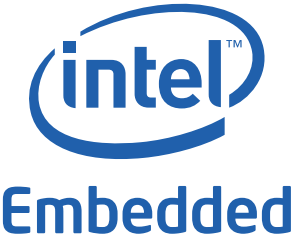

# Intel® Xeon® E3-1125C v2, E3-1105C v2, Intel® Pentium® Processor B925C, and Intel® Core™ i3-3115C Processors for Communications Infrastructure

## - Volume 1 of 2

**Supporting:**

**Intel® Xeon® Processor E3-1125C v2**
**Intel® Xeon® Processor E3-1105C v2**
**Intel® Core™ Processor i3-3115C**
**Intel® Pentium® Processor B925C**

***Mobile/Desktop 3rd Generation Intel® Core™ Processor Family Datasheet, Volume 2, completes the documentation set and contains additional product information.***

***November 2013***

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# Revision History

| Date | Revision | Description |
|---|---|---|
| November 2013 | 002 | SKU table changes |
| August 2013 | 001 | Initial release |

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# 1.0 Introduction

## 1.1 Purpose / Scope / Audience

This document contains the following processor information:

- DC electrical specifications
- Pinout and signal definitions
- Interface functional descriptions
- Additional product feature information
- Configuration registers pertinent to the implementation and operation of the processor on its respective platform.

For register details, see the *Mobile 3rd Generation Intel® Core™ Processor Family, Intel® Pentium® Processor Family, and Intel® Celeron® Processor Family Datasheet, Volume 2 of 2*

## 1.2 Related Documents

See the following documents for additional information.

**Table 1-1. Processor Documents**

| Document | Document Number/ Location |
|---|---|
| *Mobile 3rd Generation Intel® Core™ Processor Family, Intel® Pentium® Processor Family, and Intel® Celeron® Processor Family Datasheet, Volume 2 of 2* | 326769 https://www-ssl.intel.com/content/www/us/en/processors/core/3rd-gen-core-family-mobile-vol-2-datasheet.html |

**Table 1-2. Intel® Communications Chipset 89xx Documents**

| Document | Document Number/ Location |
|---|---|
| *Intel® Communications Chipset 89xx Series Datasheet* | 327879 |
| *Intel® Communications Chipset 89xx Series Thermal/Mechanical Design Guide (TMDG)* | 328012 |

## Table 1-3. Public Specifications

| Document | Document Number/ Location |
|---|---|
| *Advanced Configuration and Power Interface Specification 3.0* | http://www.acpi.info/ |
| *PCI Local Bus Specification 3.0* | http://www.pcisig.com/specifications |
| *PCI Express Base Specification, Rev. 2.0* | http://www.pcisig.com |
| *DDR3 SDRAM Specification* | http://www.jedec.org |
| Intel® *64 and IA-32 Architectures Software Developer's Manuals:*<br>• *Volume 1: Basic Architecture*<br>• *Volume 2A: Instruction Set Reference, A-M*<br>• *Volume 2B: Instruction Set Reference, N-Z*<br>• *Volume 3A: System Programming Guide*<br>• *Volume 3B: System Programming Guide* | http://www.intel.com/products/processor/manuals/index.htm<br>• 253665<br>• 253666<br>• 253667<br>• 253668<br>• 253669 |
| *Intel® 64 and IA-32 Architectures Software Developer's Manual Documentation Changes* | http://www.intel.com/content/www/us/en/architecture-and-technology/64-ia-32-architectures-software-developers-manual.html |
| *Intel® Virtualization Technology Specification for Directed I/O Architecture Specification* | http://download.intel.com/technology/computing/vptech/Intel(r)_VT_for_Direct_IO.pdf |

## 1.3 Terminology

### Table 1-4. Terminology (Sheet 1 of 2)

| Term | Description |
|---|---|
| BLT | Block Level Transfer |
| BMC | Baseboard Management Controller |
| DDR3 | Third-generation Double Data Rate SDRAM memory technology |
| DMA | Direct Memory Access |
| DMI | Direct Media Interface |
| DPC | DIMMs Per Channel |
| DTS | Digital Thermal Sensor |
| ECC | Error Correction Code |
| Enhanced Intel SpeedStep® Technology | Technology that provides power management capabilities to laptops. |
| Execute Disable Bit | The Execute Disable bit allows memory to be marked as executable or non-executable, when combined with a supporting operating system. If code attempts to run in non-executable memory the processor raises an error to the operating system. This feature can prevent some classes of viruses or worms that exploit buffer overrun vulnerabilities and can thus help improve the overall security of the system. See the *Intel® 64 and IA-32 Architectures Software Developer's Manuals* for more detailed information. |
| EU | Execution Unit |
| HFM | High Frequency Mode |
| IMC | Integrated Memory Controller |
| Intel® 64 Technology | 64-bit memory extensions to the IA-32 architecture |
| Intel® DPST | Intel® Display Power Saving Technology |
| Intel® TXT | Intel® Trusted Execution Technology is a versatile set of hardware extensions to Intel® processors and chipsets that enhance the digital office platform with security capabilities such as measured launch and protected execution. Intel® Trusted Execution Technology provides hardware-based mechanisms that help protect against software-based attacks and protects the confidentiality and integrity of data stored or created on the client PC. |
| Intel® VT-d | Intel® Virtualization Technology (Intel® VT) for Directed I/O. Intel® VT-d is a hardware assist, under system software (Virtual Machine Manager or OS) control, for enabling I/O device virtualization. Intel VT-d also brings robust security by providing protection from errant DMAs by using DMA remapping, a key feature of Intel VT-d. |
| Intel® Virtualization Technology | Processor virtualization which when used in conjunction with Virtual Machine Monitor software enables multiple, robust independent software environments inside a single platform. |
| IOV | I/O Virtualization |
| ITPM | Integrated Trusted platform Module |
| LFM | Low Frequency Mode |
| NCTF | Non-Critical to Function. NCTF locations are typically redundant ground or non-critical reserved, so the loss of the solder joint continuity at end of life conditions will not affect the overall product functionality. |
| ODT | On-Die termination |
| PCH | Platform Controller Hub. The new, 2009 chipset with centralized platform capabilities including the main I/O interfaces along with power management, manageability, security and storage features. |

## Table 1-4. Terminology (Sheet 2 of 2)

| Term | Description |
|---|---|
| PCLMULQDQ | Single Instruction Multiple Data (SIMD) instruction that computes the 128-bit carry-less multiplication of two, 64-bit operands without generating and propagating carries. |
| PECI | Platform Environment Control Interface. |
| Processor | The 64-bit, single-core or multi-core component (package). |
| Processor Core | The term "processor core" refers to Si die itself which can contain multiple execution cores. Each execution core has an instruction cache, data cache, and 256-KB L2 cache. All execution cores share the L3 cache. |
| PCU | Power Control Unit |
| Rank | A unit of DRAM corresponding four to eight devices in parallel, ignoring ECC. These devices are usually, but not always, mounted on a single side of a DIMM. |
| SCI | System Control Interrupt. Used in ACPI protocol. |
| Storage Conditions | A non-operational state. The processor may be installed in a platform, in a tray, or loose. Processors may be sealed in packaging or exposed to free air. Under these conditions, processor landings should not be connected to any supply voltages, have any I/Os biased or receive any clocks. Upon exposure to "free air" (i.e., unsealed packaging or a device removed from packaging material) the processor must be handled in accordance with moisture sensitivity labeling (MSL) as indicated on the packaging material. |
| SVID | Serial Voltage Identification |
| System Agent | Consists of all the uncore functions within the processor other than the cores and cache. This includes the integrated memory controller, PCIe controller, PCU, etc. |
| TAC | Thermal Averaging Constant |
| TDP | Thermal Design Power. |
| TDC | Thermal Design Current is the maximum current that the VR must be thermally capable of sustaining indefinitely in the worst-case thermal environment defined for the platform. |
| TLP | Transaction Layer Packets |
| TPM | Trusted Platform Module |
| $V_{CC}$ | Processor core power supply. |
| $V_{SS}$ | Processor ground. |
| $V_{TT}$ | L3 shared cache, memory controller, and processor I/O power rail. |
| $V_{DDQ}$ | DDR3 power rail. |
| $V_{CCSA}$ | System Agent (memory controller, DMI and PCIe controllers) power supply |
| $V_{CCIO}$ | High Frequency I/O logic power supply |
| $V_{CCPLL}$ | PLL power supply |
| VLD | Variable Length Decoding |
| x1 | Refers to a Link or Port with one Physical Lane. |
| x4 | Refers to a Link or Port with four Physical Lanes. |
| x8 | Refers to a Link or Port with eight Physical Lanes. |
| x16 | Refers to a Link or Port with sixteen Physical Lanes. |

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# 2.0 Product Overview

The Intel® Xeon® E3-1125C v2, E3-1105C v2, Intel® Pentium® Processor B925C, and Intel® Core™ i3-3115C Processors for Communications Infrastructure is a repackaging of the 3rd Generation Intel® Core™ Mobile Processor. This document addresses pairing the Intel® Xeon® E3-1125C v2, E3-1105C v2, Intel® Pentium® Processor B925C, and Intel® Core™ i3-3115C Processors for Communications Infrastructure processor with Intel® Communications Chipset 89xx SeriesPlatform Controller Hub (known as the PCH). This platform was developed to provide flexible design options, powerful processor performance, and acceleration services that include Intel® QuickAssist Technology. Figure 2-1 shows a block diagram of the platform.

This publication provides DC electrical specifications, signaling specifications, pinout and signal definitions, interface functional descriptions, thermal specifications, and additional feature information pertinent to the implementation and operation of the processor.

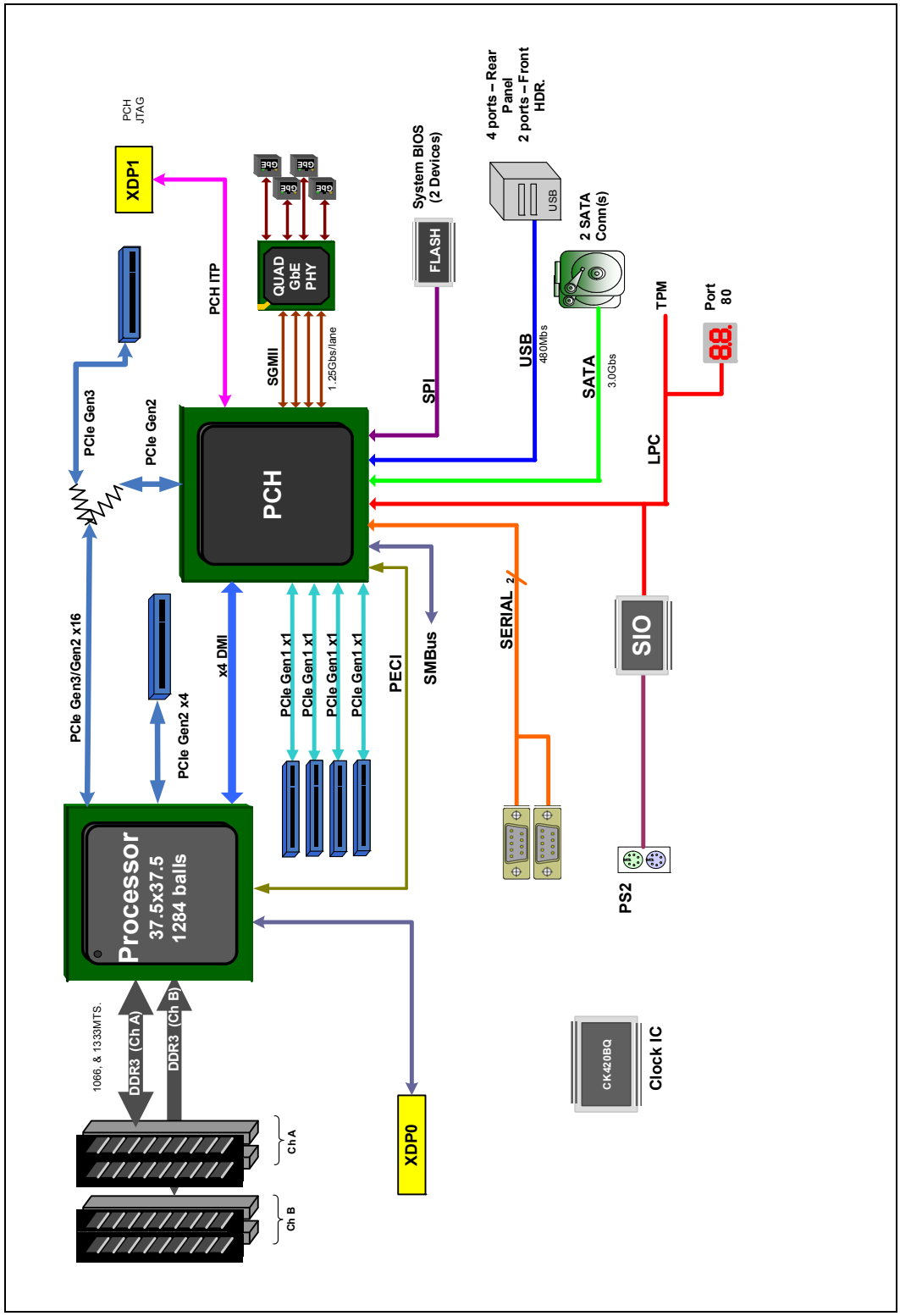
The processor is offered in a Quad Core or Dual Core 1284-ball FC-BGA (Flip Chip Ball Grid Array) package. Each of the processor offerings are fully pin-compatible and provided in the same 37.5 x 37.5 mm FCBGA package size with a ball pitch of 1.016 mm. The processor is a 64-bit, multi-core processor built on 22-nanometer process technology. It supports DDR3/DDR3L with Error Correction Code (ECC) and up to 20 PCI Express* lanes. The processor is based on Intel® micro-architecture and is designed for a two-chip platform.

Included in the processor is an integrated memory controller (IMC) and integrated I/O (PCI Express* and DMI) on a single silicon die. This single die solution is known as a monolithic processor. The integration of the memory and PCI Express* controllers into the processor silicon will benefit I/O intensive applications in the communications segments.

*Note:* Some processor features are not available on all platforms. See Table 5-1 for list of processor SKUs.

*Note:* The processors for this platform do not include the Integrated Display Engine or the Graphics Processor Unit (GPU). Disregard references to graphics and Intel® Turbo Boost in the *Mobile 3rd Generation Intel® Core™ Processor Family, Intel® Pentium® Processor Family, and Intel® Celeron® Processor Family Datasheet, Volume 2 of 2*.

## Figure 2-1. Platform Example Block Diagram



## 2.1 Processor Feature Details

- Four, two, or single execution cores (4C, 2C, or 1C respectively)
- 32-KB data first-level cache (L1) for each core, parity protected
- 32-KB instruction first-level cache (L1) for each core, ECC protected
- 256-KB shared instruction/data second-level cache (L2) for each core, ECC protected
- Up to 8-MB shared instruction/data third-level cache (L3) across all cores, ECC protected

### 2.1.1 Supported Technologies

- Intel® Virtualization Technology for Directed I/O (Intel® VT-d)
- Intel® Virtualization Technology (Intel® VT-x)
- Intel® Trusted Execution Technology (Intel® TXT)
- Intel® Streaming SIMD Extensions 4.1 (Intel® SSE4.1)
- Intel® Streaming SIMD Extensions 4.2 (Intel® SSE4.2)
- Intel® Hyper-Threading Technology
- Intel® 64 Architecture
- Execute Disable Bit
- Intel® Advanced Vector Extensions (Intel® AVX)
- Advanced Encryption Standard New Instructions (AES-NI)
- PCLMULQDQ Instruction
- RDRAND instruction for random number generation
- SMEP – Supervisor Mode Execution Protection
- PAIR – Power Aware Interrupt Routing

## 2.2 Interface Features

### 2.2.1 System Memory Support

- One or two channels of DDR3/DDR3L memory with a maximum of two UDIMMs or two SO-DIMMs per channel
- ECC Memory Down topology of up to eighteen x8 SDRAM devices per channel
- Non-ECC Memory Down topology of up to eight x16 DDR3/DDR3L SDRAM devices per channel
- Single- and dual-channel memory organization modes
- Memory capacity supported from 512 MB up to 32 GB
- Using 4-Gb device technologies, the largest total memory capacity possible is 32 GB, assuming Dual Channel Mode with four x8, double-sided, dual-ranked unbuffered DIMM memory configuration
- 1-Gb, 2-Gb, and 4-Gb DDR3/DDR3L DRAM technologies are supported for x8 and x16 devices
- Processor on-die Reference Voltage (VREF) generation for both DDR3 Read (RDVREF) and Write (VREFDQ)
- Data burst length of eight for all memory organization modes

- Memory DDR3/DDR3L data transfer rates of 1333 MT/s and 1600 MT/s.
- 72-bit wide channels, 64-bit data + 8-bit ECC
- 64-bit wide channels, without ECC option
- System Memory Interface I/O Voltage of 1.35V and 1.5V
- DDR3 and DDR3L DIMMs/DRAMs running at 1.5V
- DDR3L DIMMs/DRAMs running at 1.35V
- Supports memory configurations that mix DDR3 DIMMs/DRAMs with DDR3L DIMMs/DRAMs running at 1.5V
- Supports ECC and non-ECC, unbuffered DDR3 DIMMs
  - — Mixing of ECC and Non-ECC DIMMS is not supported
- Theoretical maximum memory bandwidth of:
  - — 21.3 GB/s in dual-channel mode assuming DDR3 1333 MT/s
  - — 25.6 GB/s in dual-channel mode assuming DDR3 1600 MT/s
- Up to 64 simultaneous open pages, 32 per channel (assuming 8 ranks of 8 bank devices)
- Memory organizations:
  - — Single-channel modes
  - — Dual-channel modes - Intel® Flex Memory Technology: Dual-channel symmetric (Interleaved)
- Command launch modes of 1n/2n
- On-Die Termination (ODT)
- Intel® Fast Memory Access (Intel® FMA):
  - — Just-in-Time Command Scheduling
  - — Command Overlap
  - — Out-of-Order Scheduling

### 2.2.2 PCI Express*

The PCI Express* Port 1 is fully-compliant to the *PCI Express Base Specification*, Rev. 3.0 including support for 8.0 GT/s transfer speeds.

