

# Intel® Rapid Storage Technology enterprise (RSTe)

## Technical Product Specification (TPS) Document

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# Revision History

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# 1 Introduction

This is the Technical Product Specifications for the Intel® Rapid Storage Technology enterprise (Intel® RSTe) product. The intent of this document is to present the Intel® RSTe functional requirements (or features) that make up this product. The features addressed include those for the Pre Operating System (Pre-OS) components, the Windows* based drivers and the Windows* Graphical User Interface.

## 1.1 ACRONYMS

The following acronyms will be used throughout this document.

**Table 1-1. Common Acronyms**

| Term | Definition |
|---|---|
| AHCI | Advanced Host Controller Interface |
| ATA | Advanced Technology Attachment |
| ATAPI | Advanced Technology Attachment Packet Interface |
| BIOS | Basic Input / Output System |
| BBE | Boot Behind Expander |
| Chipset | A term used to define a collection of The PNHCI components required to make a PC function. |
| CIM | Common Information Model |
| CLI | Command Line Interface |
| Cougar Point | Platform Controller Hub |
| CSMI | Common Storage Management Interface |
| DMA | Direct Memory Access |
| DOS | Disk Operating System |
| DIPM | Device Initiated Power Management |
| DSJ | Dirty Stripe Journaling |
| Disk's Write Cache | A memory device within a hard drive, which is allocated for the temporary storage of data before that data is copied to its permanent storage location. |
| EBDA | Extended BIOS Data Area |
| EN | Entry Server |
| EP | Efficient Performance |
| GB | Giga-byte |

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| Term | Definition |
|---|---|
| HDD | Hard Disk Drive |
| HIPM | Host Initiated Power Management |
| HII | Human Interface Infrastructure |
| Hot Plug | A term used to describe the removal or insertion of a SATA hard drive when the system is powered on. |
| ICH | Input / Output Controller Hub |
| IHV | Independent Hardware Vendor |
| LPM | Link Power Management |
| MB | Mega-bytes |
| NAI | Notification Area Icon |
| NCQ | Native Command Queuing |
| NTFS | NT File System |
| ODD | Optical Disk Devices |
| ODM | Original Design Manufacturer |
| OEM | Original Equipment Manufacturer |
| OROM | Option ROM |
| OS | Operating System |
| PCH | Platform Control Hub |
| Pre-OS | Pre Operating System Environment (Legacy OROM and/or UEFI) |
| Port | The point at which a SATA drive physically connects to the SATA controller. |
| PPL | Partial Parity Logging |
| PRD | Product Requirements Document |
| RHEL | Redhat Enterprise Linux |
| RRT | Rapid Recover Technology |
| RST | Rapid Storage Technology |
| RSTe | Rapid Storage Technology enterprise |
| SAS | Serial Attached SCSI |
| SATA | Serial ATA |
| sSATA | Secondary Serial ATA |
| SCU | Storage Controller Unit |
| SES | SCSI Enclosure Service |
| SGPIO | Serial General Purpose I/O |
| SMART | Self-Monitoring, Analysis and Reporting Technology: an open standard for developing hard drives and software systems that automatically monitors a hard drive's health and reports potential problems. |
| SLES | SUSE Linux Enterpise Server |
| SMIS | Storage Management Initiative Specification |



| Term | Definition |
|---|---|
| SSD | Solid State Device – non volatile memory |
| UI | User Interface |
| UEFI | Unified Extensible Firmware Interface |

## 1.2 Intended Use

This document is intended to provide high level information on the technical features of the Intel® RSTe product.

## 1.3 Intended Audience

The intended audience of this document is OEMs and ODMs requiring detailed information of the new features and technical specifications of the Intel® RSTe product. It contains only information pertaining to the Intel® RSTe product.





# 2 Product Overview

The Intel® RSTe product package is the enterprise class RAID product designed to operate in enterprise class platforms with the following Platform Control Hubs (PCHs):

- Intel® C600 series chipset
  - 1 Advanced Host Controller Interface (AHCI)/SATA
  - 1 Storage Controller Unit (SCU)
- Intel® C610 series chipset
  - 1 Advanced Host Controller Interface (AHCI)/SATA
  - 1 secondary Advanced Host Controller Interface (AHCI)/sSATA
- Intel® C220 series chipset
  - 1 Advanced Host Controller Interface (AHCI)/SATA
- Intel® C230 series chipset
  - 1 Advanced Host Controller Interface (AHCI)/SATA

For these platforms, Intel® RSTe product package is designed to support Hard Disk Drives (HDDs) and SATA Solid State Drives (SSDs) to enable an optimal enterprise storage solution.

Some of the RAID features supported by Intel® RSTe include RAID level 0 (striping), RAID level 1 (mirroring), RAID level 5 (striping with parity), RAID level 10 (striping and mirroring) and booting from a RAID system (OS) volume.

Please review the entire document for the complete list of features in the Intel® RSTe product package



## 2.1 Supported Platforms/Chipsets/SKUs

### 2.1.1 The Intel® RSTe product package was designed to work on and had been tested on the Intel Customer Reference Boards (CRBs) outlined in this section.Intel® C600 series chipset (Romley/Romley Refresh) Platforms

- Intel® Server Series (Sandy Bridge) Chipset-based platform CRBs with the Intel® C600 series chipset (PCH)
  - River City (Workstation, 2 CPUs/Sockets)
  - Harbor City (EN Server, 2 CPUs/Sockets)
  - Rose City (EP, 2 CPU)
  - Potter City (EX, 4 CPUs/Sockets)

### 2.1.2 Intel® C220 series chipset (Denlow/Denlow Refresh) Platforms

- Intel® Server Series (Haswell) Chipset-based platform CRBs with the Intel® C220 series chipset (PCH)
  - Agate Beach (Server Platform, 1 CPU)
  - Flathead Creek

### 2.1.3 Intel® C610 series chipset (Grantley/Grantley Refresh) Platforms

- Intel® Server Series (Haswell/Broadwell) Chipset-based platform CRBs with the Intel® C610 series chipset (PCH)
  - Mayan City 2S -EP
  - Yakima City 2S -EN
  - Aztec City 2S -EP Workstation
  - Inca City 4S -EP

### 2.1.4 Intel® C230 series chipset (Greenlow) Platforms

- Intel® Xeon® processor E3-1200 v5 (Sky Lake) product family w/ Intel® C230 series chipset family
  - Zumba Beach
    - Intel® C232 series chipset for Servers with 6 6Gb/s SATA 3.0 Ports
    - Intel® C236 series chipset for Servers and Workstations with 8 6Gb/s SATA 3.0 Ports

## 2.2 Supported Chipset SKU Overview

### 2.2.1 Intel® C600 series chipset SKU's

#### 2.2.1.1 Intel® C600 series chipset SKU Breakdown

| SKUs / Features | -A (SATA Only) C202 | -B C204 | -D C206 | -T C208 |
|---|---|---|---|---|
| SATA – SATA2 Ports (3Gb/s) | 4 | 4 | 4 | 4 |
| SATA – SATA3 ports (6Gb/s) | 2 | 2 | 2 | 2 |
| SCU ports (3Gb/s) | 4 | 4 | 8 | 8 |
| Intel® RSTe SATA RAID Support | 0/1/10/5 | 0/1/10/5 | 0/1/10/5 | 0/1/10/5 |
| Intel® RSTe SCU RAID Support | 0/1/5/10 | 0/1/10* | 0/1/10* | 0/1/5/10 |

* Intel® RSTe RAID 5 supported on SATA Only configurations with specific BIOS enabled settings.

Please reference CDI/IBL Document No. 454672 for information on properly configuring the PCHSTRP16 strap in BIOS. It is Intel's recommendation that the PCHSTRP16 strapping be left to the default –T SKU value.

#### 2.2.1.2 Intel® C600 series chipset Upgrade ROM Options

Intel® RSTe will provide support for the Intel® C600 series chipset Upgrade ROM feature. When the Upgrade ROM is implemented to modify the base SKU of the Intel® C600 series chipset, the Intel® RSTe driver will not be required to be changed, updated or reinstalled.

| Upgrade ROM SKU # | SCU Ports | Protocol | RSTe SCU RAID 5 | Equivalent SKU (Device ID) |
|---|---|---|---|---|
| **Intel® C600 series chipset-A with no upgrade ROM** | 4 ports | SATA Only | Yes | -A (1D6Bh) |



| | | | | |
|---|---|---|---|---|
| 1 | 4 ports | SATA/SAS | No | -B (1D69h) |
| 2 | 4 ports | SATA/SAS | Yes | (1D65h) |
| 5 | 8 ports | SATA/SAS | No | -D (1D68h) |
| 6 | 8 ports | SATA/SAS | Yes | -T (1D60h) |
| 9 | 8 ports | SATA Only | Yes | (1D6Ah) |

### 2.2.2 Intel® C610 series chipset SKU's

| SKU Features | SATA | sSATA |
|---|---|---|
| 6 Gb/s SATA3 Ports | 6/8 | 4/6 |
| Equivalent SKU (Intel® RSTe Device ID) | 2826 | 2827 |
| Intel® RSTe SATA RAID Support | 0/1/5/10 | 0/1/5/10 |

### 2.2.3 Intel® C220/230 series chipset SKU's

| SKU Features | SATA |
|---|---|
| 6 Gb/s SATA3 Ports | 6/8 |
| Equivalent SKU (Intel® RSTe Device ID) | 2826 |
| Intel® RSTe SATA RAID Support | 0/1/5/10 |

## 2.3 Intel® RSTe Major Components

Intel® RSTe product package 0is comprised of several components that provide a complete platform solution. The components are:

- RSTe Pre-OS images
- RSTe OS Runtime Drivers
- RSTe Tools and Utilities

### 2.3.1 Intel® RSTe Pre-OS Images

Intel® RSTe will provide a Pre-OS package for BIOS vendors and OEM/ODMs developing their own BIOS. The Pre-OS package will contain the binary images necessary to provide RAID management within a BIOS environment to support RAID mode booting. These images are intended to be compiled into the system BIOS on the supported platforms (Intel® C600/C610/C220 and C230 series chipsets).

#### 2.3.1.1 Intel® RSTe RAID Legacy Option ROMs

Intel® RSTe will provide Legacy RAID OROM images that support standard Int13 BIOS environments. These images provide a BIOS level menu-driven configuration tool for managing RSTe RAID volumes outside of an OS and are include following:

1. Individual images for each of the PCH controllers on the Intel® C600/C610/C220/ and C230 series chipset platforms: There is one RAID Legacy OROM image that supports each of the SATA and sSATA controllers for these PCHs.

2. Individual image for the SCU controller on the Intel® C600 series chipset platforms.

#### 2.3.1.2 Intel® RSTe RAID Unified Extensible Firmware Interface (UEFI) Drivers

Intel® RSTe will provide UEFI drivers to support a UEFI BIOS environment. The UEFI drivers provide an HII interface to support a BIOS level menu-driven configuration tool that is accessed in the BIOS setup. The RSTe UEFI images are:

1. Intel® C600/C610/C220/C320 series chipset: There is one RAID UEFI driver image that supports the SATA controller for these PCHs.

2. Intel® C600 series chipset: There is one RAID UEFI driver image that supports the SCU controller for this PCH.

### 2.3.2 Intel® RSTe OS Runtime Drivers

The RSTe OS runtime drivers are based on the Windows* Storport Miniport device driver model. This provides for improved performance along with simplified functional maintainability. There are three sets of Windows* runtime drivers and they are as follows:



#### 2.3.2.1 Drivers Supporting the Intel® C600 series chipset

1. There are two drivers for the SATA (AHCI) Controller. The first driver supports the SATA controller in AHCI mode and a second driver supports RAID mode.

   Note: The system BIOS Configuration utility is used to select either AHCI or RAID modes for the SATA controller

2. The SCU Controller will have its own driver that supports both pass-through and RAID configurations. This driver will support/manage/control SAS and/or SATA devices connected to the SCU controller.

   Note: The SCU controller does not currently support a non-RAID mode of operation analogous to "AHCI Mode" on the AHCISATA controllers

3. Graphical User Interface (Intel® RSTe GUI) – This is an application that can be used to manage RAID arrays and volumes on drives attached (only) to the SATA and SCU controllers.

   NOTE: RAID spanning across controllers is not supported.

#### 2.3.2.2 Drivers supporting the Intel® C220/C230 series chipset

There are two SATA (AHCI) Controller drivers and GUI described above also support these platforms. The first driver supports the SATA controller in AHCI mode and a second driver supports RAID mode.

Note: The system BIOS Configuration utility is used to select either AHCI or RAID modes for the SATA controller.

#### 2.3.2.3 Drivers Supporting the Intel® C610 series chipset

There are two SATA (AHCI) Controller drivers and GUI described above also support this platform. The first driver supports the SATA controller in AHCI mode and a second driver supports RAID mode.

In addition, there are two additional drivers included to support the sSATA controllers. The first driver supports the sSATA controller in AHCI mode and a second driver supports RAID mode.

NOTE: The system BIOS Configuration utility is used to select either AHCI or RAID modes for the SATA and sSATA controllers.

NOTE: RAID spanning across controllers is not supported in the RSTe Windows driver.

### 2.3.3 Intel® RSTe RAID Tools and Utility

#### 2.3.3.1 Intel® RSTe Command Line Interface (CLI) Utility

The Intel® RSTe package provides the OEM/ODM's factory/manufacturing environment utility that will support command line scripting. This application is designed to operate as a scripting

tool and runs in either Windows* PE or a Windows* command prompt window. There are separate tools for each controller for the Intel® C600/C610/C220 and C230 series chipsets.

