SATA	SAS and SATA	SAS, SATA, and PCIe (NVMe)[a]	SAS and SATA	SAS, SATA, and PCIe (NVMe)

    a. NVMe is supported for internal connection only.

Chapter 2: Features

2.1 RAID Features

The following list includes some primary RAID features that the MegaRAID Tri-Mode storage adapters support. For a full description of the RAID features, refer to the *12Gb/s MegaRAID Tri-Mode Software User Guide*, located at http://www.broadcom.com/support/download-search.

- RAID levels 0, 1, 5, and 6
- RAID spans 10, 50, and 60
- Online Capacity Expansion (OCE) Online RAID Level Migration (RLM)
- Auto resume after loss of system power during array rebuild or reconstruction
- Single controller multipathing
- Load balancing
- Configurable stripe size up to 1 MB
- Fast initialization for quick array setup
- Check Consistency for background data integrity
- SSD support with SSD Guard™ technology
- Patrol read for media scanning and repairing
- 64-logical drive support
- Disk data format (DDF)-compliant Configuration on Disk (COD)
- Self-Monitoring, Analysis, and Reporting Technology (S.M.A.R.T) support
- Global and dedicated hot spare with Revertible Hot Spare support
- Automatic rebuild
- Enclosure affinity
- Emergency SATA hot spare for SAS arrays
- Enclosure management
- SCSI Enclosure Services (SES) (inband)
- SGPIO (sideband)
- DataBolt bandwidth optimizer technology support for compatible expander-based enclosures
- Shield state drive diagnostic technology

2.2 Operating System Support

The Tri-Mode storage adapters support the operating systems in the following list. For specific version information, refer to the *MegaRAID SAS Device Driver Installation User Guide*, located at http://www.broadcom.com/support/download-search.

- Microsoft Windows
- VMware vSphere/ESXi
- Red Hat Linux
- SuSE Linux
- Ubuntu Linux
- Oracle Linux
- CentOS Linux
- Debian Linux

- Fedora
- FreeBSD

NOTE: Contact Oracle for Oracle Solaris driver software or support.

The firmware and drivers are routinely updated and made available on the Broadcom Support and Download center. Visit http://www.broadcom.com/support/download-search, and download the latest firmware and driver for the adapter.

2.3 PCIe Host Interface

The Tri-Mode storage adapter PCIe host interface provides maximum transmission and reception rates of up to 128 GT/s (x16) or 64 GT/s (x8). The Tri-Mode controller uses a packet-based communication protocol to communicate over the serial interconnect. Other PCIe host interface features include the following:

- Eight and sixteen lane PCIe host interface
- PCIe Hot Plug
- Power management
  - Supports the *PCI Bus Power Management Interface Specification Revision 1.2*
  - Supports Active State Power Management, including the L0 states, by placing links in a power-saving mode during times of no link activity
- Error handling
- High bandwidth per pin with low overhead and low latency
- Lane reversal and polarity inversion
- Single-phy (one-lane) link transfer rate of 8 GT/s, 5 GT/s, and 2.5 GT/s in each direction
- Eight-lane aggregate bandwidth of up to 8 GB/s (8000 MB/s)
- Support of x16, x8, x4, x2, and x1 link widths

2.4 LED Management

Internal Tri-Mode storage adapters offer LED management support for SAS/SATA backplanes and (PCIe) NVMe backplanes. External connect adapters offer enclosure LED management support for enclosure implementations through SES. See Chapter 4, Mid-Plane Management, for more information.

2.5 Tri-Mode Storage Interface Features

The Tri-Mode storage adapter's storage interface supports concurrent operation with SAS, SATA, and PCIe (NVMe) devices to provide a fully functional solution for any storage environment.

- PCIe (NVMe) interface features:
  - Up to eight x2 or four x4 NVMe direct-attach drive support
  - Data transfer at 8 GT/s, 5 GT/s, and 2.5 GT/s
- SAS features:
  - Data transfers at 12Gb/s, 6Gb/s, and 3Gb/s
  - DataBolt technology on all SAS phys
  - Serial, point-to-point, enterprise-level storage interface
  - Wide ports that contain multiple phys
  - Narrow ports that contain a single phy
  - SAS phy power management
- SATA interface features:
  - SATA and STP data transfers at 6Gb/s and 3Gb/s
  - Addressing of multiple SATA targets through an expander

Chapter 3: Tri-Mode Storage Interface

The adapters can direct attach to SAS, SATA, or (PCIe) NVMe drives using SFF-8680 or SFF-8639 bays. The adapters support the following direct-attach options:

- SFF-8680 bay: One phy
  – x1 NVMe
  – x1 SAS
  – x1 SATA
- SFF-8680 bay: Two phys
  – x2 NVMe
  – x2 SAS (multi-link)
  – Two x1 SAS (dual port using MPIO)
- SFF-8639 bay: One, two, or four phys
  – x4 NVMe
  – x2 NVMe
  – x1 NVMe

The adapters support the SFF-TA-1001 Universal Link definition that enables tri-mode operation on the traditional SAS wiring of the SFF-8680 bay.

The Tri-Mode storage adapters also support enclosure connectivity through SAS expanders and PCIe switches. See Section 6, Configuration Scenarios, for more information on storage connectivity options.

NOTE: Carefully assess any decision to mix SAS, SATA, and NVMe drives within the same *virtual drive*. Although you can mix drives, the practice is discouraged.

3.1 SAS/SATA Support

The Tri-Mode storage adapters support internal and external storage devices, which allow you to use a system that supports enterprise-class SAS drives and desktop-class SATA III drives.

The storage interface is comprised of either 16 phys or 8 phys, depending on the controller. The phys are managed in groups of eight by dedicated hardware in ascending phy order. One dedicated instance of the SAS phy management hardware manages PHY 0 to PHY 7, and a separate instance of the SAS phy management hardware manages PHY 8 to PHY 15. These SAS phy management hardware instances, or SAS cores, cannot communicate with each other.

When you configure a wide port, the connections must attach exclusively to phys all managed by the same SAS core. If the ports are not managed by the same SAS core, unexpected controller and host behavior occurs. The figures at the following locations show how the connectors are designated for each adapter.

- MegaRAID 9460-16i – Figure 8, Card Layout for the MegaRAID 9460-16i Tri-Mode Storage Adapter
- MegaRAID 9460-8i – Figure 9, Card Layout for the MegaRAID 9460-8i Tri-Mode Storage Adapter
- MegaRAID 9480-8i8e – Figure 10, Card Layout for the MegaRAID 9480-8i8e Tri-Mode Storage Adapter
- MegaRAID 9440-8i – Figure 11, Card Layout for the MegaRAID 9440-8i Tri-Mode Storage Adapter
- HBA 9400-16i – Figure 12, Card Layout of the HBA SAS 9400-16i Tri-Mode Storage Adapter
- HBA 9400-8i – Figure 13, Card Layout of the HBA SAS 9400-8i Tri-Mode Storage Adapter
- HBA 9400-16e – Figure 14, Card Layout of the HBA 9400-16e Storage Adapter
- HBA 9400-8e – Figure 15, Card Layout of the HBA 9400-8e Storage Adapter
- HBA 9400-8i8e – Figure 16, Board Layout for the HBA 9400-8i8e Tri-Mode Storage Adapter

■ HBA 9405W-16i – Figure 17, Card Layout of the HBA 9405W-16i Tri-Mode Storage Adapter
■ HBA 9405W-16e – Figure 18, Card Layout of the HBA 9405W-16e Storage Adapter

The following table indicates the connector to SAS core mapping for each board.

Table 3 Board Port-to-SAS Port Associations

Board	Connector 0 SAS Port 0 to Port 3	Connector 1 SAS Port 4 to Port 7	Connector 2 SAS Port 8 to Port 11	Connector 3 SAS Port 12 to Port 15
9460-16i	SAS Core 1	SAS Core 1	SAS Core 0	SAS Core 0
9460-8i	SAS Core 0	SAS Core 0	N/A	N/A
9480-8i8e	SAS Core 0	SAS Core 0	SAS Core 1	SAS Core 1
9440-8i	SAS Core 0	SAS Core 0	N/A	N/A
9400-16i	SAS Core 1	SAS Core 1	SAS Core 0	SAS Core 0
9400-8i	SAS Core 0	SAS Core 0	N/A	N/A
9400-16e	SAS Core 1	SAS Core 1	SAS Core 0	SAS Core 0
9400-8e	SAS Core 0	SAS Core 0	N/A	N/A
9400-8e	SAS Core 0	SAS Core 0	N/A	N/A
9405W-16i	SAS Core 1	SAS Core 1	SAS Core 0	SAS Core 0
9405W-16e	SAS Core 1	SAS Core 1	SAS Core 0	SAS Core 0

NOTE: A single wide port cannot combine individual ports or phys sourced by different SAS cores.

Port 0 to Port 7 can be configured as eight separate ports or combined into one or more groups called wide ports (one x4, two x4s, one x8, and so on). Similarly, port 8 to port 15 can be configured as eight separate ports or combined into one or more wide ports.

When you configure a boot device in a multi-path environment, the target must connect to one or more ports on the same SAS core with AutoPortConfig enabled. The boot device appears to the host system as a single device on the active path. A different controller is managed by the multi-path environment as the passive path.

When you configure data-storage devices in a multi-path environment, the rule for creating wide ports applies, but multiple ports from different SAS cores can connect to the data-storage devices. The multi-path environment manages data-storage devices that the controller presents more than once.

3.2 PCIe (NVMe) Support

This section applies to NVMe drive connections only. Users of SAS or SATA see no difference in behavior compared to previous generation devices.

The following table shows how many NVMe drives or PCIe switches can directly attach to each Tri-Mode storage adapter.

Table 4 Number of NVMe Devices Supported for Each Adapter

Adapter	x4 PCIe (NVMe)	x2 PCIe (NVMe)
9460-16i	4	8
9460-8i	2	4
9480-8i8e	2[a]	4
9440-8i	2	4
9400-16i	4	8

Table 4 Number of NVMe Devices Supported for Each Adapter (Continued)

Adapter	x4 PCIe (NVMe)	x2 PCIe (NVMe)
9400-8i	2	4
9400-16e[a]	N/A	N/A
9400-8e[a]	N/A	N/A
9400-8i8e[a]	2	4
9405W-16i	4	8
9405W-16e[a]	N/A	N/A

    a. NVMe is supported for internal connection only.

