BROADCOM®

P411W-32P PCIe 4.0
NVMe Switch Adapter

User Guide
Version 2.1

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P411W-32P NVMe Switch Adapter User Guide

The Broadcom® P411W-32P NVMe PCIe 4.0 switch adapter (model number 50054) provides high-performance storage connectivity for servers and workstations. The adapter uses the PEX88048 PCIe 4.0 switch that provides a x16 PCIe 4.0, 16 GT/s interface to a host system with up to 32 PCIe 4.0 16 GT/s ports for NVMe device connection.

NVMe technology is a logical device interface specification used to access nonvolatile storage media that attach by using a PCIe bus. Nonvolatile memory is usually flash memory in SSDs.

1 Features

This section lists the adapter features.

- Supports 32 PCIe 4.0 lanes, which can be configured as x4, x2, and x1 ports for NVMe connectivity
- Supports 16-lane, PCIe 4.0 host-interface performance
- Supports PCIe link rates of 16 GT/s
- Provides four internal x8 Slimline connectors (SFF-8654)
- Complies with SFF-9402 sideband signaling
- Offered with a full-profile bracket and a low-profile vented bracket
- Provides one heartbeat LED and one system error status LED
- Complies with *SFF-TA-1005 Specification for Universal Backplane Management (UBM)*

2 PCIe Interface

PCIe is a high-speed standard local bus for point-to-point interfacing of I/O components to the processor and the memory subsystems in high-end computers and servers. The PEX88048 switch provides the PCIe functionality for the adapter. The PEX88048 switch connects directly to the PCIe bus and generates timing and protocol in compliance with PCIe specifications.

The adapter supports 16-lane PCIe 4.0 16 Gb/s performance up to 256 Gb/s single direction and 512 Gb/s dual direction. Each port supports PCIe speeds up to 16 Gb/s in each direction.

3 Operating System and Driver Support

The adapter does not require a driver for operation or communication to attached NVMe drives. The drives are presented natively to the host and use the native NVMe drivers.

Use the inbox Fusion-MPT™ SAS driver for firmware updates. The following operating systems support the inbox Fusion-MPT SAS driver. See Firmware Download Operation for firmware update steps.

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

- Fedora
- FreeBSD

4 Backplane Management

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
    - Maximum speeds
    - Dual-port support
    - Support for drive power enable and disable (PWDIS)
- 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.

4.1 SFF-TA-1005 (UBM)-Based Backplanes

Backplanes that use SFF-TA-1005 (UBM) automatically report the slot number to the adapter. For more information, refer to the SFF-TA-1005 specification. Because of this automation, no specific cable ordering requirements exist between the adapter and the backplane connectors.

Most backplanes use x4 or x8 host facing connectors. Each x8 connector has an "A" side and "B" side. Use one UBM controller for each connector to maximize cable flexibility. The following figure shows a backplane that uses x8 connectors with one UBM target for each connector. The red line indicates the I^{2}C bus connection.

Figure 1 Backplane with x8 Connectors

3_04090-01
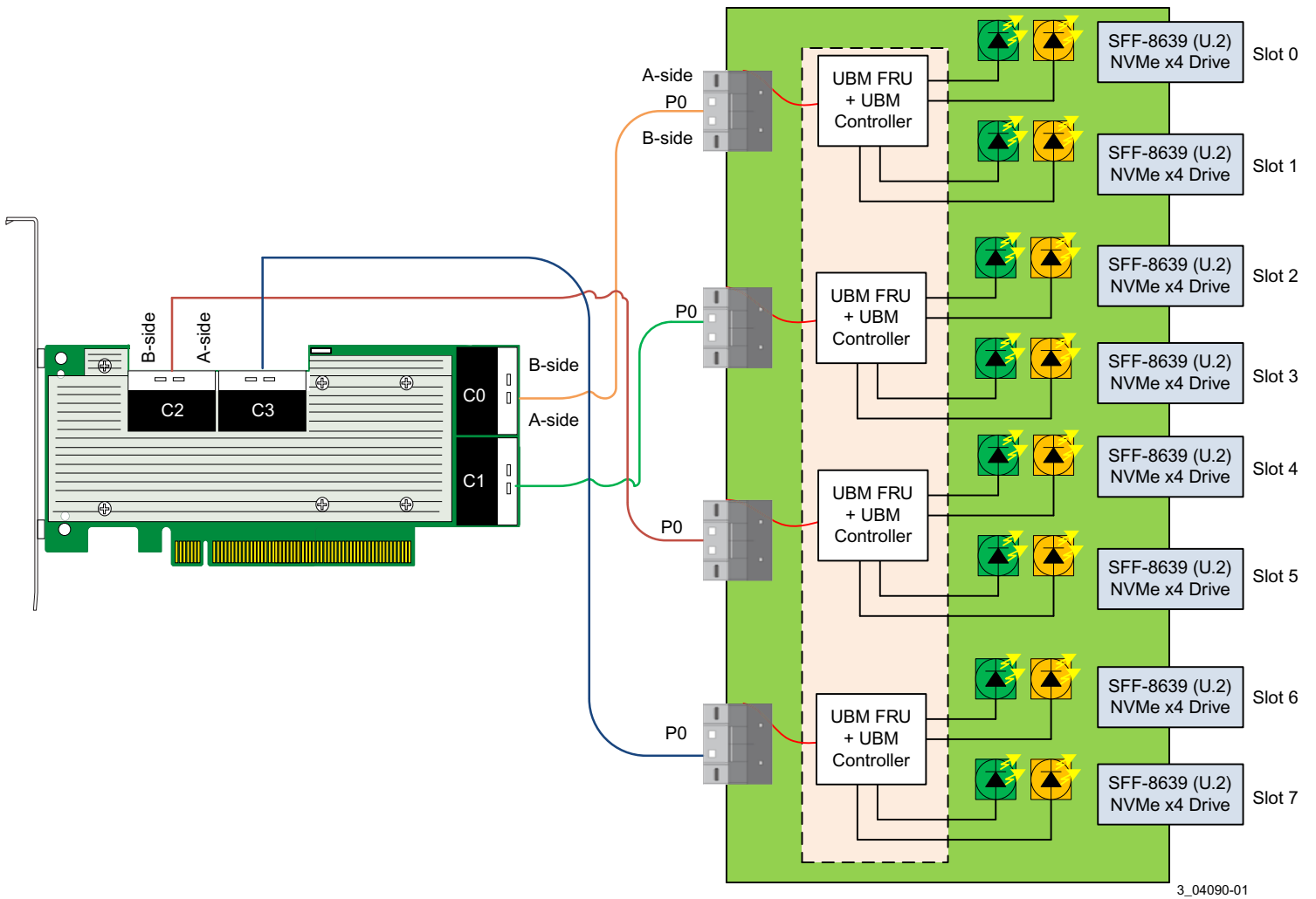
The following figure represents a backplane that uses x4 connectors with one UBM target for each connector. The red line indicates the I^{2}C bus connection.

