Intel® RAID Controller RS2PI008

Technical Product Specification

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Enterprise Platforms and Services Marketing

Revision History

Date	Revision Number	Modifications
June 2009	1.0	Initial Release

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1. Introduction

This document provides a detailed description of the Intel® RAID Controller RS2PI008 and the software that supports it.

1.1 Product Overview

The Intel® RAID Controller RS2PI008 is a high-performance, intelligent PCI Express*-to-SCSI/Serial ATA II adapter, with RAID control capability. The SAS RAID controller provides reliability, high performance, and a fault-tolerant drive subsystem management. It is an ideal RAID solution for the external storage needs of workgroups, departmental, and enterprise systems. The Intel® RAID Controller RS2PI008 provides flexibility and helps lower the total cost of ownership with a standardized server and storage infrastructure.

The SAS RAID controllers support the SAS protocol as described in the *Serial Attached SCSI Standard, Version 2.*0. The controllers also support the Serial ATA II (SATA II) protocol defined by the *Serial ATA Specification, Version 1.0a* and the *Serial ATA II Extension to the Serial ATA Specification, Version 1.1*. SATA II is an extension to SATA 1.0a.

Note: *SATA II is the only type of SATA supported by this RAID controller.*

This RAID controller has eight external SAS/SATA ports through two SFF8088 Mini SAS 4i external connectors. The controller uses a x8 or wider PCI Express* 2.0 server board slot.

1.2 Operating System Support

The latest service pack/update available at the start of the test run is tested. The following operating systems are fully validated and supported at product launch:

- Microsoft Windows Server 2003* 32-bit
- Microsoft Windows Server 2003* 64-bit Edition
- Microsoft Windows Server 2008* 32-bit
- Microsoft Windows Server 2008* 64-bit Edition
- Microsoft Windows Vista* 32-bit
- Microsoft Windows Vista* 64-bit Edition
- Red Hat* Linux 4.0 32-bit
- Red Hat* Linux 4.0 64-bit Edition
- Red Hat* Linux 5.0 32-bit
- Red Hat* Linux 5.0 64-bit Edition
- SuSE* Linux Enterprise Server 10 32-bit
- SuSE* Linux Enterprise Server 10 64-bit Edition
- SuSE* Linux Enterprise Server 11 32-bit
- SuSE* Linux Enterprise Server 11 64-bit Edition

The following operating systems will be validated as a baseline operating system installation post launch:

- Sun Solaris* 10 32-bit
- Sun Solaris* 10 64-bit Edition

1.3 Features List

The Intel® RAID Controller RS2PI008 offers the following features:

- Supports SAS/SATA devices at speeds up to 6 Gb/s per port
- Supports the SATA II protocol over SAS transport
- Contains eight external SAS/SATA ports through two SFF8088 Mini SAS 4i external connectors
- Supports up to 240 SAS/SATA II devices through expanders
- Supports up to 64 virtual disks
- Supports up to 128 arrays
- Supports RAID levels 0, 1, 5, 6, 10, 50, and 60
- Hardware exclusive OR (XOR) assistance
- Online capacity expansion
- Online RAID level migration
- Drive roaming
- Drive migration
- Fast virtual drive initialization
- Hot-spare drive configuration, both private and global
- SATA drive hot-plug
- Staggered spin-up
- Native command queuing
- Support for SMART*
- Auto rebuild with user-specified rebuild rate
- Variable data stripe size configured per virtual drive
- 512 MB of ECC DDR2 800-MHz SDRAM integrated on the controller
- Read and write cache policy
- SES2 intelligent enclosure support
- PCI hot-plug support
- Background media scan (patrol read)
- Background data integrity test
- More than 200 Qtags per array
- Load balancing

* 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.

2. Hardware

2.1 Block Diagram

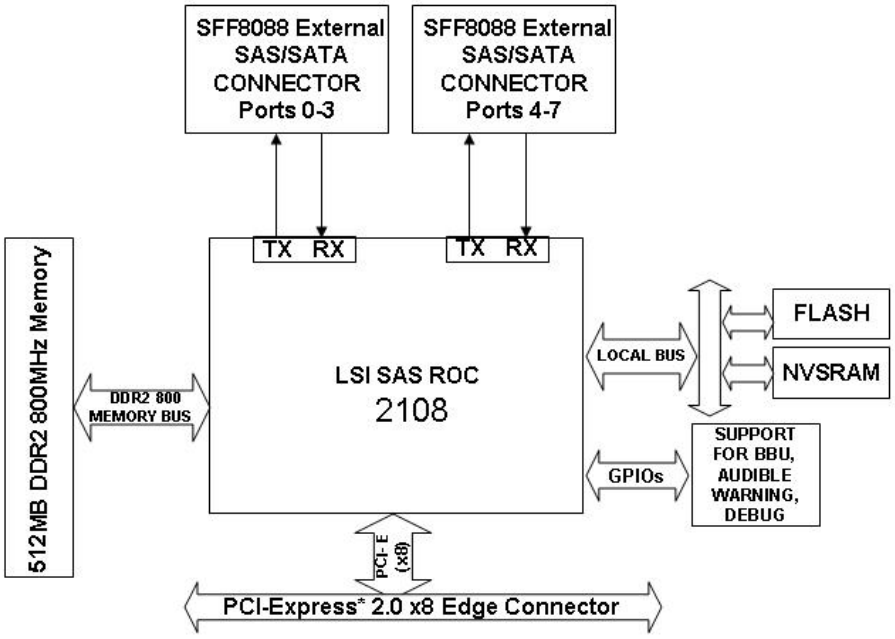

Figure 1. Hardware Block Diagram

2.2 Controller Layout

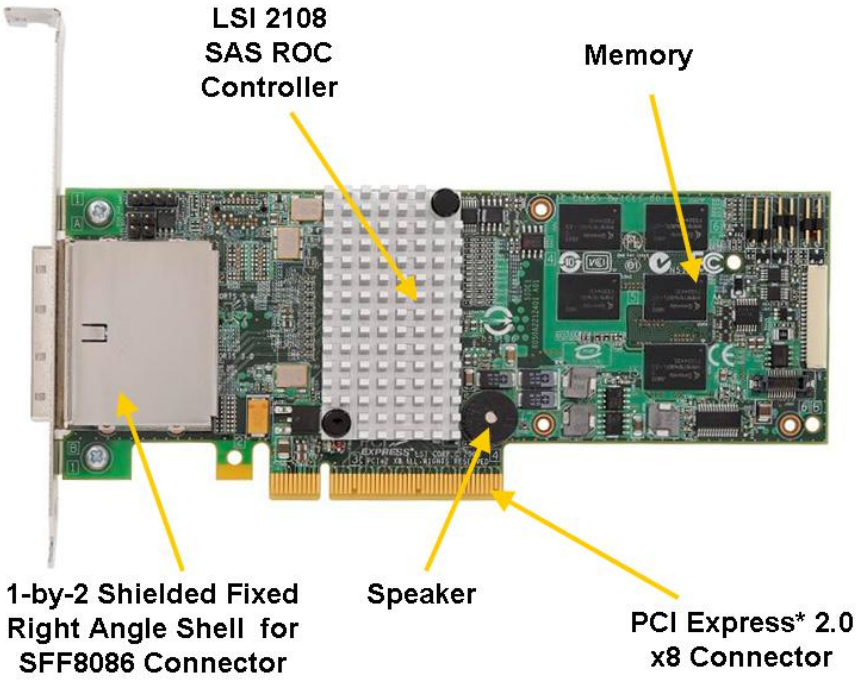

Figure 2. Intel® RAID Controller RS2PI008 Physical Layout

2.3 Major Components

The major components of the Intel® RAID Controller RS2PI008 are described in the subsections that follow.

2.3.1 LSI*SAS2108 ROC

The LSI*SAS2108 RAID-On-Chip (ROC) is an integrated SAS and I/O controller with an embedded Power PC* 440 core running at 800 MHz. For more information, see http://www.lsi.com/. The LSI*SAS2108 ROC provides the following functionality:

- x8 PCI Express* bus operating at 5.0 Gb/s serial transfer rate
- Spread Spectrum Clocking (SSC)
- SAS/SMP/STP/SATA support
- Supports SAS and SATA devices
- Initiator and Target mode (SSP)
- Wide port support
- T10 End-to-End Data Protection (EEDP)
- Local 72-bit DDR2 SDRAM interface with ECC checking
- Fusion MPT message unit
- PCI Express* interface supports x8, x4, and x1 lane configurations

2.3.2 Flash ROM

An 8-MB CFI-compliant flash ROM is used to accommodate RAID firmware and RAID BIOS Console 2 OpROM.