The Tri-Mode device interface contains a SAS core and a PCIe device bridge (PDB). The PDB enables the PCIe (NVMe) storage interface connections and each PDB can support direct connect to NVMe devices or to x4 PCIe switches. The storage interface is comprised of 16 phys or 8 phys depending on the controller. One PDB manages PHY 0 to PHY 7 and a second PDB manages PHY 8 to PHY 15. The PDBs cannot communicate with each other. This arrangement means that a PCIe port of greater than one lane must attach exclusively to phys all managed by the same PDB and must be comprised of adjacent lanes.

The figures at the following locations show how the connectors are designated for each adapter.
- MegaRAID 9460-16i – Figure 8, Card Layout for the MegaRAID 9460-16i Tri-Mode Storage Adapter
- MegaRAID 9460-8i – Figure 9, Card Layout for the MegaRAID 9460-8i Tri-Mode Storage Adapter
- MegaRAID 9480-8i8e – Figure 10, Card Layout for the MegaRAID 9480-8i8e Tri-Mode Storage Adapter
- MegaRAID 9440-8i – Figure 11, Card Layout for the MegaRAID 9440-8i Tri-Mode Storage Adapter
- HBA 9400-16i – Figure 12, Card Layout of the HBA SAS 9400-16i Tri-Mode Storage Adapter
- HBA 9400-8i – Figure 13, Card Layout of the HBA SAS 9400-8i Tri-Mode Storage Adapter
- HBA 9400-16e – Figure 14, Card Layout of the HBA 9400-16e Storage Adapter
- HBA 9400-8e – Figure 15, Card Layout of the HBA 9400-8e Storage Adapter
- HBA 9400-8i8e – Figure 16, Board Layout for the HBA 9400-8i8e Tri-Mode Storage Adapter
- HBA 9405W-16i – Figure 17, Card Layout of the HBA 9405W-16i Tri-Mode Storage Adapter
- HBA 9405W-16e – Figure 18, Card Layout of the HBA 9405W-16e Storage Adapter

Because of the lane-to-connector mapping shown in the following table, connections to NVMe storage devices or PCIe switches require U.2 enabler cables. These cables align the lanes so that adjacent lanes comprise each PCIe port. Other cables do not work and the drives will not be recognized. This cable requirement is unique to PCIe (NVMe) connections and is not required for standard SAS/SATA connections. For more information on U.2 enabler cables and connection configurations, see Chapter 5, Cables and Cabling Configurations.

Table 5 Board Lanes-to-PDB Core Associations

Board	Connector 0 Lanes 7, 5, 3, 1	Connector 1 Lanes 6, 4, 2, 0	Connector 2 Lanes 7, 5, 3, 1	Connector 3 Lanes 6, 4, 2, 0
9460-16i	PDB 1	PDB 1	PDB 0	PDB 0
9460-8i	PDB 0	PDB 0	N/A	N/A
9480-8i8e[a]	PDB 0	PDB 0	N/A	N/A
9440-8i	PDB 0	PDB 0	N/A	N/A
9400-16i	PDB 1	PDB 1	PDB 0	PDB 0
9400-8i	PDB 0	PDB 0	N/A	N/A
9400-16e[a]	N/A	N/A	N/A	N/A

Table 5 Board Lanes-to-PDB Core Associations (Continued)

Board	Connector 0 Lanes 7, 5, 3, 1	Connector 1 Lanes 6, 4, 2, 0	Connector 2 Lanes 7, 5, 3, 1	Connector 3 Lanes 6, 4, 2, 0
9400-8e[a]	N/A	N/A	N/A	N/A
9400-8i8e[a]	PDB 0	PDB 0	N/A	N/A
9405W-16i	PDB 1	PDB 1	PBD 0	PBD 0
9405W-16e[a]	N/A	N/A	N/A	N/A

a. NVMe connect is not supported for external connections.

3.3 Common REFCLK Support

For connections that require a common REFCLK, one REFCLK is supplied per connector. For x4 NVMe or PCIe switch connections, the REFCLK sourced by each connector directly clocks each attached x4 PCIe connection. To directly attach x2 NVMe drives that require a common REFCLK, where more than one drive is sourced from a single connector, take care to properly fan-out the shared REFCLK on the backplane.

Chapter 4: Mid-Plane Management

The SFF-8448 standard defines how to detect whether the mid-plane supports SGPIO or 2Wire (I^2C) for SAS/SATA usage. SFF-9402 is a superset of SFF-8448, adding the PCIe-defined side-band signal, which means that SAS/SATA users see no change in mid-plane management detection when using Tri-Mode storage adapters.

The following table describes the behavior of these signals in each operation mode.

Table 6 Signal Behavior Descriptions

Name	Setting	Description
BP_TYPE	0 = SGPIO 1 = 2Wire	BP_TYPE follows SFF-8448 defined behavior. Additionally, SGPIO is not available when using drives that require a shared REFCLK. Therefore mid-planes must be set to 2Wire when using a shared REFCLK.
CNTRLR_TYPE/ CPRSNT#	If BP_TYPE = 0, CNTRLR_TYPE = BP_TYPE If BP_TYPE = 1: 0 = A PCIe device is present 1 = No PCIe device is detected	CONTRLR_TYPE is an open-drain driven signal when operating in SAS/SATA mode. When operating in PCIe (NVMe) mode and BP_TYPE indicates 2Wire, the signal indicates the connected component is a x4-capable PCIe interface.

For PCIe or NVMe connections that require a shared REFCLK, it is not possible to use SGPIO for mid-plane management. As shown in the connector tables in Chapter 3, Tri-Mode Storage Interface, REFCLK shares the same signal as SGPIO on the Mini SAS HD connector. Because they share the same signals, mid-plane management, specifically LED management, must be done over the I^2C or 2Wire signals.

4.1 Universal Backplane Management

The adapters provide LED operation and other backplane management of NVMe only, SAS/SATA only, or mixed-protocol backplanes based on the SFF-TA-1005 specification. SFF-TA-1005 is an industry-standard backplane management specification commonly known as Universal Backplane Management (UBM). As long as the backplane management controller is designed in accordance with the UBM specification, the adapter will automatically detect the backplane type and function appropriately.

The adapter supports the industry-standard *SFF-TA-1005 Specification for Universal Backplane Management (UBM)*. UBM provides the following key features:
- Reports the backplane capabilities, including the following:
  - NVMe drive widths
  - Common REFCLK or separate REFCLK support
  - Maximum speeds
  - Designed slot power
- Supports cable order independence
  - Drive LED control and slot ID are not dependent on cable order
- Enables drive hot-plug insertion through control of PERST# timing

Refer to the *SFF-TA-1005 Specification for Universal Backplane Management (UBM)* for more UBM details.

4.2 SGPIO Backplane Management

For existing SAS/SATA backplanes, if BP_TYPE = 0, the adapter uses SGPIO for legacy backplane management. Refer to the SFF-8485 specification for functionality details. New backplanes should use the industry-standard SFF-TA-1005 (UBM) specification for backplane management.

4.3 Virtual Pin Port Management

Broadcom requires new designs to enable UBM for backplane management. The adapter maintains support for Virtual Pin Port (VPP) backplane management for legacy implementations. The adapters provide LED operation for NVMe devices based on the VPP over I^2C definition. Standard VPP implementation calls for one PCA9555 target per two devices. For each drive pair, the adapter expects to see one PCA9555 target responding to address 0x40 on each pair of NVMe drives. Each leg of the U.2 enabler cable must connect to adjacent drives; otherwise, the LEDs might not work properly. It does not matter which leg of the cable is plugged into which connector pair as long as adjacent pairs are used.

The following figure shows expected connections from the 9460-16i storage adapter to NVMe drives using VPP over I^2C for LED management. The red lines in the figure represent the I^2C bus.

Figure 1 NVMe LED Operation
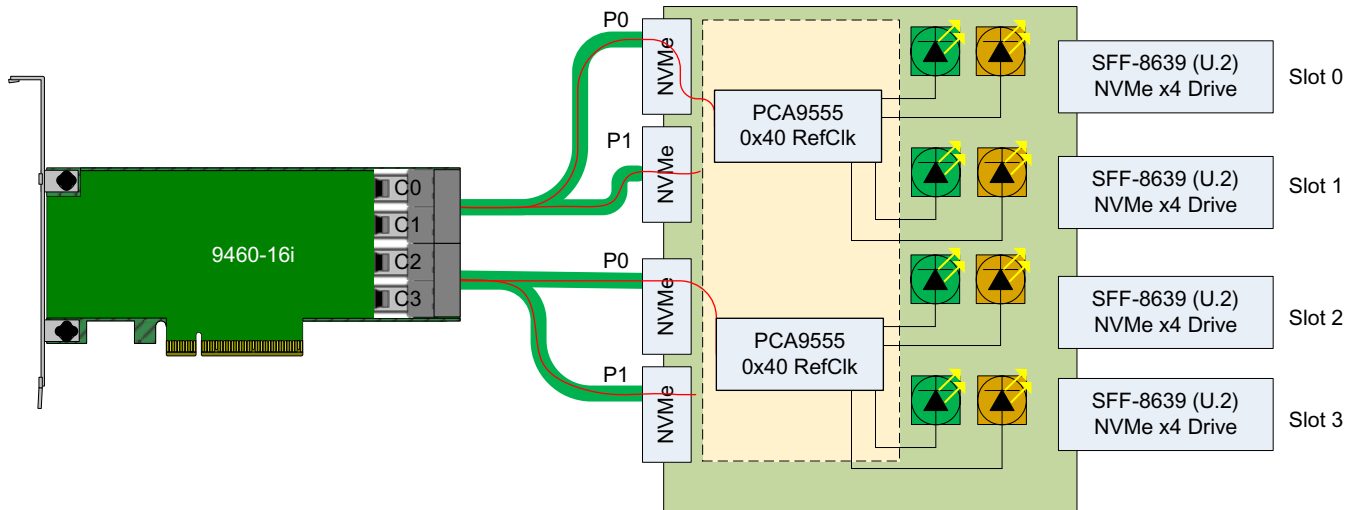
3_03884-00

Chapter 5: Cables and Cabling Configurations

5.1 PCIe (NVMe) Storage Interface Cabling

Direct-attach connections to backplanes that support NVMe U.2 drives or a PCIe switch require use of the U.2 enabler cable. The U.2 enabler cable provides proper REFCLK pairing and shielding and enables the adapter to support VPP over I^2C for LED management. The U.2 enabler cable has a 1x8 Mini SAS HD connector on the PCIe adapter side and provides connections to OCuLink, SlimLine, or Mini SAS HD for the backplane NVMe connection. The following figure shows an example of a U.2 enabler cable.