#### 2.3.3.2 Intel® RSTe Pre-OS Tools

The Intel® RSTe package provides the OEM/ODM's factory/manufacturing environment with a set of Pre-OS tools to preconfigure and test the platform environment to help make sure the system is setup and configured as needed.

##### 2.3.3.2.1 Intel® RSTe SATA/sSATA RAID Configuration

There are two Intel® RSTe SATA RAID configuration tools. One is a DOS based utility that runs from a DOS bootable USB memory stick. The other is a UEFI tool that runs from a USB memory stick from the platforms UEFI Shell environment. HII tool that is controlled by the system UEFI BIOS. The purpose of these tools is to help identify and manage drives attached to the SATA (AHCI) controller on both the Intel® C600 and C610 series chipsets. There is also a corresponding set of tools that supports the sSATA controller (Intel® C610 series chipset).

##### 2.3.3.2.2 Intel® RSTe SATA/sSATA RAID Compatibility

There are two types of Intel® RSTe SATA RAID compatibility tools. One is a DOS based utility that runs from a DOS bootable USB memory stick. The other is a UEFI tool that runs from a UEFI Shell environment. Both tools need to be loaded/copied to a USB key in order to use in the system being tested. The purpose of these tools is to help verify that the RSTe SATA/sSATA legacy RAID Legacy OROMs and the RSTe SATA RAID UEFI driver have been properly implemented/incorporated into the system BIOS. These tools support both the Intel® C600/C610/C220 and C230 series chipsets.

##### 2.3.3.2.3 Intel® RSTe SCU RAID Configuration

There are two Intel® RSTe SCU RAID configuration tools. One is a DOS based utility that runs from a DOS bootable USB memory stick. The other is a UEFI tool that runs from a UEFI Shell environment. Both tools need to be loaded/copied to a USB key in order to use in the system being tested. The purpose of these tools is to help identify and manage drives attached to the SCU controller on the Intel® C600 series chipsets.

##### 2.3.3.2.4 Intel® RSTe SCU RAID Compatibility

There are two Intel® RSTe SCU RAID compatibility tools. One is a DOS based utility that runs from a DOS bootable USB memory stick. The other is a UEFI tool that runs from the UEFI Shell environment. Both tools need to be loaded/copied to a USB key in order to use in the system being tested. The purpose of these tools is to help verify that the RSTe SCU legacy RAID OROM and the RSTe SCU RAID UEFI driver have been properly implemented/incorporated into the system BIOS. This also verifies that the OEM Parameters have been properly programmed into the SPI Flash memory. These tools manage drives attached to the SCU controller on the Intel® C600 series chipsets.



## 2.4 Unsupported Features

The following is a non-comprehensive list of features that are not be supported in Intel® RSTe:

- Web Browser RAID configuration utility
- RAID array and volume(s) Spanning across the SATA (AHCI) and SCU ports
- RAID array and volume(s) spanning across the SATA and sSATA controllers (Intel® C610 series chipset)
- Port-Multipliers
- SATA RAID Legacy OROM support for Optical Devices (Optical Devices are managed by Platform BIOS)
- SCU RAID Legacy OROM support for Optical Devices
- SCU UEFI Driver support for Optical Devices
- Intel® Rapid Recovery Technology (Intel® RRT)
- Hard Drive Password
- Zero Power ODD
- NVSRAM
- Link Power Management (LPM)
- Time Limited Error Recovery (TLER)
- Installing Windows 2003 to a RAID Volume
- Combining all 8 SCU ports into a single X8 Wide Port connection – this configuration will behave as a single X4 Wide Port connection.
- SCU Controller operating at 6 Gb/s – Please refer to the latest C600 series chipset Sightings Report and/or Spec. update
- Windows* 8/Server 2012 (or greater) Operating Systems (OS) “inbox” SATA (RAID Mode) drivers to support installing the OS to a RAID Volume.

## 2.5 Key Product Features

The product features described in this section, along with additional functionality. The following is a summary of the key features of this product.

| Name | Key Features | |
|---|---|---|
| **RAID** | • Support for Matrix RAID 0/1/5/10<br>• Pass-through drives<br>• Hot Plug with I/O<br>• Hot Spare Disk<br>• Auto Rebuild on Hot Insert<br>• Rebuild & Migration Check Pointing<br>• NCQ (SATA) and CQ (SAS) support<br>• UEFI using common metadata<br>• SAS Expanders (Intel® C600 series chipset only)<br>• SMART Support<br>• Bad Block Management<br>• Controller configuration rules<br>• Drive roaming<br>• RAID Volume roaming between Linux* and Windows*<br>• On Line Capacity Expansion<br>• Large Stripe Size Support<br>• RAID-Ready | • Disk Coercion<br>• Manual & Auto Rebuild<br>• Instant Initialization<br>• Read Patrol<br>• SGPIO<br>• Volume creation/verify<br>• Selectable Boot Volume<br>• Email Alerting<br>• CIM<br>• RAID Level Migration (RAID 0, 1, or 10 to RAID 5)<br>• Dirty Stripe Journaling<br>• Partial Parity Logging (PPL)<br>• Verify and Repair<br>• Auto Rebuild on Hot Insert |
| **Utilities** | • Install/Uninstall Utility<br>• Configuration and Management Utilities | |
| **Intel® RSTe** (Window only) | Intel® RSTe provides software for high-performance for SAS and SATA RAID +<br>• Matrix RAID for two RAID volumes on single array<br>• Improved user interface for enhanced usability | |

### 2.5.1 Operating Systems Supported

#### 2.5.1.1 Microsoft OS Support

Intel® RSTe will support both 32 and 64 bit versions of the following Microsoft OSs:

- Intel® C600/C220 Series Chipset platforms only
  - Windows* Vista (Supported until RSTe 4.0)
  - Windows* Server 2003 (Supported until RSTe 4.0)
    - The “In Box” installation image for Windows 2003 does support the Microsoft Storport Miniport Driver Model. Microsoft made enhancements to the Storport Miniport architecture that was implemented following the release of Windows 2003. Microsoft has made a Hot-Fix available for download. The issue will only be

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encountered when accessing a RAID volume. Detailed instruction on applying the Hot-Fix to the installation images can be found:

- http://technet.microsoft.com/en-us/library/cc766320(WS.10).aspx

- To install Windows 2003:
  - Install to a single Pass-thru disk, and then apply the appropriate Hot-Fix to bring the Storport driver up to current standards. The hotfix can be downloaded at: http://support.microsoft.com/kb/932755. Reboot the system and use RST GUI to create the desired RAID Volume from the existing boot drive.

- Windows* 7
- Windows* Server 2008 SP2 (Supported until RSTe 4.0)
- Windows* Server 2008 R2 (64 bit only)
- Windows* PE 3.0
- Windows* 8 (Supported until RSTe 4.0)
- Windows* Server 2012
- Windows* 8.1
- Windows* Server 2012 R2
- Windows* 10
- Windows* Server 2016

### 2.5.2 Intel® RSTe Pre-OS Package

The Intel® RSTe product package will provide two options for the Pre-OS implementation. The first option is the two image option and the second is a single image. The two image option contains separate sets of images for the SATA and sSATA Controller. The single image option has one image that will control both SATA and sSATA controller.

NOTE: For the Intel® C600 series chipset, the only option is the two images. One for the SATA controller and the second image for the SCU controller.

#### 2.5.2.1 Intel® RSTe Pre-OS Package Two Images Option

For the two image options, the Intel® RSTe product package will provide 2 sets of binary images that are compiled into the system BIOS to provide the RAID mode Pre-OS driver for the Intel® C600/C610/C220 and C230 series chipsets based platforms. The BIOS vendor (or the OEM/ODMs developing their own BIOS) will take these images and compile them into their system BIOS for these platforms. How they are included and how the information is presented is up to the BIOS vendor (or the OEM/ODMs developing their own BIOS).

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#### 2.5.2.1.1 Intel® RSTe Basic Requirement for the System BIOS

For Intel® RSTe to properly operate, the system BIOS for the Intel® C600/C610/C220 and C230 series chipsets based platforms must properly incorporate the Intel® RSTe Pre-OS images. An example of how a BIOS vendor (or the OEM/ODMs developing their own BIOS) may implement the Intel® RSTe Pre-OS package is by adding the following configuration options to the BIOS configuration:

- The option for the user to select which controller they would like to boot from (SATA, sSATA or SCU). Intel® RSTe will provide support for the ability to perform a minimal installation of the Legacy RAID Option ROM for the controllers not selected as the boot controller. Due to limited shadow RAM and EBDA space, and the fact that many platforms may require multiple Option ROMs be loaded, there might not be enough runtime space for multiple Intel RSTe Legacy RAID Option ROMs to load. To support they condition and INT15 interface has been defined. When the user selects the Boot Controller, the INT 15 interface allows the system BIOS to inform the Intel RSTe Legacy OROM image being loaded if it is the boot controller. When the controller is not the boot controller, it will execute the minimal amount of code needed to pass the required information to the controller and to the OS driver. Please reference the platform's BIOS Writer's Guide for more information (or the Release notes included with this package).
- The option to select which pre-boot environment to use (Legacy Option ROM or UEFI). The Intel® RSTe Pre-boot package will support only one boot method of either Legacy RAID OROM or RAID UEFI, but not both.
- The option to select which mode to configure the Intel® C600/C610/C220 and C230 series chipset SATA and/or sSATA controller (AHCI or RAID mode)
    - When AHCI mode is selected the BIOS's own AHCI int13 driver or (UEFI driver) will be used instead of the Intel® RSTe SATA RAID Legacy Option ROM (or Intel® RSTe UEFI driver). In this mode, the Intel® RSTe SATA OS driver will function as a pass-through driver. No RAID functionality will be allowed on the SATA controllers.
    - When RAID mode is selected, the Intel® RSTe SATA and/or sSATA RAID Legacy Option ROM (or Intel® RSTe RAID SATA and/or sSATA UEFI driver) will be loaded and used by the system BIOS to access the devices connected to the SATA and/or sSATA controllers.
    - In both cases, Optical Disk Drives will be managed by the System BIOS.

### 2.5.2.2 Intel® RSTe SCU OEM Parameters

For those platforms that include the Intel® C600 series chipset, to properly configure and initialize the SCU Controller there are OEM defined parameters that must be established and properly programed into SPI Flash. The information contained this field must be supplied to the SCU Pre-OS images (Intel® RSTe SCU Legacy Option ROM or Intel® RSTe SCU UEFI driver). The information is then used to properly initialize the SCU controller. These values are very dependent on the design of the platform. The mechanism that is used to pass the OEM Parameter information from SPI Flash to the SCU Pre-OS the INT15 interface outlined in the platform's BIOS Writer's Guide (and the release notes included in this package).



NOTE: The SCU controller will not work properly if the OEM Parameters have not been properly programmed into SPI Flash and properly supplied to the SCU Pre-OS.

#### 2.5.2.2.1 Intel® RSTe SATA Legacy RAID Option ROMs

The Intel® RSTe Pre-OS two image option package will contain the Intel® RSTe SATA Legacy Option ROM image that will be loaded with the SATA controller is configured for RAID Mode. This image provides a menu driven interface that allows for the RAID management of RAID data volumes and RAID boot volumes on drives directly attached to the SATA controller. When there are two or more drives attached to the SATA Controller (in RAID mode) the Intel RSTe menu driven GUI Splash screen will appear. To access the menu driven GUI, just enter "CTRL-I" when prompted. Through this menu driven GUI, RAID volumes can be created before installing the operating system. This will allow the operating system to be installed onto the RAID volume created.

#### 2.5.2.2.2 Intel® RSTe sSATA Legacy RAID Option ROMs

The Intel® RSTe Pre-OS two image option package will contain the Intel® RSTe sSATA Legacy Option ROM image that will be loaded with the sSATA controller is configured for RAID Mode. This image provides a menu driven interface that allows for the RAID management of RAID data volumes and RAID boot volumes on drives directly attached to the sSATA controller. When there are two or more drives attached to the sSATA Controller (in RAID mode) the Intel RSTe menu driven GUI Splash screen will appear. To access the menu driven GUI, just enter "CTRL-I" when prompted. Through this menu driven GUI, RAID volumes can be created before installing the operating system. This will allow the operating system to be installed onto the RAID volume created.

The Intel® SATA and/or sSATA Legacy RAID Option ROMs and Intel® RSTe SATA/sSATA UEFI drivers only supports drives that are direct attached to the SATA and/or sSATA controllers.