2.3.3 Boot Strap ROM (SEEPROM)

The serial bootstrap ROM is used to configure the LSI*SAS2108 ROC before the server board configures the PCI Express* registers. The bootstrap ROM sets the Phase Lock Loop (PLL) dividers, bootstrap configuration, and so on.

2.3.4 NVSRAM

A 32-KB NVSRAM is used to store disk and drive setup information.

2.3.5 SDRAM (Cache)

The Intel® RAID Controller RS2PI008 includes 512 MB of integrated DDR2 800 MHz ECC SDRAM memory. This DIMM is connected directly to the memory controller interface bus of the ROC and serves as storage for the executable code transferred from the flash. It also serves as cache during RAID transactions. Cache mode selection takes immediate effect while the server is online and is available on a per virtual drive basis. The ROC memory controller provides single-bit ECC error correction with multi-bit detection support.

The Intel® RAID Controller RS2PI008 supports the optional Intel® RAID Smart Battery AXXRSBBU7 which can be mounted directly to the J6B2 connector on the RAID controller or connected remotely to the J6B1 connector on the RAID controller through a supplied cable to provide a battery backup option for data cached in the memory. See Figure 3.

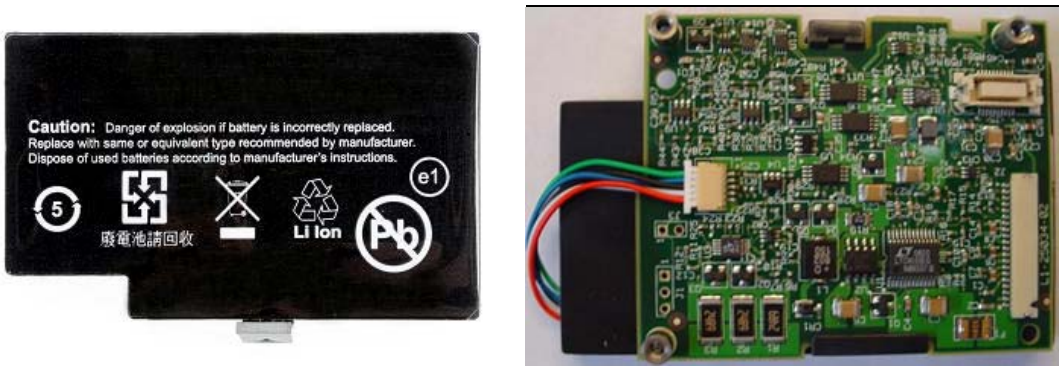

Figure 3 Intel® RAID Smart Battery AXXRSBBU7

***Note**: Only one option can be used at a time. Attempting to install two Smart Batteries may result in system errors.*

2.3.6 Diagnostics

2.3.6.1 Audible Alarm

The audible alarm beeps when a drive fails and also during a rebuild. The drive failure alarm beeps are:

- Degraded array: Short tone, one second on, one second off.
- Failed array: Long tone, three seconds on, one second off.
- Hot spare commissioned: Short tone, one second on, three seconds off.

The drive failure tones repeat until the problem is corrected, or until the alarm is silenced or disabled. The alarm can be silenced or disabled on the controller's properties page in the BIOS Console or by using the failed drive options pane in the Intel® RAID Web Console 2.

Silencing the alarm is temporary. If the cause of failure still exists or if an additional failure is detected, then the alarm sounds again when the system is rebooted. Disabling the alarm is persistent across errors and reboots. When the alarm is disabled, a failure does not cause it to sound until it is re-enabled.

The build alarm tone functions differently. It remains ON during the rebuild. After the rebuild completes, an alarm with a different tone sounds to signal that the rebuild is complete. This is a one-time, non-repeating tone.

2.3.6.2 LED Placement and Function

The Intel® RAID Controller RS2PI008 contains the following LEDs:

- One surface-mounted heartbeat ("CR3B1") LED (Green Color) to indicate SAS2108 activity.
- Another surface-mounted system error ("CR3B2") LED (Red Color) to indicate a board error.
- Additional LED signaling is available through stake pin connectors on the controller.

2.3.7 SAS / SATA Connectors

The Intel® RAID Controller RS2PI008 provides the external storage support through two external SFF8088 SAS / SATA signal connectors.

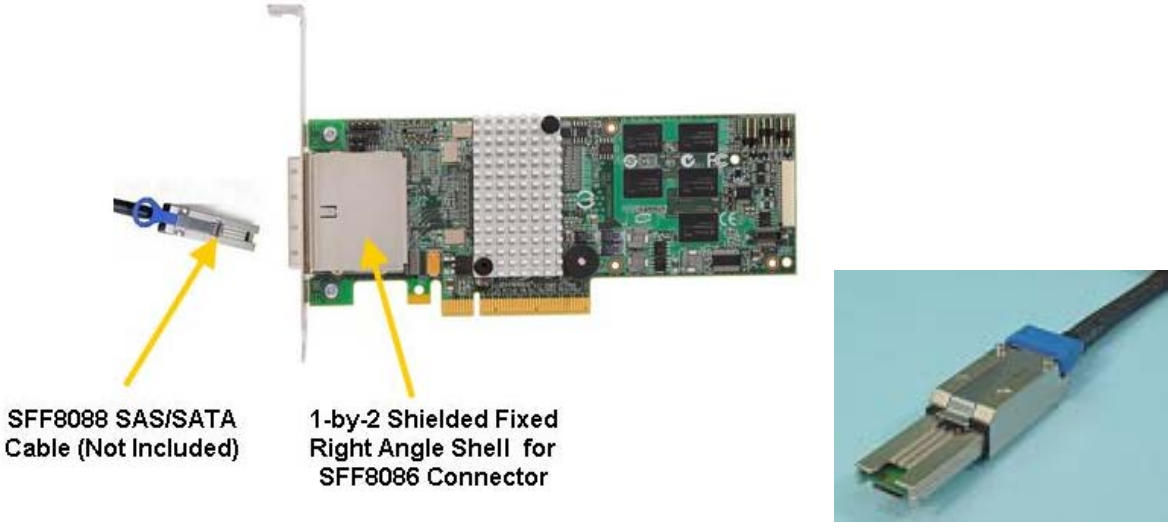

Figure 4. SAS/SATA Connectors

2.3.7.1 SAS / SATA Connector Pin-out

Signal names are with respect to the host. The device connected to the host reverses the signal names. Transmit pins connect to receive pins on the other device. The SAS / SATA connector is keyed at pin 1. These pin-outs for the serial ATA connector are not compatible with the legacy PATA connector.

Table 1. SFF8088 External Connector Pin-out

Signal	Pin	Signal	Pin
GND	A1	GND	B1
RX 0+	A2	TX 0+	B2
RX 0-	A3	TX 0-	B3
GND	A4	GND	B4
RX 1+	A5	TX 1+	B5
RX 1-	A6	TX 1-	B6
GND	A7	GND	B7
RX 2+	A8	RX 2+	B8
RX 2-	A9	RX 2-	B9
GND	A10	GND	B10
RX 3+	A11	RX 3+	B11
RX 3-	A12	RX 3-	B12
GND	A13	GND	B13

2.3.8 Board-to-Board BBU Interface

The Intel® RAID Controller RS2PI008 board can be attached to an external backup battery unit (BBU) through the BBU board-to-board connector.