Figure 2 U.2 Enabler Cable 1x8 Mini SAS HD (Adapter Side) to 2x4 SlimLine

Pick the proper cable for the given backplane type and connectors. The correct choice is especially important for backplanes that use Mini SAS HD for the NVMe connectors. Many of these backplanes use an older legacy-recommended pinout for the NVMe connector instead of a connector pinout based on the SFF-9402 specification. Most backplanes that use either OCuLink or SlimLine follow the SFF-9402 specification. The pinout recommended in the *PCI Express OCuLink Specification* is equivalent to that recommended for SFF-9402. Verify the connector pinout for the backplane targeted to make sure the proper cable is used when connecting to NVMe drives.

5.2 Backplanes with Mini SAS HD Connectors

Many backplanes that support NVMe use white Mini SAS HD connectors to indicate which connectors are for NVMe and which are for SAS/SATA. Usually backplanes have the protocol screen-printed on the backplane near the connectors. The following table provides the legacy PCIe Mini SAS HD connector pinout that you may use on Mini SAS HD-based NVMe backplanes. In the table, TX signals indicate outputs from backplane connector; RX signals indicate inputs to the backplane connector.

Table 7 Legacy PCIe over Mini SAS HD Backplane Connector Pinout

Pin	Description	Pin	Description
D1	BMC_SMB_CLK	B1	GND
D2	BMC_SMB_DAT	B2	PE_RST_N
D3	GND	B3	GND
D4	TX0_P	B4	RX0_P
D5	TX0_N	B5	RX0_N
D6	GND	B6	GND
D7	TX2_P	B7	RX2_P
D8	TX2_N	B8	RX2_N
D9	GND	B9	GND
C1	CPU_SMB_CLK	A1	PCIE_CLK_100M_N
C2	CPU_SMB_DAT	A2	PCIE_CLK_100M_P
C3	GND	A3	GND
C4	TX1_P	A4	RX1_P
C5	TX1_N	A5	RX1_N
C6	GND	A6	GND
C7	TX3_P	A7	RX3_P
C8	TX3_N	A8	RX3_N
C9	GND	A9	GND

NOTE: The pinout in this table is not the pinout used on the Broadcom Tri-Mode storage adapter. For Tri-Mode versatility (for SAS and NVMe support), the adapters follow the SFF-9402 pinout.

5.3 Backplanes with OCuLink or SlimLine Connectors

OCuLink or SlimLine are the preferred connectors to use for NVMe backplane connectors. This approach enables a straightforward keying mechanism to prevent connecting NVMe drives with standard 12Gb/s SAS cables.

Backplanes that use OCuLink connectors should follow the *PCI Express OCuLink Specification*. This pinout is also equivalent to the SFF-9402 specification recommendations. Verify the backplane connector pinout to make sure you use proper cabling to the NVMe drive. Refer to the *PCI Express OCuLink Specification* and the SFF-9402 specification for backplane NVMe connector pinout information.

Chapter 6: Configuration Scenarios

The following section describes the various configuration scenarios for the internal port count boards. This list of scenarios is not exhaustive, but it shows some different available options. Each scenario includes a view of the cabling between the adapter and the mid-plane.

6.1 SAS/SATA Connect

The Tri-Mode storage adapters support connections to SAS/SATA drives or SAS expanders using standard 12Gb/s SAS cables. The adapter supports connections to both single-ported and dual-ported SAS drives. See Section 3.1, SAS/SATA Support, for more information on using wide port SAS connections on 16-port adapters.

The following figure shows a typical direct-attach SAS/SATA configuration. Using expanders, you can increase the number of drives attached to a single adapter.

Figure 3 Standard 12Gb/s SAS Cable Direct Attach

3_03545-00
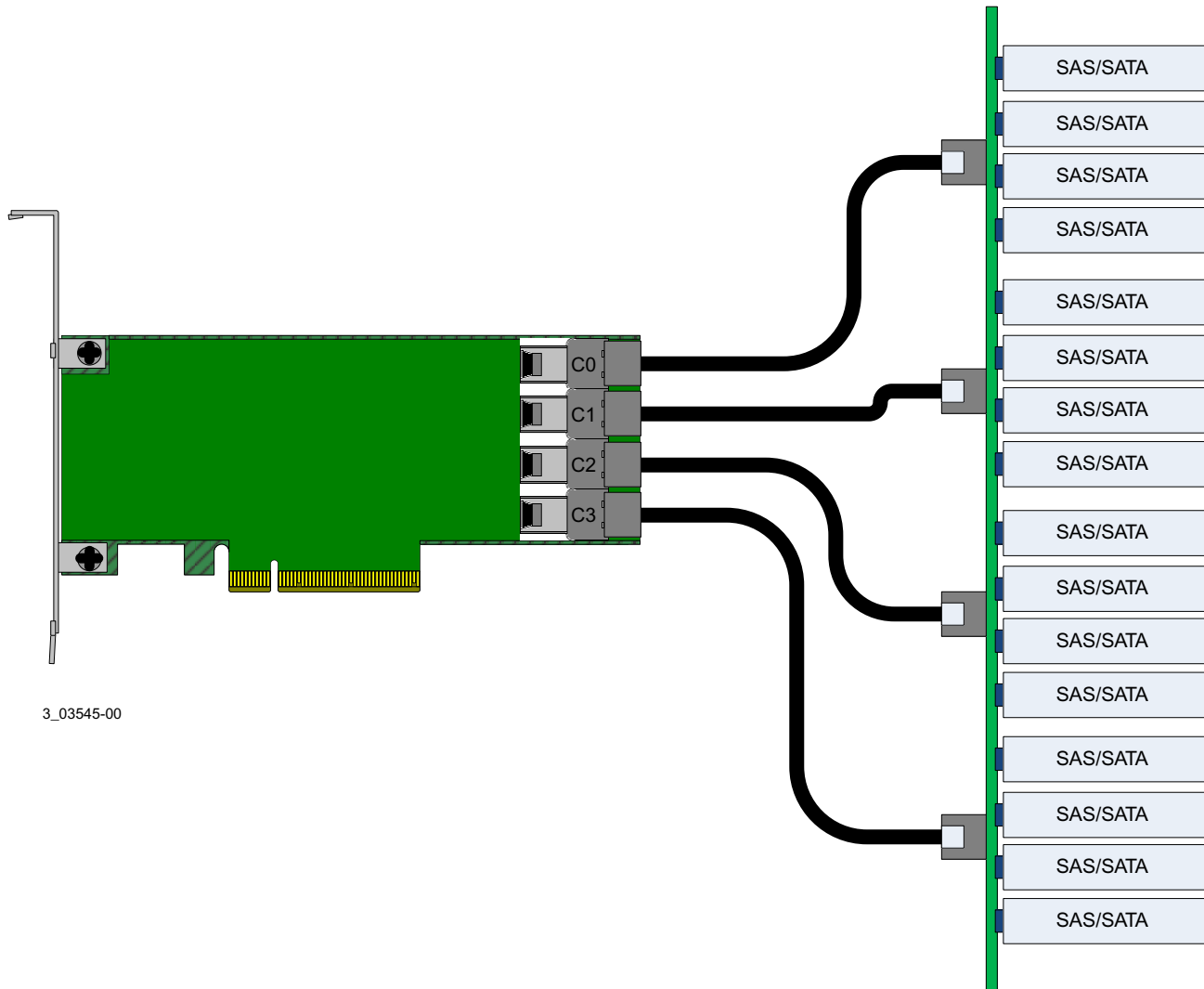
6.2 x2 NVMe Direct Attach

The following figure shows eight x2 NVMe drives that attach directly to the adapter. Each drive must be connected using adjacent lanes and stay within the same PDB. See Section 3.2, PCIe (NVMe) Support, for more information on PDB and connector arrangement. Design the backplane NVMe connectors based on the SFF-9402 pinout standard, and use the available U.2 enabler cables described in Chapter 5, Cables and Cabling Configurations, to avoid improper connection scenarios.

One REFCLK is supplied per connector. To directly attach x2 NVMe where more than one drive is sourced from a single connector, take care to properly fan-out the shared REFCLK on the backplane.

Figure 4 Connecting x2 NVMe Drives with U.2 Enabler Cables

3_03549-00
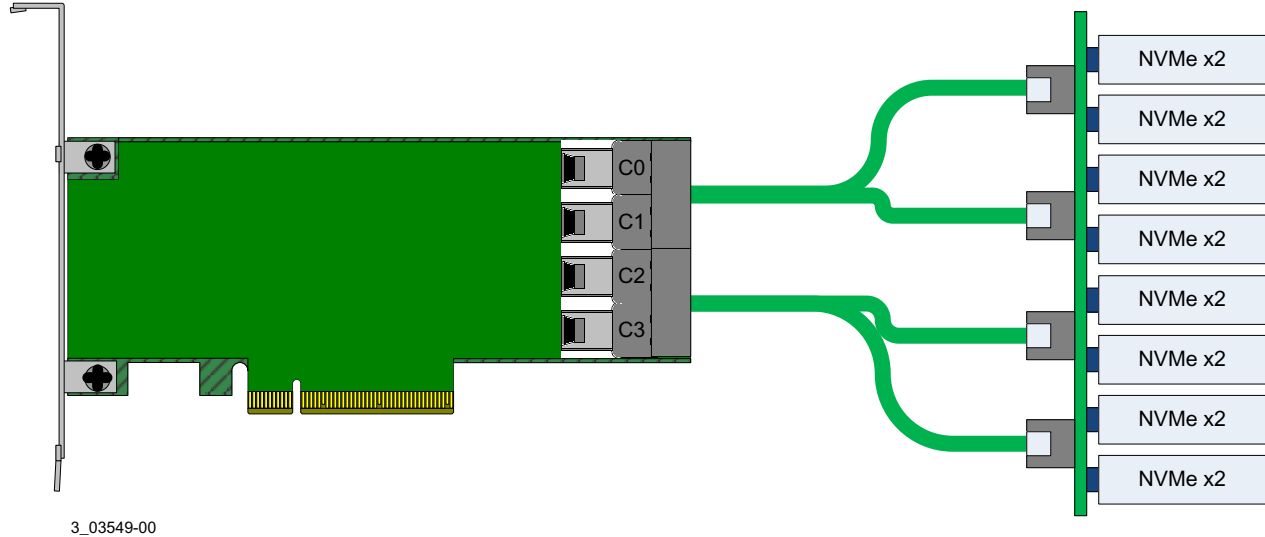
6.3 x4 NVMe Direct Attach

The following figure shows attaching four x4 NVMe drives directly to the adapter. Each drive must be connected using adjacent lanes and stay within the same PDB. Connector 0 and Connector 1 can connect to two x4 NVMe drives, and Connector 2 and Connector 3 can connector to two x4 NVMe drives. See Table 5, Board Lanes-to-PDB Core Associations, for more information on PDB and connect arrangement. Design the backplane NVMe connectors based on the SFF-9402 pinout standard and use the available U.2 enabler cables described in Chapter 5, Cables and Cabling Configurations, to avoid improper connection scenarios.