The PCI Express* Port 2 is fully-compliant to the *PCI Express Base Specification*, Rev. 2.0 including support for 5.0 GT/s transfer speeds.

Ivy Bridge Gladden processor with Cave Creek PCH configurations:

**Configuration 1**

- — One 16-lane PCI Express* port intended to connect Processor Root Port to EndPoint
- — One 4-lane PCI Express* port intended for I/O
- — Four single-lane PCI Express* ports intended for I/O via the PCH

**Configuration 2**

- — One 8-lane PCI Express* port intended to connect Processor Root Port to EndPoint
- — One 8-lane PCI Express* port intended for I/O

  - — One 4-lane PCI Express* port intended for I/O
  - — Four single-lane PCI Express* ports intended for I/O via the PCH

  **Configuration 3**

  - — One 4-lane PCI Express* port intended to connect Processor Root Port to EndPoint
  - — Three 4-lane PCI Express* port intended for I/O
  - — Four single-lane PCI Express* ports intended for I/O via the PCH
- PCI Express* 1 x16 port is mapped to PCI Device 1.
  - — One 16-lane/Two 8-lane/One 8-lane and Two 4-lane PCI Express* port
- PCI Express* 1 x4 port is mapped to PCI Device 6.
- The port may negotiate down to narrower widths.
  - — Support for x16/x8/x4/x1 widths for a single PCI Express* mode.
- 2.5 GT/s 5.0 GT/s and 8.0 GT/s PCI Express* frequencies are supported.
- Gen1 Raw bit-rate on the data pins of 2.5 Gb/s, resulting in a real bandwidth per pair of 250 MB/s given the 8b/10b encoding used to transmit data across this interface. This also does not account for packet overhead and link maintenance.
- Maximum theoretical bandwidth on interface of 4 GB/s in each direction simultaneously, for an aggregate of 8 GB/s when x16 Gen 1.
- Gen2 Raw bit-rate on the data pins of 5.0 Gb/s, resulting in a real bandwidth per pair of 500 MB/s given the 8b/10b encoding used to transmit data across this interface. This also does not account for packet overhead and link maintenance.
- Maximum theoretical bandwidth on interface of 8 GB/s in each direction simultaneously, for an aggregate of 8 GB/s when x16 Gen 2.
- Gen 3 raw bit-rate on the data pins of 8.0 GT/s, resulting in a real bandwidth per pair of 800 MB/s using 128b/130b encoding to transmit data across this interface. This also does not account for packet overhead and link maintenance.
- Maximum theoretical bandwidth on the interface of 16 GB/s in each direction simultaneously, for an aggregate of 32 GB/s when x16 Gen 3.
- Hierarchical PCI-compliant configuration mechanism for downstream devices.
- Traditional PCI style traffic (asynchronous snooped, PCI ordering).
- PCI Express* extended configuration space. The first 256 bytes of configuration space aliases directly to the PCI Compatibility configuration space. The remaining portion of the fixed 4-KB block of memory-mapped space above that (starting at 100h) is known as extended configuration space.
- PCI Express* Enhanced Access Mechanism. Accessing the device configuration space in a flat memory mapped fashion.
- Automatic discovery, negotiation, and training of link out of reset.
- Traditional AGP style traffic (asynchronous non-snooped, PCI-X Relaxed ordering).
- Peer segment destination posted write traffic (no peer-to-peer read traffic) in Virtual Channel 0:
  - — DMI -> PCI Express* Port 1
  - — DMI -> PCI Express* Port 2
  - — PCI Express* Port 1 -> DMI
  - — PCI Express* Port 2 -> DMI

- 64-bit downstream address format, but the processor never generates an address above 64 GB (Bits 63:36 will always be zeros).
- 64-bit upstream address format, but the processor responds to upstream read transactions to addresses above 64 GB (addresses where any of Bits 63:36 are nonzero) with an Unsupported Request response. Upstream write transactions to addresses above 64 GB will be dropped.
- Re-issues configuration cycles that have been previously completed with the Configuration Retry status.
- PCI Express* reference clock is 100-MHz differential clock.
- Power Management Event (PME) functions.
- Dynamic width capability
- Message Signaled Interrupt (MSI and MSI-X) messages.
- Polarity inversion.
- Static lane numbering reversal
  - — Does not support dynamic lane reversal, as defined (optional) by the *PCI Express Base Specification*, Rev. 2.0.
- Supports Half Swing "low-power/low-voltage" mode.

*Note:* The processor does not support PCI Express* Hot-Plug.

### 2.2.3 Direct Media Interface (DMI)

- DMI 2.0 support.
- Four lanes in each direction.
- 2.5 GT/s and 5.0 GT/s DMI interface to PCH
- Gen1 Raw bit-rate on the data pins of 2.5 GT/s, resulting in a real bandwidth per pair of 250 MB/s given the 8b/10b encoding used to transmit data across this interface. Does not account for packet overhead and link maintenance.
- Gen2 Raw bit-rate on the data pins of 5.0 GT/s, resulting in a real bandwidth per pair of 500 MB/s given the 8b/10b encoding used to transmit data across this interface. Does not account for packet overhead and link maintenance.
- Maximum theoretical bandwidth on interface of 2 GB/s in each direction simultaneously, for an aggregate of 4 GB/s when DMI x4.
- Shares 100-MHz PCI Express* reference clock.
- 64-bit downstream address format, but the processor never generates an address above 64 GB (Bits 63:36 will always be zeros).
- 64-bit upstream address format, but the processor responds to upstream read transactions to addresses above 64 GB (addresses where any of Bits 63:36 are nonzero) with an Unsupported Request response. Upstream write transactions to addresses above 64 GB will be dropped.
- Supports the following traffic types to or from the PCH:
  - — DMI -> DRAM
  - — DMI -> processor core (Virtual Legacy Wires (VLWs), Resetwarn, or MSIs only)
  - — Processor core -> DMI
- APIC and MSI interrupt messaging support:
  - — Message Signaled Interrupt (MSI and MSI-X) messages
- Downstream SMI, SCI and SERR error indication.

- Legacy support for ISA regime protocol (PHOLD/PHOLDA) required for parallel port DMA, floppy drive, and LPC bus masters.
- DC coupling – no capacitors between the processor and the PCH.
- Polarity inversion.
- PCH end-to-end lane reversal across the link.
- Supports Half Swing "low-power/low-voltage".

### 2.2.4 Platform Environment Control Interface (PECI)

The PECI is a one-wire interface that provides a communication channel between a PECI client (the processor) and a PECI master. The processors support the PECI 3.0 Specification.

## 2.3 Power Management Support

### 2.3.1 Processor Core

- Full support of ACPI C-states as implemented by the following processor C-states: C0, C1, C1E, C3, C6, C7
- Enhanced Intel SpeedStep® Technology

### 2.3.2 System

Full support of the ACPI S-states as implemented by system S-states S0, S3, S4, S5

### 2.3.3 Memory Controller

- Conditional self-refresh (Intel® Rapid Memory Power Management (Intel® RMPM))
- Dynamic power-down

### 2.3.4 PCI Express*

- L0s and L1 ASPM power management capability

### 2.3.5 DMI

- L0s and L1 ASPM power management capability

## 2.4 Thermal Management Support

- Digital Thermal Sensor
- Intel® Adaptive Thermal Monitor
- THERMTRIP# and PROCHOT# support
- On-Demand Mode
- Open and Closed Loop Throttling
- Memory Thermal Throttling
- External Thermal Sensor (TS-on-DIMM and TS-on-board)
- Fan speed control with DTS

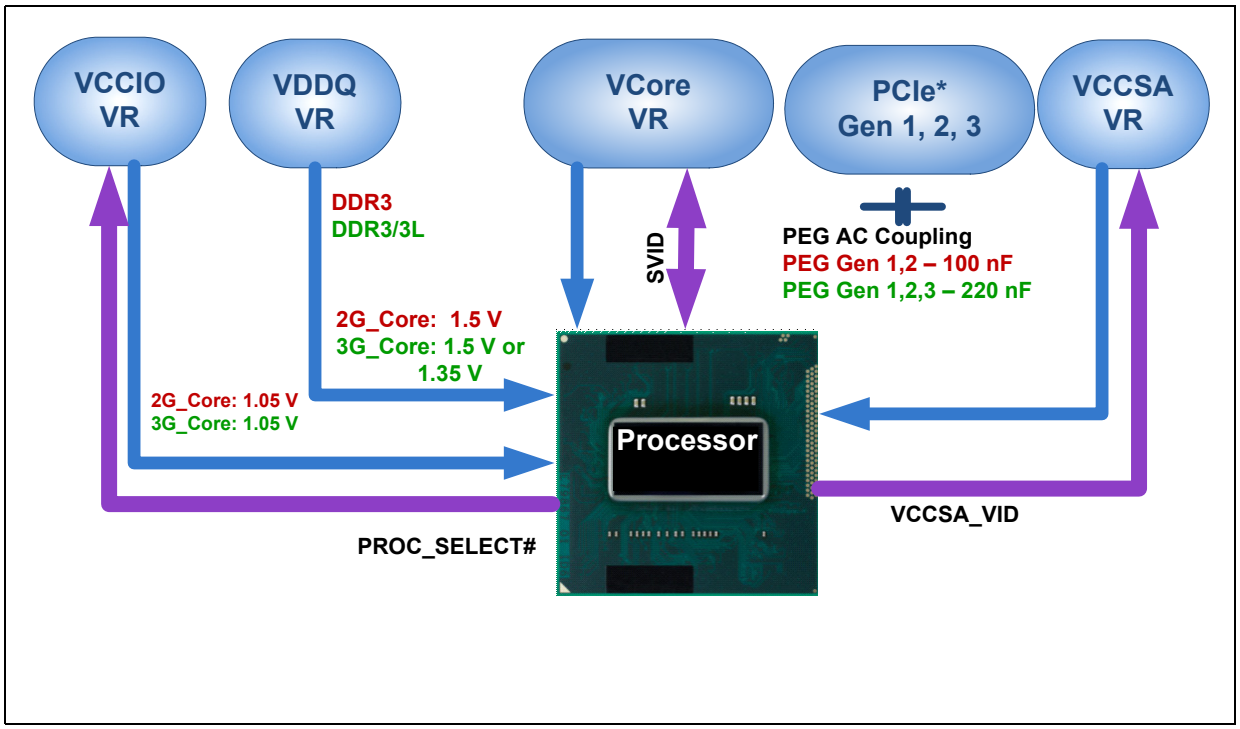
## 2.5 Package

- The processor is available in one package size:
  - — A 37.5 x 37.5 mm 1284-ball FCBGA package (BGA1284)
  - — 1.016 mm ball pitch

## 2.6 Processor Compatibility

The *3rd Generation Intel® Core™ Processor For Communications Infrastructure* family has specific platform requirements that differentiate it from a *2nd Generation Intel® Core™ Processor For Communications Infrastructure* family. Platforms that are to support both processor families need to address the platform compatibility requirements detailed in Figure 2-2.

**Figure 2-2. Processor Compatibility Diagram**




***Notes:***
1. 2G_Core = *2nd Generation Intel® Core™ Processor For Communications Infrastructure*
2. 3G_Core = *3rd Generation Intel® Core™ Processor For Communications Infrastructure*

# 3.0 Interfaces

This chapter describes the interfaces supported by the processor.

## 3.1 System Memory Interface

### 3.1.1 System Memory Configurations Supported

The Integrated Memory Controller (IMC) of the processor supports DDR3/DDR3L protocols with two independent, 72-bit wide channels. These two memory channels are capable of running speeds up to 1600 MT/s. Each channel consists of 64 data and 8 ECC bits. In the dual-channel configuration, it supports DIMMs on both channels, or DIMMs on one channel and memory down configuration on the other channel, or memory down configuration on both channels. The processor supports up to two DIMMs per channel.

*Note:* Very Low Profile (VLP) UDIMMs are supported wherever UDIMMs are supported. However, VLP UDIMMs have not been fully validated.

*Note:* Mixing of ECC and Non-ECC DIMMs is not supported.

- DDR3/DDR3L at 1.5 V Data Transfer Rates:
  - — 1333 MT/s (PC3-10600), 1600 MT/s (PC3-12800)
- DDR3L at 1.35 V Data Transfer Rates:
  - — 1333 MT/s (PC3-10600), 1600 MT/s (PC3-12800)
- DDR3/DDR3L DRAM Device Technology:
  - — Standard 1-Gb, 2-Gb, and 4-Gb technologies and addressing are supported for x16 and x8 devices. There is no support for memory modules with different technologies or capacities on opposite sides of the same memory module. If one side of a memory module is populated the other side is either identical or empty.

### 3.1.1.1 UDIMM Configurations

This section describes the UDIMM modules supported. The following DDR3/DDR3L Data Transfer Rates are supported:

- 1333 MT/s (PC3-10600), and 1600 MT/s (PC3-12800)
- DDR3/DDR3L UDIMM Modules:
  - — Raw Card A - Single Sided x8 unbuffered non-ECC
  - — Raw Card B - Double Sided x8 unbuffered non-ECC
  - — Raw Card C - Single Sided x16 unbuffered non-ECC
  - — Raw Card D - Single Sided x8 unbuffered ECC
  - — Raw Card E - Double Sided x8 unbuffered ECC

**Table 3-1. Supported UDIMM Module Configurations[1, 3]**

| Raw Card Version | DIMM Capacity | DRAM Device Technology | DRAM Organization | # of DRAM Devices | # of Physical Device Ranks | # of Row/ Col Address Bits | # of Banks Inside DRAM | Page Size |
|---|---|---|---|---|---|---|---|---|
| **Unbuffered/Non-ECC Supported DIMM Module Configurations** | | | | | | | | |
| A | 1 GB | 1 Gb | 128 M X 8 | 8 | 2 | 14/10 | 8 | 8 K |
| | 2 GB | 2 Gb | 128 M X 16 | 16 | 2 | 14/10 | 8 | 16 K |
| B | 2 GB | 1 Gb | 128 M X 8 | 16 | 2 | 14/10 | 8 | 8 K |
| | 4 GB | 2 Gb | 256 M X 8 | 16 | 2 | 15/10 | 8 | 8 K |
| | 8 GB | 4Gb | 512 M X 8 | 16 | 2 | 16/10 | 8 | 8 K |
| C | 512 MB | 1 Gb | 64 M X 16 | 4 | 1 | 13/10 | 8 | 16 K |
| | 1 GB | 2 Gb | 128 M X 16 | 4 | 1 | 14/10 | 8 | 16 K |
| **Unbuffered/ECC Supported DIMM Module Configurations** | | | | | | | | |
| D | 1 GB | 1 Gb [2] | 128 M X 8 | 9 | 1 | 14/10 | 8 | 8 K |
| | 2 GB | 2 Gb [2] | 256 M X 8 | 9 | 1 | 15/10 | 8 | 8 K |
| E | 2 GB | 1 Gb | 128 M X 8 | 18 | 2 | 14/10 | 8 | 8 K |
| | 4 GB | 2 Gb | 256 M X 8 | 18 | 2 | 15/10 | 8 | 8 K |
| | 8 GB | 4 Gb | 512 M X 8 | 18 | 2 | 16/10 | 8 | 8 K |

***Notes:***
1. DIMM module support is based on availability and is subject to change
2. Supported but not fully validated.
3. Interface does not support DDR3U DIMMs.

### 3.1.1.2 SO-DIMM Configurations

The processor supports SO-DIMM and ECC SO-DIMM designs. Table 3-2 details the SO-DIMM modules that are supported. However, these have not been fully validated.

**Table 3-2. Supported DDR3/DDR3L SO-DIMM Module Configurations[1,2]**

| Raw Card Version | DIMM Capacity | DRAM Device Technology | DRAM Organization | # of DRAM Devices | # of Physical Device Ranks | # of Row/Col Address Bits | # of Banks Inside DRAM | Page Size |
|---|---|---|---|---|---|---|---|---|
| **Unbuffered/Non-ECC Supported SO-DIMM Module Configurations** | | | | | | | | |
| A | 1 GB | 1 Gb | 64 M X 16 | 8 | 2 | 13/10 | 8 | 8 K |
| | 2 GB | 2 Gb | 128 M X 16 | 8 | 2 | 14/10 | 8 | 8 K |
| | 4 GB | 4 Gb | 256 M X 16 | 8 | 2 | 15/10 | 8 | 8 K |
| B | 1 GB | 1 Gb | 128 M X 8 | 8 | 1 | 14/10 | 8 | 8 K |
| | 2GB | 2 Gb | 256 M X 8 | 8 | 1 | 15/10 | 8 | 8 K |
| | 4 GB | 4 Gb | 512 M X 8 | 8 | 1 | 16/10 | 8 | 8 K |
| C | 512 MB | 1 Gb | 64 M X 16 | 4 | 1 | 13/10 | 8 | 8 K |
| | 1 GB | 2 Gb | 128 M X 16 | 4 | 1 | 14/10 | 8 | 8 K |
| | 2 GB | 4 Gb | 256 M X 16 | 4 | 1 | 15/10 | 8 | 8 K |
| F | 2 GB | 1 Gb | 128 M X 8 | 16 | 2 | 14/10 | 8 | 8 K |
| | 4 GB | 2 Gb | 256 M X 8 | 16 | 2 | 15/10 | 8 | 8 K |
| | 8 GB | 4 Gb | 512 M X 8 | 16 | 2 | 16/10 | 8 | 8 K |
| **Unbuffered/ECC Supported SO-DIMM Module Configurations** | | | | | | | | |
| D | 1 GB | 1 Gb | 128 M X 8 | 9 | 1 | 14/10 | 8 | 8 K |
| | 2 GB | 2 Gb | 256 M X 8 | 9 | 1 | 15/10 | 8 | 8 K |
| E | 2 GB | 1 Gb | 128 M X 8 | 18 | 2 | 14/10 | 8 | 8 K |
| | 4 GB | 2 Gb | 256 M X 8 | 18 | 2 | 15/10 | 8 | 8 K |
| | 8 GB | 4 Gb | 512 M X 8 | 18 | 2 | 16/10 | 8 | 8 K |

***Notes:***
1. DIMM module support is based on availability and is subject to change.
2. Interface does not support DDR3U SO-DIMMs.
3. Supported, but not fully validated on Intel® Xeon® and Intel® Core Processors for Communication Infrastructure.
4. Fully validated on 2nd Generation Intel® Core™ Mobile Processor

### 3.1.1.3 Supported Maximum Memory Size Per SODIMM

**Table 3-3. Supported Maximum Memory Size Per SODIMM**

| Memory | Max Size per DIMM [GB] | Max Size Per Configuration [GB] | | | |
|---|---|---|---|---|---|
| | | 1 Ch 1 DPC | 1 Ch 2 DPC | 2 Ch 1 DPC | 2 Ch 2 DPC |
| SODIMM RC A | 4 | 4 | 8 | 8 | 16 |
| SODIMM RC B | 4 | 4 | 8 | 8 | 16 |
| SODIMM RC C | 2 | 2 | 4 | 4 | 8 |
| SODIMM RC F | 8 | 8 | 16 | 16 | 32 |

### 3.1.1.4 Memory Down Configurations

The processor supports the following Memory Down configurations.