#### 2.5.2.2.3 Intel® RSTe SCU Legacy RAID Option ROM

Intel® RSTe SCU Legacy RAID Option ROM is part of the two image option and is included to provide support for Legacy mode booting. The BIOS configuration utility may provide an option to select the SCU controller as the boot controller. When the system is configured to boot from the SCU controller, the complete Intel® RSTe SCU Legacy RAID Option ROM will be loaded and will provide the interface to the drives attached to the SCU controller. The Intel® RSTe SCU Legacy RAID Option ROM will manage and boot from drives that are directly attached to the SCU controller from within a single level SAS expander. For the single level SAS expander the Intel® RSTe SCU Legacy Option ROM only support:

- The SAS expander attached to the first 4 ports to the SCU controller.
- Drive that reside within the first 8 ports (port0 thru port7) of the expander. Those will be the only ports scanned for drives and reported to the BIOS. No other ports will be scanned
- In a mixed configuration (some but not all of the first 4 ports [of the SCU controller] contain direct attached drives and the other [of the first 4] ports are connected to an expander), only the drives in the first 8 ports, of the expander, will be exposed to the BIOS as bootable
    - **NOTE: Intel does not recommend this type of configuration**

- If an expander is attached to any of the first 4 ports of the SCU controller, the second 4 ports will not be scanned for drives.
- An expander connected to second 4 ports of the SCU controller will not be scanned

While booting, a BIOS Splash Screen will appear on the display (provided that there are a least two drives attached) that will show what is attached to the SCU controller. There is also an option to stop the booting process and enter into the Intel® RSTe SCU Legacy RAID Option ROM user interface. This is done by pressing the [CTRL]-I key combination. Through this menu driven GUI, RAID volumes can be created before installing the operating system. This is mainly used to create a RAID volume that can be used as the system OS boot device.

The Intel RSTe Legacy SCU RAID Option ROM Splash Screen can be controlled based off of the BCFS settings outlined in BCFS Bit Settings section.

***It is required for the SCU RAID Legacy Option ROM to be used in PCI 3.0 compliant BIOS's only.***

#### 2.5.2.2.4 Intel® RSTe SATA RAID UEFI Drivers

The Intel® RSTe Pre-OS two image option package will contain the Intel® RSTe SATA UEFI driver image that will be loaded with the SATA controller is configured for RAID Mode. This image provides an HII menu driven user interface that allows for the RAID management of RAID data volumes and RAID boot volumes on drives directly attached to the SATA controller. The UEFI HII menu driven interface is accessed via the Platform system BIOS setup. Through this menu driven user interface, RAID volumes can be created before installing the operating system. This will allow the operating system to be installed onto the RAID volume created. The Intel® RSTe SATA UEFI RAID Driver will support only drives directly attached to a SATA controller.

#### 2.5.2.2.5 Intel® RSTe sSATA RAID UEFI Drivers

The Intel® RSTe Pre-OS two image option package will contain the Intel® RSTe sSATA UEFI driver image that will be loaded with the sSATA controller is configured for RAID Mode. This image provides an HII menu driven user interface that allows for the RAID management of RAID data volumes and RAID boot volumes on drives directly attached to the sSATA controller. The UEFI HII menu driven interface is accessed via the Platform system BIOS setup. Through this menu driven user interface, RAID volumes can be created before installing the operating system. This will allow the operating system to be installed onto the RAID volume created. The Intel® RSTe sSATA UEFI RAID Driver will support only drives directly attached to the sSATA controller.

#### 2.5.2.2.6 Intel® RSTe SCU RAID UEFI Driver

The Intel® RSTe Pre-OS two image option package will contain the Intel® RSTe SCU UEFI driver image that will be loaded with the SCU controller. This image provides an HII menu driven user interface that allows for the RAID management of RAID data volumes and RAID boot volumes on drives directly attached to the SCU controller. The UEFI HII menu driven interface is accessed via the Platform system BIOS setup. Through this menu driven user interface, RAID volumes can be created before installing the operating system. This will allow the operating system to be installed onto the RAID volume created. The Intel® RSTe SCU UEFI RAID Driver will support drives directly attached to the SCU controller and will provide at least one level of SAS expander support.



### 2.5.3 Intel® RSTe Configuration Tools

The Intel® RSTe will support multiple ways for OEMs/ODMs and users to manage RAID arrays and volumes. There is a Pre-boot package, factory installation utilities and an optional end user GUI tool.

#### 2.5.3.1 Intel® RSTe UEFI Human Interface Infrastructure

Intel® RSTe will provide support for a UEFI HII RAID management interface for Intel® C600/C610/C220 and C230 series chipset based platforms. This functionality will be included in the Intel RSTe UEFI driver and need to be included in the system BIOS. The system BIOS must adhere to the UEFI 2.3.1 Spec in order to take advantage of this feature and must expose the interface to the user.

#### 2.5.3.2 Intel® RSTe RAID Configuration Utilities

Intel® RSTe will provide support for Pre-OS environment command line Intel RSTe RAID configuration utilities that can be used in manufacturing environment. There is a DOS base command line Intel RSTe RAID configuration utility that can be used in conjunction with the Legacy Option ROMs. There is also a UEFI based command line Intel RSTe RAID configuration utility that operated from the UEFI Shell environment.

The Intel® RSTe product package provides a set of these tools for each of the SATA and sSATA controllers and one for the SCU controller. There is also a set of tools to work with the single Pre-OS images for the SATA/sSATA controllers.

To use the DOS based tools, copy the tool(s) to a DOS bootable media (floppy drive or USB drive). Once booted to that device the tool(s) can be used.

To use the UEFI based tools, copy the tool(s) to a USB drive. Once the system is booted to a UEFI shell, the tool(s) can be used from the USB drive.

#### 2.5.3.3 Intel® RSTe RAID Compliance Utilities

Intel® RSTe will provide support for Pre-OS environment command line Intel RSTe RAID compliance utilities that can be used in manufacturing environment. This tool is used to verify that the Pre-OS images have been properly implemented in the system BIOS. There is a DOS base command line Intel RSTe RAID compliance utility that can be used in conjunction with the Legacy Option ROMs. This is used to help verify that the Legacy Options ROMs have been properly incorporated into the system BIOS

There is also a UEFI based command line Intel RSTe RAID compliance utility that operated from the UEFI Shell environment. This tool helps verify that the Intel RSTe UEFI drivers have been properly incorporated into the system BIOS.

The Intel® RSTe product package provides a set of these tools for each of the SATA and sSATA controllers and one for the SCU controller. There is also a set of tools to work with the single Pre-OS images for the SATA/sSATA controllers.

To use the DOS based tools, copy the tool(s) to a DOS bootable media (floppy drive or USB drive). Once booted to that device the tool(s) can be used.

To use the UEFI based tools, copy the tool(s) to a USB drive. Once the system is booted to a UEFI shell, the tool(s) can be used from the USB drive.

### 2.5.3.4 Intel® RSTe Command Line Interface (CLI) Application

Intel ® RSTe will provide support for a command line application that can run under a Windows* command prompt and/or a Windows* PE environments. This application can be used to perform basic RAID operations on the platforms that have or will have Intel® RSTe installed. Intel® RSTe CLI provides basic support for creating and managing RAID arrays and volumes without a dependency on the system OS being installed. (I.e. a factory environment that builds both Windows* and Linux* systems)

### 2.5.3.5 Intel® RSTe Graphical User Interface (Intel® RSTe GUI)

Intel® RSTe will provide support for a graphical user interface for management of RAID arrays and volumes. The Intel® RSTe GUI is used to manage RAID arrays and volumes on the devices attached to the SATA, sSATA and/or SCU controllers. It will be able to distinguish between direct attached devices and expander attached storage devices (expanders are only supported on the SCU controller).Intel® RSTe Management Tools.

NOTE: The Intel RSTe GUI does not support Volumes spanned across controllers.

### 2.5.3.6 Common Information Model (CIM)

Intel® RSTe will support an industry standard management API based on CIM model and Storage Management Initiative Specification (SMIS) specification. Samples of the CIM Profiles that will be included in the initial Intel® RSTe release are as follows:

- Host hardware raid controller profile
- Block services profile
- Physical asset profile
- Software inventory profile
- Generic initiator ports profile
- Direct attached target ports profile
- Job control profile
- Indication profile

Intel® RSTe will support an industry standard management API based on CIM model and Storage Management Initiative Specification (SMIS) specification (Linux).

This feature will be supported on platforms that have installed Linux, Windows*7 and Windows* 2008R2 (64 and 32 bit).

### 2.5.3.7 Common Storage Management Interface (CSMI)

Intel® RSTe will support the Common Storage Management Interface (CSMI) for reporting RAID configurations and SMP, SSP, STP pass through.

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* Other brands and names may be claimed as the property of others.



## 2.5.4 Intel® RSTe System Configurations supported

This section addresses to physical components of the system configuration supported by the Intel® RSTe product package.

### 2.5.4.1 Intel® C600 series chipset SATA Controller Support

Intel® RSTe will provide support for managing RAID volumes on drives attached to the SATA ports of the Intel® C600 series chipset.

### 2.5.4.2 Intel® C600 series chipset SCU Controller Support

Intel® RSTe will provide support for managing RAID volumes on drives attached to the SCU ports of the Intel® C600 series chipset.

### 2.5.4.3 Intel® C600 series chipset - SCU OEM Parameters

Intel® RSTe will provide support for the OEM to define some of their own operational parameters (i.e. SAS Addresses) into the PDR region of SPI Flash. This information will be passed to Intel RSTe components from the BIOS who will access the OEM parameters. Please review the platform BIOS Writer's Guide for more details.

### 2.5.4.4 Intel® C600 series chipset - SAS Expander Support

Intel® RSTe will support 1 expander attached to an SCU controller (provide external HW drive and expander compatibility list). Intel® RSTe will not support the use of port multipliers on either the SATA or SCU controller. This expander will also be reported and exposed to the Device Manager.

### 2.5.4.5 Maximum Hard Drives supported on Intel® C600 series chipset Based Platforms

Intel® RSTe will provide support for the following quantity of physical disks (direct attached or through SAS expanders):

- SKU –A:
    - Physical Disks (Pass Through and RAID):
        - Single SCU configuration (SATA disks only) – 4
        - SATA - 6
            - 3 Gb/s – 4
            - 6 Gb/s - 2
    - Maximum number of RAID volumes on the direct attached physical disks:
        - SCU – 4
        - SATA - 4
- SKU -B:
    - Physical Disks (Pass Through and RAID):
        - Single SCU configuration (SAS and SATA supported) – 32
        - SATA - 6
            - 3 Gb/s – 4

        - 6 Gb/s - 2
    - Maximum disks managed by Intel® RSTe RAID – 32
    - Maximum number of RAID volumes on the direct attached physical disks:
        - SCU – 4
        - SATA - 4

**NOTE**: With both SKUs –A and –B, all of the SCU traffic is moved up to the processor through the DMI uplink, which is shared by the other components managed by Intel® C600 series chipset.

- SKU –D and -T:
    - Physical Disks:
        - Dual SCU configuration (SAS and SATA supported) – 64
        - SATA
            - 3 Gb/s – 4
            - 6 Gb/s - 2
    - Maximum disks managed by Intel® RSTe RAID – 32
    - Maximum number of RAID volumes on the direct attached physical disks:
        - SCU – 8
        - SATA - 4

There is no OS RAID software limitations imposed.

### 2.5.4.6 Intel® C600 series chipset - SCU Controller RAID Management Limitations

Intel® RSTe will support the RAID management of up to 32 physical drives attached to the SCU controller. Drives added beyond this limitation (up to a total of 64 drives) will be supported as pass-through drives but will not be validated as part of supported RAID array configurations. The Intel® RSTe GUI will allow up to 8 RAID volumes to be created across the 32 drives. For example, a RAID array that encompasses all 32 drives will result RAID volume limitation of up to 2 volumes (Matrix RAID allows 2 RAID volumes per RAID array).

No OS based software RAID (non-Intel® RSTe 3.0) limitations are imposed.

### 2.5.4.7 Intel® C220 series chipset SATA Controller Support

Intel® RSTe will provide support for managing RAID volumes on drives attached to the SATA ports of the Intel® C220 series chipset.

### 2.5.4.8 Intel® C610 series chipset SATA/sSATA Controller Support

Intel® RSTe will provide support for managing RAID volumes on drives attached to the SATA and sSATA ports of the Intel® C610 series chipset.

NOTE: Spanning RAID volumes across the SATA and sSATA controllers is not supported.



### 2.5.4.9 Intel® C230 series chipset SATA Controller Support

Intel® RSTe will provide support for managing RAID volumes on drives attached to the SATA ports of the Intel® C230 series chipset.

### 2.5.4.10 Pass-through drives

Intel® RSTe will support the ability to expose non-RAID configured disks (pass-through) to Host OS. Please refer to section 2.5.4.5 for additional information.

### 2.5.4.11 Hot Plug

Intel® RSTe will support the ability to Hot Plug (remove and replace) disk drives on the controllers of the Intel® C600/C610/C220 and C230 series chipsets, whether or not I/O is being processed. To enable this functionality, the system BIOS must have this feature enabled

### 2.5.4.12 Drive roaming

Intel® RSTe will support the ability to move and recognize RAID arrays and volumes between the controllers of the Intel® C600/C610/C220 series chipsets. RAID Boot volumes may have limitations based on the drivers loaded and the controller configurations.

### 2.5.4.13 Volume Roaming between Linux* and Windows*

Intel® RSTe will support the ability to move RAID data volumes (configured appropriately) between Linux* and Windows* environments and the RAID data volumes will be recognized and available for use.

### 2.5.4.14 SGPIO on SATA Controller (RAID Mode Only)

Intel® RSTe will support enclosure management, compliant to SFF-8485 as well as SFF-8489, to identify drive location or unit failures on the SATA/sSATA controllers.

### 2.5.4.15 SGPIO on SCU

Intel® RSTe will support enclosure management, compliant to SFF-8485 as well as SFF-8489, to identify drive location or unit failures on the SCU controller.

### 2.5.4.16 NCQ (SATA/sSATA) and CQ (SCU) support

Intel® RSTe will support Native Command Queuing (SATA/sSATA) and Command Queuing (SAS).