Figure 5 x4 NVMe Direct Attach with U.2 Enabler Cables

3_03555-00
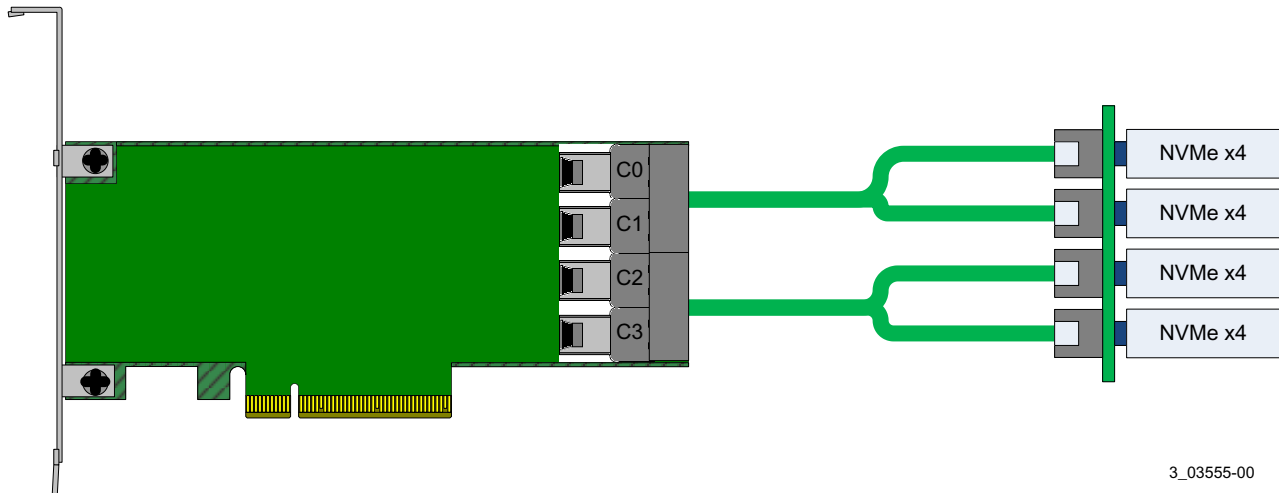
6.4 x4 NVMe and x1 SAS Direct Attach

The following figure shows two x4 NVMe drives and eight x1 SAS that attach directly to the adapter. The x4 NVMe drives require use of the U.2 enabler cable described in Chapter 5, Cables and Cabling Configurations, and the SAS drives use standard 12Gb/s SAS cables. Each x4 NVMe drive must be connected using adjacent lanes within a single PDB. The figure shows using Connector 0 and Connector 1 for the NVMe connections and Connector 2 and Connector 3 for the SAS connections. This arrangement can be reversed so that Connector 2 and Connector 3 are used for the NVMe connections and Connector 0 and Connector 1 are used for the SAS connections.

Figure 6 x4 NVMe and x1 SAS Direct Attach
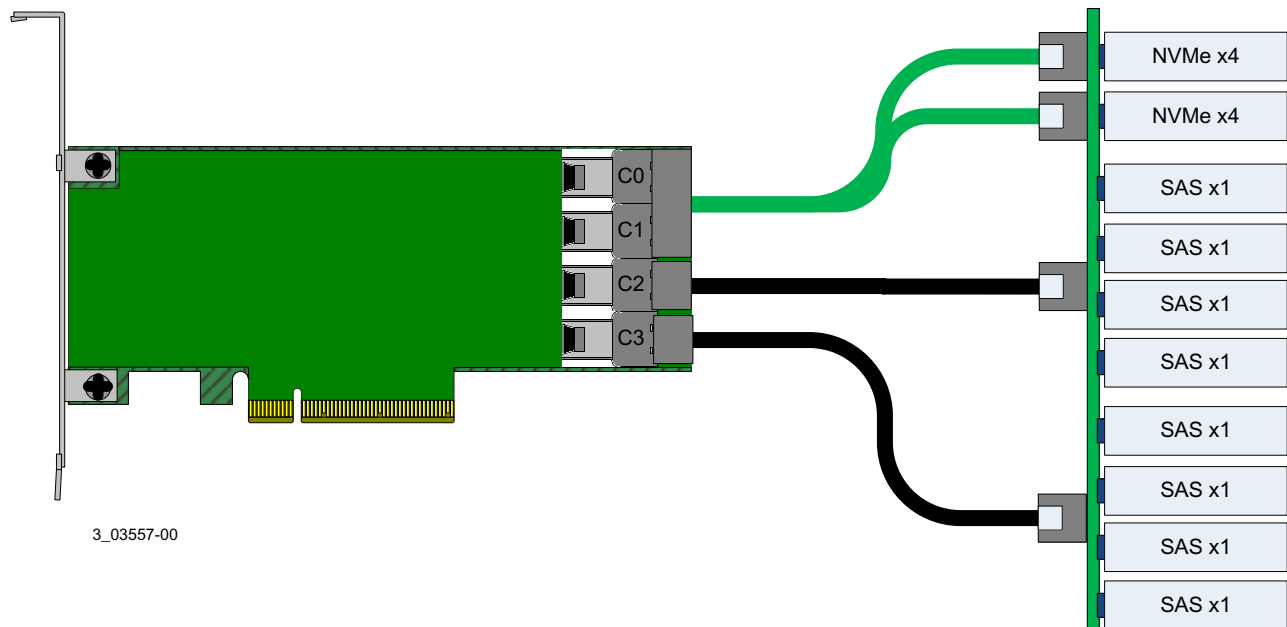
Chapter 7: CacheVault Data Protection

The MegaRAID Tri-Mode storage adapters support data retention by using NAND flash memory down on the adapter, backed up by a CacheVault™ Power Module 05 (CVPM05).

NOTE: The MegaRAID 9440-8i Tri-Mode storage adapter and the HBAs do not support CacheVault data protection.

The CVPM05 module is a super-capacitor pack that provides power for the backup of your data in case of host power loss or server failure. The CVPM05 module connects to the controller remotely by cable. The data is backed up to the NAND flash memory available on the MegaRAID storage adapter.

In the event of host power loss or server failure, any data available in the cache is offloaded to the on-board NAND memory. During this process, the CVPM05 power module powers the necessary components needed for offload.

NOTE: You cannot hot-plug CVPM05 modules. Removing or inserting a CVPM05 module with the adapter powered on might damage the board and the super-capacitor functionality. To attach or remove a CVPM05 module from an adapter, you must fully power down the adapter before you attach the module to or remove the module from its mating connector.

For more information on installation of the CVPM05 module, refer to the *CacheVault Power Module 05 Getting Started Guide* available at http://www.broadcom.com/support/download-search.

Chapter 8: Adapter Installation Instructions

This chapter provides detailed instructions on how to install your Tri-Mode storage adapter.

NOTE: Figure 7, Installing the MegaRAID 9480-8i8e Tri-Mode Storage Adapter in a PCIe Slot, shows the installation of the MegaRAID 9480-8i8e Tri-Mode storage adapter in a PCIe slot. You can install other Tri-Mode storage adapters in the same way.

To install the adapter, follow these steps:

1. **Unpack your Tri-Mode storage adapter.**

   Unpack and remove the adapter. Inspect the adapter for damage. If it appears damaged, contact Broadcom Technical Support.

ATTENTION: To avoid the risk of data loss, back up your data before you change your system configuration.

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 adapter, make sure that the computer is disconnected from the power and from any networks.

CAUTION! Disconnect the computer from the power supply and from any networks to which you will install the adapter, or you risk damaging the system or experiencing electrical shock.

3. **Review the adapter connectors.**

   See Chapter 9, Broadcom MegaRAID and HBA Tri-Mode Storage Adapter Characteristics, for diagrams of the Tri-Mode storage adapters that show their connectors.

4. **Check the mounting bracket on the adapter.**

   If required for your system, replace the full-profile mounting bracket that ships on the adapter with the low-profile bracket supplied. Complete the following steps to attach the low-profile bracket.

   a. Using a No. 1 Phillips screwdriver that is ESD safe, remove the two Phillips screws that connect the full-profile bracket to the board. Unscrew the two screws located at the top and bottom edges of the board. Avoid touching any board components with the screwdriver or the bracket.

   b. Remove the full-profile bracket. Do not damage the adapter.

   c. Place the adapter on top of the low-profile bracket. Position the bracket so that the screw holes in the tabs align with the openings in the board.

   d. Using a No. 1 Phillips torque screwdriver that is ESD safe, set to a maximum torque of 4.8 ± 0.5 inch-pounds. Replace the two Phillips screws removed in Step a.

**ATTENTION:** Exceeding this torque specification can damage the board, connectors, or screws, and can void the warranty on the board.

ATTENTION: Damage caused to the board as a result of changing the bracket can void the warranty on the board. Adapters returned without a bracket mounted on the board will be returned without return merchandise authorization (RMA) processing.

5. **Insert the Tri-Mode storage adapter into an available PCIe slot.** Select a PCIe slot, and align the controller's PCIe bus connector to the slot, as shown in the following figure. 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.

NOTE: Adapters with a x8 host interface can operate in x8 or x16 slots. However, some x16 PCIe slots support only PCIe graphics cards; an adapter installed in one of these slots will not function. Refer to the guide for your motherboard for information about the PCIe slots.