**Table 3-4. Supported Memory Down Configurations [1]**

| Raw Card Equivalent | Memory Capacity | DRAM Device Technology | DRAM Organization | # of DRAM Devices | # of Physical Device Ranks | # of Row/Col Address Bits | # of Banks Inside DRAM | Page Size |
|---|---|---|---|---|---|---|---|---|
| **Unbuffered/Non-ECC Supported Memory Down Configurations** | | | | | | | | |
| A | 1 GB | 1 Gb [2] | 64 M X 16 | 8 | 2 | 13/10 | 8 | 8 K |
| | 2 GB | 2 Gb [2] | 128 M X 16 | 8 | 2 | 14/10 | 8 | 8 K |
| B | 1 GB | 1 Gb [2] | 128 M X 8 | 8 | 1 | 14/10 | 8 | 8 K |
| | 2GB | 2 Gb [2] | 256 M X 8 | 8 | 1 | 15/10 | 8 | 8 K |
| C | 512 MB | 1 Gb [2] | 64 M X 16 | 4 | 1 | 13/10 | 8 | 8 K |
| | 1 GB | 2 Gb [2] | 128 M X 16 | 4 | 1 | 14/10 | 8 | 8 K |
| F | 2 GB | 1 Gb [2] | 128 M X 8 | 16 | 2 | 14/10 | 8 | 8 K |
| | 4 GB | 2 Gb [2] | 256 M X 8 | 16 | 2 | 15/10 | 8 | 8 K |
| | 8 GB | 4 Gb [2] | 512 M X 8 | 16 | 2 | 16/10 | 8 | 8 K |
| **Unbuffered/ECC Supported Memory Down Configurations** | | | | | | | | |
| D | 1 GB | 1 Gb [2] | 128 M X 8 | 9 | 1 | 14/10 | 8 | 8 K |
| | 2 GB | 2 Gb [2] | 256 M X 8 | 9 | 1 | 15/10 | 8 | 8 K |
| E | 2 GB | 1 Gb [2] | 128 M X 8 | 18 | 2 | 14/10 | 8 | 8 K |
| | 4 GB | 2 Gb [2] | 256 M X 8 | 18 | 2 | 15/10 | 8 | 8 K |
| | 8 GB | 4 Gb [2] | 512 M X 8 | 18 | 2 | 16/10 | 8 | 8 K |

***Notes:***
1. Interface does not support memory devices running DDR3U (1.25 V) Voltage Levels.
2. Supported, but not fully validated.

## 3.1.2 System Memory Timing Support

The processor supports the following DDR3/DDR3L Speed Bin, CAS Write Latency (CWL), and command signal mode timings on the main memory interface:

- tCL = CAS Latency
- tRCD = Activate Command to READ or WRITE Command delay
- tRP = PRECHARGE Command Period

- CWL = CAS Write Latency
- Command Signal modes = 1n indicates a new command may be issued every clock and 2n indicates a new command may be issued every 2 clocks. Command launch mode programming depends on the transfer rate and memory configuration.

**Table 3-5. DDR3 System Memory Timing Support**

| Processor SKUs | DIMMs Per Channel (DPC) | Transfer Rate (MT/s) | tCL (tCK) | tRCD (tCK) | tRP (tCK) | CWL (tCK) | CMD Mode |
|---|---|---|---|---|---|---|---|
| 4-Core or 2-Core SKUs | 1 | 1333 | 9 | 9 | 9 | 7 | 1N/2N |
| | 2 | | | | | | 2N |
| | 1 | 1600 | 11 | 11 | 11 | 8 | 1N/2N |

***Note:*** System memory timing support is based on availability and is subject to change.

## 3.1.3 System Memory Organization Modes

The processor supports two memory organization modes, single-channel and dual-channel. Depending upon how the DIMM Modules are populated in each memory channel, a number of different configurations can exist.

### 3.1.3.1 Single-Channel Mode

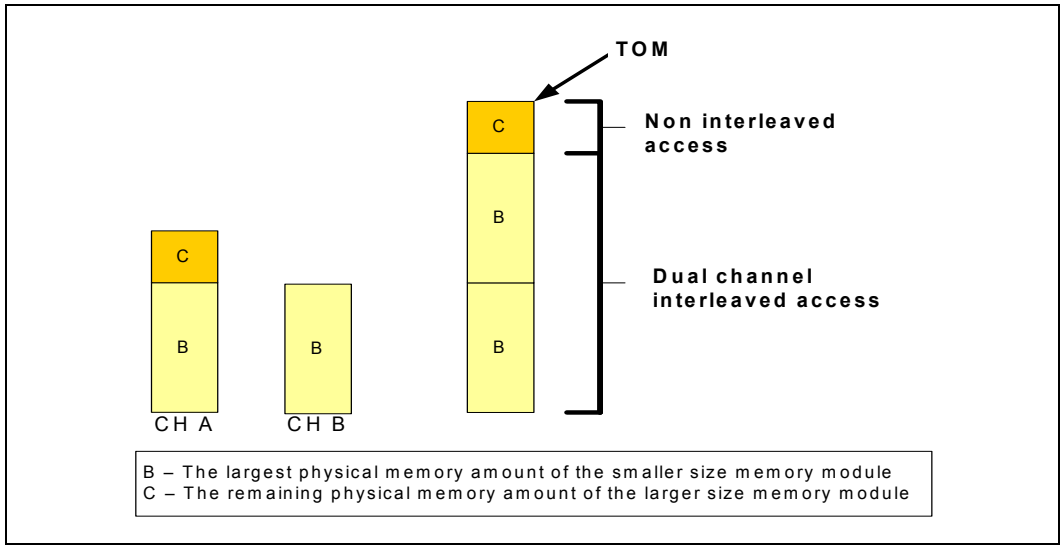
In this mode, all memory cycles are directed to a single-channel. Single-channel mode is used when either Channel A or Channel B DIMM connectors are populated in any order, but not both.

### 3.1.3.2 Dual-Channel Mode - Intel® Flex Memory Technology Mode

The processor supports Intel® Flex Memory Technology Mode. Memory is divided into a symmetric and an asymmetric zone. The symmetric zone starts at the lowest address in each channel and is contiguous until the asymmetric zone begins or until the top address of the channel with the smaller capacity is reached. In this mode, the system runs with one zone of dual-channel mode and one zone of single-channel mode, simultaneously, across the whole memory array.

*Note:* Channels A and B can be mapped for physical channels 0 and 1 respectively or vice versa; however, channel A size must be greater or equal to channel B size.

**Figure 3-1. Intel® Flex Memory Technology Operation**




#### 3.1.3.2.1 Dual-Channel Symmetric Mode

Dual-Channel Symmetric mode, also known as interleaved mode, provides maximum performance on real world applications. Addresses are ping-ponged between the channels after each cache line (64-byte boundary). If there are two requests, and the second request is to an address on the opposite channel from the first, that request can be sent before data from the first request has returned. If two consecutive cache lines are requested, both may be retrieved simultaneously, since they are ensured to be on opposite channels. Use Dual-Channel Symmetric mode when both Channel A and Channel B DIMM connectors are populated in any order, with the total amount of memory in each channel being the same.

When both channels are populated with the same memory capacity and the boundary between the dual channel zone and the single channel zone is the top of memory, IMC operates completely in Dual-Channel Symmetric mode.

*Note:* The DRAM device technology and width may vary from one channel to the other.

### 3.1.4 Rules for Populating Memory Slots

In all modes, the frequency of system memory is the lowest frequency of all memory modules placed in the system, as determined through the SPD registers on the memory modules. The system memory controller supports one or two DIMM connectors per channel. The usage of DIMM modules with different latencies is allowed. For dual-channel modes both channels must have a DIMM connector populated and for single-channel mode only a single-channel can have an DIMM connector populated.

### 3.1.5 Technology Enhancements of Intel® Fast Memory Access (Intel® FMA)

The following sections describe the Just-in-Time Scheduling, Command Overlap, and Out-of-Order Scheduling Intel® FMA technology enhancements.

#### 3.1.5.1 Just-in-Time Command Scheduling

The memory controller has an advanced command scheduler where all pending requests are examined simultaneously to determine the most efficient request to be issued next. The most efficient request is picked from all pending requests and issued to system memory Just-in-Time to make optimal use of Command Overlapping. Thus, instead of having all memory access requests go individually through an arbitration mechanism forcing requests to be executed one at a time, they can be started without interfering with the current request allowing for concurrent issuing of requests. This allows for optimized bandwidth and reduced latency while maintaining appropriate command spacing to meet system memory protocol.

#### 3.1.5.2 Command Overlap

Command Overlap allows the insertion of the DRAM commands between the Activate, Precharge, and Read/Write commands normally used, as long as the inserted commands do not affect the currently executing command. Multiple commands can be issued in an overlapping manner, increasing the efficiency of system memory protocol.

#### 3.1.5.3 Out-of-Order Scheduling

While leveraging the Just-in-Time Scheduling and Command Overlap enhancements, the IMC continuously monitors pending requests to system memory for the best use of bandwidth and reduction of latency. If there are multiple requests to the same open page, these requests would be launched in a back to back manner to make optimum use of the open memory page. This ability to reorder requests on the fly allows the IMC to further reduce latency and increase bandwidth efficiency.

#### 3.1.5.4 Memory Type Range Registers (MTRRs) Enhancement

In this processor there are additional 2 MTRRs (total 10 MTRRs). These additional MTRRs are especially important in supporting system memory beyond 4 GB.

### 3.1.6 Data Scrambling

The memory controller incorporates a DDR3 Data Scrambling feature to minimize the impact of excessive di/dt on the platform DDR3 VRs due to successive 1's and 0's on the data bus. Past experience has demonstrated that traffic on the data bus is not random and can have energy concentrated at specific spectral harmonics creating high di/dt which is generally limited by data patterns that excite resonance between the package inductance and on die capacitances. As a result the memory controller uses a data scrambling feature to create pseudo-random patterns on the DDR3 data bus to reduce the impact of any excessive di/dt.

### 3.1.7 DRAM Clock Generation

Every supported DIMM has two differential clock pairs. There are total of four clock pairs driven directly by the processor to two DIMMs.

### 3.1.8 DDR3 Reference Voltage Generation

The processor memory controller has the capability of generating the DDR3 Reference Voltage (VREF) internally for both read (RDVREF) and write (VREFDQ) operations. The generated VREF can be changed in small steps, and an optimum VREF value is determined for both during a cold boot through advanced DDR3 training procedures in order to provide the best voltage and signal margins.

## 3.2 PCI Express* Interface

This section describes the PCI Express* interface capabilities of the processor. See the PCI Express Base Specification for PCI Express* details. The processor has a total of 20 PCI Express* lanes. Port 1 lanes are fully compliant with *PCI Express Base Specification*, Rev. 3.0. Port 2 lanes are fully compliant with *PCI Express Base Specification*, Rev. 2.0. This section will discuss how these 20 PCI Express* lanes can be utilized in various configurations on the platform.

The processor has four PCI Express* controllers that can be independently configured to either Gen 1, Gen 2, or Gen 3 allowing operation at 2.5 GT/s (giga-transfers per second) 5.0 GT/s or 8.0 GT/s data rates. These four PCIe* devices operate simultaneously which are configurable in the following combinations:

- 1 x16 PCI Express* port with 1 x4 PCI Express port
- 2 x8 PCI Express* ports with 1 x4 PCI Express* port
- 1 x8 PCI Express* ports with 3 x4 PCI Express* ports

### 3.2.1 PCI Express* Architecture

Compatibility with the PCI addressing model is maintained to ensure that all existing applications and drivers operate unchanged.

The PCI Express* configuration uses standard mechanisms as defined in the PCI Plug-and-Play specification. The initial recovered clock speed of 1.25 GHz results in 2.5 Gb/s/direction, which provides a 250 MB/s communications channel in each direction (500 MB/s total), nearly twice the data rate of classic PCI. The fact that 8b/10b encoding is used accounts for the 250 MB/s where quick calculations would imply 300 MB/s.

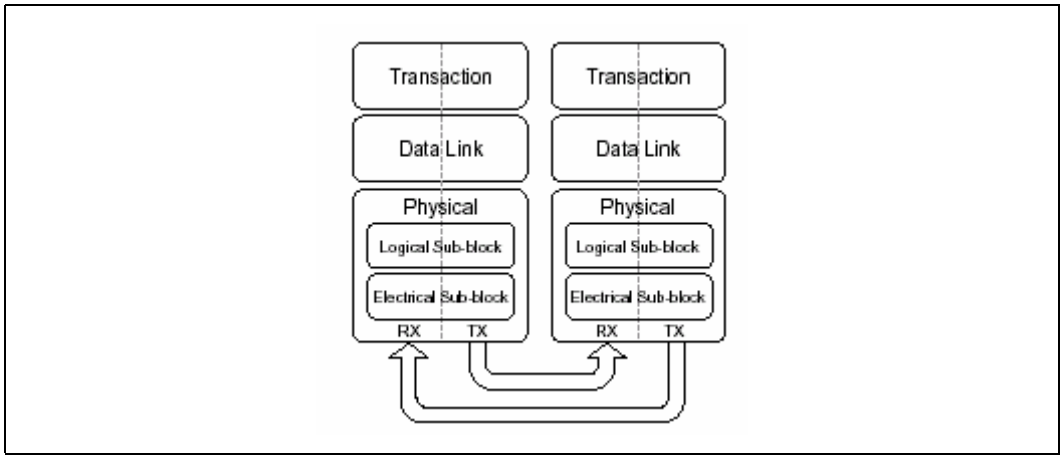
PCI Express* Port 1 supports Gen 3 speed. At 8 GT/s, Gen 3 operation results in twice as much bandwidth per lane as compared to the Gen 2 operation. The 16-lane PCI Express * port can operate at 2.5 GT/s, 5 GT/s, or 8 GT/s.

PCI Express* Port 2 supports Gen 2 speed. At 5.0 GT/s, Gen 2 operation results in double the bandwidth per lane as compared to Gen 1 operation. When operating with two PCI Express* controllers, each controller can operate at 2.5 GT/s or 5.0 GT/s.

PCI Express* Gen 3 uses a 128/130b encoding scheme, eliminating nearly all of the overhead of the 8b/10b encoding as much bandwidth per lane as compared to the Gen 1 operation.

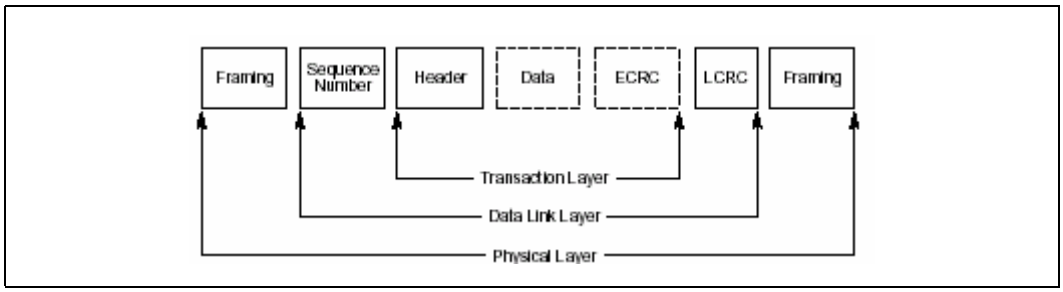
The PCI Express* architecture is specified in three layers: Transaction Layer, Data Link Layer, and Physical Layer. The partitioning in the component is not necessarily along these same boundaries. See Figure 3-2 for the PCI Express* layering diagram.

**Figure 3-2. PCI Express* Layering Diagram**




PCI Express* uses packets to communicate information between components. Packets are formed in the Transaction and Data Link Layers to carry the information from the transmitting component to the receiving component. As the transmitted packets flow through the other layers, they are extended with additional information necessary to handle packets at those layers. At the receiving side, the reverse process occurs and packets get transformed from their Physical Layer representation to the Data Link Layer representation and finally (for Transaction Layer Packets) to the form that can be processed by the Transaction Layer of the receiving device.

**Figure 3-3. Packet Flow through the Layers**




### 3.2.1.1 Transaction Layer

The upper layer of the PCI Express* architecture is the Transaction Layer. The Transaction Layer's primary responsibility is the assembly and disassembly of Transaction Layer Packets (TLPs). TLPs are used to communicate transactions, such as read and write, as well as certain types of events. The Transaction Layer also manages flow control of TLPs.

### 3.2.1.2 Data Link Layer

The middle layer in the PCI Express* stack, the Data Link Layer, serves as an intermediate stage between the Transaction Layer and the Physical Layer. Responsibilities of Data Link Layer include link management, error detection, and error correction.

The transmission side of the Data Link Layer accepts TLPs assembled by the Transaction Layer, calculates and applies data protection code and TLP sequence number, and submits them to Physical Layer for transmission across the Link. The

receiving Data Link Layer is responsible for checking the integrity of received TLPs and for submitting them to the Transaction Layer for further processing. On detection of TLP error(s), this layer is responsible for requesting retransmission of TLPs until information is correctly received, or the Link is determined to have failed. The Data Link Layer also generates and consumes packets which are used for link management functions.

#### 3.2.1.3 Physical Layer

The Physical Layer includes all circuitry for interface operation, including driver and input buffers, parallel-to-serial, and serial-to-parallel conversion, PLL(s), and impedance matching circuitry. It also includes logical functions related to interface initialization and maintenance. The Physical Layer exchanges data with the Data Link Layer in an implementation-specific format, and is responsible for converting this to an appropriate serialized format and transmitting it across the PCI Express* Link at a frequency and width compatible with the remote device.