Figure 2 Backplane with x4 Connectors
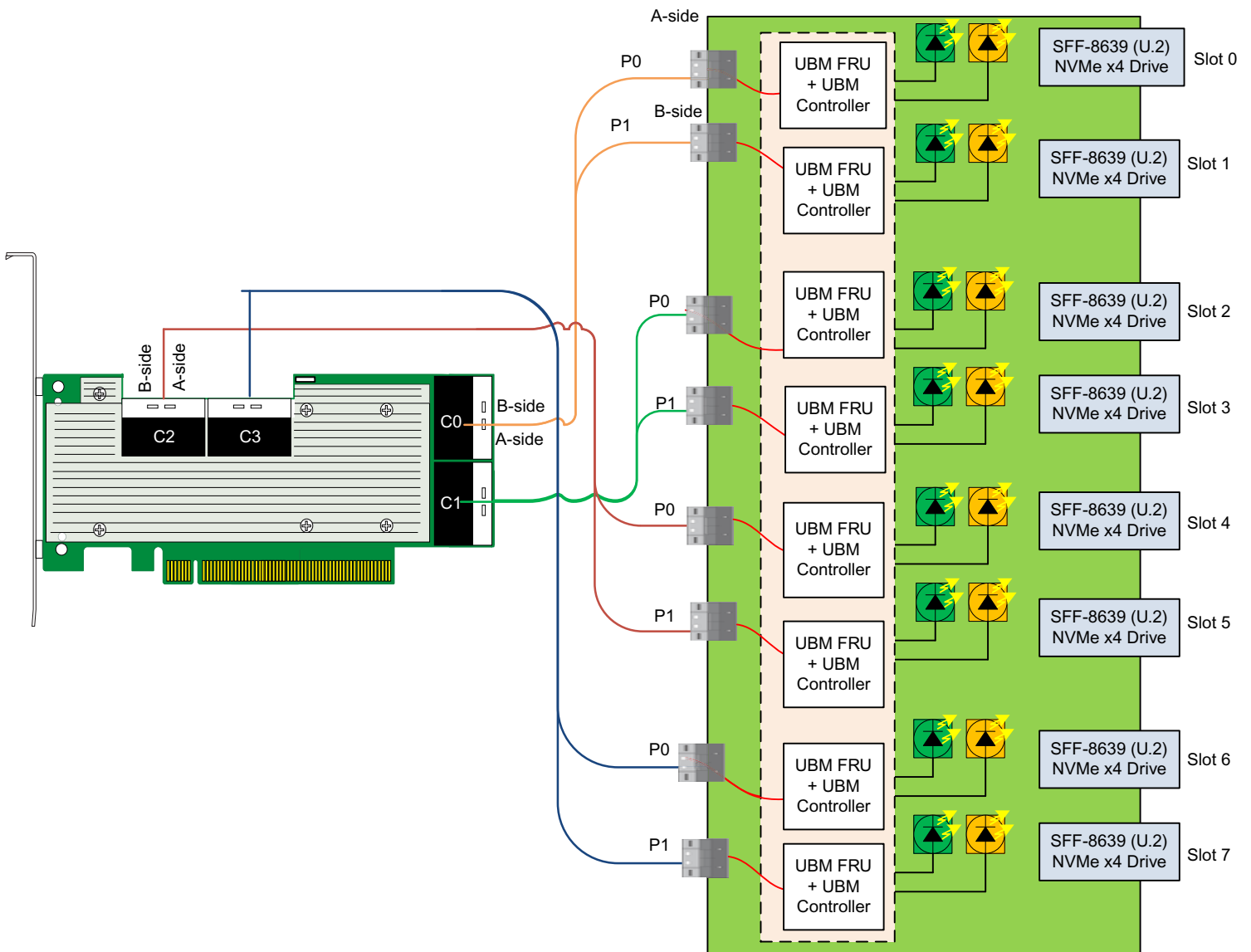
3_04091-01