Figure 7 Installing the MegaRAID 9480-8i8e Tri-Mode Storage Adapter in a PCIe Slot
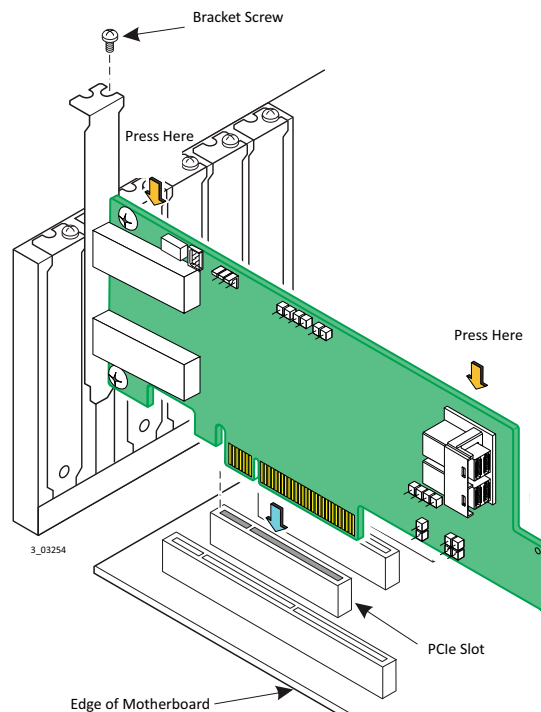
6. **Configure and install the SAS, SATA, and PCIe (NVMe) devices in the host computer case.**

Refer to documentation for the devices for any pre-installation configuration requirements.

7. **Connect the Tri-Mode storage adapter to the devices.**

For SAS/SATA connections, connect standard 12Gb/s SAS cables with an internal Mini SAS HD connector on one end to connect to the controller and the appropriate connector on the other end to attach to the backplane or SAS/SATA devices.

For PCIe (NVMe) connections, special cables are needed depending on the type of NVMe drive in use. The adapter connector's pin definitions follow the SFF-9402 specification and cables must support this connector pin definition. For more information on types of cables needed for NVMe connectivity, see Chapter 5, Cables and Cabling Configurations.

CAUTION! For NVMe connections to a SFF-8639 (U.2) bay or connections to a PCIe switch, use only approved cables with REFCLK forwarded on the proper pins. Improperly connecting a standard 12Gb/s SAS cable to a SFF-8639 bay could damage the PCIe storage adapter and the drive.

The maximum cable length is 1 meter (39.37 in.). A single wide-port SAS or multi-lane PCIe (NVMe) device cannot connect to phys controlled by different SAS cores or PDBs. See Chapter 3, Tri-Mode Storage Interface, for more information.

8. Provide the required airflow for the installed adapter. See Section 10.1, Operating and Nonoperating Conditions, to find the adapter's cooling requirements.

9. **Turn on the power to the system.**

    Reinstall the computer cover, and reconnect the AC power cords. Make sure that the power is turned on to the storage devices before or at the same time that the power is turned on to the host computer. Turn on power to the host computer. If the computer is powered on 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 shows the adapter controller number, firmware version, and cache SDRAM size. The numbering of the controllers follows the PCI slot scanning order used by the host motherboard.

10. **Choose the correct storage profile.**

    The adapters can run in different profiles to enable storage interface connections to SAS/SATA only, PCIe only, or mixed (SAS/SATA and PCIe). The default firmware loaded on the HBAs enables mixed-mode operation. You can download the SAS/SATA only profile for the HBAs from Support and Download center at http://www.broadcom.com/support/download-search.

    The MegaRAID adapters support the following three basic modes or profiles of operation for the storage interface:

    - SAS/SATA only mode
    - NVMe only mode
    - Mixed mode

    Refer to the *12Gb/s MegaRAID Tri-Mode Software User Guide* for a complete list of supported profiles. Each profile is set through StorCLI, Human Interface Infrastructure (HII), or LSI® Storage Authority software (LSA). The default mode is the SAS/SATA only profile.

    StorCLI: Use the following two commands to perform profile ID management on StorCLI:

    - `storcli /cx show profile`
    - `storcli /cx set profile profileid=<value>`

    After you set the new profile, reboot the system for the changes to take effect.

    HII: For information on how to manage profiles through HII, refer to the section on profile m

    anagement in the *12Gb/s MegaRAID Tri-Mode Software User Guide*.

    LSA: For information on how to manage profiles through LSA, refer to the section on profile management in the *LSI Storage Authority Software User Guide*.

11. **Install the operating system driver.**

    The Tri-Mode storage adapters can operate under various operating systems. To operate under these operating systems, you must install the software drivers. The firmware and drivers are routinely updated and made available on the Support and Download center. Visit http://www.broadcom.com/support/download-search and download the latest firmware and driver for the controller.

The hardware installation of your Tri-Mode storage adapter is complete.

Chapter 9: Broadcom MegaRAID and HBA Tri-Mode Storage Adapter Characteristics

9.1 MegaRAID 9460-16i Adapter – Connector and LED Designations

The MegaRAID 9460-16i Tri-Mode storage adapter is a 6.127 in. × 2.712 in. (155.65 mm × 68.90 mm) board. The component height on the top and bottom of the adapter complies with the PCIe specification. This section provides the connector and LED designations for the MegaRAID 9460-16i Tri-Mode storage adapter.

The following figure shows the connectors and LED locations on the MegaRAID 9460-16i Tri-Mode storage adapter. Pin 1 on the headers and connectors is highlighted in red in the figure.

Figure 8 Card Layout for the MegaRAID 9460-16i Tri-Mode Storage Adapter
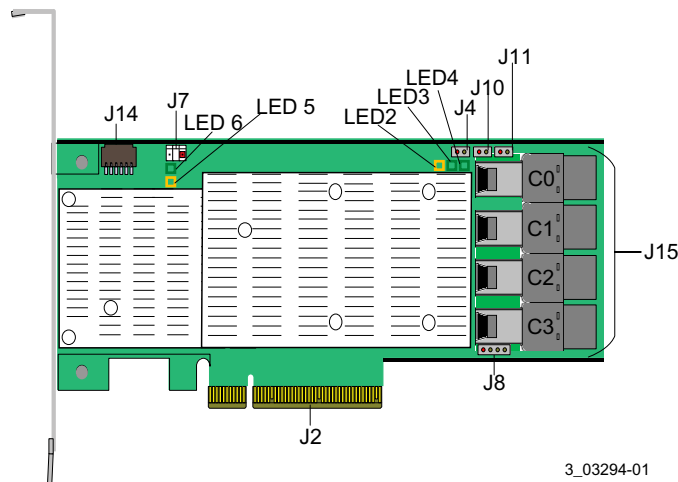
3_03294-01

The following table describes the headers and connectors on the MegaRAID 9460-16i Tri-Mode storage adapter.

Table 8 Headers and Connectors

Connector	Type	Description
J2	Standard edge card connector	The interface between the storage adapter and the host system.
		With the PCIe interface, this connector provides power to the board and an I^2C interface connected to the I^2C bus for the Intelligent Platform Management Interface (IPMI).
J4	Default serial boot ROM (SBR) header	2-pin connector. Reserved for Broadcom use.
J7	Advanced software options hardware key header	2-pin header (middle pin is not populated). Enables support for selected advanced features.
J8	On-board Serial Universal Asynchronous Receiver/Transmitter (UART) connector	4-pin connector. Reserved for Broadcom use.
J10	Global hard disk drive (HDD) activity LED header	2-pin connector. Connects to an LED that indicates activity on the drives connected to the controller.

Table 8 Headers and Connectors (Continued)

Connector	Type	Description
J11	Global drive fault LED header	2-pin connector. Connects to an LED that indicates whether a drive is in a fault condition.
J14	CacheVault power module interface	9-pin connector. Connects the adapter to a CacheVault power module.
J15	Storage interface connectors	Four SFF-8643 Mini-SAS HD 4-port internal connectors. Connects the adapter by cable to the storage devices.

The following table describes the LEDs on the Tri-Mode storage adapter.

Table 9 LED Designations

LED	Type	Description
LED 2	Yellow RoC over temperature	Stays on solid to indicate that the SAS3516 device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.
LED 3	Green system heartbeat	Indicates that the SAS3516 RoC ASIC is operating normally. This LED blinks at 1 Hz.
LED 4	Green dirty cache	Indicates the cache is dirty, that is, not yet saved to the storage devices.
LED 5	Yellow supercap fault	Indicates that the CacheVault power module is in fault state or is over temperature.
LED 6	Green Open NAND Flash Interface (ONFI) activity	Indicates when the ONFI is active for cache offload or recovery.

9.2 MegaRAID 9460-8i Adapter – Connector and LED Designations

The MegaRAID 9460-8i Tri-Mode storage adapter is a 6.127 in. × 2.712 in. (155.65 mm × 68.90 mm) board. The component height on the top and bottom of the adapter complies with the PCIe specification. This section provides the connector and LED designations for the MegaRAID 9460-8i Tri-Mode storage adapter.

The following figure shows the connector and LED locations on the MegaRAID 9460-8i Tri-Mode storage adapter. Pin 1 on the headers and connectors is highlighted in red in the figure.

Figure 9 Card Layout for the MegaRAID 9460-8i Tri-Mode Storage Adapter
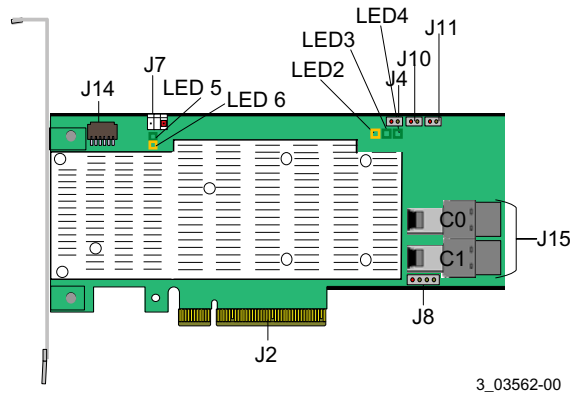
3_03562-00

The following table describes the headers and connectors on the MegaRAID 9460-8i Tri-Mode storage adapter.

Table 10 Headers and Connectors

Connector	Type	Description
J2	Standard edge card connector	The interface between the storage adapter and the host system. With the PCIe interface, this connector provides power to the board and an I^2C interface connected to the I^2C bus for the IPMI.
J4	Default SBR header	2-pin connector. Reserved for Broadcom use.
J7	Advanced software options hardware key header	2-pin header (middle pin is not populated). Enables support for selected advanced features.
J8	On-board serial UART connector	4-pin connector. Reserved for Broadcom use.
J10	Global HDD activity LED header	2-pin connector. Connects to an LED that indicates activity on the drives connected to the controller.
J11	Global drive fault LED header	2-pin connector. Connects to an LED that indicates whether a drive is in a fault condition.
J14	CacheVault power module interface	9-pin connector. Connects the storage adapter to a CacheVault power module.
J15	Storage interface connectors	Two SFF-8643 Mini-SAS HD 4-port internal connectors. Connects the controller by cable to the storage devices.

The following table describes the LEDs on the storage adapter.