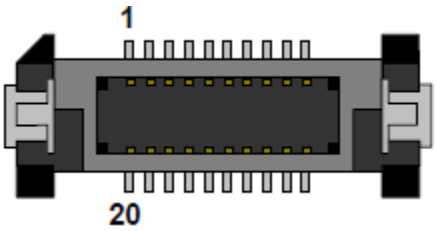

Figure 5. BBU Board-to-Board Connector

Table 2. BBU Connector Pin-out

Pin #	Signal	Description
1	VBB_DDR_MEM	DDR/DDRII power
2	GND	Ground
3	P12V	+12V power
4	GND	Ground
5	PFAIL_L	Power fail
6	BBE	Battery backup enabled
7	P1V8	1.8V power
8	BATT_PRSNT	Battery present
9	P3V3_STBY	3.3V auxiliary power
10	GND	Ground
11	GND	Ground
12	P3V3	3.3V power
13	SCL	I2C Clock
14	GND	Ground
15	SDA	I2C Data
16	BBSTATUS	Battery backup status
17	GND	Ground
18	BBSTROBE	Battery Backup Strobe
19	GND	Ground
20	VBB_DDR_MEM	DDR/DDRII Power

2.3.9 Remote BBU Interface

The Intel® RAID Controller RS2PI008 board can be attached to an external backup battery unit using a cable assembly attached to the BBU connector.

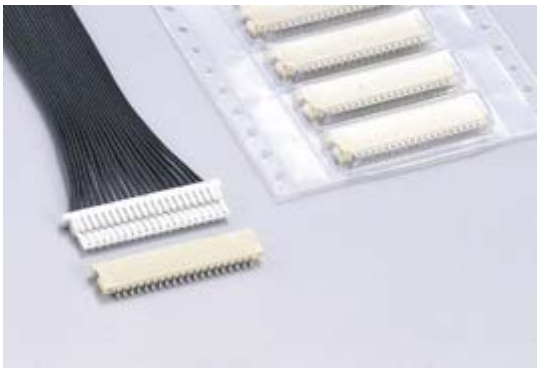

Figure 6. BBU Interface

Table 3 BBU Connector Pin-out

Pin #	Signal	Description
1	P12V_STBY	+12Vdc Standby
2	GND	Ground
3	P12V_STBY	+12Vdc Standby
4	GND	Ground
5	P1V8	+1.8Vdc
6	GND	Ground
7	P3V3	+3.3Vdc
8	GND	Ground
9	P1V8_BB	Sideband 1
10	GND	Ground
11	P3V3_STBY	+3.3Vdc Standby
12	GND	Ground
13	BBU_SMBCL	I2C Clock
14	GND	Ground
15	BBU_SMBDA	I2C Data
16	TM_PFAIL	Battery Backup Power Fail Detect
17	GND	Ground
18	BBE	Battery Backup Enable
19	BBSTROBE	Battery Backup Strobe
20	TM_STATUS	Battery Backup Status

2.3.10 PCI Interface

The Intel® RAID Controller RS2PI008 must be installed into a standard x8 or larger PCI Express* slot that complies with the *PCI Express* Specification, Revision 2.0*. The controller is PCI Express* 1.0 compatible and is backward-compatible with x8 or larger slots that are wired with x1, x2, and x4 PCI Express* lanes.

2.3.11 Jumpers and Connectors

The following figure shows the jumpers and connectors on Intel® RAID Controller RS2PI008. A description for each jumper and connector is provided in the following table.

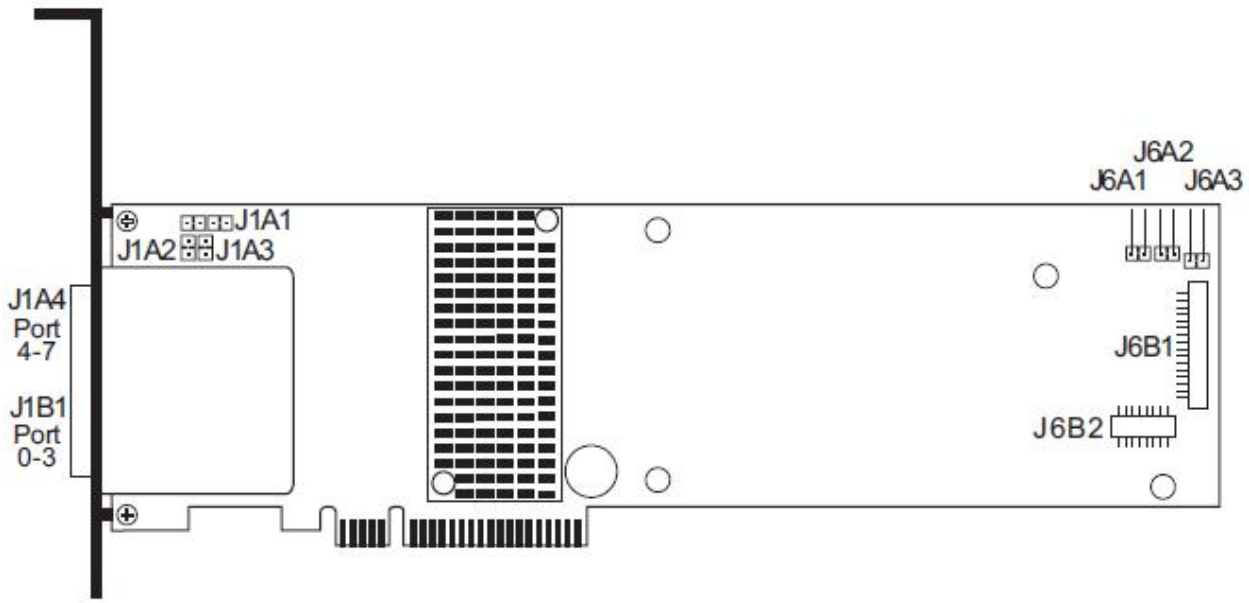

Figure 7. Jumpers and Connectors

Table 4. Jumpers and Connectors

Jumper	Description	Type	Comments
J1A1	Universal Asynchronous Receiver/Transmitter (UART)	4-pin connector	For factory and debug use.
J1A2	Test header	2-pin connector	Reserved for factory use only
J1A3	Set Factory Defaults Connector	2-pin connector	Resets the board settings to the defaults set in the factory.
J1A4	External Mini SAS 4i Connector, Ports 4-7	SFF8088	Connection to SAS/SATA devices.
J1B1	External Mini SAS 4i Connector, Ports 0-3	SFF8088	Connection to SAS/SATA devices.
J6A1	Drive Fault LED Header	2-pin connector	LED signal for any drive fault.
J6A2	Drive Activity LED Header	2-pin connector	LED signal for drive activity
J6A3	Dirty Cache LED Header	2-pin connector	For connection to enclosure LED. When lit, indicates the data in the cache has not been written to disk.
J6B1	Remote Battery Backup Unit Connector	20-pin connector	Provides an interface to the remote battery backup unit
J6B2	Board-to-board Connector for Battery Backup Unit	20-pin connector	Provides an interface to the daughter card that contains the battery backup unit.

2.4 Hardware Architectural Features

Table 5 Hardware Architectural Features

Feature	Intel® RAID Controller RS2PI008
RAID levels	0, 1, 5, 6, 10, 50, 60
Number of devices	Up to 240 devices per controller
Device types	SAS and SATA hard drives
Data transfer rate	600 MB/s per port
PCI bus	x8 PCI Express* 2.0
Memory	512 MB ECC DDR2 800-MHz SDRAM integrated on the controller
Battery backup (optional)	Intel® RAID Smart Battery AXXRSBBU7
SAS connector	Two external SFF8088 connectors
ROC	LSI*SAS2108 ROC, which provides hardware exclusive OR (XOR) assistance
Card dimensions	6.600 inches by 2.731 inches (MD2)
Weight	114g
Serial port	4-pin serial debug (requires transceiver)
Compatible devices	240 physical devices, 64 logical drives, mixed capacity drives, SAS and SATA hard drives, and non-disk devices including expanders.
Firmware	8 MB in flash ROM

2.5 Electrical Characteristics

The *PCI Express* Specification* requires that the 12-V rail and the 3.3-V rail have a voltage tolerance of 8% and 9% respectively. The amount of power that an adapter card can use is also limited.