4.2 VPP-Based Backplanes

Broadcom requires new designs to enable UBM for backplane management. However, the adapter maintains support for Virtual Pin Port (VPP) backplane management for legacy implementations. If using x4 connectors on the backplane, each leg of the cable must connect to adjacent drives; otherwise, the LEDs might not work properly.

For proper slot identification, cables must connect based on the desired slot enumeration. The most common backplane connector types are x4 or x8 SFF-8654 or SFF-8611 connectors. Each x8 connector on the adapter has an "A" side and "B" side. The adapter searches for the VPP target on the side to which the VPP target is connected.

The following figure shows expected connections to a backplane that uses x4 SFF-8654 connectors from the adapter to NVMe drives by using VPP over I^{2}C for backplane management. The red line indicates the I2C bus connection. For proper LED functionality when using Broadcom supplied cables, connect the P0 labeled leg of the cable to the PCA9555 target. Refer to the backplane's documentation to verify which host facing connector maps to a given slot.

Figure 3 Backplane with x4 Connectors and VPP
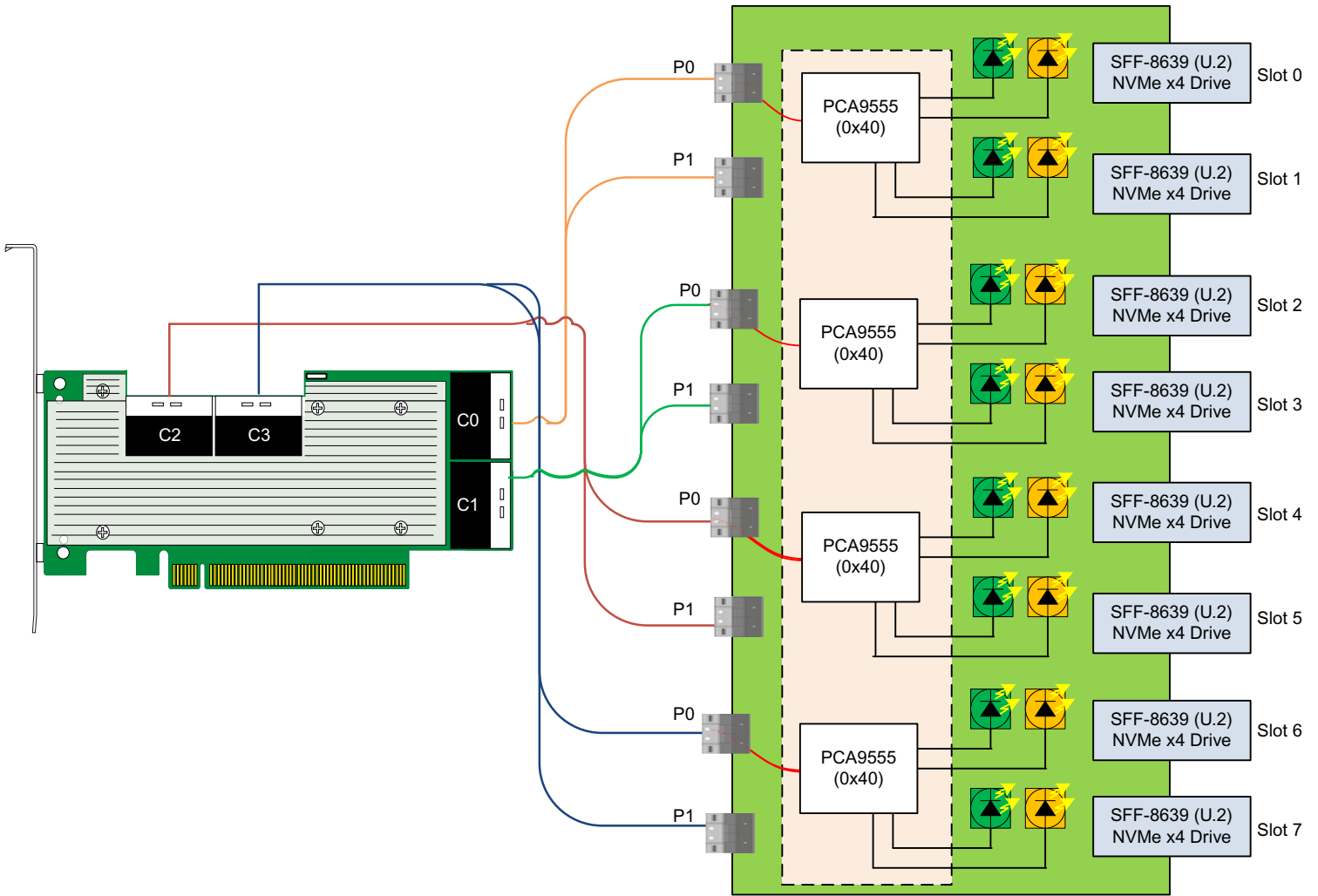
The following figure shows expected connections to a backplane that uses x8 SFF-8654 connectors from the adapter to NVMe drives by using VPP over I^{2}C for backplane management. The red line indicates the I^{2}C bus connection, and, for proper LED functionality, the backplane must connect the VPP target's I^{2}C connection to the A side of the x8 SFF-8654 connector. Refer to the backplane's documentation to verify which host facing connector maps to a given slot.