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* Other brands and names may be claimed as the property of others.

#### 2.5.4.17 SCSI Enclosure Service (SES) v2

Intel® RSTe will provide support management of enclosures that are compliant with SES (SCSI Enclosure Services) v2 attached to the SCU controller. Intel® RSTe also supports in-band management to SES compliant expanders attached to the SCU.

### 2.5.5 Software RAID Functional Support

This section will focus on RAID specific features unless the particular requirement specifies differently.

#### 2.5.5.1 Matrix RAID

Intel® RSTe will support up to two logical RAID volumes on the same array. A RAID array simply refers to the set of disk drives that can be formed into a RAID volume.

#### 2.5.5.2 RAID 0/1/5/10 Volumes

Intel® RSTe will support base level RAID volumes on both drives connected to the SATA, sSATA and/or SCU controllers. RAID volume spanning across the SATA, sSATA and SCU controllers is not supported.

#### 2.5.5.3 Software RAID 5 on SCU

Intel® RSTe will support software RAID 5 on Intel® C600 series chipset–T SKUs as an optional feature. This feature is enabled by means of the “upgrade ROM” capabilities or by purchasing the –T SKU of Intel® C600 series chipset.

#### 2.5.5.4 Simultaneous RAID Arrays

Intel® RSTe will provide support for RAID volume management on disks attached to the SCU controller separate from disks attached to the SATA controllers. However, Intel® RSTe will provide support for simultaneous RAID management on both.

#### 2.5.5.5 Disk Coercion

Intel® RSTe will provide support for Disk Coercion. When a RAID volume is created, this feature will analyze the physical disks and will automatically adjust (round down) the capacity of the disk(s) to 95% of the smallest physical disk. This allows for the variances in the physical disk capacities from different vendors.

#### 2.5.5.6 Hot Spare Disk

Intel® RSTe will support the ability to set a drive as a hot spare that would automatically be used to rebuild a failed or degraded RAID volume without any user interaction. This applies to both the SATA, sSATA and/or SCU controllers. This support is provided in the Intel® RSTe GUI as well as in the Pre-OS images.



### 2.5.5.7 Auto Rebuild on Hot Insert

Intel® RSTe will support the ability to initiate an automatic RAID rebuild when a physical disk of the appropriate size is hot inserted into the same directly attached port that the failed drive was removed from. When configured appropriately, if a RAID volume issue occurs (failure, degradation, or SMART event) and the questionable drive is hot removed, if a drive of the appropriate size (new or and from an off-line RAID volume) is hot inserted into that same port, the volume will be rebuilt on the inserted drive.

### 2.5.5.8 Manually Invoked Rebuild

Intel® RSTe will provide a manual method to initiate a RAID volume rebuild if a hot spare has not been configured or is not available.

### 2.5.5.9 RAID SMART Support

Intel® RSTe will provide support for SMART Alerts for SAS and SATA disks. A SMART drive event response alert on failure will initiate rebuild to hot spare disk.

### 2.5.5.10 RAID-Ready Mode

A RAID-Ready system refers to a system that has been configured to support Intel® RSTe. The system BIOS has the appropriate pre-boot drivers and has been configured for RAID mode. RAID mode can be either:

- The system is configured to boot off the SATA/sSATA controllers and it is in RAID mode
- The system is configured to boot off the SCU controller

Intel® RSTe will support an Intel® C600/C610/C220 and C230 series chipset based platform configured in RAID-Ready mode.

### 2.5.5.11 RAID Volume Creation with Data Preservation

Intel® RSTe will support the ability to preserve the data from one of the disks used for the volume creation. A non-RAID disk can be migrated to a RAID volume while retaining the existing data on that disk.

Note: When creating a system boot volume, the maximum stripe size supported is 128K.

In a RAID-Ready configuration, the user can take their single system drive and turn it into a supported RAID volume by using the Intel® RSTe GUI application. This process does not require the reinstallation of the operating system. All applications and data will remain intact.

The following are examples of RAID level creations that will be supported by Intel® RSTe (depending on the chipset being used):

- Individual pass-through to 2 16 drives for RAID 0
- Individual pass-through to 2 drive RAID 1
- Individual pass-through to 4 drive RAID 10
- Individual pass-through to 3 to 6 drive RAID 5

### 2.5.5.12 Instant Initialization

Intel® RSTe will support a newly created volume to be used immediately (no reboot required), protecting newly written data and creating parity data concurrently.

For a RAID 5 configuration that consists of 3 or 4 drives, the RAID volume will be shown as normal as soon as the volume is created. Parity will be computed and written with every RAID 5 write activity.

For a RAID 5 configuration that consists of 5 or more drives, the parity initialization will begin as soon as the volume is created. This is done to improve the operational performance of RAID 5 volumes.

### 2.5.5.13 RAID Level Migrations

The RAID level migration feature in Intel® RSTe product will enable the ability to convert the contents of a drive (attached to the SATA, sSATA and/.or SCU controller) into a RAID volume (RAID 0, RAID 1, RAID 5, or RAID 10). The RAID level migration feature also supports the ability to migrate from a one RAID volume to another.

The size of the hard drives determines how much time is required to complete the migration but the system will remain fully functional during the migration process. The only limitation is that some disk-intensive tasks may have slower performance during a RAID migration.

**NOTE**: Single volume per array only. This is dependent on required capacity and implicit array expansion.

**NOTE**: When using a GPT partition, make sure there is at least 5 Megabytes of disk space available **for RAID Metadata when the OS is being installed.**

The following are some examples of RAID level migrations supported by Intel® RSTe (depending on the chipset being used):

- N-drive RAID 0 to N+1 – 32 drive RAID 5 (where N can be 2 to 31)
- 2-drive RAID 1 to 3 - 32 drive RAID 5
- 4-drive RAID 10 to 4 - 32 drive RAID 5

**NOTE**: Additional information on RAID level migration can be found in the Intel RSTe GUI help

### 2.5.5.14 RAID Reconfiguration (Stripe size)

Intel® RSTe will provide the ability to change stripe size on existing volumes (migration required). Intel® RSTe will support a stripe size migration in conjunction with a RAID level migration.

Note: Migration supports stripe sizes for the respective RAID levels supported. Stripe Size Support for (values are in Kilobytes):

- RAID 0 volumes – 4, 8, 16, 32, 64, 128, 256, 512, 1024
- RAID 10 volumes - 4, 8, 16, 32, 64, 128, 256, 512, 1024
- RAID 5 volumes - 4, 8, 16, 32, 64, 128, 256, 512, 1024



### 2.5.5.15 Expanded Stripe Size

Intel® RSTe will support the ability to expand the RAID volume stripe size for the following RAID volumes (values are in Kilobytes):

- RAID 0 volumes – 256, 512, 1024
- RAID 10 volumes – 256, 512, 1024
- RAID 5 volumes – 256, 512, 1024

### 2.5.5.16 Online Array / Volume Capacity Expansion

Intel® RSTe will provide the ability to add new drives to an existing array and expand existing volumes accordingly. This is supported only under RAID 0 and RAID 5.

### 2.5.5.17 Read Patrol

Intel® RSTe will provide support for Read Patrol, which checks the RAID volumes for errors that could result in a failure. The checks are done periodically in background and will verify all sectors of all RAID volumes that are connected to the SATA, sSATA and/or SCU controllers. If an issue is discovered an attempt at corrective action is taken. Read Patrol can be enabled or disabled manually.

The background process begins when there is no I/O to the RAID volume, though it can continue to run while I/O's are being processed.

### 2.5.5.18 Verify and Repair

Intel® RSTe will provide support for Verify and Repair.

The RAID volume data verification process identifies any inconsistencies or bad data on a RAID 0, RAID 1, RAID 5, or RAID 10 volume.

The RAID volume data verification and repair process identifies and repairs any inconsistencies or bad data on a RAID 1, RAID 5, or RAID 10 volume.

The following describes what occurs for each RAID level:

| RAID Level | Verify | Verify & Repair |
|---|---|---|
| **RAID 0** | Bad blocks are identified. | N/A |
| **RAID 1** | Bad blocks are identified | Bad blocks are reassigned. |
| | Data on the mirror drive is compared to data on the source drive. | If the data on the mirror drive does not match the data on the source drive, the data on the |

| | | |
|---|---|---|
| | | mirror is overwritten with the data on the source. |
| **RAID 5** | Bad blocks are identified. | Bad blocks are reassigned. |
| | Parity is recalculated and compared to the stored parity for that stripe. | If the newly calculated parity does not match the stored parity, the stored parity is overwritten with the newly calculated parity. |
| **RAID 10** | Bad blocks are identified. | Bad blocks are reassigned. |
| | Data on the mirror is compared to data on the source. | If the data on the mirror does not match the data on the source, the data on the mirror is overwritten with the data on the source. |

#### 2.5.5.19 Check Pointing

Intel® RSTe will provide the ability to perform Check Pointing to be able to track forward progress on read patrol, array rebuilds and volume migration if interrupts occur. After resuming, the operation will restart from the last valid stage reached.

#### 2.5.5.20 Bad Block Management

Intel® RSTe will provide support for Bad Block Management.

In the course of rebuilding a degraded RAID volume, where one of the member disks has failed or been removed, and is being replaced by a 'spare' drive, the redundant contents of the other drive(s) are read and then used to reconstruct data to be written to the spare drive. In case a read failure occurs sometime during this rebuild process, the data to be written to the spare will not be available and therefore lost. In this scenario, rather than mark the entire RAID volume as failed, we can mark only those sectors on the spare that are known to have indeterminate data, in a log of such bad sectors. This bad block management log can be used to reflect error status whenever any attempts are made to access those sectors of the spare.

#### 2.5.5.21 Dirty Stripe Journaling

Intel® RSTe will provide support for Dirty Stripe Journaling (DSJ). DSJ is used to help speed up RAID 5 write power loss recovery by storing the write stripes that were in progress at the time of the failure. The DSJ allows rapid recovery without having to rebuild the entire volume. The DSJ is only utilized when disk write cache is DISABLED



### 2.5.5.22 Partial Parity Logging (PPL)

Intel® RSTe will provide support for Partial Parity Logging (PPL). PPL is used to record the results of XORing old data with old parity. PPL is currently saved as part of the RAID member information and is only utilized when writing RAID 5 parity. It helps protect against data loss when a power failure or a system crash occurs by allowing data to be rebuilt by utilizing the PPL information.

### 2.5.5.23 OS Installation

Intel® RSTe will provide the OS appropriate Intel RSTe driver files required for installation during the OS setup onto a drive or RAID volume attached to either the SATA, sSATA or SCU controllers.

### 2.5.5.24 Selectable Boot Volume

Intel® RSTe will support the ability to select any volume as the OS boot volume. The OS installer will be able to install the operating system onto RAID volume. There will be no need for RAID management (e.g. volume creation/deletion) support from within OS installer.

### 2.5.5.25 Auto Rebuild

Intel® RSTe will provide support for the ability to automatically rebuild a failed or degraded RAID volume. This feature will begin when a member disk of the array has failed and a suitable replacement disk with sufficient capacity is available. As soon as the failure occurs the rebuild process will begin automatically, using the marked Hot Spare disk, without user intervention.

If a marked Hot Spare disk is not present, the automatic rebuild process will begin under the following conditions:

- Another free disk is plugged into the same directly attached physical location as the failed drive
- The newly inserted disk size is at least as large as the amount of space used per disk in the current array
- The newly inserted disk must be the same type (SAS/SATA) as the disk being replaced or the rebuild will not start.
- If the newly inserted disk contains Intel® RSTe (or Intel® RST) metadata with current status of member being offline or contains no Intel® RSTe (or Intel® RST) metadata.
- The newly inserted disk has not reported a SMART event.

The following table summarizes the functionality:

| **Controller** | **Auto Rebuild Support** | **Action** |
|---|---|---|
| SATA & SCU | Previously marked Hot Spare available. | Rebuild starts when spare found. This takes precedence over auto-spare disk. |

| | | |
|---|---|---|
| SATA | No Hot Spare previously marked | No auto rebuild: Manual steps required to rebuild array using new disk |
| SCU | Auto rebuild conditions described above are met. | Auto rebuild starts without any user intervention |
| SCU | One or more of the above conditions was not met. | No auto rebuild: Manual steps required to rebuild array using new disk |
| sSATA | Auto rebuild conditions described above are met. | Auto rebuild starts without any user intervention |
| sSATA | One or more of the above conditions was not met. | No auto rebuild: Manual steps required to rebuild array using new disk |

Automatic rebuild support will default to OFF for Intel® RSTe and can be enabled through the Intel® RSTe GUI.

### 2.5.5.26 Error Threshold Monitoring/Handling

Intel® RSTe will support the ability to initiate an automatic RAID rebuild to a marked hot spare drive in the event of a drive SMART event alert that indicates a failure. (Windows*Only)

### 2.5.5.27 Unified Extensible Firmware Interface (UEFI)

Intel® RSTe will support UEFI for the SCU, SATA and sSATA controllers using common metadata.

### 2.5.5.28 Extended SCSI Passthru

Intel® RSTe will support the following Extended SCSI Passthru commands as per Unified Extensible Firmware Interface Specification v2.3.1, Errata D:

- EFI_EXT_SCSI_PASS_THRU_PROTOCOL protocol for physical disk devices
- Support for EFI_DEVICE_PATH_PROTOCOL for physical disk devices
- Support for EFI_SCSI_IO_PROTOCOL for physical disk devices

### 2.5.5.29 Disk Write Cache

Intel® RSTe will support the ability to enable/disable Disk Write Cache through the Intel® RSTe GUI. Disk Data Cache will be disabled by default.