All power is supplied to the Intel® RAID Controller RS2PI008 through the PCI Express* 3.3-V rails and the 12-V rails. The on-board switching regulator circuitry, operating from these rails, provides the necessary voltages. The following states determine the typical current consumption of the controller:

- State 1: Battery is charging
- State 2: Battery is full
- State 3: Battery is discharging

The supply voltages are 12 V ± 8 percent from PCI edge connector only and 3.3 V ± 9 percent from PCI edge connector only. The following table lists the power supply for the RAID controller for each state at the different voltages:

Table 6. Electrical Characteristics

	PCI Express* +12 V	PCI Express* +3.3 V	PCI Express* +3.3 V Auxiliary Supply
State 1	950 mA	773 mA	30 mA
State 2	730 mA	773 mA	30 mA
State 3	733 mA	770 mA	30 mA

The voltage level used in the charging circuitry for the battery pack on the optional Intel® RAID Smart Battery AXXRSBBU7 is +12 V. The numbers above are generated with battery attached, with adapter running heavy I/O pattern.

2.6 Environmental Specifications

Table 7. Environmental Specifications

Specification	Description
Operating temperature	0 degrees Celsius to 60 degrees Celsius. The maximum operating temperature decreases to +44.5 degrees Celsius when the Intel® RAID Smart Battery AXXRSBBU7 is installed
Relative humidity range	20% to 80% non-condensing
Airflow	200 linear feet per minute (LFPM)
MTBF (electrical components)	370,447 hours at 40 degrees Celsius

Table 8. Storage and Transit Specifications

Specification	Description
Temperature range without battery	-30 degrees Celsius to +80 degrees Celsius (dry bulb)
Temperature range with battery	0 degrees Celsius to 45 degrees Celsius (dry bulb)
Relative humidity range	5% to 90 % non-condensing

2.6.1 Safety Characteristics

The Intel® RAID Controller RS2PI008 meets or exceeds 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.

The board is designed and implemented to minimize electromagnetic emissions, susceptibility, and the effects of electrostatic discharge. All testing and verification of these characteristics are done at the parent or end-unit level.

2.7 Supported Device Technology

The various device technologies supported by the Intel® RAID Controller RS2PI008 are described in the subsections that follow.

2.7.1 Support for Hard Disk Drive Devices

The Intel® RAID Controller RS2PI008 integrates eight external high-performance SAS/SATA II ports that support SAS and enterprise-class SATA hard drives. Each port supports both SAS and SATA devices using the SAS Serial SCSI Protocol (SSP), Serial Management Protocol (SMP), and Serial Tunneling Protocol (STP). The SSP protocol enables communication with

other SAS devices. STP allows the SAS RAID controller to communicate with SATA devices using the SATA commands.

2.7.2 SAS Expander Support

The Intel® RAID Controller RS2PI008 supports LSI expanders, Vitesse SAS expanders, and PMC expanders that are used as a component in Intel enclosures. Other expanders may be supported post launch, based on market conditions and customer requirements.

2.7.3 Support for Non-Hard Disk Drive Devices

As SAS-based non-hard drive devices were not available when this controller was in development, support for these devices will be determined as they become available. For information on support for non-hard drive devices, see the *Intel® RAID Controller RS2PI008 Tested Hardware and Operating System List*.

2.7.4 Enclosure Management Support

The Intel® RAID Controller RS2PI008 supports in-band SES2 enclosure management.

3. Software

The SAS Software Stack is planned for use with current SAS RAID controllers and future RAID controllers that are compatible with SAS and SATA technology. This software stack includes software pieces used in RAID controller firmware, RAID controller BIOS, and RAID controller drivers and utilities. Figure 7 shows the inter-relationship between these software pieces.

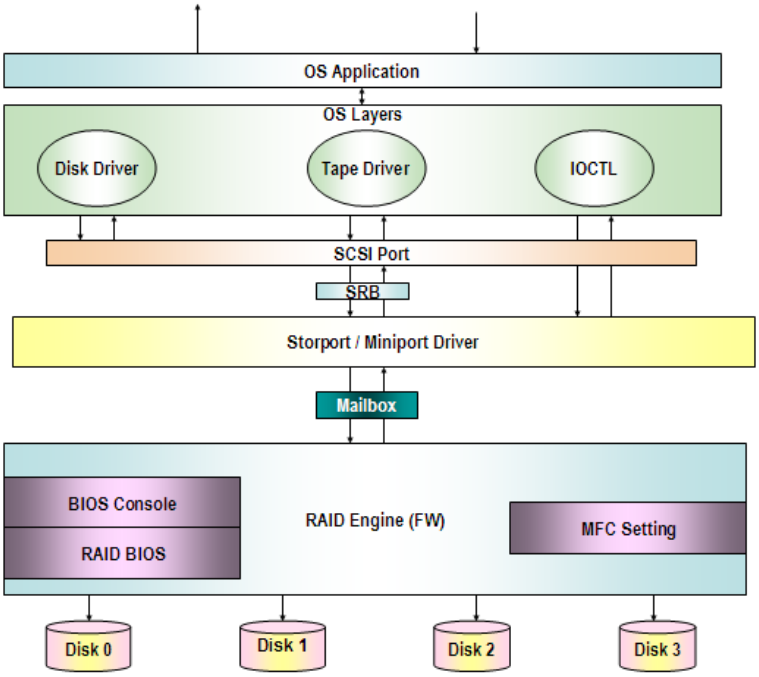

Figure 7. Software Block Diagram

3.1 Common Layers

3.1.1 Firmware

The firmware is composed of multiple software layers, allowing for maximum flexibility, reuse, and maintainability. These layers are described in the following subsections.

3.1.1.1 MFC Settings

The default MFC settings are factory programmed and consist of two types of settings:

- Settings that cannot be modified in the field. These include the PCI IDs.
- Settings that can be modified using a utility. These include default cache settings, rebuild rates, and other BIOS and operational defaults. Access to the MFC modification utility is restricted.

Additional information about MFC definitions and default settings is available upon request.

3.1.1.2 RAID BIOS

The RAID BIOS is the expansion ROM software defined in the *PCI Express*Specification*. It performs the RAID controller initialization from the host system memory during POST.

3.1.1.3 Intel® RAID BIOS Console 2 Configuration Utility

The Intel® RAID BIOS Console 2 configuration utility provides a graphical user interface to manage all aspects of the RAID subsystem and many features of the RAID controller. To access this utility, press <Ctrl> + <G> during system boot time. For details about this utility, see the *Intel® RAID Software User's Guide* (Document number: D29305-00x).

3.1.1.4 RAID Firmware Engine

The RAID firmware contains the algorithms for mapping physical to virtual devices, RAID level algorithms, data redundancy calculation algorithms, and error detection, logging, and reporting capabilities.

3.1.2 API

To configure the Intel® RAID Controller RS2PI008, a set of interfaces known as the IOCTL interface is provided, which allows an application to issue commands to the controller through the driver. Commands can be issued to determine adapter properties and change the parameter settings. The API package defines a higher level of commands and functions for developers who want to configure the RAID adapters with their own utility. This is implemented as a 32-bit dynamic link library (DLL) for Microsoft Windows* operating systems and through a set of binaries for other operating systems. Access to the API libraries is restricted.

3.1.3 Operating System Driver

The operating system driver communicates between the host resident application and the RAID controller using specific communication protocols.

3.2 User Interface

3.2.1 Intel® RAID BIOS Console 2 Configuration Utility

The Intel® RAID BIOS Console 2 configuration utility is an X-ROM based utility. To access this utility, press <Ctrl> + <G> during POST. This utility usually starts at the completion of POST, but it may expand and operate during POST if sufficient PMM memory is available.

This utility is GUI-based and is most easily used with a mouse. The utility enables the user to configure the RAID controller properties, manage physical devices attached to the RAID controller, create and manage virtual drives, and manage the battery backup module. The Intel® RAID BIOS Console 2 configuration utility includes a configuration wizard that simplifies the process of creating disk arrays and virtual drives. The following table describes the available options.