Figure 4 Backplane with x8 Connectors and VPP
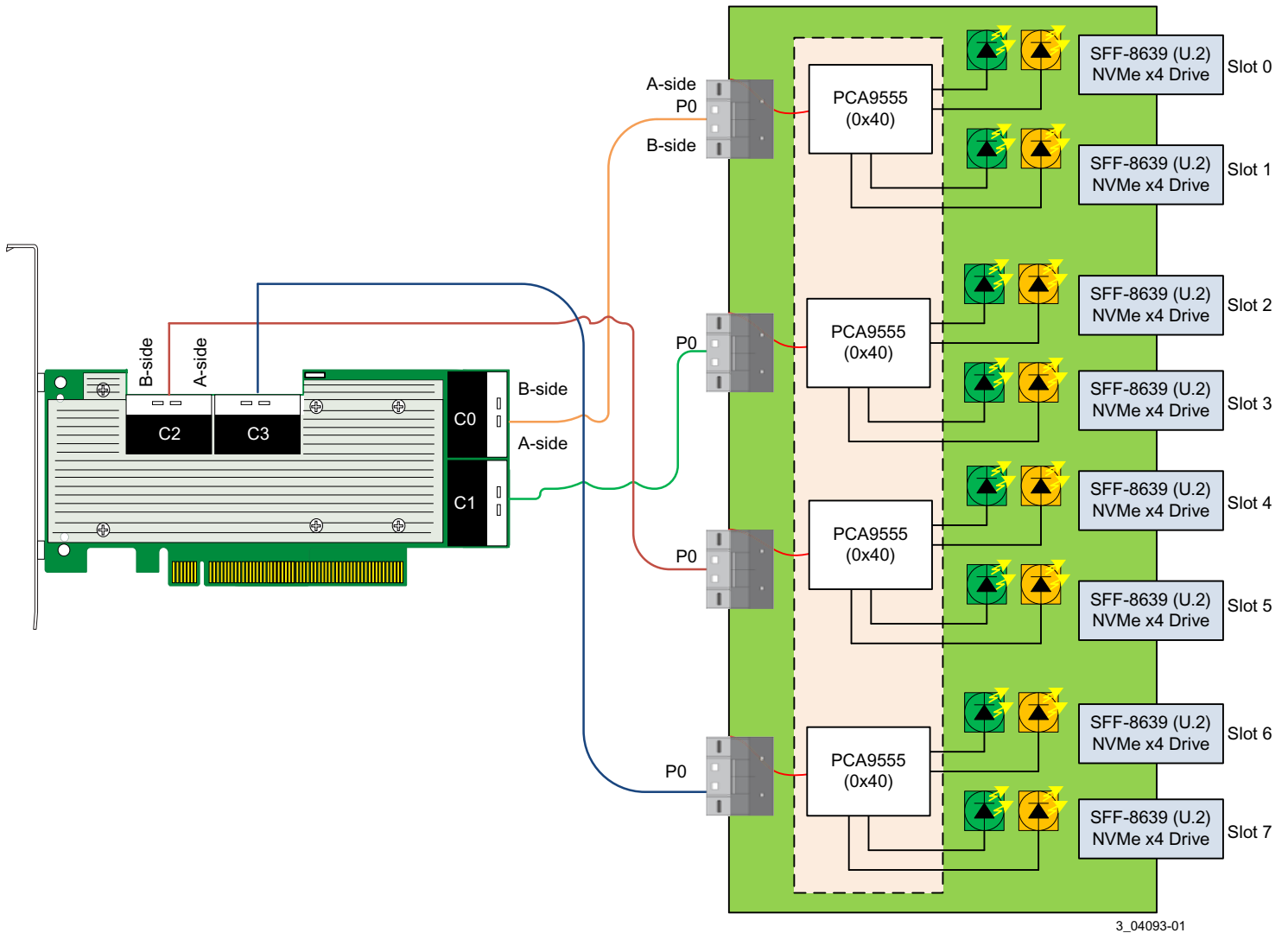
3_04093-01

5 Sideband Signals

The adapter has four x8 SFF-8654 connectors. Each x8 connector provides two sets of sidebands. This section describes the sideband signals usage. The following table defines the sideband signal's pins on the SFF-8654 connector. The last column in the table indicates the strength of the pull-up resistor or pull-down resistor values on the adapter. See Table 2, Sideband Management Pin Settings, for the signal descriptions, and see Table 7, Internal Connector Pinout, for a complete connector pinout.