---

* Other brands and names may be claimed as the property of others.



### 2.5.5.30 RAID Volume Read Cache

Intel® RSTe will support the ability to enable/disable RAID Volume Read Cache through the Intel® RSTe GUI. RAID Volume Read Cache will be enabled by default.

### 2.5.5.31 Write Back Cache

Intel® RSTe will support the ability to enable/disable Write Back Cache through the Intel® RSTe GUI. Write Back Cache will be disabled by default.

### 2.5.5.32 Volume Cache Increase

Intel® RSTe will increase the volume cache size to 16MB for SCU volumes and 16MB for SATA and sSATA volumes.

### 2.5.5.33 RAID Data Volume Size

Intel® RSTe will provide support for RAID volumes that are larger than 2 Terabytes.

### 2.5.5.34 RAID Boot Volume Size

Intel® RSTe will provide support for RAID Boot volumes that are larger than 2 Terabytes.

### 2.5.5.35 Disk Monitor Service

Intel® RSTe will support the ability to provide a disk monitoring service. The service will be active by default and executed as a system service. The service will monitor the system for SMART and RAID volume state changes events. The changes will be logged in the system log.

### 2.5.5.36 Failed Drive Reinsertion

Intel® RSTe will support the ability to recognize a failed drive re-inserted into the array. If able, Intel® RSTe will attempt to rebuild the volume to that drive. If not able, Intel® RSTe will mark the drive accordingly in the GUI.

### 2.5.5.37 Drives Supported

Intel® RSTe will provide support for current production SATA drives from “any” manufacturer on the SATA controllers. SAS and SATA drives supported on the SCU controller are outlined in

### 2.5.5.38 Safe Mode Support

Intel® RSTe will provide support for booting into Safe Mode for all supported OSs.

### 2.5.5.39 Non-Intel Controller Support

Intel® RSTe will not hinder, break or prevent operation of non-Intel® Controllers (SATA, PATA, SATA or RAID).

### 2.5.5.40 Device Configuration

Intel® RSTe will support the ability, at initialization, to read the system registry to get configuration setting in order to set the appropriate operational parameters.

### 2.5.5.41 Power Management

The Intel® RSTe product will support all the necessary power management functions required by the OSs.

### 2.5.5.42 Staggered Spin-up

Intel® RSTe will provide support for staggered spin-up on the SCU controller for those hard drives that support this feature.

### 2.5.5.43 Exporting SATA Drives on SATA/sSATA Controller

Intel® RSTe RAID Legacy Option ROMs will export those drives directly attached on a port order basis. This will be for both the SATA and sSATA controllers.

### 2.5.5.44 ATAPI on SATA/sSATA Controller

Intel® RSTe will provide support for ATAPI devices connected to the SATA/sSATA controller. Intel® RSTe Legacy RAID Option ROM will only support HDD devices (not ATAPI).

ATAPI support is handled by the platform system BIOS.

### 2.5.5.45 Solid State Drives (SSD)

Intel® RSTe will support SSDs as if they are Hard Disk Drives.

### 2.5.5.46 Hybrid Drives

Intel® RSTe will support Hybrid Drives as if they are Hard Disk Drives.

### 2.5.5.47 TRIM Command

***Note:*** This feature is not an end-user visible feature. There is no Intel® RSTe application or user interface control to configure the feature. Registry settings are provided for OEM use.

Support for the TRIM command allows the OS to pass information to the Solid State Disk (SSD) that identifies sectors that can be deleted. The SSD will then go through and clear out that information in the background thereby minimizing the chances of an “Overwriting” process happening at crucial times. The SSD is also free to do some additional optimizations with those sectors. E.g. an SSD can pre-erase any sector that has been TRIM'ed. The TRIM command improves the long term Write performance and the life-span of SSDs.

RAID 0/1/5/10



#### 2.5.5.47.1 SATA/sSATA Controllers

Intel® RSTe supports TRIM on both SATA controllers in a non-RAID configurations as well as on RAID0, RAID1 and RAID10 volumes.

#### 2.5.5.47.2 SCU Controller

Intel® RSTe will support TRIM on the SCU controller in a non-RAID configurations as well as on RAID0, RAID1 and RAID10 volumes.

### 2.5.5.48 Email Alerting and Notification[1]

Intel® RSTe will support email notification of certain storage events (see Appendix B for supported events). The Intel® RSTe UI will provide the interface for enabling/disabling and configuring the email notification feature. **The default setting in the UI is '<u>disabled</u>'**.

The email notification feature allows the user to configure the platform to send alert / notification emails for each storage subsystem event that gets reported by the Intel® RSTe monitor service.

#### 2.5.5.48.1 Configuration

The Intel® RSTe user application will provide the interface to allow the user to configure the email alert notification feature via the 'Preferences' tab of the UI (***user must be logged on with administrative privileges***).

- User can enable/disable the email notification feature
- User can configure the level of storage system events to be sent via email notification (Storage system Information, Warning, and/or Error). Any combination of the three alert levels can be configured to trigger an email notification
- User can configure the email settings:
  - SMTP host (required)
    - Port (required)
    - Return email address (required)
    - Recipient email addresses (one address required, up to 3 maximum)
  - User can configure the Email alert / notifications to send test emails to all addresses specified

#### 2.5.5.48.2 Email Message Format

- Message header:
  - Item1. Return email address: email address of the originating computer
  - Item2. Recipient email address: email address of computer receiving the email notification
  - Item3. Subject: system formatted subject content with product name, the storage system event level and the hostname of the originating computer
- Message body:
  - Item4. Log file text: contains the text of the event as it is displayed in the event log

[1] This feature has a platform specific limitation. It is supported only on Intel® C600 series chipset based platforms; not supported on legacy platforms/chipsets.

  - Item5. System report: contains the system configuration information of the originating computer as seen in the Intel® RSTe GUI Preferences page.

- Optional text:
  - Item6. This section is blank unless the originating computer's OS is in a language other than English. If the originating computer sends items 4 and 5 in non-English, the English translation of those two items will appear in this section (for test emails, only item 4 will be translated here)

Figure 1 Email Format shows detail of how an email alert is formatted.

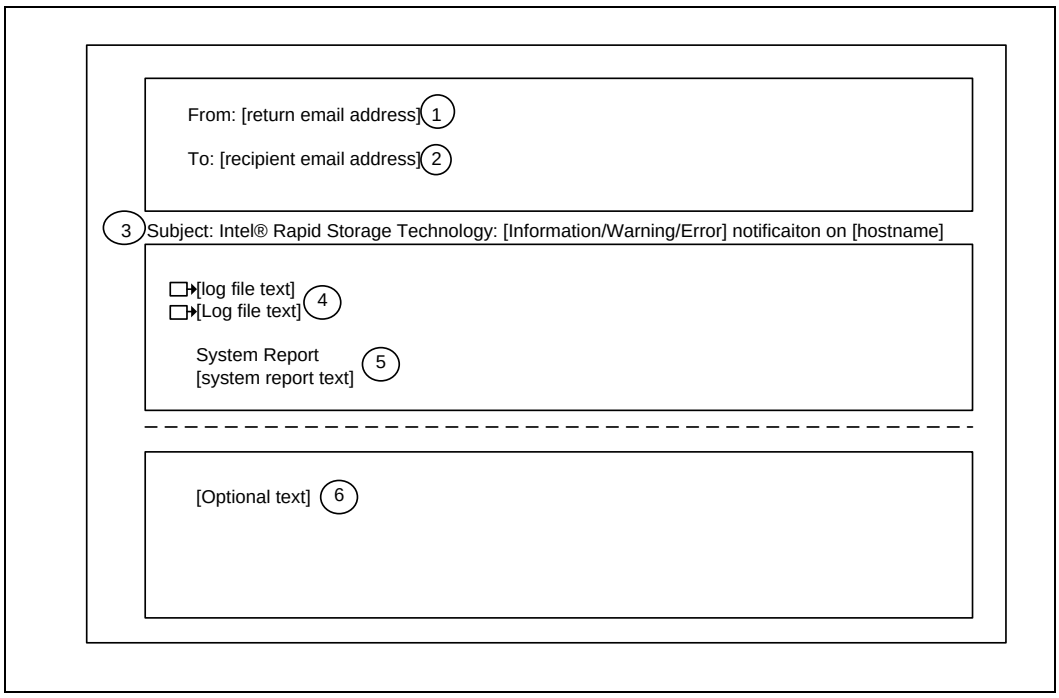



**Figure 1 Email Format**

### 2.5.5.48.3 Protocol Support

Email alert shall support SMTP host & SMTP port.

### 2.5.5.48.4 Error Conditions

See Appendix B for list of supported storage events and their notification mechanism:

- In the event of an SMTP server failure, the system will immediately attempt 3 retries. If the retries are unsuccessful, the system will discard the message without further attempts. The unsuccessful attempt will be written to the NT Event log.
- In the event of an improperly formatted email address in the "To' field, the alert will fail and the failure will be written to the NT Event log.



- In the event of an improperly formatted email address in the “From” field, the alert will fail and the failure written to the NT Event log.
- If the SMTP name entered during configuration is an invalid format, the alert will fail and the failure written to the NT Event log.

## 2.5.6 Utilities

### 2.5.6.1 Install/Uninstall Utility

Intel® RSTe will be available through the use of an install package. The install package will automatically install the proper RSTe driver and GUI that corresponds to the OS being installed on. There will also be a mechanism available to uninstall the driver and GUI.

**NOTE**: Great care must be taken when trying to perform the uninstall process. Removal of the driver could result in a system crash that could require a complete reinstallation of the operating system.





# 3 Product Certifications

## 3.1 WHQL

The Intel® RSTe drivers are required to be logo certified on the Microsoft Windows* WLK 1.5 test suite for storage device drivers running on legacy OSs.

The Intel® RSTe drivers are required to be logo certified on the Microsoft Windows* WLK 2.0 test suite for storage device drivers.

* Other brands and names may be claimed as the property of others.

*

# 4 Appendix A

**Table 4-1. Relevant Specifications**

| |
|---|
| ATA/ATAPI-7 (http://www.t13.org/Documents/UploadedDocuments/project/d1532v3r4a-ATA-ATAPI-7.pdf) |
| ATA Command Set 2 (http://www.t13.org/Documents/UploadedDocuments/docs2009/d2015r2-ATAATAPI_Command_Set_-_2_ACS-2.pdf) |
| ATA8-ACS-8 (http://www.t13.org/Documents/UploadedDocuments/docs2007/D1699r4c-ATA8-ACS.pdf) |
| SATA 1.0 Specification (http://www.serialata.org) |
| SATA II Specification (http://www.serialata.org) |
| SATA 3 (http://www.sata-io.org/documents/SATA-Revision-3.0-Press-Release-FINAL-052609.pdf) |
| Serial Attached SCSI - 2 (SAS-2) (http://www.t10.org) |

**Table 4-2. Relevant Documents**

| CDI / IBL # | Title/Location |
|---|---|
| **Reference Documents** | |
| 441979 | **Intel® 6 Series Chipset/ Intel® C200 Series Chipset/ Intel® C600 series chipset Platform Controller Hub (PCH) BIOS Specification Update – NDA** |
| 473093 | Intel Patsburg PhyTune Tool -RC Ver 2.0<br>**Note: This package contains the PhyTune tool along with the SASAddress efi utility. Please refer to the documentation included in the package for additional information.** |
| 453321 | **Intel® Server Platform Services Manageability Engine Firmware for Patsburg chipset Product Line Firmware Startup Guide** |
| 454672 | **Patsburg Chipset SPI Programming Guide** |
| 450911 | **Patsburg Chipset External Design Specification (EDS)** |
| 445721 | **Patsburg Chipset External Design Specification (EDS) Specification Update - NDA** |
| 458143 | **Sandy Bridge-E Processor External Design Specification (EDS) - Volume One of Two** |
| 459924, | **Sandy Bridge-E Processor External Design Specification - Volume Two of Two** |



| CDI / IBL # | Title/Location |
|---|---|
| 30051 | RS – Intel® 6 Series Chipset/<br>Intel® C200 Series Chipset/<br>Intel® C600 series chipset Platform Controller Hub (PCH)<br>BIOS Spec<br>***Contact your Intel FAE to get access to this document through Anacapa*** |
| Kit 33272 | Intel® Server Platform Services Alpha SPS_02.01.01.009.0<br><br>Note: This package is the Intel® Server Platform Services Manageability Engine Firmware for Intel® C600 series chipset Product Line - Alpha Full Release and contains key tools such as FITc and fpt for the Intel® C600 series chipset<br>**This document can be downloaded from ARMS/VIP** |
| 511555 | Intel® C610 Series Chipset and Intel® X99 Chipset Platform Controller Hub (PCH) |
| 558771 | Skylake Server Processor External Design Specification (EDS) |
| 546955 | Skylake Platform Controller Hub (SKL PCH-H) External Design Specification (EDS) |
| 509027 | Haswell-EN/EP/EP 4S/EX Processor BIOS Writer's Guide (BWG) |
| 541497 | Broadwell-EP/EP 4S/EX Processor External Design Specification (EDS) |
| 558749/ 486708 | Intel® 8 Series/C220 Series Chipset Family Platform Controller Hub (PCH) External Design Specification (EDS) |
| 547817 | Lewisburg Platform Controller Hub External Design Specification |
| **RST Legacy Requirements Documents** | |
| 443658 | ***Intel® Rapid Storage Technology (Intel® RST) 9.6 Product Requirements Document (PRD) Differences Document*:** http://www.intel.com/cd/edesign/library/asmo-na/eng/443658.htm |
| 409399 | *Intel® Rapid Storage Technology 9.5 Product Requirements Document (PRD) Differences Document :* **http://www.intel.com/cd/edesign/library/asmo-na/eng/409399.htm** |
| 375707 | *Intel® Matrix Storage Manager 8.5 Product Requirements Document (PRD) Differences Document :* |
| 373388 | *Intel® Matrix Storage Manager 8.0 Product Requirements Document (PRD) :* **http://www.intel.com/cd/edesign/library/asmo-na/eng/373388.htm** |
| 558079 | *Intel® Xeon® Processor E3-1200 v4 Product Family External Design Specification (EDS)* |

| CDI / IBL # | Title/Location |
|---|---|
| **Technical Guides / White papers** | |
| N/A | *Intel® Rapid Storage Technology OEM Technical Guide:* (location) Intel® Validation Internet Portal (VIP **https://platformsw.intel.com/** ) in each major or maintenance release version of Intel® Rapid Storage Technology release. |
| 445153 | *Reference Manual for Safe Removal with Link Power Management (LPM) on Hot Plug Capable Port (HPCP)* : **http://www.intel.com/cd/edesign/library/asmo-na/eng/445153.htm** |