Table 11 LED Designations

LED	Type	Description
LED 2	Yellow RoC over temperature	Stays on solid to indicate that the SAS3508 device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.
LED 3	Green system heartbeat	Indicates that the SAS3508 RoC ASIC is operating normally. This LED blinks at 1 Hz.
LED 4	Green dirty cache	Indicates the cache is dirty, that is, not yet saved to the storage devices.
LED 5	Yellow supercap fault	Indicates that the CacheVault power module is in fault state or is over temperature.
LED 6	Green ONFI activity	Indicates when the ONFI is active for cache offload or recovery.

9.3 MegaRAID 9480-8i8e Adapter – Connector and LED Designations

The MegaRAID 9480-8i8e Tri-Mode storage adapter is a 6.600 in. × 2.712 in. (167.65 mm × 68.90 mm) board. The component height on the top and bottom of the adapter complies with the PCIe specification. This section provides the board connector and LED designations for the MegaRAID 9480-8i8e Tri-Mode storage adapter.

The following figure shows the connector and LED locations on the MegaRAID 9480-8i8e Tri-Mode storage adapter. Pin 1 on the headers and connectors is highlighted in red in the figure.

Figure 10 Card Layout for the MegaRAID 9480-8i8e Tri-Mode Storage Adapter

The following table describes the headers and connectors on the MegaRAID 9480-8i8e Tri-Mode storage adapter.

Table 12 Headers and Connectors

Connector	Type	Description
J2	Standard edge card connector	The interface between the adapter and the host system.
		With the PCIe interface, this connector provides power to the board and an I^{2}C interface connected to the I^{2}C bus for the IPMI.
J4	Mode select header	2-pin connector.
		Reserved for Broadcom use.
J7	Advanced software options hardware key header	2-pin header (middle pin not populated).
		Enables support for selected advanced features.
J8	On-board serial UART connector	4-pin connector.
		Reserved for Broadcom use.
J10	Global HDD activity LED header	2-pin connector.
		Connects to an LED that indicates activity on the drives connected to the controller.
J11	Global drive fault LED header	2-pin connector.
		Connects to an LED that indicates activity on the drives connected to the controller.
J14	CacheVault power module interface	9-pin connector.
		Connects the storage adapter to a super-capacitor to provide power to back up your data in case of host power loss or server failure.
J15	Storage interface connectors	Two SFF-8643 Mini-SAS HD internal connectors.
		Connects the adapter by cable to the storage devices.
	Storage interface connectors	Two SFF-8644 Mini-SAS HD external connectors.
		Connects the adapter by cable to the storage devices.

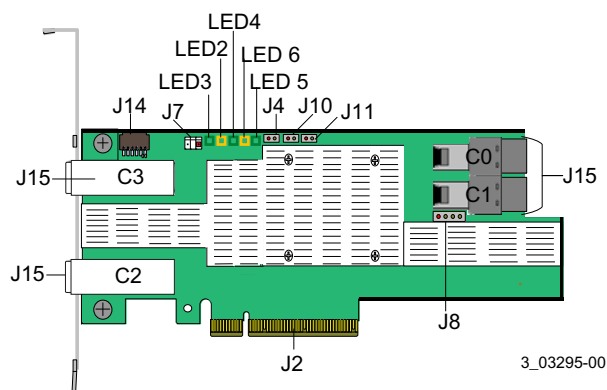The following table describes the LEDs on the storage adapter.

Table 13 LED Designations

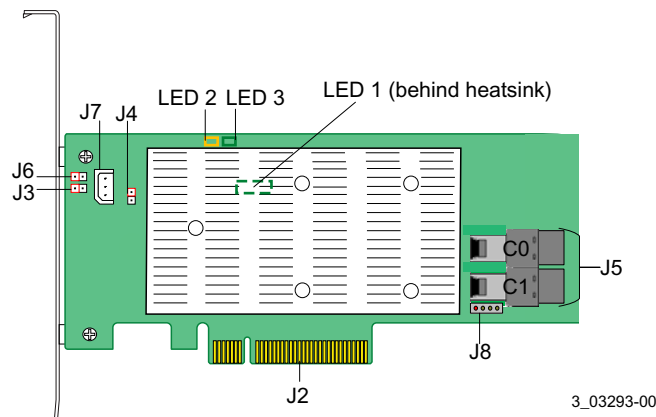| LED	Type	Description
LED 2	Yellow RoC over temperature	Stays on solid to indicate that the SAS3508 device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.

Table 13 LED Designations (Continued)

LED	Type	Description
LED 3	Green system heartbeat	Indicates that the SAS3508 RoC ASIC is operating normally. This LED blinks at 1 Hz.
LED 4	Green dirty cache	Indicates the cache is dirty, that is, not yet saved to the storage devices.
LED 5	Yellow supercap fault	Indicates that the CacheVault power module is in fault state or is over temperature.
LED 6	Green ONFI activity	Indicates when the ONFI is active for cache offload or recovery.

9.4 MegaRAID SAS 9440-8i Adapter – Connector and LED Designations

The MegaRAID 9440-8i Tri-Mode storage adapter is a 6.127 in. × 2.712 in. (155.65 mm × 68.90 mm) board. The component height on the top and bottom of the adapter complies with the PCIe specification. This section provides the board connector and LED designations for the MegaRAID 9440-8i Tri-Mode storage adapter.

The following figure shows the connector and LED locations on the MegaRAID 9440-8i Tri-Mode storage adapter. Pin 1 on the headers and connectors is highlighted in red in the figure.

Figure 11 Card Layout for the MegaRAID 9440-8i Tri-Mode Storage Adapter

The following table describes the headers and connectors on the MegaRAID 9440-8i Tri-Mode storage adapter.

Table 14 Headers and Connectors

Connector	Type	Description
J2	Standard edge card connector	The interface between the adapter and the host system. With the PCIe interface, this connector provides power to the board and an I^2C interface connected to the I^2C bus for the IPMI.
J3	Global drive fault LED header	2-pin connector. Connects to an LED that indicates activity on the drives connected to the controller.
J4	Default SBR header	2-pin connector. Reserved for Broadcom use.
J5	Storage interface connectors	Two SFF-8643 mini-SAS HD-4i internal connectors. Connects the adapter by cable to the storage devices.
J6	Global HDD activity LED header	2-pin connector. Connects to an LED that indicates activity on the drives connected to the controller.
J7	RAID premium key feature header	3-pin header. Enables support for selected advanced features.

Table 14 Headers and Connectors (Continued)

Connector	Type	Description
J8	On-board serial UART connector	4-pin port. Reserved for Broadcom use.

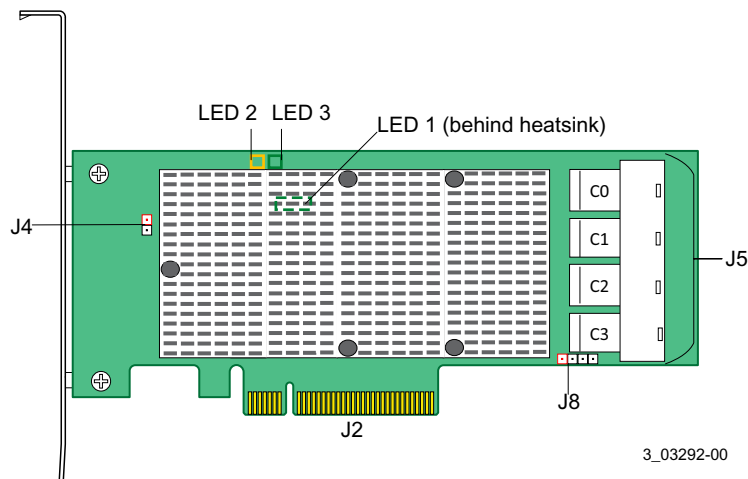The following table describes the LEDs on the storage adapter.

Table 15 LED Designations

LED	Type	Description
LED 1	Green Programmable System-on-Chip (PSoC) heartbeat LED	Indicates that the PSoC is operating normally.
LED 2	Yellow IOC over temperature	Stays on solid to indicate that the SAS3408 device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.
LED3	Green system heartbeat	Indicates that the SAS3408 IOC is operating normally.

9.5 HBA 9400-16i Adapter – Connector and LED Designations

The HBA 9400-16i Tri-Mode storage adapter is a a 6.127 in. × 2.712 in. (155.65 mm × 68.90 mm) board. The component height on the top and bottom of the HBA complies with the PCIe specification. This section provides the board connector and LED designations for the HBA 9400-16i Tri-Mode storage adapter.

The following figure shows the HBA board layout for the HBA 9400-16i Tri-Mode storage adapter. Pin 1 is highlighted in red in the figure.

Figure 12 Card Layout of the HBA SAS 9400-16i Tri-Mode Storage Adapter

The following table describes the connectors on the HBA 9400-16i Tri-Mode storage adapter.

Table 16 Connectors

Connector	Type	Description
J2	Standard board edge connector	PCIe x8 board edge connector. With the PCIe interface, this connector provides power to the board and an I^{2}C interface connected to the I^{2}C bus for the IPMI.
J4	Mode select header	2-pin connector. Reserved for Broadcom use.
J5	Storage interface connectors	Four SFF-8643 Mini SAS HD internal connectors. Connects the adapter by cable to storage devices.
J8	On-board serial UART connector	4-pin connector. Reserved for Broadcom use.

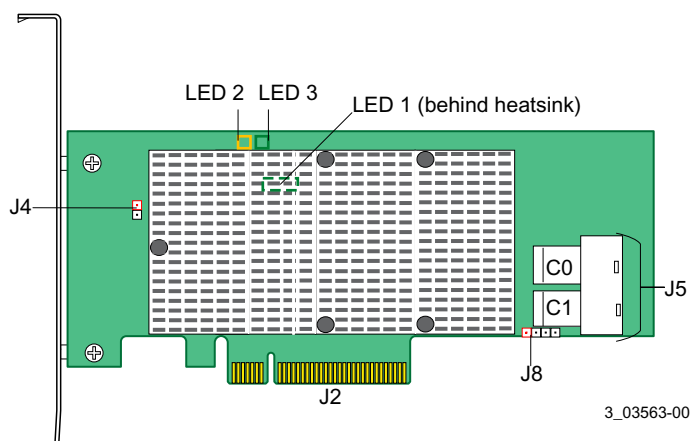The following table describes the LEDs on the storage adapter.

Table 17 LED Designations

LED	Type	Description
LED 1	Green PSoC heartbeat LED	Indicates that the PSoC is operating normally.
LED 2	Yellow IOC over temperature	Stays on solid to indicate that the SAS3416 device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.
LED3	Green system heartbeat	Indicates that the SAS3416 IOC is operating normally.