Table 9. Intel® RAID BIOS Console 2 Configuration Utility Options

Option	Description
Adapter Properties	When you select the Adapter Selection option on the Main screen, the Intel® RAID BIOS Console 2 displays a list of the Intel® RAID adapters in the system. The Adapter Properties screen allows you to view and configure the software and hardware of the selected adapter.
Scan Devices	When you select the Scan Devices option on the Main screen, the Intel® RAID BIOS Console 2 checks the physical and virtual drives for any changes in the drive status. The Intel® RAID BIOS Console 2 displays the results of the scan in the physical and virtual drive descriptions.
Virtual Disks	The Virtual Disks screen provides options to Fast Initialize or Slow Initialize Virtual Disk, Check Consistency, Display Virtual Disk properties, and Set Boot Drive using a specified virtual disk. **Caution:** Initializing a virtual drive deletes all information on the physical drives that compose the virtual drive.
Physical Drives	This screen displays the physical drives for each port. From this screen, you can rebuild the physical arrays or view the properties for the physical drive you select.
Configuration Wizard	This option enables you to clear a configuration, create a new configuration, or add a configuration.
Adapter Selection	This option allows you to choose an Intel® RAID controller installed in the system.
Physical view	This option toggles between Physical View and Virtual View.
Events	This option displays the events generated by virtual disks, physical devices, enclosures, the Intel® RAID Smart Battery, and the SAS controller.

3.2.2 Intel® RAID Web Console 2

The Intel® RAID Web Console 2 utility runs within the operating system. It is Java* GUI-based and enables the user to configure the RAID controller, disk drives, Intel® RAID Smart Battery, and other storage related devices connected to the RAID controller or embedded on the server board.

The utility is used most easily with a mouse, and standard right and left mouse clicks are functional based on the operating system's mouse configuration.

The Intel® RAID Web Console 2 includes a Configuration Wizard that simplifies the process of creating disk arrays and virtual drives. Within the Configuration Wizard, the user can select from several options:

- Auto Configuration mode automatically creates the best possible configuration based on options configurable with the available hardware.
- Guided Configuration mode asks brief questions about the configuration, and then creates the configuration based on the answers provided.
- Manual Configuration mode provides complete control over all aspects of the storage configuration.

A Reconstruction Wizard increases or reduces the size of a virtual disk and changes the RAID level of an array.

The following table briefly describes the available options. For a detailed description of these functions, see the *Intel® RAID Software User's Guide* (Document number: D29305-0xx).

Table 10. Intel® RAID Web Console 2 Options

Option	Description
Menu Bar	Provides menu options including exit, rescan, operations, log, and online help.
Physical / Virtual View Panel	Shows the hierarchy of physical / virtual devices in the server.
Properties / Operations / Graphical View Panel	Displays information about the selected device and the operations that can be performed on the device.
Event Log Panel	Displays the event log entries for the selected RAID controller.
Adapter Properties	Configures adapter properties. The configuration of these properties within the Intel® RAID Web Console 2 is limited to properties that can be performed without a reboot of the controller or that are not data destructive.
Physical Drive Properties	View physical drive properties including drive model, serial number, defect tables, and association with virtual drives.
Virtual Disk Properties	View virtual disk properties, including drive size, stripe size, disk cache policy, array cache policy, virtual disk name, and virtual disk status.
Configuration Wizard	Clears a configuration, creates a new configuration, or adds a configuration.

3.3 Command-line Utility

The command-line utility (CLU) is an operating system-based text utility that allows the configuration of the RAID controller properties, configuration of disk arrays and virtual drives, configuration of cache settings, firmware updates, and error reporting. The CLU is available for DOS*, UEFI*, Microsoft Windows*, and Linux* operating systems. For a list of all command-line options, see the *Intel® RAID Controller Command Line Tool 2 User Guide*. The following table provides a synopsis of available options:

Table 11. Command-line Utility Options

Option	Description
Help	Command-line tool option to command help.
Controller Information	Provides information about controller properties and configuration.
Configuration information	Provides information on physical and virtual drives attached to the controller.
Configuration management	Allows configuration of the RAID controller, virtual drive properties, and hard drive cache configuration.
Configuration creation/deletion	Allows configuration or deletion of virtual drives, including RAID level configuration, cache policy configuration, and hot spare configuration.

3.4 Flash Utility

This utility is an operating system-based utility that allows you to update the RAID controller firmware. It is available for UEFI*, DOS*, Microsoft Windows*, and Linux*. It is designed for use with a separate firmware update file. For a complete list of options, see the *Release Notes* for the specific version of the utility in use.

3.5 SNMP Support

SNMP support includes MIB files that are available upon request for recompilation compatibility with existing SNMP-enabled monitoring applications. An SNMP agent is also available. For operational details, see the *Release Notes* that accompany these files.

4. RAID Functionality and Features

4.1 Hierarchy

The fundamental purpose of a RAID system is to present a usable data storage medium (virtual drive) with some level of redundancy to a host operating system. The Intel® RAID firmware is based on the concept of associating physical drives in arrays and then creating a virtual drive from that array that includes a functional RAID level. To create a virtual drive and present it to the host operating system, the RAID firmware typically follows these steps:

1. One or more physical drives are selected and associated as an array.

2. One or more arrays are associated and given a RAID level. This process creates a virtual drive and provides an option to initialize the virtual drive.

3. The RAID firmware presents the virtual drive to the operating system.

4.1.1 RAID Physical Drive Status

Table 12. RAID Physical Drive Status

Drive State	Code	Description
Unconfigured Good	Unconfigured Good	The drive is functioning normally, but is not part of a configured virtual drive and is not a hot spare.
Online	ONLN	The drive is online, is part of a configured virtual drive, and is functioning normally.
Hot Spare	HOTSP	A physical drive that is configured as a hot spare.
Failed	FAILED	A physical drive that was originally configured as Online or Hot Spare, but on which the firmware detects an unrecoverable error.
Rebuilding	REBUILD	A physical drive to which data is being written to restore full redundancy for a virtual drive.
Unconfigured Bad	Unconfigured Bad	A physical drive on which the firmware detects an unrecoverable error; the physical drive was Unconfigured Good or the physical drive could not be initialized.
Missing	Missing	A physical drive that was online, but which has been removed from its location.
Offline	Offline	A physical drive that is part of a virtual drive but which has invalid data as far as the RAID configuration is concerned.
None	None	A physical drive with an unsupported flag set. An Unconfigured Good or Offline physical drive that has completed the ‘prepare for removal’ operation.

4.1.2 RAID Virtual Drive Status

Table 13. RAID Virtual Drive Status

Drive State	Code	Description
Optimal	Optimal	The drive operating system is good. All configured drives are online.
Degraded	Degraded	The drive operating condition is not optimal because one of the configured drives has failed or is offline.
Offline	Offline	The drive is not available to the operating system and is unusable.

4.1.3 RAID Controller Drive Limitations

Only drives that comply with the SAS and SATA specification extensions are supported.

4.2 SAS Bus and ID Mapping

Devices on the SAS bus are persistently mapped based on a SAS address.

4.3 RAID Features

4.3.1 RAID Level Support

The supported RAID levels are summarized in the following table.

Table 14. Supported RAID Levels

RAID Level	Description
RAID 0	Data is striped to one or more physical drives. If using more than one disk, each stripe is stored on the drives in a “round robin” fashion. RAID 0 includes no redundancy. If one hard disk fails, all data is lost.
RAID 1	Disk mirroring: All data is stored twice, making each drive the image of the other. Missing data on one drive can be recovered from data on the other drive. RAID 1 requires two drives for each mirrored array.
RAID 5	Data striping with distributed parity: Data is striped across the hard disks and the controller calculates redundancy data (parity information) that is also striped across the hard disks. Missing data is rebuilt from parity. RAID 5 requires a minimum of three drives in the array but can be expanded to the capacity of the controller.
RAID 6	Data striping with two distributed parities: Data is striped across all disks in the array and two parity disks are used to provide protection against the failure of up to two physical disks. In each row of data blocks, two sets of parity data are stored.
RAID 10	RAID 10 is accomplished by striping data across two or more RAID 1 arrays. Missing data is rebuilt from redundant data stripes. RAID 10 requires a minimum of four drives. RAID 10 provides high data throughput rates.
RAID 50	RAID 50 is accomplished by striping data across two or more RAID 5 arrays. Missing data is rebuilt from redundant data stripes. RAID 50 requires a minimum of six drives. RAID 50 provides high data throughput rates.
RAID 60	RAID 60 is accomplished by striping data across two or more RAID 6 arrays. Missing data is rebuilt from redundant data stripes. RAID 60 requires a minimum of eight drives. RAID 60 provides high fault tolerance.