### 3.2.2 PCI Express* Configuration Mechanism

All of the PCI Express* controllers are mapped through a PCI-to-PCI bridge structure.

PCI Express* extends the configuration space to 4096 bytes per-device/function, as compared to 256 bytes allowed by the *Conventional PCI Specification.* PCI Express* configuration space is divided into a PCI-compatible region (that consists of the first 256 bytes of a logical device's configuration space) and an extended PCI Express* region (that consists of the remaining configuration space). The PCI-compatible region can be accessed using either the mechanisms defined in the PCI specification of using the enhanced PCI Express configuration access mechanism described in the PCI Express Enhanced Configuration Mechanism section.

The PCI Express* Host Bridge is required to translate the memory-mapped PCI Express* configuration space accesses from the host processor to PCI Express configuration cycles. To maintain compatibility with PCI configuration addressing mechanisms, it is recommended that systems software access the enhanced configuration space using 32-bit operation (32-bit aligned) only. See the *PCI Express* Base Specification* for details of both the PCI-compatible and PCI Express* Enhanced configuration mechanisms and transaction rules.

The controllers for the 16 lanes (Port 1) are mapped to the root port of Device 1:

- The x16 controller is mapped to Function 0
- The x8 controller is mapped to Function 1
- The x4 controller is mapped to Function 2

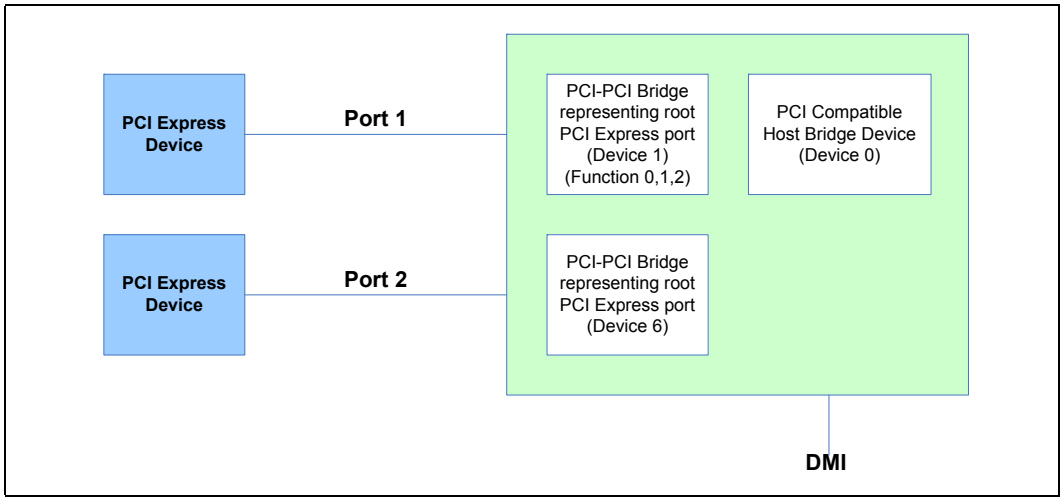
The additional x4 controller (Port 2) is PCIe* Gen1/Gen2 compatible and is mapped to Device 6 Function 0.

Three of the four controllers create Port 1 and can automatically operate on lower lane width modes allowing up to three simultaneous operating devices on these 16 lanes. Bifurcation details are described in Section 3.2.3, "PCI Express* Port Bifurcation", and the hardware straps required to enable the x16, x8 and the x4 controllers are described in Section 3.2.4, "PCI Express* Lanes Connection".

The fourth controller is a single dedicated controller, which creates the x4 Port 2 that enumerates on Device 6. Port 2 can be configured to operate in 1x4, 1x2, or 1x1 mode, but there are no hardware straps.

*Note:* The controllers in Port 1 cannot be used to function with the controller in Port 2. Therefore, the x16 lanes of Port 1 must not be combined with the x4 lanes of Port 2.

**Figure 3-4. PCI Express* Related Register Structures**



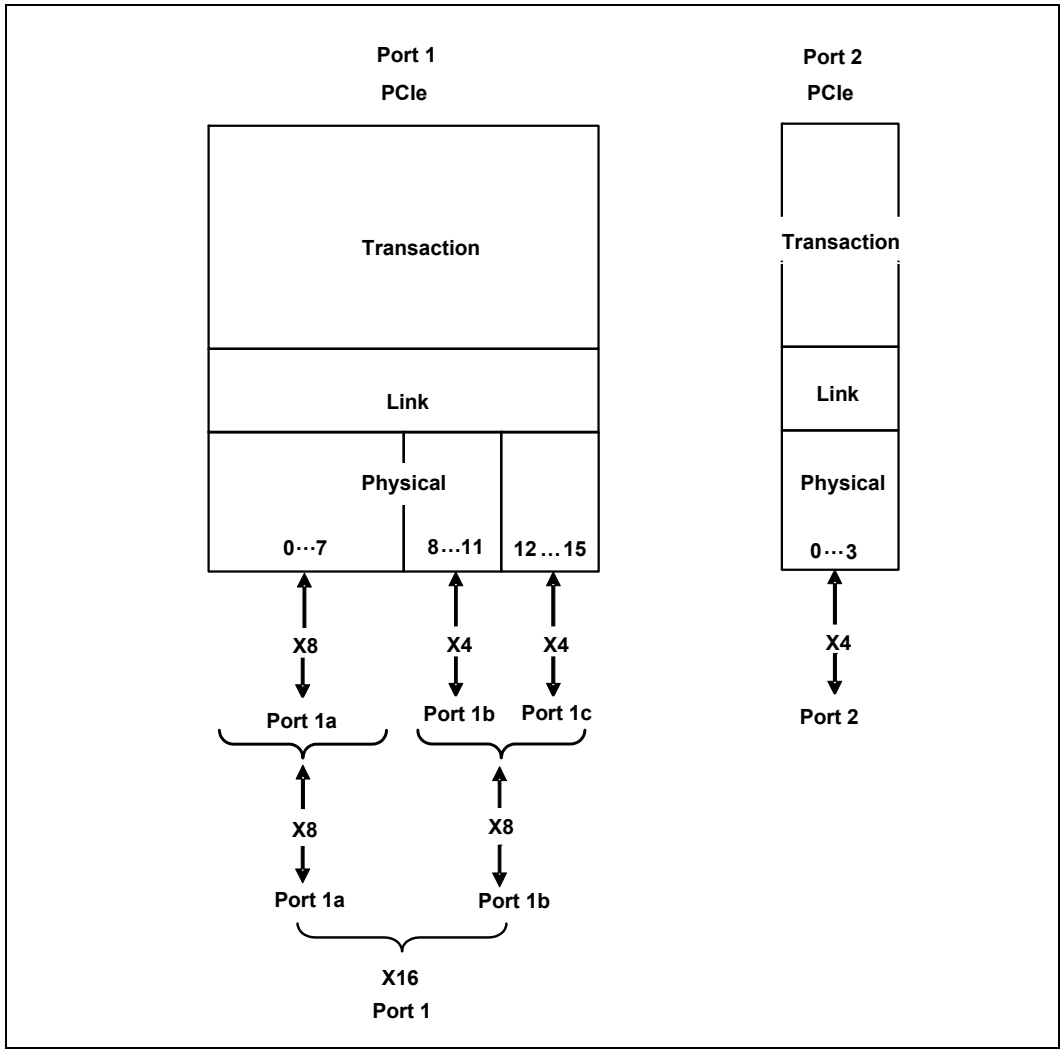

## 3.2.3 PCI Express* Port Bifurcation

Only the three controllers on Port 1 can be bifurcated. When bifurcated, the wires which had previously been assigned to lanes [15:8] of the single x16 primary port are reassigned to lanes [7:0] of the x8 secondary controller (Function 1). This assignment applies whether the lane numbering is reversed or not. Further bifurcation of Port 1 is possible through the third contoller (Function 2) to create two x4 PCI Express*.

When Port 1 is not bifurcated, Function 1 and Function 2 are hidden from the discovery mechanism used in PCI enumeration.

The controls for Port 2 and the associated virtual PCI-to-PCI bridge can be found in PCI Device 6, which provides an additional x4 port.

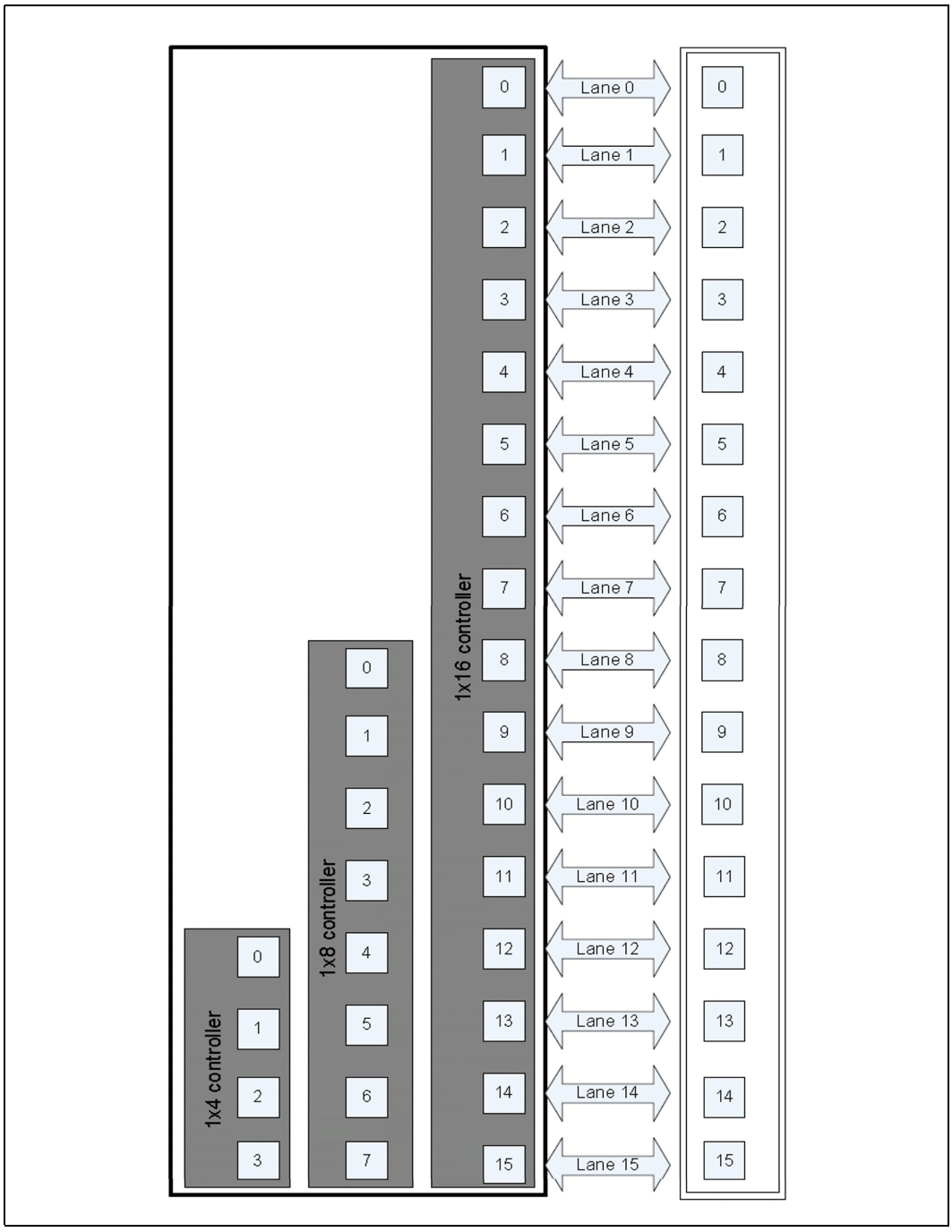
**Figure 3-5. PCI Express* PCI Port Bifurcation**



### 3.2.4 PCI Express* Lanes Connection

Figure 3-6 demonstrates the PCIe* lanes mapping.

**Figure 3-6. PCIe* Typical Operation 16 Lanes Mapping**



### 3.2.5 Configuring PCIe* Lanes

*Note:* The controllers in Port 1 cannot be used to function with the controller in Port 2. Therefore, the x16 lanes of Port 1 must not be combined with the x4 lanes of Port 2.

The following details apply to the three controllers in Port 1; Port 2 cannot be bifurcated.

The configuration of the PCIe* bus is statically determined by the pre-boot software prior to initialization. The pre-boot software determines the configuration by looking at the two configuration pins, CFG[6:5], that determine whether the additional two controllers of the 16 lanes need to be enabled or not. These strap values are read upon power up and the pre-boot software enables the appropriate number of controllers in use as follows:

**Table 3-6. Hardware Straps for PCIe* Controller Enabling (Port 1 Only)**

| CFG [6:5] | Mode |
|---|---|
| 00 | 1x8 +2x4 |
| 01 | Reserved |
| *10* | 2x8 |
| *11 (default)* | 1x16 |

No strapping is required to enable the additional four lanes (lanes [16-19]) in any of the permissible modes because it has a single dedicated controller.

The CFG[6:5] inputs have a default value of [1:1] if they are not terminated on the board. By default, a single x16 controller is enabled. When a logic 0 is required on the strap, it is recommended that they be pulled down to ground with a 1 K Ohm resistor.

*Note:* If the x16 controller is enabled by the hardware strapping and a x8 device is plugged in, the controller automatically operates in the x8 mode. The same is true for any controller that is connected to a device operating at narrower lane widths.

Hot plug is not supported on these PCIe* interfaces. If a device is not present at power up, it is not detected when it is plugged in after power up. The strap values are read upon power up and the pre-boot software enables the appropriate controller based on the value read on CFG[6:5]. Hence, if a device of lower lane width than the width of the controller that is enabled is plugged in before power up, then it is automatically detected. But if a device with higher lane width is plugged in, then the device is not detected. The same is true for the number of controllers enabled. If a single controller is enabled at power up, then a single device of any width equal to or lower than the width of the controller is detected.

For example, if upon power up, the value on CFG [6:5] is [1:1], then the 1x16 controller is enabled. A single device of width x16 will be detected upon power up. But if two devices of any lower width are plugged in; only the device connected to Device 1, Function 0 will be detected.

### 3.2.6 Lane Reversal on PCIe* Interface

The PCI Express* lanes can be reversed for ease of design and layout. Lane reversal is done statically, which means that the BIOS needs to configure the reversal before the relevant root port is enabled. For the x16 configuration, only one reversal option is supported allowing either a straight or a rotated CPU on the motherboard. No other combination of partial slot reversal is permitted. The reversal on x8 and x4 configurations are applied in a similar fashion.

The normal or reversed configuration is determined by the configuration pins CFG[2] for PCI express lanes on Port 1 and CFG[3] for lanes on Port 2. A value of '1' on these inputs would indicate normal operation and a '0' would indicate reversed mode of operation.

**Table 3-7. Hardware Straps for Normal/Reversed Operation of PCIe* Lanes**

| PCI-e Lanes | Normal | Reversed |
|---|---|---|
| Port 1 | CFG [2] =1 | CFG [2] =0 |
| Port 2 | CFG [3] =1 | CFG [3] =0 |

*Note:* Performance estimates on early silicon have shown that bandwidth in x16 mode for Gen 2 is approximately twice the bandwidth in x8 mode for read, write and read-write transaction.

## 3.3 Direct Media Interface

DMI connects the processor and the PCH. Next generation DMI 2.0 is supported.

*Note:* Only DMI x4 configuration is supported.

### 3.3.1 DMI Error Flow

DMI can only generate SERR in response to errors, never SCI, SMI, MSI, PCI INT, or GPE. Any DMI related SERR activity is associated with Device 0.

### 3.3.2 DMI Link Down

The DMI link going down is a fatal, unrecoverable error. If the DMI data link goes to data link down after the link was up, then the DMI link hangs the system by not allowing the link to retrain to prevent data corruption. The PCH controls this link behavior.

Downstream transactions that had been successfully transmitted across the link prior to the link going down may be processed as normal. No completions from downstream, non-posted transactions are returned upstream over the DMI link after a link down event.

## 3.4 Platform Environment Control Interface (PECI)

The PECI is a one-wire interface that provides a communication channel between a PECI client (processor) and a PECI master. The processor implements a PECI interface to:

- Allow communication of processor thermal and other information to the PECI master.
- Read averaged Digital Thermal Sensor (DTS) values for fan speed control.

## 3.5 Interface Clocking

### 3.5.1 Internal Clocking Requirements

**Table 3-9. Reference Clock**

| Reference Input Clock | Input Frequency | Associated PLL |
|---|---|---|
| BCLK/BCLK# | 100 MHz | Processor/Memory/PCIe/DMI |

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# 4.0 Technologies

## 4.1 Intel® Virtualization Technology

Intel® Virtualization Technology (Intel® VT) makes a single system appear to software as multiple independent systems. This allows multiple, independent operating systems to run simultaneously on a single system. Intel® VT comprises technology components to support virtualization of platforms based on Intel architecture microprocessors and chipsets. Intel® Virtualization Technology (Intel® VT) for IA-32, Intel® 64 and Intel® Architecture (Intel® VT-x) added hardware support in the processor to improve the virtualization performance and robustness. Intel® Virtualization Technology for Directed I/O (Intel® VT-d) adds chipset hardware implementation to support and improve I/O virtualization performance and robustness.

Intel® VT-x specifications and functional descriptions are included in the Intel® *64 and IA-32 Architectures Software Developer's Manual, Volume 3B* and available at http://www.intel.com/products/processor/manuals/index.htm

The Intel® VT-d spec and other Intel® VT documents can be referenced at http://www.intel.com/technology/platform-technology/virtualization/index.htm

### 4.1.1 Intel® VT-x Objectives

Intel® VT-x provides hardware acceleration for virtualization of IA platforms. Virtual Machine Monitor (VMM) can use Intel® VT-x features to provide improved reliable virtualized platform. By using Intel® VT-x, a VMM is:

- **Robust:** VMMs no longer need to use paravirtualization or binary translation. This means that they will be able to run off-the-shelf OSs and applications without any special steps.
- **Enhanced:** Intel® VT enables VMMs to run 64-bit guest operating systems on IA x86 processors.
- **More reliable:** Due to the hardware support, VMMs can now be smaller, less complex, and more efficient. This improves reliability and availability and reduces the potential for software conflicts.
- **More secure:** The use of hardware transitions in the VMM strengthens the isolation of VMs and further prevents corruption of one VM from affecting others on the same system.