Table 1 Sideband Signal Pinout

Connector A Side	Connector B Side	Sideband or Vendor Specific Pin Number	UBM Assignments	Direction	Resistor Value
A8	A26	7	BP_TYPE	Input	10 kΩ pull-up
A9	A27	4	2W_RESET#	Output	1.0 kΩ pull-up
A10	A28	3	GND	—	—
A11	A29	+	REFCLK+	Output	—

Table 1 Sideband Signal Pinout (Continued)

Connector A Side	Connector B Side	Sideband or Vendor Specific Pin Number	UBM Assignments	Direction	Resistor Value
A12	A30	–	REFCLK-	Output	—
B8	B26	0	2W_CLK	Input/Output	4.75 kΩ pull-up
B9	B27	1	2W_DATA	Input/Output	4.75 kΩ pull-up
B10	B28	2	GND	—	—
B11	B29	5	PERST#	Output	1.0 kΩ pull-up
B12	B30	6	C_TYPE, D_INPL#, CHANGE_DET#	Input/Output	10 kΩ pull-up

The following table describes the UBM pin settings. For the adapter to properly recognize the backplane, the BP_TYPE pin must be set to 1. The adapter skips configuration if the BP_TYPE pin is 0, and the firmware logs a message to report that an unrecognized backplane exists on the connector.

Table 2 Sideband Management Pin Settings

| Pin Name	Settings	Description
BP_TYPE	■ 0: SGPIO (not supported) ■ 1: 2-Wire	Backplanes must be set to the two-wire interface when using the P411W-32P NVMe switch adapter. SGPIO is not supported.
2W_RESET#	■ 0: Reset is asserted ■ 1: Reset is not asserted	Optional reset driven by the host if the UBM target reports that the target can be reset.
REFCLK+/-	—	PCIe REFCLK HCSL 100-MHz clock driven by the device side ports to PCIe devices that require REFCLK. If D_INPL# is 0, the adapter enables the REFCLK outputs for that quad of high-speed lanes. When the UBM Clock Routing bit on the backplane is 0, this output is turned off.
2W_CLK	—	The two-wire interface clock signal.
2W_DATA	—	The two-wire interface data signal.
PERST#	■ 0: Reset is asserted ■ 1: Reset is not asserted	The adapter drives the PCIe RESET# signal. This signal uses a clamp to ground so that the signal on the adapter powers up LOW until backplane detection warrants the release of this signal for open-drain use. This method ensures that PERST# does not deassert until the directly connected NVMe drive is successfully detected.
C_TYPE, D_INPL#, CHANGE_DET#	—	Open collector/drain input or output signal. ■ C_TYPE. Because BP_TYPE is 1, this signal adheres to the SFF-8448 requirement to drive this signal to 1 in response to floating the signal. Because this signal is an open drain signal, 'driving' to 1 is when a pull-up resistor pulls this signal HIGH. ■ D_INPL#. Because this signal is an open collector and the adapter floats this signal HIGH, the backplane pulls this signal to ground to indicate an NVMe device is connected and a two-wire interface backplane management target might be on the sideband's two-wire interface. ■ CHANGE_DET#. If D_INPL# is 0 and a UBM FRU device is discovered on the two-wire interface, the UBM FRU data can inform the adapter that the device is CHANGE_DET# feature capable. The adapter can rely on this signal as the CHANGE_DET# signal as described in the UBM specification. In this mode, the UBM controller drives this signal LOW to assert CHANGE_DET#.

6 Connector Physical-to-Logical Mapping

The following table shows the adapter's physical connector to logical connector mapping as viewed from the UART interface, when used with the `bpview` CLI command. The adapter uses x8 SFF-8654 connectors. Each connector is segregated into quads and mapped accordingly.

Table 3 Physical Connector-to-Logical Connector Mapping

Adapter Label	Tool Mapping	Port Number	PEX88048 Switch Lowest Lane Number
C0	C0.1	0	0
	C0.0	4	4
C1	C1.1	8	8
	C1.0	12	12
C2	C2.1	32	32
	C2.0	36	36
C3	C3.1	40	40
	C3.0	44	44

The following figure shows how the connectors are mapped.