4.3.2 Cache Policies

The RAID cache can temporarily store data, so it can be more quickly accessed while it awaits drive readiness. The cache is available both on the RAID controller and on hard drives. The RAID controller's read and write cache policy is set on a virtual drive level. This policy is set when the virtual drive is created, but it can be changed using the Intel® RAID BIOS Console 2 configuration utility, the command-line utility, or the Intel® RAID Web Console 2 utility.

The user should not enable specific cache policies if the Intel® RAID Smart Battery is not installed. The drive cache is managed through a user-configurable RAID controller option, but the RAID controller battery does not protect data in the drive cache in the event of a power interruption. Exercise caution when enabling the drive cache.

Table 15. Cache Policies

Array Cache Policy	Cache Option	Description
Cache Policy	Direct I/O	When possible, no cache is involved for both reads and writes. The data is transferred directly from host to disk and from disk to host.
	Cached I/O	All reads first look at cache. If a cache hit occurs, the data is read from cache; if not, the data is read from disk and the read data is buffered into cache. All writes to drive are also written to cache.
Read Policy	No Read Ahead	The controller does not use read-ahead.
	Read Ahead	Specifies that additional consecutive data stripes are read and buffered into cache.
	Adaptive Read Ahead	Specifies that the controller begins using read-ahead if the two most recent disk accesses occurred in sequential sectors.
Write Policy	Write Through	The controller sends a data transfer completion signal to the host after the disk subsystem receives all the data in a transaction and the data is successfully written to disk.
	Write Back	The controller sends a data transfer completion signal to the host when the controller cache receives all the data in a transaction and the data is then written to disk as the drive becomes available. If the 'Use Write Through for failed or missing battery' option is disabled, the Write Back mode is enabled even if the battery backup unit is bad or missing.
Hard Drive Cache	Read and Write Cache	Memory located on the hard drive is used to cache data going to or coming from the drive. Enabling the hard drive cache can result in a performance improvement but data held in drive cache is not protected by the RAID controller.

4.3.3 Stripe Size

The stripe size determines the size of each data stripe on each hard drive. The options are 8, 16, 32, 64, 128, 256, 512, and 1024 KB. The stripe size is set when the virtual drive is created. It cannot be changed without removing the virtual drive configuration and all data contained on the virtual drive.

4.3.4 Hot-spare Drives

Hot-spare drives are designated to automatically replace a failed drive. Hot-spare drives must be the same size or larger than the drives they will replace. They can be designated as a private hot-spare drive assigned to one virtual drive, or they may be a global hot-spare that is assigned to all virtual drives attached to the RAID controller. Hot-spare drives can be designated using

the Intel® RAID BIOS Console 2 utility, the Intel® RAID Web Console 2 utility, or the command line utility.

4.3.5 Hot-plug Drive Support

Hot-plug support allows hard drives to be inserted or removed without rebooting the system, as long as both the hard drive and server system backplane support hard drive hot-plug functions.

The RAID controller immediately recognizes when a drive is removed and sets the virtual status to “Missing” until an I/O to the drive fails. The drive status then changes to “Failed.”

A drive inserted into an attached intelligent enclosure is recognized as present. A drive inserted into an attached non-intelligent enclosure may require a bus scan before it is detected. Hot plug of new drives is supported in both intelligent and non-intelligent enclosures.

4.3.6 Auto-declare Hot Spare Drive

If the RAID controller has a RAID array drive that is in a failed (degraded) state and the failed drive is removed and a new hard drive of the same or larger size is inserted into the same slot, the new drive is automatically marked as a hot-spare drive and a rebuild begins. A bus scan may be required in a non-intelligent enclosure.

4.3.7 Physical Drive Roaming

Physical drive roaming allows the user to move drives to any port on the RAID controller without losing the configuration.

4.3.8 Virtual Drive Roaming

Virtual drive roaming allows the user to move a virtual drive from one controller to another system/controller without losing the configuration or data. All virtual drives attached to the RAID controller must be moved as a unit.

4.3.9 RAID Controller Migration

The RAID controller migration feature allows a defective RAID controller to be removed and replaced by a compatible RAID controller without losing the configuration or data. To avoid a configuration mismatch, it is wise to reset the new controller configuration before attaching the array drives. If a configuration mismatch occurs, care must be taken to use the configuration on the drives or all data may be lost.

4.3.10 Online Capacity Expansion

Online capacity expansion (OCE) allows additional drives to be added to a virtual drive in an array. OCE is available as an option in the Intel® BIOS Console 2 utility, the Intel® RAID Web Console 2 utility, or the command-line utility.

4.3.11 RAID Level Migration

RAID level migration allows for the migration from one RAID level to another. RAID level migration may require the addition of additional physical drives as part of the process. RAID

level migration is an option in the Intel® RAID BIOS Console 2 utility, the Intel® RAID Web Console 2 utility, or the command-line utility.

4.4 Operating Certifications

Microsoft Windows* Winqual certification (WHQL).

5. Safety and Regulatory Certifications

This RAID Controller Card complies with the following safety and electromagnetic compatibility (EMC) regulations:

5.1 Product Safety Compliance

- UL 1950 - CSA 950 (US/Canada)
- EN 60 950 (European Union)
- IEC60 950 (International)
- CE - Low Voltage Directive (2006/95/EEC) (European Union)

5.2 Product EMC Compliance – Class A Compliance

- FCC / ICES-003 (USA/Canada)
- CISPR 22 (International)
- EN55022 (Europe)
- EN55024 (Europe)
- CE - EMC Directive 2004/108//EEC (Europe)
- VCCI (Japan) – Verification Only
- AS/NZS 3548 (Australia / New Zealand)
- BSMI CNS13438 (Taiwan)
- KCC Certification (Korea)

5.3 Product Regulatory Compliance Markings

Some of the marking information is provided on the packaging and/or in the product documentation due to limited marking space on the product. Some markings and warnings are provided in the literature if no room was deemed on product for marking The RAID Controller Card is with the following compliance markings:

- ETL or NRTL Mark (US/Canada)
- FCC (US)
- ICES-003 (Canada)
- CE Mark (Europe)
- KCC Mark (Korea)
- BSMI DOC Mark (Taiwan)
- ACS C-Tick Mark (Australia)

Table 16. Product Regulatory Compliance Markings

Regulatory Compliance	Country	Marking
NRTL Certification Marking	USA/Canada	 or 
CE Mark	Europe	
FCC Marking (Class A)	USA	This device complies with Part 15 of the FCC Rules. Operation of this device is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.
EMC Marking (Class A)	Canada	CANADA ICES-003 CLASS A CANADA NMB-003 CLASSE A
BSMI Marking (Class A) and Class A EMC Warning	Taiwan	 警告使用者： 這是甲類的資訊產品，在居住的環境中使用時，可能會造成射頻干擾，在這種情況下，使用者會被要求採取某些適當的對策
KCC Mark	Kortea	
C-Tick Mark	Australia	

5.4 Electromagnetic Compatibility Notices

FCC Verification Statement (USA). This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and

2. This device must accept any interference received, including interference that may cause undesired operation.

```
Intel Corporation
5200 N.E. Elam Young Parkway
Hillsboro, OR 97124-6497
Phone: 1-800-628-8686
```

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a commercial installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Intel is not responsible for any radio or television interference caused by unauthorized modification of this equipment for substitution or attachment of connecting cables and equipment other than those specified by Intel. The correction of interferences caused by such unauthorized modification, substitution, or attachment will be the responsibility of the user.

This RAID Controller has been tested to comply with FCC standards for office use.

- ICES-003 (Canada) This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the interference-causing equipment standard entitled "Digital Apparatus," ICES-003 of the Canadian Department of Communications.

  Cet appareil numúrique respecte les limites bruits radioúlectriques applicables aux appareils numúriques de Classe Aprescrites dans la norme sur le matúriel brouilleur: "Appareils Numúriques", NMB-003 údictúe par le Ministre Canadien des Communictations.
- Europe (CE Declaration of Conformity) This product has been tested in accordance too, and complies with the Low Voltage Directive (73/23/EEC) and EMC Directive (89/336/EEC). The product has been marked with the CE Mark to illustrate its compliance.