### 4.1.2 Intel® VT-x Features

The processor core supports the following Intel® VT-x features:

- Extended Page Tables (EPT)
  - — EPT is hardware assisted page table virtualization
  - — It eliminates VM exits from guest OS to the VMM for shadow page-table maintenance

- Virtual Processor IDs (VPID)
  - — Ability to assign a VM ID to tag processor core hardware structures (e.g., TLBs)
  - — This avoids flushes on VM transitions to give a lower-cost VM transition time and an overall reduction in virtualization overhead.
- Guest Preemption Timer
  - — Mechanism for a VMM to preempt the execution of a guest OS after an amount of time specified by the VMM. The VMM sets a timer value before entering a guest
  - — The feature aids VMM developers in flexibility and Quality of Service (QoS) guarantees
- Descriptor-Table Exiting
  - — Descriptor-table exiting allows a VMM to protect a guest OS from internal (malicious software based) attack by preventing relocation of key system data structures like IDT (interrupt descriptor table), GDT (global descriptor table), LDT (local descriptor table), and TSS (task segment selector).
  - — A VMM using this feature can intercept (by a VM exit) attempts to relocate these data structures and prevent them from being tampered by malicious software.

### 4.1.3 Intel® VT-d Objectives

The key Intel® VT-d objectives are domain-based isolation and hardware-based virtualization. A domain can be abstractly defined as an isolated environment in a platform to which a subset of host physical memory is allocated. Virtualization allows for the creation of one or more partitions on a single system. This could be multiple partitions in the same operating system, or there can be multiple operating system instances running on the same system, offering benefits like system consolidation, legacy migration, activity partitioning, or security.

### 4.1.4 Intel® VT-d Features

The processor supports the following Intel® VT-d features:

- Memory controller complies with Intel® VT-d 1.2 specification.
- Intel® VT-d DMA remap engines.
  - — DMI (non-high def audio)
  - — PCI Express*
- Support for root entry, context entry and default context
- 39-bit guest physical address and host physical address widths
- Support for 4K page sizes only
- Support for register-based fault recording only (for single entry only) and support for MSI interrupts for faults
- Support for both leaf and non-leaf caching
- Support for boot protection of default page table
- Support for non-caching of invalid page table entries
- Support for hardware based flushing of translated but pending writes and pending reads, on IOTLB invalidation
- Support for page-selective IOTLB invalidation

- MSI cycles (MemWr to address FEEx_xxxxh) not translated
  - — Translation faults result in cycle forwarding to VBIOS region (byte enables masked for writes). Returned data may be bogus for internal agents, PEG/DMI interfaces return unsupported request status
- Interrupt Remapping is supported
- Queued invalidation is supported
- VT-d translation bypass address range is supported (Pass Through)
- Support for ARI (Alternative Requester ID - a PCI SIG ECR for increasing the function number count in a PCIe device) to support IOV devices

### 4.1.5 Intel® VT-d Features Not Supported

The following features are not supported by the processor with Intel® VT-d:

- No support for PCISIG endpoint caching (ATS)
- No support for Intel® VT-d read prefetching/snarfing i.e. translations within a cacheline are not stored in an internal buffer for reuse for subsequent translations.
- No support for advance fault reporting
- No support for super pages
- No support for Intel® VT-d translation bypass address range (such usage models need to be resolved with VMM help in setting up the page tables correctly)

## 4.2 Intel® Trusted Execution Technology (Intel® TXT)

Intel Trusted Execution Technology (Intel® TXT) defines platform-level enhancements that provide the building blocks for creating trusted platforms.

The Intel® TXT platform helps to provide the authenticity of the controlling environment such that those wishing to rely on the platform can make an appropriate trust decision. The Intel® TXT platform determines the identity of the controlling environment by accurately measuring and verifying the controlling software.

Another aspect of the trust decision is the ability of the platform to resist attempts to change the controlling environment. The Intel® TXT platform will resist attempts by software processes to change the controlling environment or bypass the bounds set by the controlling environment.

Intel® TXT is a set of extensions designed to provide a measured and controlled launch of system software that will then establish a protected environment for itself and any additional software that it may execute.

These extensions enhance two areas:

- The launching of the Measured Launched Environment (MLE)
- The protection of the MLE from potential corruption

The enhanced platform provides these launch and control interfaces using Safer Mode Extensions (SMX)

The SMX interface includes the following functions:

- Measured/Verified launch of the MLE
- Mechanisms to ensure the above measurement is protected and stored in a secure location
- Protection mechanisms that allow the MLE to control attempts to modify itself

For more information, see the *Intel® TXT Measured Launched Environment Developer's Guide* in http://www.intel.com/content/www/us/en/software-developers/intel-txt-software-development-guide.html.

## 4.3 Intel® Hyper-Threading Technology

The processor supports Intel® Hyper-Threading Technology (Intel® HT Technology), which allows an execution core to function as two logical processors. While some execution resources such as caches, execution units, and buses are shared, each logical processor has its own architectural state with its own set of general-purpose registers and control registers. This feature must be enabled via the BIOS and requires operating system support.

Intel recommends enabling Hyper-Threading Technology with Microsoft Windows 7*, Microsoft Windows Vista*, Microsoft Windows* XP Professional/Windows* XP Home, and disabling Hyper-Threading Technology via the BIOS for all previous versions of Windows operating systems. For more information on Hyper-Threading Technology, see http://www.intel.com/technology/platform-technology/hyper-threading/.

## 4.4 Intel® Advanced Vector Extensions (Intel® AVX)

Intel® Advanced Vector Extensions (Intel® AVX) is the latest expansion of the Intel instruction set. It extends the Intel® Streaming SIMD Extensions (SSE) from 128-bit vectors into 256-bit vectors. Intel® AVX addresses the continued need for vector floating-point performance in mainstream scientific and engineering numerical applications, visual processing, recognition, data-mining/synthesis, gaming, physics, cryptography and other areas of applications.

The enhancement in Intel® AVX allows for improved performance due to wider vectors, new extensible syntax, and rich functionality including the ability to better manage, rearrange, and sort data. For more information on Intel® AVX, see http://www.intel.com/software/avx.

## 4.5 Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI)

The processor supports Advanced Encryption Standard New Instructions (Intel® AES-NI), which are a set of Single Instruction Multiple Data (SIMD) instructions that enable fast and secure data encryption and decryption based on the Advanced Encryption Standard (AES). Intel® AES-NI are valuable for a wide range of cryptographic applications, for example: applications that perform bulk encryption/decryption, authentication, random number generation, and authenticated encryption. AES is broadly accepted as the standard for both government and industry applications, and is widely deployed in various protocols.

Intel® AES-NI consists of six Intel® SSE instructions. Four instructions, namely AESENC, AESENCLAST, AESDEC, and AESDELAST facilitate high performance AES encryption and decryption. The other two, namely AESIMC and AESKEYGENASSIST, support the AES key expansion procedure. Together, these instructions provide a full hardware for support AES, offering security, high performance, and a great deal of flexibility.

### 4.5.1 PCLMULQDQ Instruction

The processor supports the carry-less multiplication instruction, PCLMULQDQ. PCLMULQDQ is a Single Instruction Multiple Data (SIMD) instruction that computes the 128-bit carry-less multiplication of two, 64-bit operands without generating and propagating carries. Carry-less multiplication is an essential processing component of

several cryptographic systems and standards. Hence, accelerating carry-less multiplication can significantly contribute to achieving high speed secure computing and communication.

### 4.5.2 RDRAND Instruction

The processor introduces a software visible random number generation mechanism supported by a high quality entropy source. This capability will be made available to programmers through the new RDRAND instruction. The resultant random number generation capability is designed to comply with existing industry standards in this regard (ANSI X9.82 and NIST SP 800-90).

Some possible usages of the new RDRAND instruction include cryptographic key generation as used in a variety of applications including communication, digital signatures, secure storage, and so on.

## 4.6 Intel® 64 Architecture x2APIC

The x2APIC architecture extends the xAPIC architecture which provides key mechanism for interrupt delivery. This extension is intended primarily to increase processor addressability.

Specifically, x2APIC:

- Retains all key elements of compatibility to the xAPIC architecture:
  - — delivery modes
  - — interrupt and processor priorities
  - — interrupt sources
  - — interrupt destination types
- Provides extensions to scale processor addressability for both the logical and physical destination modes.
- Adds new features to enhance performance of interrupt delivery.
- Reduces complexity of logical destination mode interrupt delivery on link based architectures.

The key enhancements provided by the x2APIC architecture over xAPIC are the following:

- Support for two modes of operation to provide backward compatibility and extensibility for future platform innovations.
  - — In xAPIC compatibility mode, APIC registers are accessed through memory mapped interface to a 4K-Byte page, identical to the xAPIC architecture.
  - — In x2APIC mode, APIC registers are accessed through Model Specific Register (MSR) interfaces. In this mode, the x2APIC architecture provides significantly increased processor addressability and some enhancements on interrupt delivery.
- Increased range of processor addressability in x2APIC mode:
  - — Physical xAPIC ID field increases from 8 bits to 32 bits, allowing for interrupt processor addressability up to 4G-1 processors in physical destination mode. A processor implementation of x2APIC architecture can support fewer than 32-bits in a software transparent fashion.
  - — Logical xAPIC ID field increases from 8 bits to 32 bits. The 32-bit logical x2APIC ID is partitioned into two sub-fields: a 16-bit cluster ID and a 16-bit logical ID within the cluster. Consequently, ((2^20) -16) processors can be addressed in

logical destination mode. Processor implementations can support fewer than 16 bits in the cluster ID sub-field and logical ID sub-field in a software agnostic fashion.

- More efficient MSR interface to access APIC registers.
  - To enhance inter-processor and self directed interrupt delivery as well as the ability to virtualize the local APIC, the APIC register set can be accessed only through MSR based interfaces in the x2APIC mode. The Memory Mapped IO (MMIO) interface used by xAPIC is not supported in the x2APIC mode.
- The semantics for accessing APIC registers have been revised to simplify the programming of frequently-used APIC registers by system software. Specifically the software semantics for using the Interrupt Command Register (ICR) and End Of Interrupt (EOI) registers have been modified to allow for more efficient delivery and dispatching of interrupts.

The x2APIC extensions are made available to system software by enabling the local x2APIC unit in the "x2APIC" mode. In order to benefit from x2APIC capabilities, a new Operating System and a new BIOS are both needed, with special support for the x2APIC mode.

The x2APIC architecture provides backward compatibility to the xAPIC architecture and forward extendibility for future Intel platform innovations.

*Note:* Intel x2APIC technology may not be available on all SKUs.

For more information see the Intel® 64 Architecture x2APIC specification at http://www.intel.com/products/processor/manuals/

## 4.7 Supervisor Mode Execution Protection (SMEP)

The processor introduces a new mechanism that provides next level of system protection by blocking malicious software attacks from user mode code when the system is running in the highest privilege level.

This technology helps to protect from virus attacks and unwanted code to harm the system.

For more information see *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 3A* at: http://www.intel.com/Assets/PDF/manual/253668.pdf.

## 4.8 Power Aware Interrupt Routing (PAIR)

The processor added enhanced power-performance technology which routes interrupts to threads or cores based on their sleep states. For example concerning energy savings, it routes the interrupt to the active cores without waking the deep idle cores. For Performance, it routes the interrupt to the idle (C1) cores without interrupting the already heavily loaded cores. This enhancement is mostly beneficial for high interrupt scenarios like Gigabit LAN, WLAN peripherals, and so on.

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# 5.0 Processor SKUs

This section details the features of the various processor SKUs. The mix of SKUs are chosen to span cost, performance, temperature environment, and power consumption.

## 5.1 SKU Features

Table 5-1 outlines the available SKUs.

**Table 5-1. Base Features by SKU**

| Intel® Xeon® and Intel® Core™ Processors for Communications Infrastructure | | | | |
|---|---|---|---|---|
| **Product Name** | **E3-1125C v2** | **E3-1105C v2** | **i3-3115C** | **B925C** |
| Target Core Speed (GHz) | 2.5 | 1.8 | 2.5 | 2.0 |
| Active Cores | 4 | 4 | 2 | 2 |
| TDP[1] (Watts) | 40 | 25 | 25 | 15 |
| L3 Cache (MB) | 8 | 8 | 4 | 4 |
| Memory Channels | 2 | 2 | 2 | 2 |
| ECC Memory | Yes | | | |
| PCI-Express* (lanes) | 20 | | | |
| PCI-Express* (root) | 1x16 +1x4 or 2x8 +1x4 or 1x8 +3x4 | | | |
| Junction Temperature | $T_{J\text{-}Min}$ = 0°C, $T_{J\text{-}MAX}$ = 100°C | | | |
| Intel® Virtualization Technology | Yes | | | |
| Intel® Hyper-Threading Technology | Yes | | | |
| Intel® Trusted Execution Technology | Yes | | | |
| Graphics | No | | | |
| Intel® Turbo Boost | No | | | |

***Notes:***

1. Thermal Design Power (TDP) is a system design target associated with the maximum component operating temperature specifications. TDP values are determined based on typical DC electrical specification and maximum component temperature for a realistic-case application running at maximum utilization.

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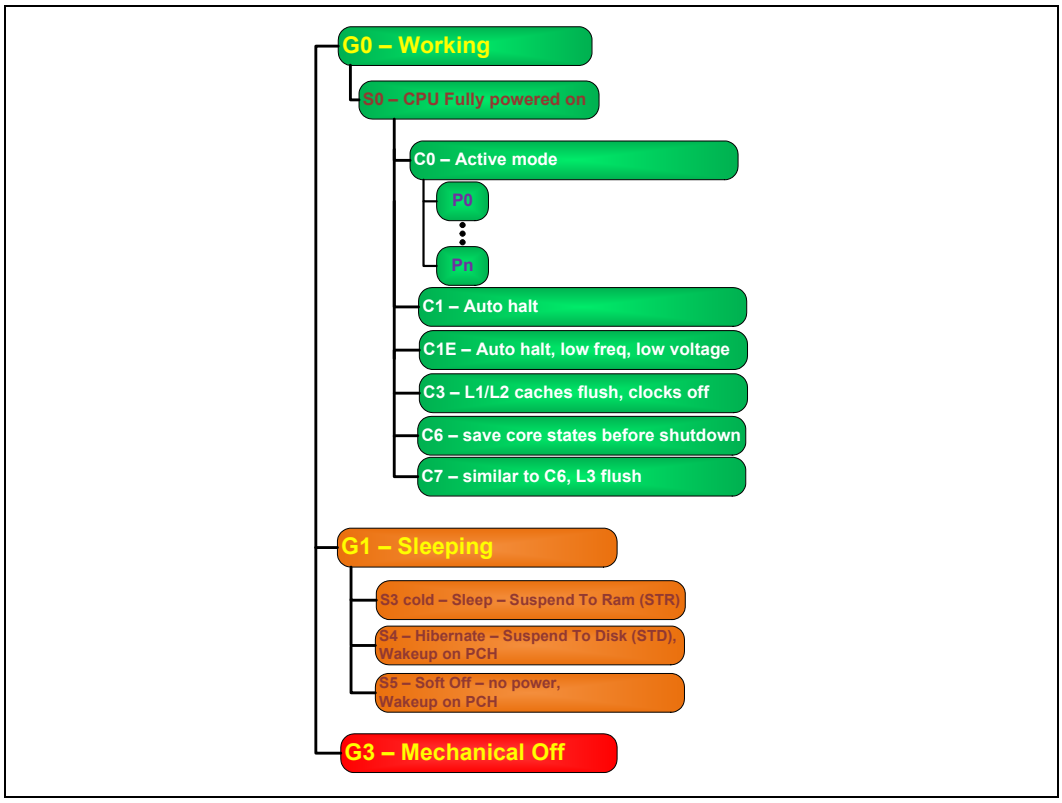
# 6.0 Power Management

This chapter provides information on the following power management topics:

- ACPI States
- Processor Core
- Integrated Memory Controller (IMC)
- PCI Express*
- Direct Media Interface (DMI)

**Figure 6-1. Power States**



## 6.1 ACPI States Supported

This section describes the ACPI states supported by the processor

### 6.1.1 System States

**Table 6-1. System States**

| State | Description |
|---|---|
| G0/S0 | Full On |
| G1/S3-Cold | Suspend-to-RAM (STR). Context saved to memory (S3-Hot is not supported by the processor). |
| G1/S4 | Suspend-to-Disk (STD). All power lost (except wakeup on PCH). |
| G2/S5 | Soft off. All power lost (except wakeup on PCH). Total reboot. |
| G3 | Mechanical off. All power (AC and battery) removed from system. |

### 6.1.2 Processor Core/Package Idle States

**Table 6-2. Processor Core/Package State Support**

| State | Description |
|---|---|
| C0 | Active mode, processor executing code. |
| C1 | AutoHALT state. |
| C1E | AutoHALT state with lowest frequency and voltage operating point. |
| C3 | Execution cores in C3 flush their L1 instruction cache, L1 data cache, and L2 cache to the L3 shared cache. Clocks are shut off to each core. |
| C6 | Execution cores in this state save their architectural state before removing core voltage. |
| C7 | Execution cores in this state behave similarly to the C6 state. if all execution cores request C7, L3 cache ways are flushed until it is cleared. |

### 6.1.3 Integrated Memory Controller States

**Table 6-3. Integrated Memory Controller States**

| State | Description |
|---|---|
| Power up | CKE asserted. Active mode. |
| Pre-charge Power-down | CKE deasserted (not self-refresh) with all banks closed. |
| Active Power-down | CKE deasserted (not self-refresh) with minimum one bank active. |
| Self-Refresh | CKE deasserted using device self-refresh. |

### 6.1.4 PCIe* Link States

**Table 6-4. PCIe* Link States**

| State | Description |
|---|---|
| L0 | Full on – Active transfer state. |
| L0s | First Active Power Management low power state – Low exit latency. |
| L1 | Lowest Active Power Management – Longer exit latency. |
| L3 | Lowest power state (power-off) – Longest exit latency. |

### 6.1.5 DMI States

**Table 6-5. DMI States**

| State | Description |
|---|---|
| L0 | Full on – Active transfer state. |
| L0s | First Active Power Management low power state – Low exit latency. |
| L1 | Lowest Active Power Management - Longer exit latency. |
| L3 | Lowest power state (power-off) – Longest exit latency. |

### 6.1.6 Interface State Combinations

**Table 6-6. G, S and C State Combinations**

| Global (G) State | Sleep (S) State | Processor Core (C) State | Processor State | System Clocks | Description |
|---|---|---|---|---|---|
| G0 | S0 | C0 | Full On | On | Full On |
| G0 | S0 | C1/C1E | Auto-Halt | On | Auto-Halt |
| G0 | S0 | C3 | Deep Sleep | On | Deep Sleep |
| G0 | S0 | C6/C7 | Deep Power-down | On | Deep Power Down |
| G1 | S3 | Power off | | Off, except RTC | Suspend to RAM |
| G1 | S4 | Power off | | Off, except RTC | Suspend to Disk |
| G2 | S5 | Power off | | Off, except RTC | Soft Off |
| G3 | NA | Power off | | Power off | Hard off |

**Table 6-7. D, S, and C State Combination (Sheet 1 of 2)**

| Graphics Adapter (D) State | Sleep (S) State | Package (C) State | Description |
|---|---|---|---|
| D0 | S0 | C0 | Full On, Displaying |
| D0 | S0 | C1/C1E | Auto-Halt, Displaying |
| D0 | S0 | C3 | Deep sleep, Displaying |
| D0 | S0 | C6 | Deep Power Down, Displaying |

**Table 6-7. D, S, and C State Combination (Sheet 2 of 2)**

| Graphics Adapter (D) State | Sleep (S) State | Package (C) State | Description |
|---|---|---|---|
| D3 | S0 | Any | Not displaying |
| D3 | S3 | N/A | Not displaying, Graphics Core is powered off |
| D3 | S4 | N/A | Not displaying, suspend to disk |

## 6.2 Processor Core Power Management

While executing code, Enhanced Intel SpeedStep® Technology optimizes the processor's frequency and core voltage based on workload. Each frequency and voltage operating point is defined by ACPI as a P-state. When the processor is not executing code, it is idle. A low-power idle state is defined by ACPI as a C-state. In general, lower power C-states have longer entry and exit latencies.