# 5 Appendix B

**Table 5-1. Storage System Events Detected by Monitor Service (IAStorDataMgrSvc)**

| Event Type | Event Level | String | Event Displayed | | |
|---|---|---|---|---|---|
| | | | NAI[1] (Notification Area Icon) | Event Log | E-Mail Notify[2] |
| **Disk Triggered Events** | | | | | |
| Failed | Error | Disk on port {n}: Failed. Open the application for details. | Yes | Yes | Yes |
| S.M.A.R.T. | Warning | Disk on port {n}: At risk. Open the application for details. | Yes | Yes | Yes |
| Unlocked | Info | Disk on port {n}: Unlocked. | Yes | Yes | Yes |
| Added | Info | Disk on port {n}: Detected. | Yes | Yes | Yes |
| Removed | Info | Disk on port {n}: Removed. | Yes | Yes | Yes |
| **Volume Triggered Events** | | | | | |
| Failed | Error | Volume {0}: Failed. Open the application for details. | Yes | Yes | Yes |
| Degraded | Warning | Volume {0}: Degraded. Open the application for details. | Yes | Yes | Yes |
| Detected | Info | A new volume was found. | Yes | Yes | Yes |
| RebuildComplete | Info | Volume {0}: Rebuilding complete. | Yes | Yes | Yes |
| VerifyStop | Info | Volume {0}: Verification complete. | Yes | Yes | Yes |
| VerifyAndRepairStop | Info | Volume {0}: Verification and repair complete. | Yes | Yes | Yes |
| MigrationComplete | Info | Volume {0}: Data migration complete. | Yes | Yes | Yes |
| InitializeComplete | Info | Volume {0}: Initialization complete. | Yes | Yes | Yes |
| Unlocked | Info | Volume {0}: Unlocked. | Yes | Yes | Yes |
| NotPresent | Info | Volume {0}: No longer present on system. | Yes | Yes | Yes |
| RebuildStarted | Info | Volume {0}: Rebuilding in progress. | Yes | No | No |
| VerifyStarted | Info | Volume {0}: Verification in progress. | Yes | No | No |
| VerifyAndRepairStarted | Info | Volume {0}: Verification and repair in progress. | Yes | No | No |
| MigrationStarted | Info | Volume {0}: Data migration in progress. | Yes | No | No |
| InitializeStarted | Info | Volume {0}: Initialization in progress. | Yes | No | No |

| Event Type | Event Level | String | Event Displayed | | |
|---|---|---|---|---|---|
| | | | NAI[1] (Notification Area Icon) | Event Log | E-Mail Notify[2] |
| **General Events** | | | | | |
| Server start failed | Error | Server failed to start. Additional information: | No | Yes | Yes |
| Event manager started | Info | Started the event manager. | No | Yes | Yes |

**NOTES:**

1. NAI true only if the user selected to receive notification under Preferences in the UI
2. Refer to Email Section above for Email feature support



# 6 Appendix C

## 6.1 Intel® C600 series chipset OEM Parameters

The Storage Controller Unit (SCU) complies with the Serial Attached SCSI (SAS) Specification's Physical and Link Layer definitions. However, when it comes to actually implementing motherboard designs, OEMs often encounter challenges that pit high-frequency design best-practices against form factor and trace lengths. Therefore, SCU provides a mechanism for OEMs to tweak its PHY parameters to find the most optimal settings for a given platform. Once determined, the OEM can capture these settings to a binary file that is placed into the platform's Serial Peripheral Interconnect (SPI) flash. If the OEM has multiple motherboard platforms using the Intel® C600 series chipset, each platform could have its own unique PHY parameter settings if needed.

SAS is a connection based protocol. Thus, the SCU requires that a valid SAS address be assigned to each of its controllers. The OEM registers these addresses through a proper naming authority. So, in addition to the PHY settings, SAS addresses are placed in the OEM parameter block as well.

SAS addresses are not unique to platforms as are the PHY settings. They are unique to each SCU controller in an individual Intel® C600 series chipset unit (i.e. SKU) similar to the way MAC addresses are unique to each LAN controller.

Since the OEM parameters are unique to platforms and chipset SKUs, they are set once at manufacturing time. OEM parameters will have been validated by OEMs with their respective platforms. Therefore, end users should not be allowed to change these settings for fear of system compatibility problems.

The remaining subsections discuss the details of the OEM parameter block and the requirements they place on the BIOS.

## 6.2 Structure of OEM Parameter Block

The OEM parameter block is 512 bytes total in size and an unpacked, unpadded binary block. It is partitioned into a header and up to two SCU controller element structures. Figure 2 shows this structure.

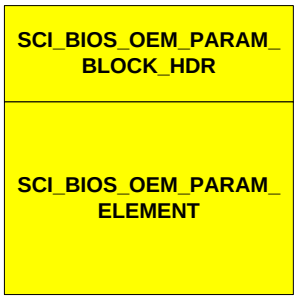



**Figure 2: Structure of OEM Parameter Block**

The following is the C programming language definition of the OEM parameter block. The comments give a full description of each field.

```
// For Intel Storage Controller Unit OEM Block
#define SCI_OEM_PARAM_SIGNATURE    "ISCUOEMB"

#define SCI_PREBOOT_SOURCE_INIT       (0x00)
#define SCI_PREBOOT_SOURCE_OROM       (0x80)
#define SCI_PREBOOT_SOURCE_EFI        (0x81)

#define SCI_OEM_PARAM_VER_1_0         (0x10)
#define SCI_OEM_PARAM_VER_1_1         (0x11)
#define SCI_OEM_PARAM_VER_1_4         (0x14)


// current version
#define SCI_OEM_PARAM_VER_CUR     SCI_OEM_PARAM_VER_1_4

// port configuration mode
#define SCI_BIOS_MODE_MPC   (0)
#define SCI_BIOS_MODE_APC   (1)


#ifndef SCI_MAX_PHYS
#define SCI_MAX_PHYS (4)
#endif

#ifndef SCI_MAX_PORTS
#define SCI_MAX_PORTS (4)
#endif


/**
 * @struct SCI_BIOS_OEM_PARAM_BLOCK_HDR
```



```
 *
 * @brief This structure defines the OEM Parameter block header.
 */
typedef struct SCI_BIOS_OEM_PARAM_BLOCK_HDR
{
  /**
   * This field contains the OEM Parameter Block Signature which is
   * used by BIOS and driver software to identify that the memory location
   * contains valid OEM Parameter data.  The value must be set to
   * SCI_OEM_PARAM_SIGNATURE which is the string "ISCUOEMB" which
   * stands for Intel Storage Controller Unit OEM Block.
   */
  U8 signature[8];
  /**
   * This field contains the size in bytes of the complete OEM
   * Parameter Block, both header and payload hdr_length +
   * (num_elements * element_length).
   */
  U16 total_block_length;
  /**
   * This field contains the size in bytes of the
   * SCI_BIOS_OEM_PARAM_BLOCK_HDR. It also indicates the offset from
   * the beginning of this data structure to where the actual
   * parameter data payload begins.
   */
  U8 hdr_length;
  /**
   * This field contains the version info defining the structure
   * of the OEM Parameter block.
   */
  U8  version;
  /**
   * This field contains a value indicating the preboot initialization
   * method (Option ROM or UEFI driver) so that after OS transition,
   * the OS driver can know the preboot method. OEMs who build a single
   * flash image where the preboot method is unknown at manufacturing
   * time should set this field to SCI_PREBOOT_SOURCE_INIT.  Then
   * after the block is retrieved into host memory and under preboot
   * driver control, the OROM or UEFI driver can set this field
   * appropriately (SCI_PREBOOT_SOURCE_OROM and SCI_PREBOOT_SOURCE_EFI,
   * respectively).
   */
  U8 preboot_source;
  /**
   * This field contains the number of parameter descriptor elements
   * (i.e. controller_elements) following this header.  The number of
```

```
   * elements corresponds to the number of SCU controller units contained
   * in the platform:
   *  controller_element[0] = SCU0
   *  controller_element[1] = SCU1
   */
  U8 num_elements;
  /**
   * This field contains the size in bytes of the descriptor element(s)
   * in the block.
   */
  U16 element_length;

  /**
  * This field contains the BIOS Controlled Feature Set and allows
  * BIOS vendors to enable/disable specific Intel RSTe product features.
   */
  U8 BCFS;
```