Figure 5 Connector Mapping

3_04094-00
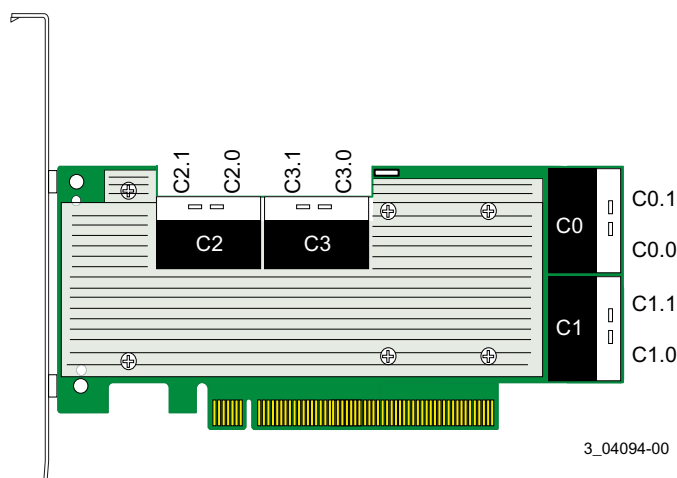
Each connected drive is a port. For example, if two x4 NVMe drives connect to C0, one drive is on port 0 and the second drive is on port 4, as shown in the following table.

Table 4 x4 Drive-to-Port Connection Example

Adapter Label	Tool Mapping	Port Number	Drive
C0	C0.1	0	x4
	C0.0	4	x4

Use the same numbering schema if you use drives of varying lanes. The following table uses C0 as an example for when a 1-lane drive or 2-lane drive is connected.

Table 5 Mixed Drive-to-Port Connection Example

Adapter Label	Tool Mapping	Port Number	Drive
C0	C0.1	0	x2
		2	x2
	C0.0	4	x1
		5	x1
		6	x1
		7	x1

7 Cable Support

Broadcom supports the following cables for use with the adapter.

Table 6 Supported NVMe Switch Adapter Cables

MPN	Cable Description	Adapter Connector	Backplane Connector
05-60001-00	x8 8654 to 2x4 8612, AltWiring 1M	1 x8 SFF-8654 Slimline	Two x4 SFF-8612 OCuLink
05-60002-00	x8 8654 to 2x4 8643 (W), SMC 1M	1 x8 SFF-8654 Slimline	Two x4 SFF-8643 Mini-SAS HD
05-60004-00	x8 8654 to 2x4 8654, 9402 1M	1 x8 SFF-8654 Slimline	Two x4 SFF-8654 Slimline
05-60005-00	x8 8654 to 2xU.2 Direct, 1M	1 x8 SFF-8654 Slimline	Two U.2 SFF-8639
05-60006-00	x8 8654 to 8xU.3 Direct 1M	1 x8 SFF-8654 Slimline	Eight U.3 SFF-8639
05-60007-00	x8 8654 to 1x8 8654, 9402 1M	1 x8 SFF-8654 Slimline	One x8 SFF-8654 (SlimSAS)

8 P411W-32P NVMe Switch Adapter Characteristics

8.1 LEDs

The adapter has one heartbeat LED and one system error status LED. The LED blinks at 1 Hz to indicate that the firmware on the board is operational. The system error status LED is lit when a system error occurs.

8.2 Physical Characteristics

The 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 *PCI Express Card Electromechanical Specification Revision 3.0*. The following figure shows the adapter board layout.

Figure 6 P411W-32P NVMe Switch Adapter Layout
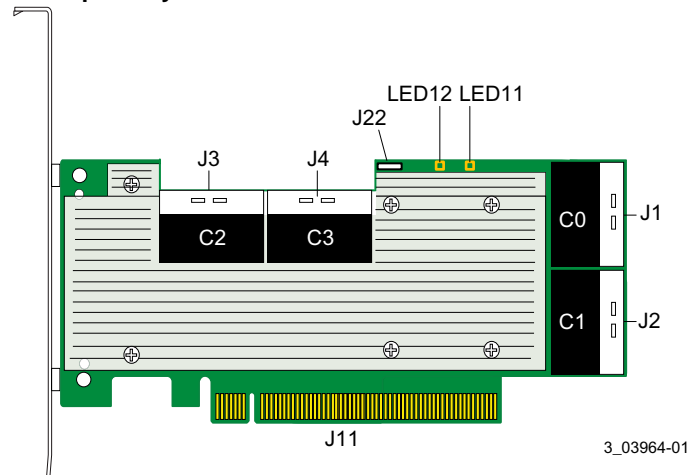
- **J1, J2, J3, J4 (C0, C1, C2, C3)** – x8 SFF-8654 Slimline internal connectors
- **J22** – UART. Reserved for Broadcom use.
- **LED11** – SYS_ERROR_N LED
- **LED12** – Heartbeat LED
- **J11** – PCIe x16 board edge connector

8.2.1 Connectors

The following table defines the adapter's internal x8 SFF-8654 SlimSAS connector pinouts. The adapter follows the SFF-9402 standard for connector sideband signal assignments. Each x8 connector includes eight PCIe transmit and receive lanes, and two sets of sidebands designated as A and B, in accordance with the SFF-9402 specification.