### 6.2.1 Enhanced Intel SpeedStep® Technology

The following are the key features of Enhanced Intel SpeedStep Technology:

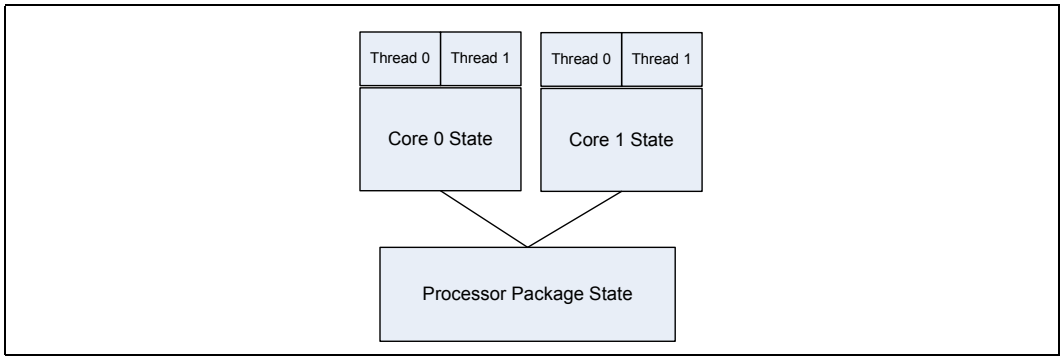
- Multiple frequency and voltage points for optimal performance and power efficiency. These operating points are known as P-states.
- Frequency selection is software controlled by writing to processor MSRs. The voltage is optimized based on the selected frequency and the number of active processor cores.
  - If the target frequency is higher than the current frequency, $V_{CC}$ is ramped up in steps to an optimized voltage. This voltage is signaled by the SVID bus to the voltage regulator. Once the voltage is established, the PLL locks on to the target frequency.
  - If the target frequency is lower than the current frequency, the PLL locks to the target frequency, then transitions to a lower voltage by signaling the target voltage on the SVID bus.
  - All active processor cores share the same frequency and voltage. In a multi-core processor, the highest frequency P-state requested amongst all active cores is selected.
  - Software-requested transitions are accepted at any time. If a previous transition is in progress, the new transition is deferred until the previous transition is completed.
- The processor controls voltage ramp rates internally to ensure glitch-free transitions.
- Because there is low transition latency between P-states, a significant number of transitions per-second are possible.

### 6.2.2 Low-Power Idle States

When the processor is idle, low-power idle states (C-states) are used to save power. More power savings actions are taken for numerically higher C-states. However, higher C-states have longer exit and entry latencies. Resolution of C-states occur at the thread, processor core, and processor package level. Thread-level C-states are available if Intel Hyper-Threading Technology is enabled.

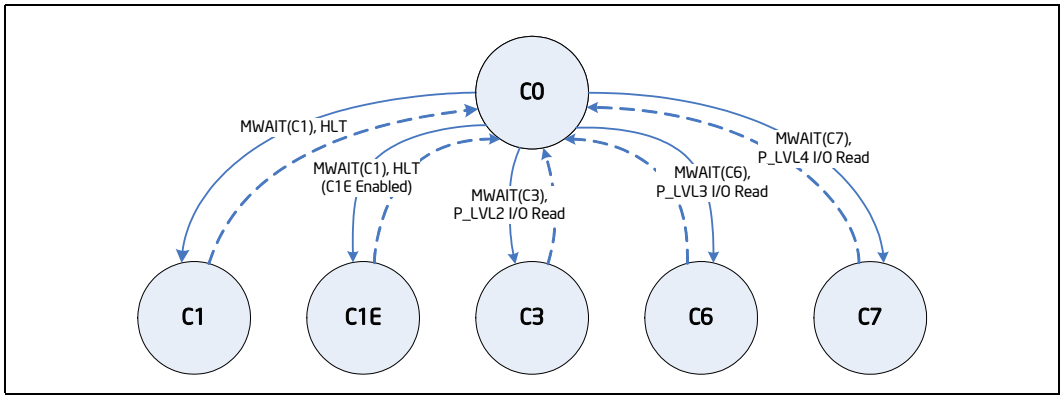
*Note:* Long term reliability cannot be assured unless all the Low Power Idle States are enabled.

**Figure 6-2. Idle Power Management Breakdown of the Processor Cores**




Entry and exit of the C-States at the thread and core level are shown in Figure 6-3.

**Figure 6-3. Thread and Core C-State Entry and Exit**




While individual threads can request low power C-states, power saving actions only take place once the core C-state is resolved. Core C-states are automatically resolved by the processor. For thread and core C-states, a transition to and from C0 is required before entering any other C-state.

**Table 6-8. Coordination of Thread Power States at the Core Level**

| Processor Core C-State | | Thread 1 | | | | |
|---|---|---|---|---|---|---|
| | | C0 | C1 | C3 | C6 | C7 |
| Thread 0 | C0 | C0 | C0 | C0 | C0 | C0 |
| | C1 | C0 | C1[1] | C1[1] | C1[1] | C1[1] |
| | C3 | C0 | C1[1] | C3 | C3 | C3 |
| | C6 | C0 | C1[1] | C3 | C6 | C6 |
| | C7 | C0 | C1[1] | C3 | C6 | C7 |

1. If enabled, the core C-state will be C1E if all active cores have also resolved a core C1 state or higher.

### 6.2.3 Requesting Low-Power Idle States

The primary software interfaces for requesting low power idle states are through the MWAIT instruction with sub-state hints and the HLT instruction (for C1 and C1E). However, software may make C-state requests using the legacy method of I/O reads from the ACPI-defined processor clock control registers, referred to as P_LVLx. This method of requesting C-states provides legacy support for operating systems that initiate C-state transitions via I/O reads.

For legacy operating systems, P_LVLx I/O reads are converted within the processor to the equivalent MWAIT C-state request. Therefore, P_LVLx reads do not directly result in I/O reads to the system. The feature, known as I/O MWAIT redirection, must be enabled in the BIOS.

*Note:* The P_LVLx I/O Monitor address must be set up before using the P_LVLx I/O read interface. Each P-LVLx is mapped to the supported MWAIT(Cx) instruction as shown in Table 6-9.

**Table 6-9. P_LVLx to MWAIT Conversion**

| P_LVLx | MWAIT(Cx) | Notes |
|---|---|---|
| P_LVL2 | MWAIT(C3) | The P_LVL2 base address is defined in the PMG_IO_CAPTURE MSR, |
| P_LVL3 | MWAIT(C6) | C6. No sub-states allowed. |
| P_LVL4 | MWAIT(C7) | C7. No sub-states allowed. |
| P_LVL5+ | MWAIT(C7) | C7. No sub-states allowed. |

The BIOS can write to the C-state range field of the PMG_IO_CAPTURE MSR to restrict the range of I/O addresses that are trapped and emulate MWAIT like functionality. Any P_LVLx reads outside of this range does not cause an I/O redirection to MWAIT(Cx) like request. They fall through like a normal I/O instruction.

*Note:* When P_LVLx I/O instructions are used, MWAIT substates cannot be defined. The MWAIT substate is always zero if I/O MWAIT redirection is used. By default, P_LVLx I/O redirections enable the MWAIT 'break on EFLAGS.IF' feature which triggers a wakeup on an interrupt even if interrupts are masked by EFLAGS.IF.

### 6.2.4 Core C-States

The following are general rules for all core C-states:

- A core C-State is determined by the lowest numerical thread state (e.g., Thread 0 requests C1E while Thread 1 requests C3, resulting in a core C1E state). See Table 6-6, "G, S and C State Combinations".
- A core transitions to C0 state when:
  - An interrupt occurs
  - There is an access to the monitored address if the state was entered via an MWAIT instruction
- For core C1/C1E, and core C3, and core C6/C7, an interrupt directed toward a single thread wakes only that thread. However, since both threads are no longer at the same core C-state, the core resolves to C0.
- A system reset re-initializes all processor cores.

#### 6.2.4.1 Core C0 State

The normal operating state of a core where code is being executed.

### 6.2.4.2 Core C1/C1E State

C1/C1E is a low power state entered when all threads within a core execute a HLT or MWAIT(C1/C1E) instruction.

A System Management Interrupt (SMI) handler returns execution to either Normal state or the C1/C1E state. See the Intel® *64 and IA-32 Architecture Software Developer's Manual, Volume 3A/3B: System Programmer's Guide for more information.*

While a core is in C1/C1E state, it processes bus snoops and snoops from other threads. For more information on C1E, see Section 6.2.5.2, "Package C1/C1E".

### 6.2.4.3 Core C3 State

Individual threads of a core can enter the C3 state by initiating a P_LVL2 I/O read to the P_BLK or an MWAIT(C3) instruction. A core in C3 state flushes the contents of its L1 instruction cache, L1 data cache, and L2 cache to the shared L3 cache, while maintaining its architectural state. All core clocks are stopped at this point. Because the core's caches are flushed, the processor does not wake any core that is in the C3 state when either a snoop is detected or when another core accesses cacheable memory.

### 6.2.4.4 Core C6 State

Individual threads of a core can enter the C6 state by initiating a P_LVL3 I/O read or an MWAIT(C6) instruction. Before entering core C6, the core will save its architectural state to a dedicated SRAM. Once complete, a core will have its voltage reduced to zero volts. During exit, the core is powered on and its architectural state is restored.

### 6.2.4.5 Core C7 State

Individual threads of a core can enter the C7 state by initiating a P_LVL4 I/O read to the P_BLK or by an MWAIT(C7) instruction. The core C7 state exhibits the same behavior as the core C6 state unless the core is the last one in the package to enter the C7 state. If it is, that core is responsible for flushing L3 cache ways. The processor supports the C7s substate. When an MWAIT(C7) command is issued with a C7s sub-state hint, the entire L3 cache is flushed one step as opposed to flushing the L3 cache in multiple steps.

*Note:* Core C7 state support is available for quad core and dual core processors. Single core processors do not support the Core C7 state.

### 6.2.4.6 C-State Auto-Demotion

In general, deeper C-states such as C6 or C7 have long latencies and have higher energy entry/exit costs. The resulting performance and energy penalties become significant when the entry/exit frequency of a deeper C-state is high. Therefore incorrect or inefficient usage of deeper C-states have a negative impact on power. In order to increase residency and improve power in deeper C-states, the processor supports C-state auto-demotion.

There are two C-state auto-demotion options:

- C7/C6 to C3
- C7/C6/C3 To C1

The decision to demote a core from C6/C7 to C3 or C3/C6/C7 to C1 is based on each core's immediate residency history. Upon each core C6/C7 request, the core C-state is demoted to C3 or C1 until a sufficient amount of residency has been established. At that point, a core is allowed to go into C3/C6 or C7. Each option can be run concurrently or individually.

This feature is disabled by default. BIOS must enable it in the PMG_CST_CONFIG_CONTROL register. The auto-demotion policy is also configured by this register.

### 6.2.5 Package C-States

The processor supports C0, C1/C1E, C3, C6, and C7 power states. The following is a summary of the general rules for package C-state entry. These apply to all package C-states unless specified otherwise:

- A package C-state request is determined by the lowest numerical core C-state amongst all cores.
- A package C-state is automatically resolved by the processor depending on the core idle power states and the status of the platform components.
  - Each core can be at a lower idle power state than the package if the platform does not grant the processor permission to enter a requested package C-state.
  - The platform may allow additional power savings to be realized in the processor.
  - For package C-states, the processor is not required to enter C0 before entering any other C-state.

The processor exits a package C-state when a break event is detected. Depending on the type of break event, the processor does the following:

- If a core break event is received, the target core is activated and the break event message is forwarded to the target core.
  - If the break event is not masked, the target core enters the core C0 state and the processor enters package C0.
- If the break event was due to a memory access or snoop request.
  - But the platform did not request to keep the processor in a higher package C-state, the package returns to its previous C-state.
  - And the platform requests a higher power C-state, the memory access or snoop request is serviced and the package remains in the higher power C-state.

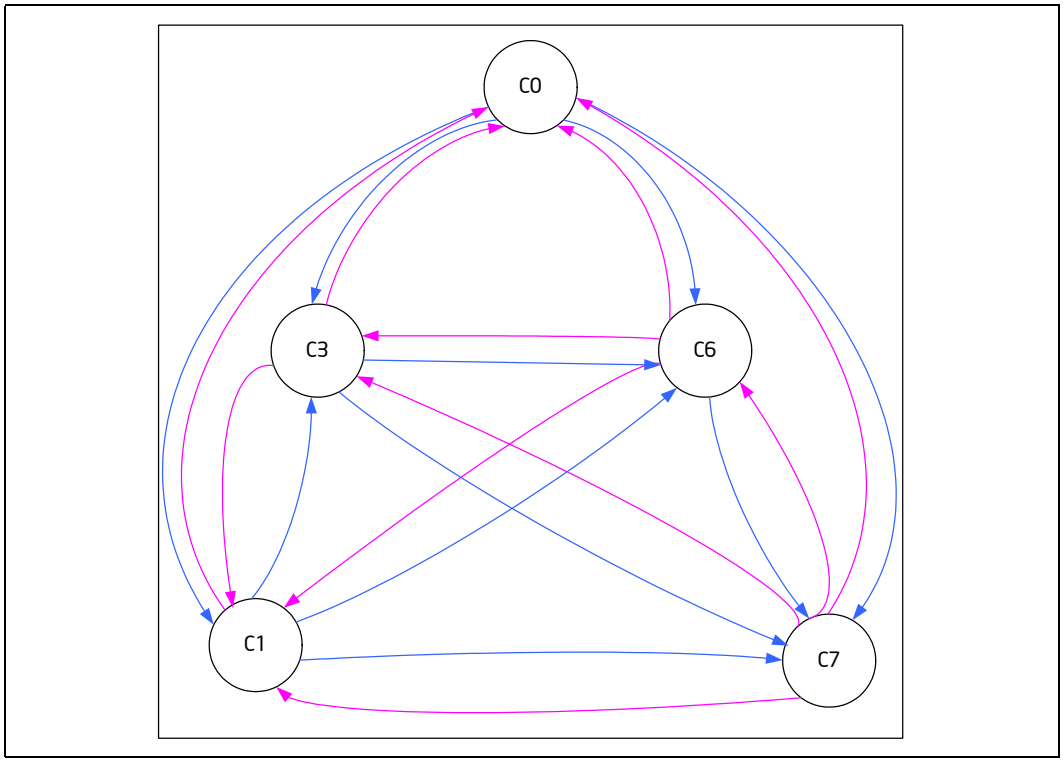
Table 6-10 shows package C-state resolution for a dual-core processor. Figure 6-4 summarizes package C-state transitions.

**Table 6-10. Coordination of Core Power States at the Package Level**

| Package C-State | | Core 1 | | | | |
|---|---|---|---|---|---|---|
| | | C0 | C1 | C3 | C6 | C7 |
| Core 0 | C0 | C0 | C0 | C0 | C0 | C0 |
| | C1 | C0 | C1[1] | C1[1] | C1[1] | C1[1] |
| | C3 | C0 | C1[1] | C3 | C3 | C3 |
| | C6 | C0 | C1[1] | C3 | C6 | C6 |
| | C7 | C0 | C1[1] | C3 | C6 | C7 |

***Notes:***
1. If enabled, the package C-state will be C1E if all actives cores have also resolved a core C1 state or higher.

**Figure 6-4. Package C-State Entry and Exit**




### 6.2.5.1 Package C0

The normal operating state for the processor. The processor remains in the normal state when at least one of its cores is in the C0 or C1 state or when the platform has not granted permission to the processor to go into a low power state. Individual cores may be in lower power idle states while the package is in C0.

### 6.2.5.2 Package C1/C1E

No additional power reduction actions are taken in the package C1 state. However, if the C1E sub-state is enabled, the processor automatically transitions to the lowest supported core clock frequency, followed by a reduction in voltage.