**NOTE: Please see the section 6.3 BCFS Bit Settings below for details on the allowed settings.**

```
  /**
   * Reserve fields for future use.
   */
  U8 reserved[6];

} SCI_BIOS_OEM_PARAM_BLOCK_HDR_T;


/**
 * @struct SCIC_SDS_OEM_PARAMETERS
 *
 * @brief This structure delineates the various OEM parameters that must
 * be set for the Intel SAS Storage Controller Unit (SCU).
 */
typedef struct SCI_BIOS_OEM_PARAM_ELEMENT
{
  /**
   * Per SCU Controller Data
   */
  struct
  {
    /**
     * This field indicates the port configuration mode for
     * this controller:
     *   Automatic Port Configuration(APC) or
     *   Manual Port Configuration (MPC).
```



```
 *
 * APC means the Platform OEM expects SCI to configure
 * SAS Ports automatically according to the discovered SAS
 * Address pairs of the endpoints, wide and/or narrow.
 *
 * MPC means the Platform OEM manually defines wide or narrow
 * connectors by apriori assigning PHYs to SAS Ports.
 *
 * By default, the mode type is APC
 * in APC mode, if ANY of the phy mask is non-zero,
 *    SCI_FAILURE_INVALID_PARAMETER_VALUE will be returned
 *      from scic_oem_parameters_set AND the default oem
 *      configuration will be applied
 * in MPC mode, if ALL of the phy masks are zero,
 *    SCI_FAILURE_INVALID_PARAMETER_VALUE will be returned
 *      from scic_oem_parameters_set AND the default oem
 *      configuration will be applied
 */
U8  mode_type;

/**
 * This field specifies the maximum number of direct attached
 * devices the OEM will allow to have powered up simultaneously
 * on this controller.  This allows the OEM to avoid exceeding
 * power supply limits for this platform.  A value of zero
 * indicates there are no restrictions.
 */
U8  max_number_concurrent_device_spin_up;

 /**
 * This bitfield indicates the OEM's desired default Tx
 * Spread Spectrum Clocking (SSC) settings for SATA and SAS.
 * NOTE: Default SSC Modulation Frequency is 31.5KHz.
 *-----------------------------------------------------------*/
/**
 * NOTE: Max spread for SATA is +0 / -5000 PPM.
 * Down-spreading SSC (only method allowed for SATA):
 *  SATA SSC Tx Disabled                = 0x0
 *  SATA SSC Tx at +0 / -1419 PPM Spread    = 0x2
 *  SATA SSC Tx at +0 / -2129 PPM Spread    = 0x3
 *  SATA SSC Tx at +0 / -4257 PPM Spread    = 0x6
 *  SATA SSC Tx at +0 / -4967 PPM Spread    = 0x7
*/
U8 ssc_sata_tx_spread_level : 4;

/**
```

```
     * SAS SSC Tx Disabled                = 0x0
     *
     * NOTE: Max spread for SAS down-spreading +0 / -2300 PPM
     * Down-spreading SSC:
     *  SAS SSC Tx at +0 / -1419 PPM Spread    = 0x2
     *  SAS SSC Tx at +0 / -2129 PPM Spread    = 0x3
     *
     * NOTE: Max spread for SAS center-spreading +2300 / -2300 PPM
     * Center-spreading SSC:
     *  SAS SSC Tx at +1064 / -1064 PPM Spread  = 0x3
     *  SAS SSC Tx at +2129 / -2129 PPM Spread  = 0x6
     */
    U8 ssc_sas_tx_spread_level : 3;
    /**
     * NOTE: Refer to the SSC section of the SAS 2.x Specification
     * for proper setting of this field. For standard SAS Initiator
     * SAS PHY operation it should be 0 for Down-spreading.
     * SAS SSC Tx spread type:
     *  Down-spreading SSC     = 0
     *  Center-spreading SSC   = 1
     */
    U8 ssc_sas_tx_type : 1;
    /*--------------------------------------------------------------------*/


    U8 reserved;

  } controller;

  /**
   * Per SAS Port data.
   */
  struct
  {
    /**
    * This field specifies the phys to be contained inside a port.
    * The bit position in the mask specifies the index of the phy
    * to be contained in the port.  Multiple bits (i.e. phys)
    * can be contained in a single port:
    *     Bit 0 = This controller's PHY index 0    (0x01)
    *     Bit 1 = This controller's PHY index 1    (0x02)
    *     Bit 2 = This controller's PHY index 2    (0x04)
    *     Bit 3 = This controller's PHY index 3    (0x08)
    *
    * Refer to the mode_type field for rules regarding APC and MPC mode.
    * General rule: For APC mode phy_mask = 0
    */
```



```
    U8 phy_mask;

} ports[SCI_MAX_PORTS]; // Up to 4 Ports per SCU controller unit

/**
 * Per PHY Parameter data.
 */
struct
{
   /**
    * This field indicates the SAS Address that will be transmitted on
    * this PHY index.  The field is defined as a union, however, the
    * OEM should use the U8 array definition when encoding it to ensure
    * correct byte ordering.
    *
    * NOTE: If using APC MODE, along with phy_mask being set to ZERO, the
    * SAS Addresses for all PHYs within a controller group SHALL be the
    * same.
    */
   union
   {
      /**
       * The array should be stored in little endian order.  For example,
       * if the desired SAS Address is 0x50010B90_0003538D, then it
       * should be stored in the following manner:
       *    array[0] = 0x90
       *    array[1] = 0x0B
       *    array[2] = 0x01
       *    array[3] = 0x50
       *    array[4] = 0x8D
       *    array[5] = 0x53
       *    array[6] = 0x03
       *    array[7] = 0x00
       */
      U8 array[8];
      /**
       * This is the typedef'd version of the SAS Address used in
       * the SCI Library.
       */
      SCI_SAS_ADDRESS_T  sci_format;

   } sas_address;

   /**
    * These are the per PHY equalization settings associated with the the
    * AFE XCVR Tx Amplitude and Equalization Control Register Set
```

```
         * (0 thru 3).
         *
         * Operational Note: The following Look-Up-Table registers are engaged
         * by the AFE block after the following:
         *  - Software programs the Link Layer AFE Look Up Table Control
         *    Registers (AFE_LUTCR).
         *  - Software sets AFE XCVR Tx Control Register Tx Equalization
         *    Enable bit.
         */
        /**
         * AFE_TX_AMP_CTRL0.  This register is associated with AFE_LUTCR
         * LUTSel=00b. It contains the Tx Equalization settings that will be
         * used if a SATA 1.5Gbs or SATA 3.0Gbs device is direct-attached.
         */
        U32 afe_tx_amp_control0;

        /**
         * AFE_TX_AMP_CTRL1.  This register is associated with AFE_LUTCR
         * LUTSel=01b. It contains the Tx Equalization settings that will
         * be used if a SATA 6.0Gbs device is direct-attached.
         */
        U32 afe_tx_amp_control1;

        /**
         * AFE_TX_AMP_CTRL2.  This register is associated with AFE_LUTCR
         * LUTSel=10b. It contains the Tx Equalization settings that will
         * be used if a SAS 1.5Gbs or SAS 3.0Gbs device is direct-attached.
         */
        U32 afe_tx_amp_control2;

        /**
         * AFE_TX_AMP_CTRL3.  This register is associated with AFE_LUTCR
         * LUTSel=11b. It contains the Tx Equalization settings that will
         * be used if a SAS 6.0Gbs device is direct-attached (which will only run
        * at SAS 3.0Gbs ) .
         */
        U32 afe_tx_amp_control3;

    } phys[SCI_MAX_PHYS];  // 4 PHYs per SCU controller unit

} SCI_BIOS_OEM_PARAM_ELEMENT_T;


/**
 *  @struct SCI_BIOS_OEM_PARAM_BLOCK
 *
```



```
 * @brief This structure defines the OEM Parameter block as it will be stored
 *  in the last 512 bytes of the PDR region in the SPI flash.  It must be
 *  unpacked or pack(1).
 */
typedef struct SCI_BIOS_OEM_PARAM_BLOCK
{
  /**
   * OEM Parameter Block header.
   */
  SCI_BIOS_OEM_PARAM_BLOCK_HDR_T  header;

  /**
   * Per controller element descriptor containing the controller's
   * parameter data. The prototype defines just one of these descriptors,
   * however, the actual runtime number is determined by the num_elements
   * field in the header.
   */
  SCI_BIOS_OEM_PARAM_ELEMENT_T controller_element[1];

} SCI_BIOS_OEM_PARAM_BLOCK_T;
```

## 6.3 BCFS Bit Settings

| BCFS bit number | Bit meaning | Values | | Additional info |
|---|---|---|---|---|
| 0 | Enable/disable Raid0 | Raid type disabled | 0x0 | If you disable all raid levels – all BCFS settings will be set back to default and OROM UI delay will be set to 2 seconds |
| | | Raid type enabled | 0x1 | |
| 1 | Enable/disable Raid1 | Raid type disabled | 0x0 | |
| | | Raid type enabled | 0x1 | |
| 2 | Enable/disable Raid10 | Raid type disabled | 0x0 | |
| | | Raid type enabled | 0x1 | |

| BCFS bit number | Bit meaning | Values | | Additional info |
|---|---|---|---|---|
| 3 | Enable/disable Raid5 | Raid type disabled | 0x0 | |
| | | Raid type enabled | 0x1 | |
| 4 | RESERVED | | | |
| 5 | Enable/disable UI | Feature disabled | 0x0 | If you set it to 0 (disable) bits 10-14 are ignored |
| | | Feature enabled | 0x1 | |
| 6-8 | RESERVED | | | |
| 9 | Dnable/disable RSTe caching | Feature disabled | 0x0 | |
| | | Feature enabled | 0x1 | |
| 10 - 12 | Delay on UI splash screen | 2 seconds | 0x000 | Default setting is 0x000: 2 seconds. |
| | | 4 seconds | 0x001 | |
| | | 6 seconds | 0x010 | |
| | | 8 seconds | 0x011 | |
| | | 10 seconds | 0x100 | |



| BCFS bit number | Bit meaning | Values | | Additional info |
|---|---|---|---|---|
| | | 15 seconds | 0x101 | |
| | | 30 seconds | 0x110 | |
| | | 60 seconds | 0x111 | |
| 13 - 14 | Mode of showing UI | Show if error or >=2 disks | 0x00 | Default setting 0x00: show if there are 2 or more disks connected or error occured |
| | | Show only if error | 0x01 | |
| | | Never show UI | 0x10 | |
| | | Show always | 0x11 | |
| 15 | RESERVED | | | |

## 6.4 Recommended Location in SPI Flash

Figure 3 shows the recommended location where the OEM parameter block should be placed in SPI flash. Intel reference images will be formatted this way, and the FITC tool supplied by Intel for constructing SPI flash images is configured to take a formatted OEM parameter block and place it appropriately in the Platform Data Region (PDR) as shown in the figure. The OEM Parameter Block should be placed in the last 512 bytes of the PDR region aligned on a 32-bit boundary. There will be more discussion on this in section *6.5 OEM Parameter and SPI Flash Tools*.

| **Note:** | The recommended SPI flash format is descriptor mode. |
|---|---|

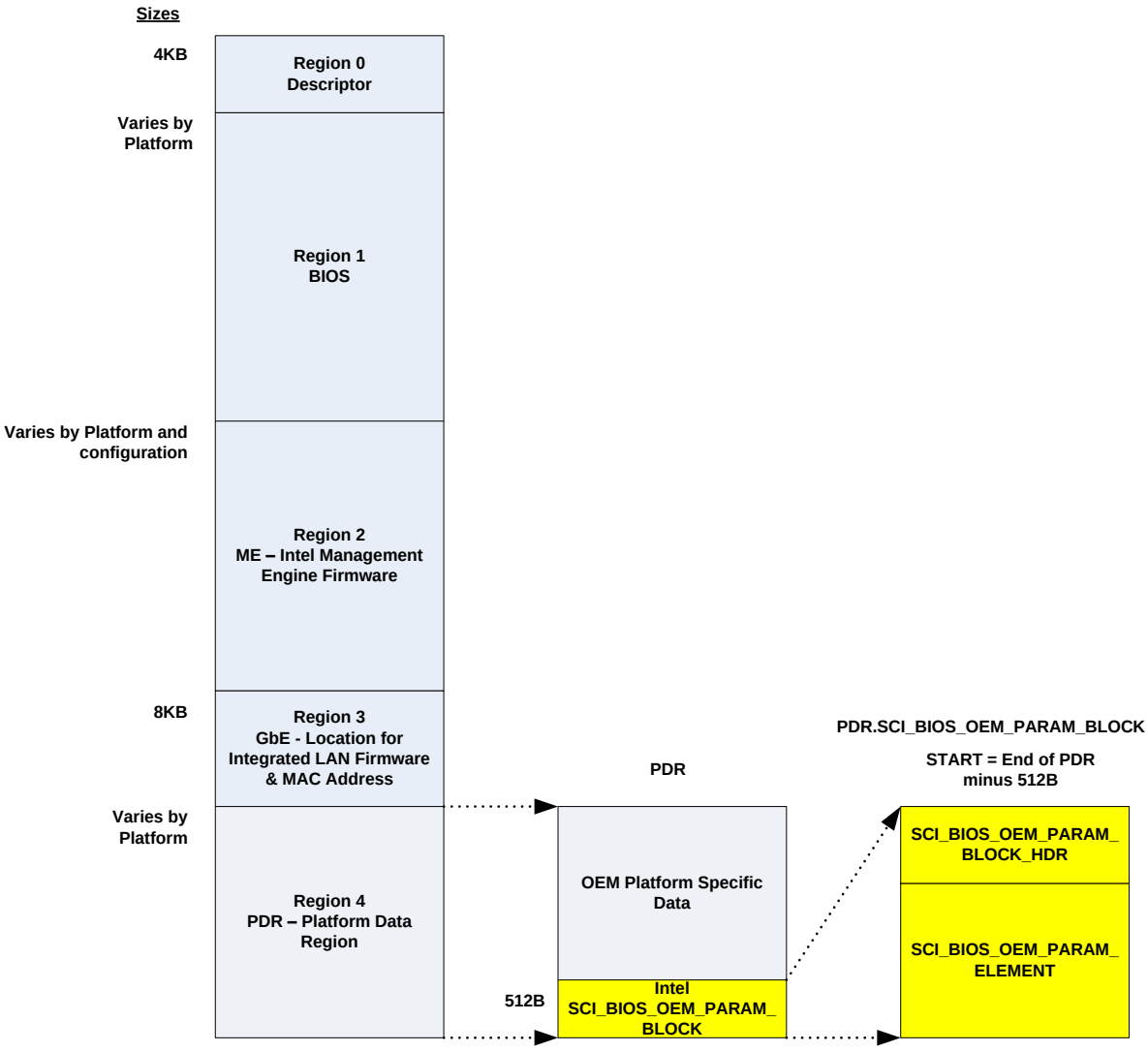



**Figure 3 Recommended OEM Param Location in SPI Flash**

Third party BIOS vendors are not obligated to follow this recommendation. For the Romley platform, if 3rd parties want Intel provided pre-OS SCU drivers (legacy OROM and UEFI drivers) to boot their systems, they are required to provide a valid OEM Parameter block in flash somewhere. Further, they are required to implement the access services defined in section *6.6 Required BIOS Services* so that legacy OROM and/or a UEFI driver can retrieve these parameters and configure the SCU. These BIOS services abstract the Intel provided pre-OS drivers from having to know where the parameters actually reside in flash.



## 6.5 OEM Parameter and SPI Flash Tools

As part of the SCU development kit, tools are provided to help Original Equipment Manufacturers (OEMs), System Integrators, and Value Added Resellers (VARs) tune SCU PHY parameters to a platform's motherboard design and mass produce SPI flash images for that platform. The names of the tools are as follows:

- PHY Tune Tool (part of SCU development kit)
- SAS Address Tool (part of SCU development kit)
- FITC Tool (part of SPI Flash Programming kit)

These tools can be found at by contacting your Intel FAE. Detailed user guides are provided in each of the respective kits. However, the following subsections do provide a brief overview of each tool.

Except for the PHY SAS Addresses, the OEM parameters are tuned and fixed for a given platform by the OEM. SAS Addresses, however, are unique to individual SCU SKUs similar to the MAC Address for LAN chips. The system OEM must provide valid SAS addresses that are registered to them. Refer back to section *6.2 Structure of OEM Parameter Block* for a detailed description of the PHY parameters.

### 6.5.1 PHY Tune Tool

PHY Tune is a Windows .Net 4.0 application. It provides a GUI front-end to display and configure SCU PHY information on the console. The tool communicates with a special SCU driver packaged with the tool. The tool is designed to run on Windows Server 2008 R2.

| | |
|---|---|
| **Note:** | The driver that comes with the PHY Tune Tool is part of an Intel Confidential toolset. That toolset is strictly for the use of the entity with an NDA with Intel and no part may be distributed. |

In addition, PHY Tune retrieves and displays special diagnostic information from the SCU. From this information, OEMs can determine which settings provide the most optimal PHY performance for that platform.