Table 7 Internal Connector Pinout

Pin	Signal Name	Pin	Signal Name
A1	GND	B1	GND
A2	PERp0	B2	PETp0
A3	PERn0	B3	PETn0
A4	GND	B4	GND
A5	PERp1	B5	PETp1
A6	PERn1	B6	PETn1
A7	GND	B7	GND
A8	BP_TYPEA	B8	2W-CLKA
A9	2W_RESETA	B9	2W-DATAA
A10	GND	B10	GND
A11	REFCLKA+	B11	PERSTA#
A12	REFCLKA-	B12	CPRSNTA#
A13	GND	B13	GND
A14	PERp2	B14	PETp2
A15	PERn2	B15	PETn2
A16	GND	B16	GND
A17	PERp3	B17	PETp3
A18	PERn3	B18	PETn3
A19	GND	B19	GND

Table 7 Internal Connector Pinout (Continued)

Pin	Signal Name	Pin	Signal Name
A20	PERp0	B20	PETp0
A21	PERn0	B21	PETn0
A22	GND	B22	GND
A23	PERp1	B23	PETp1
A24	PERn1	B24	PETn1
A25	GND	B25	GND
A26	BP_TYPEB	B26	2W-CLKB
A27	2W_RESETB	B27	2W-DATAB
A28	GND	B28	GND
A29	REFCLKB+	B29	PERSTB#
A30	REFCLKB-	B30	CPRSNTB#
A31	GND	B31	GND
A32	PERp2	B32	PETp2
A33	PERn2	B33	PETn2
A34	GND	B34	GND
A35	PERp3	B35	PETp3
A36	PERn3	B36	PETn3
A37	GND	B37	GND

8.3 Electrical Characteristics

All power is supplied to the 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 supply voltages supplied by the PCIe edge connector are 12V ± 8% and 3.3V ± 9%.

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 power requirements for the adapter under normal operation are shown in the following table.

Table 8 P411W-32P NVMe Switch Adapter Power Consumption

Power Mode	Typical Power
3.3V Supply	5.93W
+12V Supply	15.45W
Total Power	**21.38W**

8.4 Thermal and Atmospheric Limits

The atmospheric limits for the adapter are as follows:

- Temperature range: 0°C to +55°C (+32°F to +131°F) (dry bulb)
- Relative humidity range: 5% to 90% noncondensing
- Maximum dew point temperature: 32°C (89.6°F)
- Minimum airflow: 200 linear feet per minute at 55°C inlet temperature

The following limits define the storage and transit environment for the adapter:

- Temperature range: –45°C to +105°C (–49°F to +221°F) (dry bulb)
- Relative humidity range: 5% to 90% noncondensing

9 Adapter Certifications and Safety Characteristics

All Broadcom adapters meet or exceed the requirements of UL flammability rating 94V-0. Each bare board is marked with the supplier's name or trademark, type, and UL flammability rating. Because these boards are installed in a PCIe bus slot, all voltages are less than the SELV 42.4V limit.

The design and implementation of the adapter minimizes electromagnetic emissions, susceptibility to radio frequency energy, and the effects of electrostatic discharge.

The adapter, model number 50054, meets the following integrated electromagnetic interference (EMI) compliance labels shown in the following table.

Table 9 Adapter Marks and Certifications

Mark	Symbol	Description
Australia and New Zealand RCM		Meets the following standards: ■ AS/NZS CISPR 32 ■ CISPR 32:2015, Class B ■ AS/NZS CISPR 32:2015, Class B
Canada EMC	CANADA ICES-OO3 CLASS B CANADA NMB-003 CLASSE B CAN ICES-3 (B)/NMB-3 (B)	Meets the following standards: ■ ICES-003:2016 Issue 6: 2016, Class B ■ CAN/CSA CISPR 22-10 ■ CISPR 22:2008
Europe (CE)		Meets the following standards: ■ EN55022/EN55024 EN55032 ■ EN 55032:2015 +AC:2016, Class B ■ EN 50022:2010 +AC:2011, Class B ■ EN 55024:2010 +A1:2015
Korea (RRL)		xxxxx = model number Meets the KN32/KN35 testing requirements.

Table 9 Adapter Marks and Certifications (Continued)

Mark	Symbol	Description
Taiwan (BSMI)	D3B320 RoHS	Meets the following standards: ■ CNS 13438 ■ CNS15663
USA / Canada Safety (UL Listed)	c UL us LISTED ITE Accessory E257743	For use with UL listed ITE equipment only. Meets the following standards: ■ UL 60950-1, 2nd Edition, 2014-10-14 (Information Technology Equipment -Safety -Part 1: General Requirements) ■ CAN/CSA C22.2 No. 60950-1-07, 2nd Edition, 2014-10 (Information Technology Equipment -Safety -Part 1: General Requirements) ■ UL 62368-1, Second Edition ■ CAN/CSA C22.2 No. 62368-1-14
CB Scheme Safety	—	Meets the following standards: ■ IEC 60950-1:2005 (Second Edition) + Am 1:2009 + Am 2:2013 ■ EN 60950-1: 2006 + A11: 2009 + A1: 2010 + A12: 2011 + A2: 2013 ■ IEC 62368-1:2014 (Second edition) ■ EN 62368-1:2014+A11: 2017
Japan (VCCI)	VCI	Meets the following standards: ■ V-3/2015.04, Class B ■ V-4/2012.04 ■ VCCI-CISPR 32:2016 ■ CISPR 32:2015
USA / Canada (FCC)	FC	Meets the following standards: ■ 47 CFR FCC Part 15, Subpart B, Class B ■ ANSI C63.4:2014 ■ CISPR 32:2008
Country of Origin	Made in XXXX	XXXX indicates the country of origin.