9.6 HBA 9400-8i Adapter – Connector and LED Designations

The HBA 9400-8i Tri-Mode storage adapter is a 6.127 in. × 2.712 in. (155.65 mm × 68.90 mm) board. The component height on the top and bottom of the HBA complies with the PCIe specification. This section provides the board connector and LED designations for the HBA 9400-8i Tri-Mode storage adapter.

The following figure shows the connector and LED locations for the HBA 9400-8i Tri-Mode storage adapter. Pin 1 is highlighted in red in the figure.

Figure 13 Card Layout of the HBA SAS 9400-8i Tri-Mode Storage Adapter

The following table describes the connectors on the HBA 9400-8i Tri-Mode storage adapter.

Table 18 Connectors

Connector	Type	Description
J2	Standard board edge connector	PCIe x8 board edge connector. With the PCIe interface, this connector provides power to the board and an I^{2}C interface connected to the I^{2}C bus for the IPMI.
J4	Mode select	2-pin connector. Reserved for Broadcom use.
J5	Storage interface connectors	Two SFF-8643 Mini-SAS HD internal connectors. Connects the adapter by cable to the storage devices.
J8	On-board serial UART connector	4-pin connector. Reserved for Broadcom use.

The following table describes the LEDs on the storage adapter.

Table 19 LED Designations

LED	Type	Description
LED 1	Green PSoC heartbeat LED	Indicates that the PSoC is operating normally.
LED 2	Yellow IOC over temperature	Stays on solid to indicate that the SAS3408 device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.
LED3	Green system heartbeat	Indicates that the SAS3408 IOC is operating normally.

9.7 HBA 9400-16e Adapter – Connector and LED Designations

The HBA 9400-16e storage adapter is a 6.600 in. × 2.712 in. (167.65 mm × 68.90 mm) board. The component height on the top and bottom of the HBA complies with the PCIe specification. This section provides the board connector and LED designations for the HBA 9400-16e Tri-Mode storage adapter.

The following figure shows the HBA board connector and LED designations for the HBA 9400-16e storage adapter. Pin 1 is highlighted in red in the figure.

Figure 14 Card Layout of the HBA 9400-16e Storage Adapter
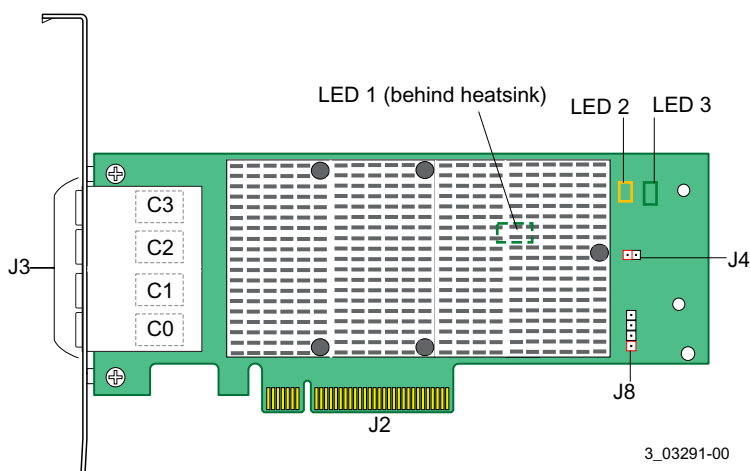
The following table describes the connectors on the HBA 9400-16e storage adapter.

Table 20 Connectors

Connector	Type	Description
J2	Standard board edge connector	PCIe x8 board edge connector. With the PCIe interface, this connector provides power to the board and an I^{2}C interface connected to the I^{2}C bus for the IPMI.
J3	Storage interface connectors	Four SFF-8644 Mini SAS HD external connectors. Connects the adapter by cable to the storage devices.
J4	Mode select	2-pin connector. Reserved for Broadcom use.
J8	On-board Serial UART connector	4-pin connector. Reserved for Broadcom use.

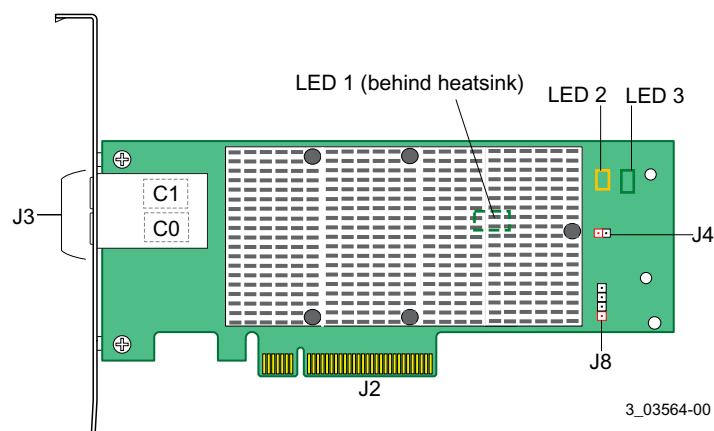The following table describes the LEDs on the storage adapter.

Table 21 LED Designations

LED	Type	Description
LED 1	Green PSoC heartbeat LED	Indicates that the PSoC is operating normally.
LED 2	Yellow IOC over temperature	Stays on solid to indicate that the SAS3416 device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.
LED3	Green system heartbeat	Indicates that the SAS3416 IOC is operating normally.

9.8 HBA 9400-8e Adapter – Connector and LED Designations

The HBA 9400-8e storage adapter is a 6.600 in. × 2.712 in. (167.65 mm × 68.90 mm) board. The component height on the top and bottom of the HBA complies with the PCIe specification. This section provides the board connector and LED designations for the HBA 9400-8e storage adapter.

The following figure shows the connectors and LED designations on the HBA 9400-8e storage adapter. Pin 1 is highlighted in red in the figure.

Figure 15 Card Layout of the HBA 9400-8e Storage Adapter

3_03564-00

The following table describes the headers and connectors on the HBA 9400-8e storage adapter.

Table 22 Headers and Connectors

Connector	Type	Description
J2	Standard board edge connector	PCIe x8 board edge connector. With the PCIe interface, this connector provides power to the board and an I^{2}C interface connected to the I^{2}C bus for the IPMI.
J3	Storage interface connectors	Two SFF-8644 Mini SAS HD external connectors. Connects the adapter by cable to the storage devices.
J4	Mode select	2-pin connector. Reserved for Broadcom use.
J8	On-board serial UART connector	4-pin connector. Reserved for Broadcom use.

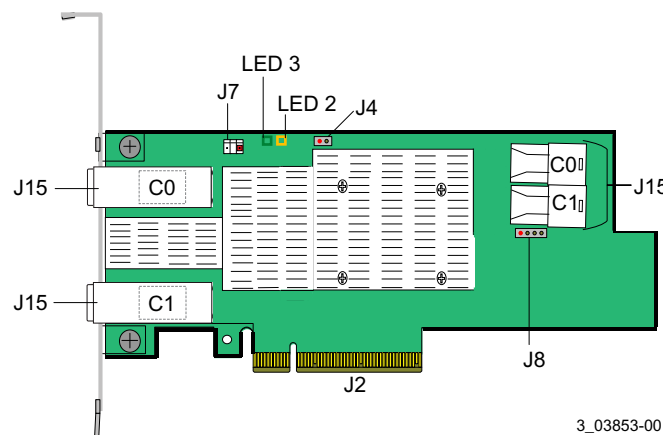The following table describes the LEDs on the storage adapter.

Table 23 LED Designations

LED	Type	Description
LED 1	Green PSoC heartbeat LED	Indicates that the PSoC is operating normally.
LED 2	Yellow IOC over temperature	Stays on solid to indicate that the SAS3408 device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.
LED3	Green system heartbeat	Indicates that the SAS3408 IOC is operating normally.

9.9 HBA 9400-8i8e Adapter – Connector and LED Designations

The HBA 9400-8i8e Tri-Mode storage adapter is a 6.600 in. × 2.712 in. (167.65 mm × 68.90 mm) board. The component height on the top and bottom of the HBA complies with the PCIe specification. This section provides the board connector and LED designations for the adapter.

The following figure shows the connectors and LED designations on the HBA 9400-8i8e Tri-Mode storage adapter. Pin 1 is highlighted in red in the figure.

Figure 16 Board Layout for the HBA 9400-8i8e Tri-Mode Storage Adapter

The following table describes the headers and connectors on the HBA 9400-8i8e Tri-Mode storage adapter.

Table 24 Headers and Connectors

Connector	Type	Description
J2	Standard edge card connector	The interface between the adapter and the host system.
		With the PCIe interface, this connector provides power to the board and an I^2C interface connected to the I^2C bus for the IPMI.
J4	Mode select header	2-pin connector. Reserved for Broadcom use.
J8	On-board serial UART connector	4-pin connector. Reserved for Broadcom use.
J15	Storage interface connectors	Two SFF-8643 Mini-SAS HD internal connectors. Connects the adapter by cable to the storage devices.
	Storage interface connectors	Two SFF-8644 Mini-SAS HD external connectors. Connects the adapter by cable to the storage devices.

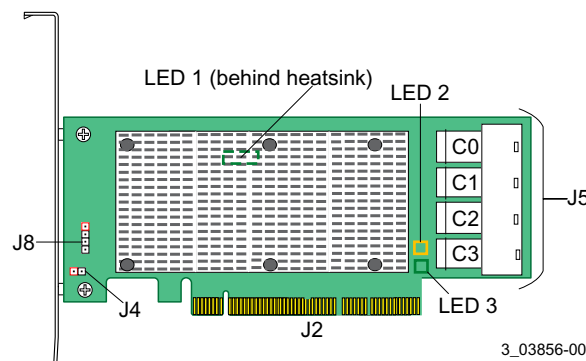The following table describes the LEDs on the storage adapter.

Table 25 LED Designations

LED	Type	Description
LED 2	Yellow RoC over temperature	Stays on solid to indicate that the SAS3516 device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.
LED 3	Green system heartbeat	Indicates that the SAS3516 RoC ASIC is operating normally.

9.10 HBA 9405W-16i Adapter – Connector and LED Designations

The HBA 9405W-16i Tri-Mode storage adapter is a 6.600 in. × 2.712 in. (167.65 mm × 68.90 mm) board. The component height on the top and bottom of the HBA complies with the PCIe specification. This section provides the board connector and LED designations for the storage adapter.

The following figure shows the connectors and LED designations on the HBA 9405W-16i Tri-Mode storage adapter. Pin 1 on the connectors is highlighted in red in the figure.