The package enters the C1 low power state when:

- At least one core is in the C1 state.
- The other cores are in a C1 or lower power state.

The package enters the C1E state when:

- All cores have directly requested C1E via MWAIT(C1) with a C1E sub-state hint.
- All cores are in a power state lower that C1/C1E but the package low power state is limited to C1/C1E via the PMG_CST_CONFIG_CONTROL MSR.
- All cores have requested C1 using HLT or MWAIT(C1) and C1E auto-promotion is enabled in IA32_MISC_ENABLES.

No notification to the system occurs upon entry to C1/C1E.

#### 6.2.5.3 Package C3 State

A processor enters the package C3 low power state when:

- At least one core is in the C3 state.
- The other cores are in a C3 or lower power state, and the processor has been granted permission by the platform.
- The platform has not granted a request to a package C6/C7 state but has allowed a package C6 state.

In package C3-state, the L3 shared cache is valid.

#### 6.2.5.4 Package C6 State

A processor enters the package C6 low power state when:

- At least one core is in the C6 state.
- The other cores are in a C6 or lower power state, and the processor has been granted permission by the platform.
- The platform has not granted a package C7 request but has allowed a C6 package state.

In package C6 state, all cores have saved their architectural state and have had their core voltages reduced to zero volts. The L3 shared cache is still powered and snoopable in this state. The processor remains in package C6 state as long as any part of the L3 cache is active.

#### 6.2.5.5 Package C7 State

The processor enters the package C7 low power state when all cores are in the C7 state and the L3 cache is completely flushed. The last core to enter the C7 state begins to shrink the L3 cache by N-ways until the entire L3 cache has been emptied. This allows further power savings.

Core break events are handled the same way as in package C3 or C6. However, snoops are not sent to the processor in package C7 state because the platform, by granting the package C7 state, has acknowledged that the processor possesses no snoopable information. This allows the processor to remain in this low power state and maximize its power savings.

Upon exit of the package C7 state, the L3 cache is not immediately re-enabled. It re-enables once the processor has stayed out of the C6 or C7 for an preset amount of time. Power is saved since this prevents the L3 cache from being re-populated only to be immediately flushed again.

#### 6.2.5.6 Dynamic L3 Cache Sizing

Upon entry into the package C7 state, the L3 cache is reduced by N-ways until it is completely flushed. The number of ways, N, is dynamically chosen per concurrent C7 entry. Similarly, upon exit, the L3 cache is gradually expanded based on internal heuristics.

## 6.3 IMC Power Management

The main memory is power managed during normal operation and in low-power ACPI Cx states.

### 6.3.1 Disabling Unused System Memory Outputs

Any system memory (SM) interface signal that goes to a memory module connector in which it is not connected to any actual memory devices (such as DIMM connector is unpopulated, or is single-sided) is tri-stated. The benefits of disabling unused SM signals are:

- Reduced power consumption.
- Reduced possible overshoot/undershoot signal quality issues seen by the processor I/O buffer receivers caused by reflections from potentially un-terminated transmission lines.

When a given rank is not populated, the corresponding chip select and CKE signals are not driven.

At reset, all rows must be assumed to be populated, until it can be proven that they are not populated. This is due to the fact that when CKE is tristated with an DIMM present, the DIMM is not guaranteed to maintain data integrity.

SCKE tristate should be enabled by BIOS where appropriate, since at reset all rows must be assumed to be populated.

### 6.3.2 DRAM Power Management and Initialization

The processor implements extensive support for power management on the SDRAM interface. There are four SDRAM operations associated with the Clock Enable (CKE) signals, which the SDRAM controller supports. The processor drives four CKE pins to perform these operations.

The CKE is one of the power-save means. When CKE is off the internal DDR clock is disabled and the DDR power is reduced. The power-saving differs according to the selected mode and the DDR type used. For more information, see the IDD table in the DDR specification.

The DDR specification defines three levels of power-down that differ in power-saving and in wakeup time:

1. Active power-down (APD): This mode is entered if there are open pages when deasserting CKE. In this mode the open pages are retained. Power-saving in this mode is the lowest. Power consumption of DDR is defined by IDD3P. Exiting this mode is defined by tXP – small number of cycles.
2. Precharged power-down (PPD): This mode is entered if all banks in DDR are precharged when de-asserting CKE. Power-saving in this mode is intermediate – better than APD, but less than DLL-off. Power consumption is defined by IDD2P1. Exiting this mode is defined by tXP. Difference from APD mode is that when waking-up all page-buffers are empty.
3. DLL-off: In this mode the data-in DLLs on DDR are off. Power-saving in this mode is the best among all power-modes. Power consumption is defined by IDD2P1. Exiting this mode is defined by tXP, but also tXPDLL (10 – 20 according to DDR type) cycles until first data transfer is allowed.

The processor supports six types of power-down. These different modes are the power-down modes supported by DDR3 and combinations of these modes. The type of CKE power-down is defined by the configuration. The options are:

1. No power-down.
2. APD: The rank enters power-down as soon as idle-timer expires, no matter what is the bank status.

3. PPD: When idle timer expires the MC sends PRE-all to rank and then enters powerdown.
4. DLL-off: same as option (2) but DDR is configured to DLL-off.
5. APD, change to PPD (APD-PPD): Begins as option (1), and when all page-close timers of the rank are expired, it wakes the rank, issues PRE-all, and returns to PPD.
6. APD, change to DLL-off (APD_DLLoff) – Begins as option (1), and when all page-close timers of the rank are expired, it wakes the rank, issues PRE-all and returns to DLL-off power-down.

The CKE is determined per rank when it is inactive. Each rank has an idle-counter. The idle-counter starts counting as soon as the rank has no accesses, and if it expires, the rank may enter power-down while no new transactions to the rank arrive to queues. The idle-counter begins counting at the last incoming transaction arrival.

It is important to understand that since the power-down decision is per rank, the MC can find many opportunities to power-down ranks even while running memory intensive applications, and savings are significant (may be a few watts, according to the DDR specification). This is significant when each channel is populated with more ranks.

Selection of power modes should be according to power-performance or thermal tradeoffs of a given system:

- When trying to achieve maximum performance and power or thermal consideration is not an issue: use no power-down.
- In a system that tries to minimize power-consumption, use the deepest power-down mode possible – DLL-off or APD_DLLoff.
- In high-performance systems with dense packaging (that is, complex thermal design) the power-down mode should be considered in order to reduce the heating and avoid DDR throttling caused by the heating.

Control of the power-mode must be controlled through the BIOS – The BIOS selects no-powerdown by default. There are knobs to change the power-down selected mode.

Another control is the idle timer expiration count. This is set through PM_PDWN_config bits 7:0 (MCHBAR +4CB0). As this timer is set to a shorter time, the MC will have more opportunities to put DDR in power-down. The minimum recommended value for this register is 15. There is no BIOS hook to set this register. Customers who choose to change the value of this register can do it by changing the BIOS. For experiments, this register can be modified in real time if BIOS did not lock the MC registers.

*Note:* In APD, APD-PPD, and APD_DLL-off, there is no point in setting the idle-counter in the same range as page-close idle timer.

Another option associated with CKE power-down is the S_DLL-off. When this option is enabled, the SBR I/O slave DLLs go off when all channel ranks are in power-down. (Do **not** confuse it with the DLL-off mode in which the DDR DLLs are off). This mode requires you to define the I/O slave DLL wakeup time.

#### 6.3.2.1 Initialization Role of CKE

During power-up, CKE is the only input to the SDRAM that has its level is recognized (other than the DDR3 reset pin) once power is applied. It must be driven LOW by the DDR controller to make sure the SDRAM components float DQ and DQS during power-up. CKE signals remain LOW (while any reset is active) until the BIOS writes to a

configuration register. Using this method, CKE is guaranteed to remain inactive for much longer than the specified 200 micro-seconds after power and clocks to SDRAM devices are stable.

### 6.3.2.2 Conditional Self-Refresh

Intel Rapid Memory Power Management (Intel RMPM) conditionally places memory into self-refresh in the package  low-power states. RMPM functionality depends on graphics/ display state (relevant only when processor graphics is being used), as well as memory traffic patterns generated by other connected I/O devices.

When entering the S3 - Suspend-to-RAM (STR) state or S0 conditional self-refresh, the processor core flushes pending cycles and then enters all SDRAM ranks into self refresh. the CKE signals remain LOW so the SDRAM devices perform self-refresh.

The target behavior is to enter self-refresh for the package  states as long as there are no memory requests to service.

**Table 6-11. Targeted Memory State Conditions**

| Mode | Memory State with Processor Graphics | Memory State with External Graphics |
|---|---|---|
| C0, C1, C1E | Dynamic memory rank power down based on idle conditions. | Dynamic memory rank power down based on idle conditions. |
| C3, C6, C7 | If the processor graphics engine is idle and there are no pending display requests, then enter self-refresh. Otherwise use dynamic memory rank power down based on idle conditions. | If there are no memory requests, then enter self-refresh. Otherwise use dynamic memory rank power down based on idle conditions. |
| S3 | Self-Refresh Mode. | Self-Refresh Mode. |
| S4 | Memory power down (contents lost). | Memory power down (contents lost) |

### 6.3.2.3 Dynamic Power Down Operation

Dynamic power-down of memory is employed during normal operation. Based on idle conditions, a given memory rank may be powered down. The IMC implements aggressive CKE control to dynamically put the DRAM devices in a power down state. The processor core controller can be configured to put the devices in *active power-down* (CKE deassertion with open pages) or *precharge power-down* (CKE deassertion with all pages closed). Precharge power-down provides greater power savings but has a bigger performance impact, since all pages will first be closed before putting the devices in power-down mode.

If dynamic power-down is enabled, all ranks are powered up before doing a refresh cycle and all ranks are powered down at the end of refresh.

### 6.3.2.4 DRAM I/O Power Management

Unused signals should be disabled to save power and reduce electromagnetic interference. This includes all signals associated with an unused memory channel. Clocks can be controlled on a per DIMM basis. Exceptions are made for per DIMM control signals such as CS#, CKE, and ODT for unpopulated DIMM slots.

The I/O buffer for an unused signal should be tri-stated (output driver disabled), the input receiver (differential sense-amp) should be disabled, and any DLL circuitry related ONLY to unused signals should be disabled. The input path must be gated to prevent spurious results due to noise on the unused signals (typically handled automatically when input receiver is disabled).

### 6.3.3 DDR Electrical Power Gating (EPG)

The DDR I/O of the processor supports on-die Electrical Power Gating (DDR-EPG) during normal operation (S0 mode) while the processor is at package C3 or deeper power state.

During EPG, the $V_{CCIO}$ internal voltage rail will be powered down, while $V_{DDQ}$ and the un-gated $V_{CCIO}$ will stay powered on.

The processor will transition in and out of DDR EPG mode on an as needed basis without any external pins or signals.

There is no change to the signals driven by the processor to the DIMMs during DDR IO EPG mode.

During EPG mode, all the DDR IO logic will be powered down, except for the Physical Control registers that are powered by the un-gated $V_{CCIO}$ power supply.

Unlike S3 exit, at DDR EPG exit, the DDR will not go through training mode. Rather, it will use the previous training information retained in the physical control registers and will immediately resume normal operation.

## 6.4 PCIe* Power Management

- Active power management support using L0s, and L1 states.
- All inputs and outputs disabled in L2/L3 Ready state.

*Note:* The PCIe* interface does not support Hot Plug. Power impact may be observed when PCIe* link disable power management state is used.

## 6.5 DMI Power Management

Active power management support using L0s/L1 state.

## 6.6 Intel® Rapid Memory Power Management (RMPM) (Also Known as CxSR)

The Intel® Rapid Memory Power Management puts rows of memory into self-refresh mode during C3/C6 to allow the system to remain in the lower power states longer. Processors routinely save power during runtime conditions by entering the C3, C6 state. Intel RMPM is an indirect method of power saving that can have a significant effect on the system as a whole.

## 6.7 Thermal Power Management

See Section 7.0, “Thermal Management” on page 61 for thermal power management-related features.

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# 7.0 Thermal Management

The thermal solution provides both the component-level and the system-level thermal management. To allow for the optimal operation and long-term reliability of Intel processor-based systems, the system/processor thermal solution should be designed so that the processor:

- Remains below the maximum junction temperature (TJ-MAX) specification at the maximum Thermal Design Power (TDP).
- Conforms to system constraints, such as system acoustics, system skin-temperatures, and exhaust-temperature requirements.

***Caution:*** Thermal specifications given in this chapter are on the component and package level and apply specifically to the processor. Operating the processor outside the specified limits may result in permanent damage to the processor and potentially other components in the system.

## 7.1 Thermal Considerations

The processor TDP is the maximum sustained power that should be used for design of the processor thermal solution. TDP represents an expected maximum sustained power from realistic applications. TDP may be exceeded for short periods of time or if running a "power virus" workload.

The processor integrates multiple CPU on a single die. This may result in differences in the power distribution across the die and must be considered when designing the thermal solution. See the Intel® Xeon® E3-1125C v2, E3-1105C v2, Intel® Pentium® Processor B925C, and Intel® Core™ i3-3115C Processors for Communications Infrastructure *Thermal and Mechanical Design Guide* for details.

Thermal solutions and platform cooling that are designed to less than thermal design guidance may experience thermal and performance issues since more applications will tend to run at or near the maximum power limit for significant periods of time. See the Intel® Xeon® E3-1125C v2, E3-1105C v2, Intel® Pentium® Processor B925C, and Intel® Core™ i3-3115C Processors for Communications Infrastructure *Thermal and Mechanical Design Guide* for details.

## 7.2 Thermal and Power Specifications

The following notes apply to Table 7-1 and Table 7-2.

| Note | Definition |
|---|---|
| 1 | The TDPs given are not the maximum power the processor can generate. Analysis indicates that real applications are unlikely to cause the processor to consume the theoretical maximum power dissipation for sustained periods of time. |
| 2 | The thermal solution needs to ensure that the processor temperature does not exceed the maximum junction temperature (Tj,max) limit, as measured by the DTS and the critical temperature bit. |
| 3 | The processor junction temperature is monitored by Digital Temperature Sensors (DTS). For DTS accuracy, see Section 7.3.1.2.1. |
| 4 | Digital Thermal Sensor (DTS) based fan speed control is required to achieve optimal thermal performance. Intel recommends full cooling capability well before the DTS reading reaches Tj,Max. An example is Tj,Max - 10ºC. |
| 5 | At Tj of Tj,max |
| 6 | For details see the Intel® Xeon® E3-1125C v2, E3-1105C v2, Intel® Pentium® Processor B925C, and Intel® Core™ i3-3115C Processors for Communications Infrastructure *Thermal and Mechanical Design Guide* |
| 7 | LFM TDP is provided as a reference and not a validated specification. |

### Table 7-1. TDP Specifications

| SKU | State | CPU Core Frequency | Thermal Design Power | Units | Notes |
|---|---|---|---|---|---|
| **Intel® Xeon® Processor E3-1125C v2** | HFM | 2.5 GHz | 40 | W | 1,5,6,7 |
| | LFM | 800 MHz | 22 | | |
| **Intel® Xeon® Processor E3-1105C v2** | HFM | 1.8 GHz | 25 | W | 1,5,6,7 |
| | LFM | 800 MHz | 22 | | |
| **Intel® Core™ i3 Processor 3115C** | HFM | 2.5GHz | 25 | W | 1,5,6,7 |
| | LFM | 800 MHz | 13 | | |
| **Intel® Pentium® Processor B925C** | HFM | 2.0 GHz | 15 | W | 1,5,6,7 |
| | LFM | 800 MHz | 13 | | |

### Table 7-2. Junction Temperature Specification (All SKUs)

| Symbol | Min | Default | Max | Units | Notes |
|---|---|---|---|---|---|
| $T_J$ | 0 | - | 100 | C | 2,3,4,6 |

## 7.3 Thermal Management Features

Thermal management features for the entire processor complex (including the processor core, and integrated memory controller hub) will be referred to as "processor package" or "the package."

Occasionally the package will operate in conditions that exceed its maximum allowable operating temperature. This can be due to internal overheating or due to overheating in the entire system. To protect processor package and the system from thermal failure, several thermal management features exist to reduce package power consumption and thereby temperature in order to remain within normal operating limits. Furthermore, the processor supports several methods to reduce memory power.

### 7.3.1 Adaptive Thermal Monitor

The purpose of the Adaptive Thermal Monitor is to reduce processor core power consumption and temperature until it operates at or below its maximum operating temperature. Processor core power reduction is achieved by:

- Adjusting the operating frequency (using the core ratio multiplier) and input voltage (using the SVID bus).
- Modulating (starting and stopping) the internal processor core clocks (duty cycle).

The Adaptive Thermal Monitor can be activated when any package temperature, monitored by a digital thermal sensor (DTS), meets or exceeds its maximum junction temperature specification ($T_{J,max}$) and asserts PROCHOT#. The assertion of PROCHOT# activates the thermal control circuit (TCC), and causes the processor core to reduce frequency and voltage adaptively. The TCC will remain active as long as any package temperature exceeds its specified limit. Therefore, the Adaptive Thermal Monitor will continue to reduce the package frequency and voltage until the TCC is de-activated.

The temperature at which the Adaptive Thermal Monitor activates the thermal control circuit is factory calibrated and is not user configurable. The default value is software visible in the TMEMPERATURE_TARGET (1A2h) MSR, bits 23:16. The Adaptive Thermal Monitor does not require any additional hardware, software drivers, or interrupt handling routines. The Adaptive Thermal Monitor is not intended as a mechanism to maintain processor TDP. The system design should provide a thermal solution that can maintain TDP within its intended usage range.

*Note:* Adaptive Thermal Monitor protection is always enabled.

#### 7.3.1.1 TCC Activation Offset

TCC Activation Offset can be used to activate the TCC at temperatures lower than $T_{J,max}$. It is the preferred thermal protection mechanism. An offset (in degrees Celsius) can be written to = []\TEMPERATURE_TARGET (1A2h) MSR, bits 27:24. This value will be subtracted from the value found in bits 23:16. The default offset is 0 °C, where throttling will occur at $T_{J,max}$. The offset should be set lower than any other protection such as ACPI _PSV trip points.