The adapter meets the following environmental directives:
■ Restriction of Hazardous Substances (RoHS)
■ Waste of electrical and electronic equipment (WEEE)

10 Hardware Installation Instructions

To install the adapter, follow these steps:

1. **Unpack the adapter.** Unpack the adapter in a static-free environment. Remove the adapter from the antistatic bag, and carefully inspect the device for damage. If you notice any damage, contact your reseller support representative.

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.

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. **Remove the cover from the chassis.**

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 adapter into an available PCIe slot.** Locate an empty PCIe slot adequate for your adapter. Remove the blank bracket panel on the rear of the computer that aligns with the empty PCIe slot. Save this bracket screw, if applicable. Align the adapter to a PCIe slot. Press down gently, but firmly, to seat the adapter correctly in the slot. The following figure shows how to insert the adapter into a PCIe slot.

NOTE: The shape, size, and locations of the components on your adapter and its bracket might vary from this illustration.

Figure 7 Install the P411W-32P NVMe Switch Adapter in a PCIe Slot
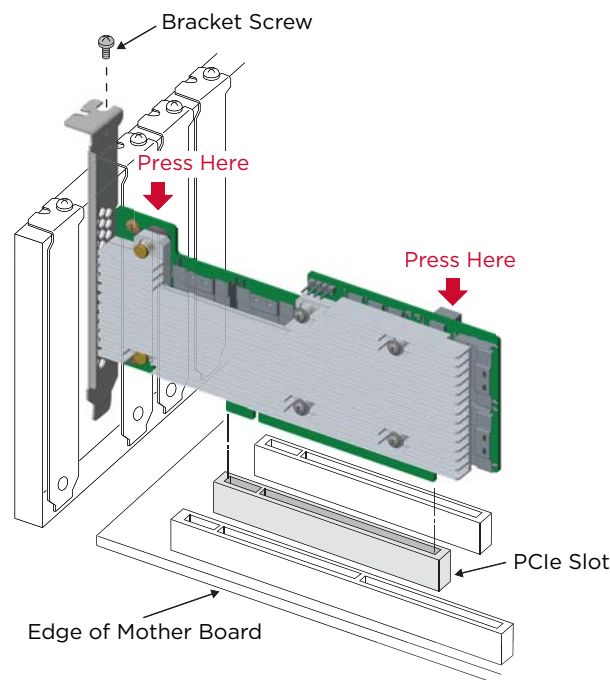
6. **Make sure the system provides the required airflow for the adapter.**

7. **Configure and install the PCIe (NVMe) devices in the host computer case.** Refer to documentation for the devices for any preinstallation configuration requirements.

8. **Connect the adapter to the devices.** The adapter connector's pin definitions follow the SFF-9402 specification, and the cables must support this connector pin definition shown in Table 7, Internal Connector Pinout. See Table 6, Supported NVMe Switch Adapter Cables, for cable ordering information. The maximum cable length is 1 meter (39.37 in.).

9. **Replace the cover, and reconnect any cords and cables.** Replace the chassis cover, reconnect any power cords, and reconnect any network cables.

10. **Power on the system.**

The hardware installation of your adapter is complete.

11 Firmware Download Operation

Use the g4Xflash tool to update the firmware on your adapter. Download the g4Xflash tool from the Broadcom download center, https://www.broadcom.com/support/download-search.

Use the following command to download the firmware and manufacturing image to the Flash memory on the adapter.

```
dl -f <firmware file> [-s] [-nv] [-nr] [-wd] [-hr]
```

Where:

-f = Firmware image that needs to be downloaded.

-s = Silent mode. Performs the download operation without confirmation.

-nv = Ignores or skips image and region validation.

12 Technical Support

For assistance installing, configuring, or running your adapter, contact Broadcom Technical Support at www.broadcom.com/support/.

Revision History

Version 2.1, December 6, 2019

The following document changes were made:

- Updated Firmware Download Operation.

Version 2.0, December 5, 2019

The following document changes were made:

- Updated VPP-Based Backplanes.
- Renamed and updated Sideband Signals.
- Added Connector Physical-to-Logical Mapping.
- Updated Cable Support.
- Updated Electrical Characteristics.
- Added Firmware Download Operation.

Preliminary, Version 1.2, September 26, 2018

The following document change was made:

- Updated Table 7, Internal Connector Pinout.

Preliminary, Version 1.1, September 7, 2018

The following document change was made:

- Added the adapter model number to Section , P411W-32P NVMe Switch Adapter User Guide.

Preliminary, Version 1.0, August 29, 2018

Initial document release.