Once the OEM determines the appropriate parameter settings for the platform, they can use a PHY Tune menu option to capture these settings. PHY Tune also allows the OEM to set initial values for the other fields in the OEM parameter block including the header fields and the PHY SAS Addresses. PHY Tune provides another menu option to export these settings to a properly formatted binary file. This block can then be loaded into the Intel FITC tool recognizes where to place this block in constructing a SPI flash image. If the OEM uses its own tools other than FITC to construct the flash image, then it just operates on the "raw" binary file.

| | |
|---|---|
| **Note:** | If FITC is used for flash image construction, it will place the block in the PDR region as described in section 6.4 Recommended Location in SPI Flash.<br><br>OEM fields initialized by PHY Tune that need to change per SKU (e.g. SAS Addresses) can be modified later by other manufacturing tools. |





### 6.5.2 SAS Address Tool (sasaddresses.efi)

The developer kit includes a UEFI application providing a command line interface that can be used by a manufacturing script to update per SKU SAS addresses. The name of the application is ***sasaddresses.efi*** . Based on input parameters, the application will either work directly on an OEM block already in the PDR of SPI flash or it will operate on a properly formatted binary input file. In the case of the binary input file, it will modify the SAS Addresses in the binary image according to the SAS addresses on the command line and then overwrite the OEM section of PDR with the binary image.

### 6.5.3 FITC Tool

The FITC tool is part of the SPI Flash Programming kit. It is used to construct flash images and modify data at manufacturing using an XML schema. The Intel FITC tool constructs a SPI flash image in descriptor mode containing the follow regions:

- Descriptor Region indicating how the flash is partitioned and where other regions begin and end.
- BIOS Region
- Intel Manufacturing Engine Region
- Gigabit Ethernet Region
- Platform Data Region

When using the FITC tool to construct a SPI flash image, FITC will place the OEM parameter block in the last 512 bytes of the Platform Data Region as described in section 6.4 Recommended Location in SPI Flash.

## 6.6 Required BIOS Services

System BIOS shall provide services to extract the OEM parameter block from SPI Flash. As mentioned earlier, the recommended location for the OEM parameter block is in the last 512 bytes of the PDR region as described in section 6.4 Recommended Location in SPI Flash.

The following subsections describe the necessary services according to the type of pre-boot driver environment whether legacy Option ROM or native UEFI.

### 6.6.1 Legacy OROM

Under legacy BIOS / OROM mode, the BIOS must provide the following software interrupt services.

#### 6.6.1.1 Get Intel RSTe OROM SCU OEM Parameter Block: INT 15, Function=F300h, Sub-Function=0001h

**INT 15 / AX=F300h / BX=0001h (Get Intel RSTe OROM SCU OEM Parameter Block)**

**Description:**

Through this function, BIOS provides to the Intel RSTe legacy OROM driver the OEM Parameter Block needed to initialize the SCU controller.



**Inputs:**

AX = F300h (Function)

BX = 0001h (Sub Function)

EAX = 0000F300h

EBX = 4F450001h ('OE') + Sub Function

EDX = 20534355h (' SCU')

ECX = size of data buffer in bytes

(512 Bytes = OEM header + Descriptor Elements)

EDI = 0000xxxxh (Upper 16bits are zero, lower 16bits defined below)

ES:DI = address of data buffer (Real mode address)

**Normal Outputs:**

CF = clear if successful

EAX = 20534355h (' SCU')

ES:DI = data buffer filled

ECX = actual transfer size in bytes (512 Bytes)

**Data Format:**

= char oem_params[512];

(512 Bytes of data as encoded by OEM or system integrator)

**Error Outputs:**

CF = set on error

AH = error code

= 86h Function Not Supported

= 87h OEM Block Not Present

### 6.6.1.2 INT 15 / AX=F300h / BX=0002h (Get Intel RSTe OROM Boot Info)

**Description:**

Through this function, BIOS provides user-settable Intel RSTe boot information to the Intel RSTe legacy OROM driver. These values are visible to the user through the BIOS Setup menus. The menu options should be linked to legacy OROM selections in the PCH-IO section.

**Inputs:**

AX = F300h (Function)

BX = 0002h (Sub Function)

EAX = 0000F300h

EBX = 4F450002h ('OE') + Sub Function

EDX = 424F4F54h ('BOOT')

**Normal Outputs:**

CF = clear if successful

EAX = 424F4F54h ('BOOT')

BL = legacy_orom_boot_controller_selection:

Due to limited shadow RAM and EBDA space, and the fact that a platform may require multiple OROMs be loaded for other functions, there might not be enough runtime space for both the Intel RSTe SATA RAID controller OROM and the Intel RSTe SCU RAID controller OROM to provide int13h support simultaneously. Even so, each Intel RSTe OROM still needs to initialize so that it can configure each controller based on platform dependencies and store data needed by the OS drivers in the Shadow RAM area even if it does not provide full int13h runtime support. Thus, through this setup option BIOS can avoid the runtime space conflict by allowing the user to select the boot controller according to the following values:

0000h = No runtime space restrictions. BIOS indicates that both Intel RSTe SATA and SCU runtime code should provide full int13h support for Intel RSTe devices.

(NOTE: The BIOS should allow this option if it knows that there is room in shadow RAM for both OROMs' runtime code. If the BIOS can always guarantee this condition, then it does NOT need to make Legacy OROM boot controller selection visible to the user in BIOS setup.)

0001h = The SCU controller is selected as boot controller. BIOS will load Intel RSTe SATA OROM first, but the SATA OROM will only initialize and then leave pertinent RAID configuration information for the SATA OS RAID Driver in runtime space. The Intel RSTe SCU OROM will initialize, relocate to runtime space, and provide full int13h support for SCU attached devices.

0002h = The SATA controller is selected as boot controller. BIOS will load Intel RSTe SCUOROM first, but the SCU OROM will only initialize and then leave pertinent RAIDconfiguration and SCU OEM parameter information for the SCU OS RAID Driver in runtime space. The Intel RSTe SATA OROM will initialize,



relocate to runtime space, and provide full int13h support for SATA controller attached devices.

0003h = Neither SATA nor SCU controller is selected as boot controller. Boot support is being provided by anotherdevice. BIOS will load both Intel RSTe OROMs, but each will only initialize and leave pertinent RAID configuration and SCU OEM parameter information for the Intel RSTe OS RAID Drivers in runtime space. Therewill NOT be int13h support for Intel RSTe devices.

BH = scu_legacy_orom_max_disk_slots_enum:

For boot_controller_selection = {0000h or 0001h}, this option allows the user to set the maximum number of disk slots the SCU legacy OROM will enumerate. Its range will be between 1 and 8.

The default value shall be 8. For boot_controller_selection = {0002h or 0003h}, this field should not be settable by the user, and OROM will automatically assume a value of 0.

**Error Outputs:**

CF = set on error

AH = error code

= 86h Function Not Supported = (boot_controller_selection = 0000h assumed)

### 6.6.2 UEFI

Under native UEFI mode, the BIOS must provide the following protocol.

```
//
// Define SCU Parameters protocol GUID
//
// EDK and EDKII have different GUID formats
//
#if !defined(EDK_RELEASE_VERSION) || (EDK_RELEASE_VERSION < 0x00020000)
#define EFI_PCH_SCU_PARAMETERS_PROTOCOL_GUID \
 { \
   0xe165e866, 0x6643 , 0x40b3, 0xb4, 0x35, 0x52, 0x6b, 0x47, 0x3f, 0x75, 0xc2 \
 }

#else
#define EFI_PCH_SCU_PARAMETERS_PROTOCOL_GUID \
 { \
```

```
    0xe165e866, 0x6643 , 0x40b3, \
    {0xb4, 0x35, 0x52, 0x6b, 0x47, 0x3f, 0x75, 0xc2} \
  }
#endif
#define SCU_PARMS_SIZE 512
//
// Protocol definition
//
struct _PCH_SCU_PARAMETERS_PROTOCOL {
  U8 SCUParameters[SCU_PARMS_SIZE];
};
```

## 6.7 Intel® C610 series Chipset Legacy OROM Boot Option

### 6.7.1 INT 15 / AX=F300h / BX=0002h (Get Intel RSTe OROM Boot Info)

**Description:**

Through this function, BIOS provides user-settable Intel RSTe boot information to the Intel RSTe legacy OROM driver. These values are visible to the user through the BIOS Setup menus. The menu options should be linked to legacy OROM selections in the PCH-IO section.

**Inputs:**

AX = F300h (Function)

BX = 0002h (Sub Function)

EAX = 0000F300h

EBX = 4F450002h ('OE') + Sub Function

EDX = 424F4F54h ('BOOT')

**Normal Outputs:**

CF = clear if successful

EAX = 424F4F54h ('BOOT')

BL = legacy_orom_boot_controller_selection:

Due to limited shadow RAM and EBDA space, and the fact that a platform may require multiple OROMs be loaded for other functions, there might not be enough runtime space for both the Intel RSTe SATA RAID controller OROM and the Intel RSTe sSATA RAID controller OROM to provide int13h support simultaneously. Even so, each Intel RSTe OROM still needs to initialize so that it can configure each controller based on platform dependencies and store data needed by the OS drivers in the Shadow RAM area even if it does not provide full int13h runtime support. Thus, through this setup



option BIOS can avoid the runtime space conflict by allowing the user to select the boot controller according to the following values:

0000h = No runtime space restrictions. BIOS indicates that both Intel RSTe SATA and sSATA runtime code should provide full int13h support for Intel RSTe devices.

(NOTE: The BIOS should allow this option if it knows that there is room in shadow RAM for both OROMs' runtime code. If the BIOS can always guarantee this condition, then it does NOT need to make Legacy OROM boot controller selection visible to the user in BIOS setup.)

0001h = The sSATA controller is selected as boot controller. BIOS will load Intel RSTe SATA OROM first, but the SATA OROM will only initialize and then leave pertinent RAID configuration information for the SATA OS RAID Driver in runtime space. The Intel RSTe sSATA OROM will initialize, relocate to runtime space, and provide full int13h support for sSATA attached devices.

0002h = The SATA controller is selected as boot controller. BIOS will load Intel RSTe sSATA OROM first, but the sSATA OROM will only initialize and then leave pertinent RAIDconfiguration and sSATA OEM parameter information for the sSATA OS RAID Driver in runtime space. The Intel RSTe SATA OROM will initialize, relocate to runtime space, and provide full int13h support for SATA controller attached devices.

0003h = Neither SATA nor sSATA controller is selected as boot controller. Boot support is being provided by anotherdevice. BIOS will load both Intel RSTe OROMs, but each will only initialize and leave pertinent RAID configuration and sSATA OEM parameter information for the Intel RSTe OS RAID Drivers in runtime space. Therewill NOT be int13h support for Intel RSTe devices.

**Error Outputs:**

CF = set on error

AH = error code

= 86h Function Not Supported = (boot_controller_selection = 0000h assumed)

# 7 Appendix D

## 7.1 Hardware Compatibly

### 7.1.1 External Hardware Compatibility

The embedded file indicates the current list of external hardware used in validation and is subject to change without notice. Please contact your factory representative for questions on any specific hardware item.

**Enterprise SAS Drives**

| Vendor | Family | Model Name/Number |
|---|---|---|
| Fujitsu | AL9Se Series (2.5") | MAY2036RC |
| Fujitsu | AL9LX Series (3.5") | MAX3036RC, |
| Fujitsu | AL10Se Series (2.5") | MBB2 Series |
| Seagate | SAS | Barracuda ES.2 7.2k rpm |
| Seagate | SAS | Cheetah 15k.6 (3.5") |
| Seagate | SAS | Cheetah 15K.4 (3.5") |
| Seagate | SAS | Cheetah 15K.5 (3.5") |
| Seagate | SAS | Cheetah 15K.7 |
| Seagate | SAS | Savvio 10K.1 (2.5") |
| Seagate | SAS | Savvio 10K.2 (2.5") |
| Seagate | SAS | Savvio 15K.1 (2.5") |
| Seagate | SAS | Cheetah NS |
| Hitachi | Ultrastar 15K147 3.5" (Viper A') | HUC101473CSS300, |
| Hitachi | Ultrastar 15K147 3.5" (Viper B) | HUS153014VLS300, HUS153073VLS300 |
| Hitachi | Ultrastar C10K147 2.5" (Cobra B) | HUC101473CSS300, |



**Enterprise SATA Drives**

| Vendor | Family | Model Name/Number |
|---|---|---|
| Fujistu | A160 (2.5") 7200 RPM FDE Option Extended Duty | MHZ2080BK |
| Hitachi | Ultrastar A7k1000 (3.5") 7.2rpm | |
| Seagate | Barracuda 7200.10 Serial ATA | |
| Seagate | Barracuda 7200.11 Serial ATA | |
| Seagate | Barracuda ES | |
| Western Digital | | WD1002FAEX |
| Western Digital | | WD6000HLHX |

**Expanders and Enclosures**

| Vendor | Model Number |
|---|---|
| AIC | XJ1100 |
| Xyratex | RS1603X |
| Supermicro | CSE-M28x |
| Promise | Vtrak E-Class E310 |
| | Vtrak J-class |
| Supermicro | SC836E1-R800V |