Appendix A: Event Messages and Error Codes

This appendix lists the Intel® RAID Web Console 2 events that may appear in the event log.

The Intel® RAID Web Console 2 utility monitors the activity and performance of all controllers in the server and any devices attached to them. When an "event" such as the completion of a consistency check or the removal of a physical drive occurs, an event message is displayed in the log, which is displayed at the bottom of the Intel® RAID Web Console 2 screen. The messages are also logged in the Windows Application Log (Event Viewer). Error event levels are:

- **Progress:** This is a progress posting event. Progress events are not saved in NVRAM.
- **Information:** Informational message. No user action is necessary.
- **Warning:** A component may be close to a failure point.
- **Critical:** A component has failed, but the system has not lost data.
- **Fatal:** A component has failed and data loss has occurred or will occur.
- **Dead:** A catastrophic error has occurred and the controller has failed. This is seen only after the controller has been restarted.

The following table lists the Intel® RAID Web Console 2 event messages

Table 17 Event Messages

Number	Type	Description
0	Information	Firmware initialization started (PCI ID %04x/%04x/%04x/%04x)
1	Information	Firmware version %s
2	Fatal	Unable to recover cache data from TBBU
3	Information	Cache data recovered from TBBU successfully
4	Information	Configuration cleared
5	Warning	Cluster down; communication with peer lost
6	Information	%s ownership changed from %02x to %02x
7	Information	Alarm disabled by user
8	Information	Alarm enabled by user
9	Information	Background initialization rate changed to %d%%
10	Fatal	Controller cache discarded due to memory/battery problems
11	Fatal	Unable to recover cache data due to configuration mismatch
12	Information	Cache data recovered successfully
13	Fatal	Controller cache discarded due to firmware version incompatibility
14	Information	Consistency Check rate changed to %d%%
15	Dead	Fatal firmware error: %s
16	Information	Factory defaults restored A249
17	Warning	Flash downloaded image corrupt
18	Critical	Flash erase error
19	Critical	Flash timeout during erase

Number	Type	Description
20	Critical	Flash error
21	Information	Flashing image: %s
22	Information	Flash of new firmware image(s)complete
23	Critical	Flash programming error
24	Critical	Flash timeout during programming
25	Critical	Flash chip type unknown
26	Critical	Flash command set unknown
27	Critical	Flash verify failure
28	Information	Flush rate changed to %d seconds
29	Information	Hibernate command received from host
30	Information	Event log cleared
31	Information	Event log wrapped
32	Dead	Multi-bit ECC error: ECAR=%x
33	Warning	Single-bit ECC error: ECAR=%x
34	Dead	Not enough controller memory
35	Information	Patrol Read complete
36	Information	Patrol Read paused
37	Information	Patrol Read Rate changed to %d%%
38	Information	Patrol Read resumed
39	Information	Patrol Read started
40	Information	Rebuild rate changed to %d%%
41	Information	Reconstruction rate changed to %d%%
42	Information	Shutdown command received from host
43	Information	Test event: '%s'
44	Information	Time established as %s; (%d seconds since power on)
45	Information	User entered firmware debugger
46	Warning	Background Initialization aborted on %s
47	Information	Background Initialization corrected medium error (%s at %lx, %s at %lx)
48	Information	Background Initialization completed on %s
49	Fatal	Background Initialization completed with uncorrectable errors on %s
50	Fatal	Background Initialization detected uncorrectable multiple medium errors (%s at %lx on %s)
51	Critical	Background Initialization failed on %s
52	Progress	Background Initialization progress on %s is %s
53	Information	Background Initialization started on %s
54	Information	Policy change on %s to %s from %s
55	N/A	OBSOLETE
56	Information	Consistency Check aborted on %s
57	Information	Consistency Check corrected medium error (%s at %lx, %s at %lx)
58	Information	Consistency Check done on %s
59	Information	Consistency Check done with corrections on %s, (corrections=%d)
60	Fatal	Consistency Check detected uncorrectable multiple medium errors (%s at %lx on %s)
61	Critical	Consistency Check failed on %s
62	Fatal	Consistency Check failed with uncorrectable data on %s
63	Information	Consistency Check found inconsistent parity on %s at stripe %lx

Number	Type	Description
64	Warning	Consistency Check inconsistency logging disabled on %s (too many inconsistencies)
65	Progress	Consistency Check progress on %s is %s
66	Information	Consistency Check started on %s
67	Information	Initialization aborted on %s
68	Critical	Initialization failed on %s
69	Progress	Initialization progress on %s is %s
70	Information	Fast initialization started on %s
71	Information	Full initialization started on %s
72	Information	Initialization complete on %s
73	Information	%s Properties updated to %s (from %s)
74	Information	Reconstruction complete on %s
75	Fatal	Reconstruction of %s stopped due to unrecoverable errors
76	Fatal	Reconstruct detected uncorrectable multiple medium errors (%s at %lx on %s at %lx)
77	Progress	Reconstruction progress on %s is %s
78	Information	Reconstruction resumed on %s
79	Fatal	Reconstruction resume of %s failed due to configuration mismatch
80	Information	Reconstruction started on %s
81	Information	State change on %s from %s to %s
82	Information	Clear aborted on %s
83	Critical	Clear failed on %s (Error %02x)
84	Progress	Clear progress on %s is %s
85	Information	Clear started on %s
86	Information	Clear completed on %s
87	Warning	Error on %s (Error %02x)
88	Information	Format completed on %s
89	Information	Format started on %s
90	Warning	Hot Spare SMART polling failed on %s (Error %02x)
91	Information	Inserted: %s
92	Warning	%s is not supported
93	Information	Patrol Read corrected medium error on %s at %lx
94	Progress	Patrol Read progress on %s is %s
95	Fatal	Patrol Read found an uncorrectable medium error on %s at %lx
96	Warning	Predictive failure: %s
97	Fatal	Puncturing bad block on %s at %lx
98	Information	Rebuild aborted by user on %s
99	Information	Rebuild completed on %s
100	Information	Rebuild completed on %s
101	Critical	Rebuild failed on %s due to source drive error
102	Critical	Rebuild failed on %s due to target drive error
103	Progress	Rebuild progress on %s is %s
104	Information	Rebuild resumed on %s
105	Information	Rebuild started on %s
106	Information	Rebuild automatically started on %s
107	Critical	Rebuild stopped on %s due to loss of cluster ownership

Number	Type	Description
108	Fatal	Reassign write operation failed on %s at %lx
109	Fatal	Unrecoverable medium error during rebuild on %s at %lx
110	Information	Corrected medium error during recovery on %s at %lx
111	Fatal	Unrecoverable medium error during recovery on %s at %lx
112	Warning	Removed: %s
113	Information	Unexpected sense: %s, CDB:%s, Sense:%s
114	Information	State change on %s from %s to %s
115	Information	State change by user on %s from %s to %s
116	Warning	Redundant path to %s broken
117	Information	Redundant path to %s restored
118	Information	Dedicated Hot Spare %s no longer useful due to deleted array
119	Critical	SAS topology error: Loop detected
120	Critical	SAS topology error: Unaddressable device
121	Critical	SAS topology error: Multiple ports to the same SAS address
122	Critical	SAS topology error: Expander error
123	Critical	SAS topology error: SMP timeout
124	Critical	SAS topology error: Out of route entries
125	Critical	SAS topology error: Index not found
126	Critical	SAS topology error: SMP function failed
127	Critical	SAS topology error: SMP CRC error
128	Critical	SAS topology error: Multiple subtractive
129	Critical	SAS topology error: Table to table
130	Critical	SAS topology error: Multiple paths
131	Fatal	Unable to access device %s
132	Information	Dedicated Hot Spare created on %s (%s)
133	Information	Dedicated Hot Spare %s (%s) disabled
134	N/A	OBSOLETE
135	Information	Global Hot Spare created on %s (%s)
136	Information	Global Hot Spare %s (%s) disabled
137	N/A	OBSOLETE
138	Information	Created %s
139	Information	Deleted %s
140	Information	Marking %s inconsistent due to active writes at shutdown
141	Information	Battery Present
142	Warning	Battery Not Present
143	Information	New Battery Detected
144	Information	Battery has been replaced
145	Warning	Battery temperature is high
146	Warning	Battery voltage low
147	Information	Battery started charging
148	Information	Battery is discharging
149	Information	Battery temperature is normal
150	Fatal	Battery needs replacement - SOH Bad
151	Information	Battery relearn started