Figure 17 Card Layout of the HBA 9405W-16i Tri-Mode Storage Adapter

The following table describes the connectors on the HBA 9405W-16i Tri-Mode storage adapter.

Table 26 Connectors

Connector	Type	Description
J2	Standard board edge connector	PCIe x8 board edge connector.
		With the PCIe interface, this connector provides power to the board and an I^{2}C interface connected to the I^{2}C bus for the IPMI.
J5	Storage interface connectors	Four SFF-8643 Mini SAS HD internal connectors.
		Connects the adapter by cable to the storage devices.
J4	Mode select	2-pin connector.
		Reserved for Broadcom use.
J8	On-board Serial UART connector	4-pin connector.
		Reserved for Broadcom use.

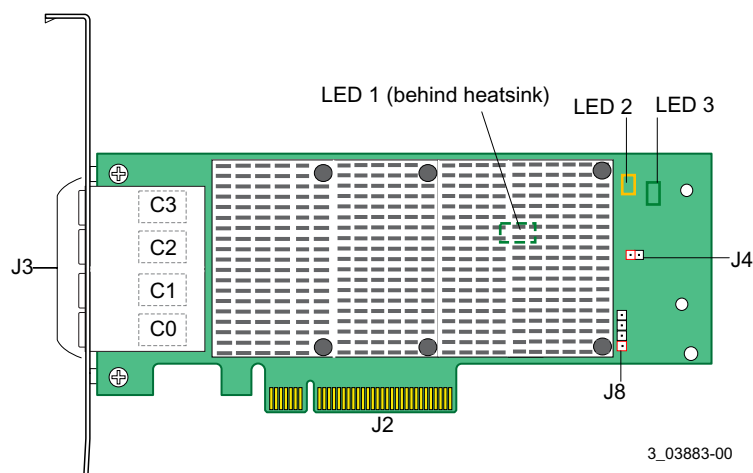The following table describes the LEDs on the storage adapter.

Table 27 LED Designations

LED	Type	Description
LED 1	Green PSoC heartbeat LED	Indicates that the PSoC is operating normally.
LED 2	Yellow IOC over temperature	Stays on solid to indicate that the SAS3616W device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.
LED3	Green system heartbeat	Indicates that the SAS3616W IOC is operating normally.

9.11 HBA 9405W-16e Adapter – Connector and LED Designations

The HBA 9405W-16e storage adapter is a 6.600 in. × 2.712 in. (167.65 mm × 68.90 mm) board. The component height on the top and bottom of the HBA complies with the PCIe specification. This section provides the board connector and LED designations for the storage adapter.

The following figure shows the connectors and LED designations on the HBA 9405W-16e storage adapter. Pin 1 on the connectors is highlighted in red in the figure.

Figure 18 Card Layout of the HBA 9405W-16e Storage Adapter

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The following table describes the connectors on the HBA 9405W-16e storage adapter.

Table 28 Connectors

Connector	Type	Description
J2	Standard board edge connector	PCIe x8 board edge connector. With the PCIe interface, this connector provides power to the board and an I^{2}C interface connected to the I^{2}C bus for the IPMI.
J3	Storage interface connectors	Four SFF-8644 Mini SAS HD external connectors. Connects the adapter by cable to storage devices.
J4	Mode select	2-pin connector. Reserved for Broadcom use.
J8	On-board serial UART connector	4-pin connector. Reserved for Broadcom use.

The following table describes the LEDs on the storage adapter.

Table 29 LED Designations

LED	Type	Description
LED 1	Green PSoC heartbeat LED	Indicates that the PSoC is operating normally.
LED 2	Yellow IOC over temperature	Stays on solid to indicate that the SAS3616W device temperature sensor is over the temperature threshold. When the device is in the proper temperature range, this LED is off.
LED3	Green system heartbeat	Indicates that the SAS3616W IOC is operating normally.

Chapter 10: Tri-Mode Storage Adapter Technical Specifications

10.1 Operating and Nonoperating Conditions

The following table lists the operating (thermal and atmospheric) conditions and nonoperating (such as storage and transit) environment for the storage adapters. The minimum airflow, measured as linear feet per minute (LFPM), must be met to avoid operating the controller's processor and board components above their maximum junction temperatures.

Table 30 Operating and Nonoperating Conditions

Storage Adapter	Operating Conditions				Nonoperating Environment	
	Relative Humidity Range (Noncondensing)	Minimum LFPM	Temperature Range[a]		Relative Humidity Range (Noncondensing)	Temperature Range
9460-16i	20% to 80%	250	10°C to +55°C		5% to 95%	−40°C to +70°C
9460-8i	20% to 80%	250	10°C to +55°C		5% to 95%	−40°C to +70°C
9480-8i8e	20% to 80%	200	10°C to +55°C		5% to 95%	−40°C to +70°C
9440-8i	20% to 80%	200	10°C to +55°C		5% to 95%	−40°C to +70°C
9400-16i	20% to 80%	200	10°C to +55°C		5% to 95%	−40°C to +70°C
9400-8i	20% to 80%	200	10°C to +55°C		5% to 95%	−40°C to +70°C
9400-16e	20% to 80%	200	10°C to +55°C		5% to 95%	−40°C to +70°C
9400-8e	20% to 80%	200	10°C to +55°C		5% to 95%	−40°C to +70°C
9400-8i8e	20% to 80%	200	10°C to +55°C		5% to 95%	−40°C to +70°C
9405W-16i	20% to 80%	200	10°C to +55°C		5% to 90%	−40°C to +70°C
9405W-16e	20% to 80%	200	10°C to +55°C		5% to 90%	−40°C to +70°C

a. For adapters with a CVPM, this range applies with or without the CVFM attached.

10.2 Tri-Mode Storage Adapter Power Supply Requirements

All power is supplied to the tri-mode storage adapter through the PCIe 3.3V rails and the 12V rail. Onboard switching regulator circuitry that operates from the 3.3V rails and the 12V rail provides the necessary voltages. The following states describe the typical power consumption of the adapters.

Typical power is measured with maximum I/O traffic, typical silicon process material, and nominal voltages operating the card at an ambient temperature of 45°C with required airflow.

The supply voltages supplied by the PCIe edge connector are 12V ± 8% and 3.3V ± 9%.

10.2.1 MegaRAID Tri-Mode Storage Adapter Power Supply Requirements

The following table describes the typical power consumption of the MegaRAID Tri-Mode storage adapters.

Table 31 MegaRAID Tri-Mode Storage Adapter Typical Power Consumption

Power Mode	Typical Power			
	9460-16i[a]	**9460-8i[a]**	**9480-8i8e[a]**	**9440-8i**
3.3V Supply	0.28W	0.28W	0.20W	1.6W
+12V Supply	16.7W	13.80W	17.48W	8.42W
3.3V Auxiliary Supply	0.08W	0.08W	0.03W	0.03W
Total Power	**17.06W**	**14.16W**	**17.71W**	**10.05W**

a. During the transparent learn cycle, the CacheVault power module consumes up to an additional 6W. The PCIe 3.3V rail supplies the power for the learn cycle.

10.2.2 HBA Tri-Mode Storage Adapter Power Supply Requirements

The following table describes the typical power consumption of the HBA Tri-Mode storage adapters.

Table 32 HBA Tri-Mode Storage Adapter Typical Power Consumption

Power Mode	Typical Power						
	9400-16i	**9400-8i**	**9400-16e**	**9400-8e**	**9400-8i8e**	**9405W-16i**	**9405W-16e**
3.3V Supply	1.6W	1.6W	1.33W	1.33W	1.33W	1.65W	1.48W
+12V Supply	10.32W	8.42W	9.82W	8.12W	8.12W	12.35W	11.90W
3.3V Auxiliary Supply	0.03W	0.03W	0.03W	0.03W	0.03W	0.03W	0.44W
Total Power	**11.95W**	**10.05W**	**11.18W**	**9.48W**	**9.48W**	**14.03W**	**13.82W**

Chapter 11: Marks, Certifications, Compliance, and Safety Characteristics

11.1 Marks, Certifications, and Compliance

The design and implementation of the Tri-Mode storage adapters minimize electromagnetic emissions, susceptibility to radio frequency energy, and the effects of electrostatic discharge. The Tri-Mode storage adapters show the following marks and certifications:

- CE mark
- RCM mark
- FCC Self-Certification logo
- Canadian Compliance Statement
- KCC
- Taiwan BSMI
- Japan VCCI
- CISPR Class B

The following models comply with CSA C22.2 No. 60950-1-07 2nd Edition 2014-10, UL 60950-1 2nd Edition 2014-10-14, UL file number E257743:

- MegaRAID 9460-16i (model number 50011)
- MegaRAID 9460-8i (model number 50011)
- MegaRAID 9480-8i8e (model number 50031)
- MegaRAID 9440-16i (model number 50008)
- HBA 9400-16i (model number 50008)
- HBA 9400-8i (model number 50008)
- HBA 9400-16e (model number 50013)
- HBA 9400-8e (model number 50013)
- HBA 9400-8i8e (model number 50031)
- HBA 9405W-16e (model number 50044)
- HBA 9405W-16i (model number 50047)

11.2 Safety Characteristics

All tri-mode storage adapters 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 PCIe bus slot, all voltages are lower than the SELV 42.4V limit.

Revision History

Version 1.4, December 31, 2018

The following changes were made:
- Updated Chapter 4, Mid-Plane Management.
- Updated step 10 in Section 8, Adapter Installation Instructions.
- Template update.

Version 1.3, April 12, 2018

The following change was made:
- Removed the NVMe feature from the HBA 9405W-16e Tri-Mode storage adapter.

Version 1.2, October 26, 2017

The following changes were made:
- Added the HBA 9405W-16i Tri-Mode storage adapter to the user guide.
- Updated Section 5.1, PCIe (NVMe) Storage Interface Cabling, title and content.
- Added LED designations to Chapter 9,Broadcom MegaRAID and HBA Tri-Mode Storage Adapter Characteristics.
- Combined operating condition and nonoperating condition information, and removed individual subsections in Chapter 10, Tri-Mode Storage Adapter Technical Specifications.
- Restructured Section 10.2, Tri-Mode Storage Adapter Power Supply Requirements.
- Updated HBA 9405W-16e Tri-Mode storage adapter power information.
- Editorial updates.

Version 1.1, August 25, 2017

The following changes were made:
- Added the HBA 9400-8i8e storage adapter and the HBA9405W-16e storage adapter to the guide.

Version 1.0, March 24, 2017

Initial document release.