Number	Type	Description
152	Information	Battery relearn in progress
153	Information	Battery relearn completed
154	Warning	Battery relearn timed out
155	Information	Battery relearn pending: Battery is under charge
156	Information	Battery relearn postponed
157	Information	Battery relearn will start in 4 days
158	Information	Battery relearn will start in 2 day
159	Information	Battery relearn will start in 1 day
160	Information	Battery relearn will start in 5 hours
161	Warning	Battery removed
162	Warning	Current capacity of the battery is below threshold
163	Information	Current capacity of the battery is above threshold
164	Information	Enclosure (SES) discovered on %s
165	Information	Enclosure (SAF-TE) discovered on %s
166	Critical	Enclosure %s communication lost
167	Information	Enclosure %s communication restored
168	Critical	Enclosure %s fan %d failed
169	Information	Enclosure %s fan %d inserted
170	Warning	Enclosure %s fan %d removed
171	Critical	Enclosure %s power supply %d failed
172	Information	Enclosure %s power supply %d inserted
173	Warning	Enclosure %s power supply %d removed
174	Critical	Enclosure %s EMM %d failed
175	Information	Enclosure %s EMM %d inserted
176	Critical	Enclosure %s EMM %d removed
177	Warning	Enclosure %s temperature sensor %d below warning threshold
178	Critical	Enclosure %s temperature sensor %d below error threshold
179	Warning	Enclosure %s temperature sensor %d above warning threshold
180	Critical	Enclosure %s temperature sensor %d above error threshold
181	Critical	Enclosure %s shutdown
182	Warning	Enclosure %s not supported; too many enclosures connected to port
183	Critical	Enclosure %s firmware mismatch (EMM %d)
184	Warning	Enclosure %s sensor %d bad
185	Critical	Enclosure %s phy bad for slot %d
186	Critical	Enclosure %s is unstable
187	Critical	Enclosure %s hardware error
188	Critical	Enclosure %s not responding
189	Warning	SAS/SATA mixing not supported in enclosure; %s disabled
190	Warning	Enclosure (SES) hot plug on %s was detected
191	Information	Clustering enabled
192	Information	Clustering disabled
193	Information	PD too small to be used for auto-rebuild on %s
194	Information	BBU enabled; changing WT virtual disks to WB
195	Warning	BBU disabled; changing WB virtual disks to WT

Number	Type	Description
196	Warning	Bad block table on %s is 80% full
197	Fatal	Bad block table on %s is full; unable to log block %lx
198	Information	Consistency Check Aborted Due to Ownership Loss on %s
199	Information	Background Initialization (BGI) Aborted Due to Ownership Loss on %s
200	Critical	Battery/charger problems detected; SOH Bad
201	Warning	Single-bit ECC error: ECAR=%x
202	Critical	Single-bit ECC error: ECAR=%x
203	Critical	Single-bit ECC error: ECAR=%x
204	Warning	Enclosure %s Power supply %d switched off
205	Information	Enclosure %s Power supply %d switched on
206	Warning	Enclosure %s Power supply %d cable removed
207	Information	Enclosure %s Power supply %d cable inserted
208	Information	Enclosure %s Fan %d returned to normal
209	N/A	OBSOLETE
210	Information	BBU Retention test passed
211	Critical	BBU Retention test failed!
212	N/A	OBSOLETE
213	Information	NVRAM Retention test passed
214	Critical	NVRAM Retention test failed!
215	Information	%s test completed %d passes successfully
216	Critical	%s test FAILED on %d pass. Fail data: errorOffset=%x goodData=%x badData=%x
217	Information	Self check diagnostics completed
218	Information	Foreign Configuration Detected
219	Information	Foreign Configuration Imported
220	Information	Foreign Configuration Cleared
221	Warning	NVRAM is corrupt; reinitializing
222	Warning	NVRAM mismatch occurred
223	Warning	SAS wide port %d lost link on PHY %d
224	Information	SAS wide port %d restored link on PHY %d
225	Warning	SAS port %d, PHY %d has exceeded the allowed error rate
226	Information	Bad block reassigned on %s at %lx to %lx
227	Information	Controller Hot Plug detected
228	Warning	Enclosure %s temperature sensor %d differential detected
229	Information	Disk test cannot start. No qualifying disks found
230	Information	Time duration provided by host is not sufficient for self check
231	Information	Marked Missing for %s on array %d row %d
232	Information	Replaced Missing as %s on array %d row %d
233	Information	Enclosure %s temperature sensor %d returned to normal
234	Information	Enclosure %s Firmware download in progress
235	Warning	Enclosure %s Firmware download failed
236	Warning	%s is not a certified drive
237	Information	Dirty cache data discarded by user
238	Warning	PDs missing from configuration at boot
239	Warning	VDs missing drives and will go offline at boot: %s

Number	Type	Description
240	Warning	VDs missing at boot: %s
241	Warning	Previous configuration completely missing at boot
242	Information	Battery charge complete
243	Information	Enclosure %s fan %d speed changed
244	Information	Dedicated spare %s imported as global due to missing arrays
245	Information	%s rebuild not possible as SAS/SATA is not supported in an array
246	Information	SEP %s has been rebooted as a part of enclosure firmware download. SEP will be unavailable until this process completes.
247	Information	Inserted: %s Info: %s
248	Information	Removed: %s Info: %s
249	Information	%s is now OPTIMAL
250	Warning	%s is now PARTIALLY DEGRADED
251	Critical	%s is now DEGRADED
252	Fatal	%s is now OFFLINE
253	Warning	Battery requires reconditioning; please initiate a LEARN cycle
254	Warning	VD %s disabled because RAID-5 is not supported by this RAID key
255	Warning	VD %s disabled because RAID-6 is not supported by this controller
256	Warning	VD %s disabled because SAS drives are not supported by this RAID key
257	Warning	PD missing: %s
258	Warning	Puncturing of LBAs enabled
259	Warning	Puncturing of LBAs disabled
260	Critical	Enclosure %s EMM %d not installed
261	Information	Package version %s
262	Warning	Global affinity Hot Spare %s commissioned in a different enclosure
263	Warning	Foreign configuration table overflow
264	Warning	Partial foreign configuration imported
265	Information	Connector %s is active
266	Information	Board Revision %s
267	Warning	Command timeout on %s
268	Warning	%s reset (Type %02x)
269	Warning	VD bad block table on %s is 80% full
270	Fatal	VD bad block table on %s is full; unable to log block %lx (on %s at %lx)
271	Fatal	Uncorrectable medium error logged for %s at %lx (on %s at %lx)
272	Information	VD medium error corrected on %s at %lx
273	Warning	Bad block table on %s is 100% full
274	Warning	VD bad block table on %s is 100% full

Appendix B: Glossary

Word / Acronym	Definition
API	Application Programming Interface
ECC	Error Correction Code
FUU	Flash Update Utility
FW	Firmware
Gb	Gigabit
GB	Gigabyte
HBA	Host Bus Adapter
Kb	Kilobit
KB	Kilobyte
LVD	Low Voltage Differential
Mb	Megabit
MB	Megabyte
PCB	Printed Circuit Board
PCI	Peripheral Component Interconnect
POST	Power-on Self Test
RAID	Redundant Array of Independent Disks
SAF-TE	SCSI Accessed Fault Tolerant Enclosure, enclosure management that supports SCSI devices
SAS	Serial Attached SCSI
SCSI	Small Computer Systems Interface
SES2	SCSI Enclosure Services 2nd generation, enclosure management that supports SAS devices
SGPIO	Serial General Purpose Input Output, Enclosure management that supports SATA devices
SNMP	Simple Network Management Protocol
XROM	PCI Expansion ROM, a BIOS utility accessed at system POST.

Appendix C: Reference Documents

- *Intel® RAID Controller RS2PI008 Hardware User's Guide* (Document number: E64395-00x)
- *Intel® RAID Software User's Guide* (Document number: D29305-0xx)
- *Intel® RAID Controller Command Line Tool 2 User Guide* (Document number: E36092-00x)