##### 7.3.1.1.1 Frequency/Voltage Control

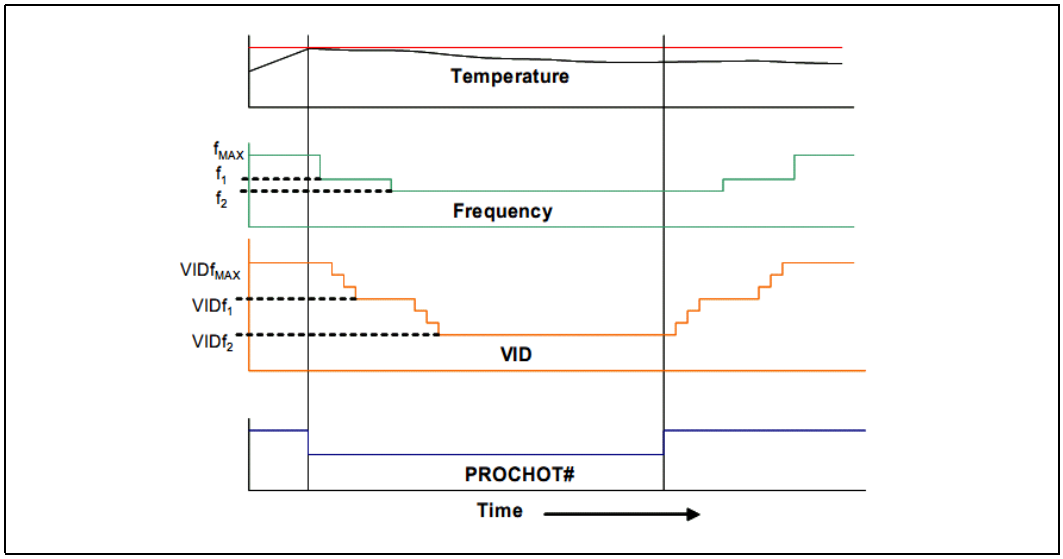
Upon TCC activation, the processor core attempts to dynamically reduce processor core power by lowering the frequency and voltage operating point. The operating points are automatically calculated by the processor core itself and do not require the BIOS to program them as with previous generations of Intel processors. The processor core scales the operating points so that:

- The voltage is optimized according to the temperature, the core bus ratio, and number of cores in deep C-states.

- The core power and temperature are reduced while minimizing performance degradation.

Once the temperature has dropped below the maximum operating temperature, the operating frequency and voltage transition back to the normal system operating point. This is illustrated in Figure 7-1.

**Figure 7-1. Frequency and Voltage Ordering**




Once a target frequency/bus ratio is resolved, the processor core transitions to the new target automatically.

- On an upward operating point transition, the voltage transition precedes the frequency transition.
- On a downward transition, the frequency transition precedes the voltage transition.

When transitioning to a target core operating voltage, a new SVID code to the voltage regulator is issued. The voltage regulator must support dynamic SVID steps to support this method.

During the voltage change:

- It is necessary to transition through multiple SVID steps to reach the target operating voltage.
- Each step is 5 mV for Intel MVP-7.0 compliant VRs.
- The processor continues to execute instructions. However, the processor halts instruction execution for frequency transitions.

If a processor load-based Enhanced Intel SpeedStep Technology/P-state transition (through MSR write) is initiated while the Adaptive Thermal Monitor is active, there are two possible outcomes:

- If the P-state target frequency is higher than the processor core optimized target frequency, the p-state transition is deferred until the thermal event has been completed.
- If the P-state target frequency is lower than the processor core optimized target frequency, the processor transitions to the P-state operating point.

#### 7.3.1.1.2 Clock Modulation

If the frequency/voltage changes are unable to end an Adaptive Thermal Monitor event, the Adaptive Thermal Monitor utilizes clock modulation. Clock modulation is done by alternately turning the clocks off and on at a duty cycle (ratio between clock "on" time and total time) specific to the processor. The duty cycle is factory configured to 25% on and 75% off and cannot be modified. The period of the duty cycle is configured to 32 microseconds when the TCC is active. Cycle times are independent of processor frequency. A small amount of hysteresis has been included to prevent excessive clock modulation when the processor temperature is near its maximum operating temperature. Once the temperature has dropped below the maximum operating temperature, and the hysteresis timer has expired, the TCC goes inactive and clock modulation ceases. Clock modulation is automatically engaged as part of the TCC activation when the frequency/voltage targets are at their minimum settings. Processor performance decreases by the same amount as the duty cycle when clock modulation is active. Snooping and interrupt processing are performed in the normal manner while the TCC is active.

### 7.3.1.2 Digital Thermal Sensor

Each processor execution core has an on-die Digital Thermal Sensor (DTS) which detects the core's instantaneous temperature. The DTS is the preferred method of monitoring processor die temperature because:

- It is located near the hottest portions of the die.
- It can accurately track the die temperature and ensure that the Adaptive Thermal Monitor is not excessively activated.

Temperature values from the DTS can be retrieved through:

- A software interface via processor Model Specific Register (MSR).
- A processor hardware interface as described in Section 7.3.5, "Platform Environment Control Interface (PECI)".

*Note:* The temperature retrieved by the processor MSR is the instantaneous temperature of the given core. The temperature retrieved via PECI is the average of the highest DTS temperature in the package over a 256 ms time window. Intel recommends using the PECI-reported temperature for platform thermal control that benefits from averaging, such as fan speed control. The average DTS temperature may not be a good indicator of package Adaptive Thermal Monitor activation or rapid increases in temperature that triggers the Out of Specification status bit within the PACKAGE_THERM_STATUS MSR 01B1h and IA32_THERM_STATUS MSR 19Ch.

*Note:* Code execution is halted in C1-C7. Therefore temperature cannot be read via the processor MSR without bringing a core back into C0. However, the temperature can still be monitored through PECI in lower C-states except for C7.

Unlike traditional thermal devices, the DTS outputs a temperature relative to the maximum supported operating temperature of the processor (TJ-MAX), regardless of TCC activation offset. It is the responsibility of software to convert the relative temperature to an absolute temperature. The absolute reference temperature is readable in the TEMPERATURE_TARGET MSR 1A2h. The temperature returned by the DTS is an implied negative integer indicating the relative offset from TJ-MAX. The DTS does not report temperatures greater than TJ-MAX.

The DTS-relative temperature readout directly impacts the Adaptive Thermal Monitor trigger point. When a package DTS indicates that it has reached the TCC activation (a reading of 0x0, except when the TCC activation offset is changed), the TCC activates and indicates an Adaptive Thermal Monitor event. A TCC activation lowers the IA core frequency, voltage or both.

Changes to the temperature can be detected via two programmable thresholds located in the processor thermal MSRs. These thresholds have the capability of generating interrupts via the core's local APIC. See the Intel® *64 and IA-32 Architectures Software Developer's Manual* for specific register and programming details.

#### 7.3.1.2.1 Digital Thermal Sensor Accuracy (Taccuracy)

The error associated with DTS measurement does not exceed ±5°C at TJ-MAX. The DTS measurement within the entire operating range meets a ±5°C accuracy.

### 7.3.1.3 Fan Speed Control with Digital Thermal Sensor

Digital Thermal Sensor based fan speed control ($T_{FAN}$) is a recommended feature to achieve optimal thermal performance. At the $T_{FAN}$ temperature, Intel recommends full cooling capability well before the DTS reading reaches $T_{j,max}$. An example is $T_{FAN} = T_{j,max} - 10$ ºC.

### 7.3.1.4 PROCHOT# Signal

PROCHOT# (processor hot) is asserted when the processor core temperature has reached its maximum operating temperature ($T_{J-MAX}$). See Figure 7-1 for a timing diagram of the PROCHOT# signal assertion relative to the Adaptive Thermal Response. Only a single PROCHOT# pin exists at a package level. When any core arrives at the TCC activation point, the PROCHOT# signal is asserted. PROCHOT# assertion policies are independent of Adaptive Thermal Monitor enabling.

*Note:* Bus snooping and interrupt latching are active while the TCC is active.

*Note:* For the package C7 state, PROCHOT# may de-assert for the duration of the C7 state residency, even if the processor enters the idle state operating at the TCC activation temperature. The PECI interface is fully operational during all C-states and it is expected that the platform continues to manage processor package thermals, even during idle states by regularly polling for thermal data over PECI.

#### 7.3.1.4.1 Bi-Directional PROCHOT#

By default, the PROCHOT# signal is defined as an output only. However, the signal may be configured as bi-directional. When configured as a bi-directional signal, PROCHOT# can be used for thermally protecting other platform components should they overheat as well. When PROCHOT# is driven by an external device:

- The package immediately transitions to the minimum operation points (voltage and frequency) supported by the processor cores. This is contrary to the internally-generated Adaptive Thermal Monitor response.
- Clock modulation is not activated.

The TCC remains active until the system deasserts PROCHOT#. The processor can be configured to generate an interrupt upon assertion and deassertion of the PROCHOT# signal. See the *VR12/IMVP7 SVID Protocol* for details on implementing the bi-directional PROCHOT# feature.

*Note:* Toggling PROCHOT# more than once in 1.5 ms period results in constant Pn state of the processor.

#### 7.3.1.4.2 Voltage Regulator Protection Versus PROCHOT#

PROCHOT# may be used for thermal protection of voltage regulators (VR). System designers can create a circuit to monitor the VR temperature and activate the TCC when the temperature limit of the VR is reached. By asserting PROCHOT# (pulled-low)

and activating the TCC, the VR cools down as a result of reduced processor power consumption. Bi-directional PROCHOT# can allow VR thermal designs to target thermal design current ($I_{CCTDC}$) instead of maximum current. Systems should still provide proper cooling for the VR and rely on bi-directional PROCHOT# only as a backup in case of system cooling failure. Overall, the system thermal design should allow the power delivery circuitry to operate within its temperature specification even while the processor is operating at its TDP.

#### 7.3.1.4.3 Thermal Solution Design and PROCHOT# Behavior

With a properly designed and characterized thermal solution, it is anticipated that PROCHOT# is only asserted for very short periods of time when running the most power intensive applications. The processor performance impact due to these brief periods of TCC activation is expected to be so minor that it would be immeasurable.

However, an under-designed thermal solution that is not able to prevent excessive assertion of PROCHOT# in the anticipated ambient environment may:

- Cause a noticeable performance loss.
- Result in prolonged operation at or above the specified maximum junction temperature and affect the long-term reliability of the processor.
- May be incapable of cooling the processor even when the TCC is active continuously (in extreme situations).

See the Intel® Xeon® E3-1125C v2, E3-1105C v2, Intel® Pentium® Processor B925C, and Intel® Core™ i3-3115C Processors for Communications Infrastructure *Thermal and Mechanical Design Guide* for information on implementing the bi-directional PROCHOT# feature and designing a compliant thermal solution.

#### 7.3.1.4.4 Low-Power States and PROCHOT# Behavior

If the processor enters a low-power package idle state such as C3 or C6/C7 with PROCHOT# asserted, PROCHOT# remains asserted until:

- The processor exits the low-power state
- The processor junction temperature drops below the thermal trip point

For the package C7 state, PROCHOT# may deassert for the duration of C7 state residency even if the processor enters the idle state operating at the TCC activation temperature. The PECI interface is fully operational during all C-states and it is expected that the platform continues to manage processor (“package”) core thermals even during idle states by regularly polling for thermal data over PECI.

#### 7.3.1.4.5 THERMTRIP# Signal

Regardless of enabling the automatic or on-demand modes, in the event of a catastrophic cooling failure, the package automatically shuts down when the silicon has reached an elevated temperature that risks physical damage to the product. At this point the THERMTRIP# signal is active.

#### 7.3.1.4.6 Critical Temperature Detection

Critical Temperature detection is performed by monitoring the package temperature. This feature is intended for graceful shutdown before the THERMTRIP# is activated, however, the processor execution is not guaranteed between critical temperature and THERMTRIP#. If the package's Adaptive Thermal Monitor is triggered and the temperature remains high, a critical temperature status and sticky bit are latched in the PACKAGE_THERM_STATUS MSR 1B1h and also generates a thermal interrupt if enabled.

## 7.3.2 Processor Core Specific Thermal Features

### 7.3.2.1 On-Demand Mode

The processor provides an auxiliary mechanism that allows system software to force the processor to reduce its power consumption via clock modulation. This mechanism is referred to as "On-Demand" mode and is distinct from Adaptive Thermal Monitor and bi-directional PROCHOT#. Processor platforms must not rely on software usage of this mechanism to limit the processor temperature. On-Demand Mode can be done via processor MSR or chipset I/O emulation.

On-Demand Mode may be used in conjunction with the Adaptive Thermal Monitor. However, if the system software tries to enable On-Demand mode at the same time the TCC is engaged, the factory configured duty cycle of the TCC overrides the duty cycle selected by the On-Demand mode. If the I/O based and MSR-based On-Demand modes are in conflict, the duty cycle selected by the I/O emulation-based On-Demand mode takes precedence over the MSR-based On-Demand Mode.

#### 7.3.2.1.1 MSR Based On-Demand Mode

If Bit 4 of the IA32_CLOCK_MODULATION MSR is set to a 1, the processor immediately reduces its power consumption via modulation of the internal core clock, independent of the processor temperature. The duty cycle of the clock modulation is programmable via Bits 3:1 of the same IA32_CLOCK_MODULATION MSR. In this mode, the duty cycle can be programmed in either 12.5% or 6.25% increments (discoverable via CPU ID). Thermal throttling using this method modulates each processor core's clock independently.

#### 7.3.2.1.2 I/O Emulation-Based On-Demand Mode

I/O emulation-based clock modulation provides legacy support for operating system software that initiates clock modulation through I/O writes to ACPI defined processor clock control registers on the chipset (PROC_CNT). Thermal throttling using this method modulates all processor cores simultaneously.

## 7.3.3 Memory Controller Specific Thermal Features

The memory controller provides the ability to initiate memory throttling based upon memory temperature. The memory temperature can be provided to the memory controller via PECI or can be estimated by the memory controller based upon memory activity. The temperature trigger points are programmable by memory mapped IO registers.

### 7.3.3.1 Programmable Trip Points

This memory controller provides programmable critical, hot and warm trip points. Crossing a critical trip point forces a system shutdown. Crossing a hot or warm trip point initiates throttling. The amount of memory throttle at each trip point is programmable.

## 7.3.4 Memory Thermal Management

The integrated memory controller (IMC) provides thermal protection for system memory DIMMs using memory bandwidth throttling. Like processor package throttling, memory throttling is initiated based on temperature. The IMC offers two levels of throttling (warm and hot). The temperature and the amount of bandwidth reduced while throttling is programmable for the warm and hot trip points through memory mapped I/O registers.

Memory temperature can be read directly by a physical thermal sensor on the DIMM (TS-on-DIMM) or a physical temperature sensor placed on the motherboard (TS-on-Board). Memory throttling based on physical temperature sensor readings is known as Closed Loop Thermal Throttling (CLTT). The memory temperature readings are reported from the platform to the memory controller using PECI.

If no physical thermal sensor is available, the memory controller can estimate the temperature based on memory activity. Memory thermal throttling that is initiated with no direct temperature reading is known as Open Loop Thermal Throttling (OLTT). The processor features the Virtual Temperature Sensor (VTS) for OLTT. For more details on the TS-on-DIMM, TS-on-Board, and the VTS enabling see the Intel® Xeon® E3-1125C v2, E3-1105C v2, Intel® Pentium® Processor B925C, and Intel® Core™ i3-3115C Processors for Communications Infrastructure *Thermal and Mechanical Design Guide*.

## 7.3.5 Platform Environment Control Interface (PECI)

The Platform Environment Control Interface (PECI) is a one-wire interface that provides a communication channel between Intel processor and chipset components to external monitoring devices. The processor implements a PECI interface to allow communication of processor thermal information to other devices on the platform. The processor provides a digital thermal sensor (DTS) for fan speed control. The DTS is calibrated at the factory to provide a digital representation of relative processor temperature. Averaged DTS values are read via the PECI interface.

The PECI physical layer is a self-clocked one-wire bus that begins each bit with a driven, rising edge from an idle level near zero volts. The duration of the signal driven high depends on whether the bit value is a Logic 0 or Logic 1. PECI also includes variable data transfer rate established with every message. The single wire interface provides low board routing overhead for the multiple load connections in the congested routing area near the processor and chipset components. Bus speed, error checking, and low protocol overhead provides adequate link bandwidth and reliability to transfer critical device operating conditions and configuration information.

### 7.3.5.1 Processor Thermal Data Sample Rate and Filtering

For additional PECI feature details, see the *Ivy Bridge Processor - Platform Environment Control Interface 3.0 - Implementation Guide.*

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# 8.0 Signal Description

This chapter describes the processor signals. They are arranged in functional groups according to their associated interface or category. The following notations are used to describe the signal type:

| Notations | Signal Type |
|---|---|
| I | Input Pin |
| O | Output Pin |
| I/O | Bi-directional Input/Output Pin |

The signal description also includes the type of buffer used for the particular signal.

## Table 8-1. Signal Description Buffer Types

| Signal | Description |
|---|---|
| PCI Express* | PCI Express* interface signals. These signals are compatible with PCI Express* 2.0/ PCI Express* 3.0 Signalling Environment AC Specifications and are AC coupled. The buffers are not 3.3-V tolerant. See the PCIe* specification. |
| DMI | Direct Media Interface signals. These signals are compatible with PCI Express* 2.0 Signaling Environment AC Specifications, but are DC coupled. The buffers are not 3.3-V tolerant. |
| CMOS | CMOS buffers. 1.1-V tolerant |
| DDR3 | DDR3 buffers. 1.5-V tolerant |
| DDR3L | DDR3L buffers. 1.35-V tolerant |
| A | Analog reference or output. May be used as a threshold voltage or for buffer compensation |
| Ref | Voltage reference signal |
| Asynchronous[1] | Signal has no timing relationship with any reference clock |

***Notes:***
1. Qualifier for a buffer type.

# 8.1 System Memory Interface

## Table 8-2. Memory Channel A (Sheet 1 of 2)

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| SA_BS[2:0] | **Bank Select:** These signals define which banks are selected within each SDRAM rank. | O<br>DDR3 |
| SA_WE# | **Write Enable Control Signal:** Used with SA_RAS# and SA_CAS# (along with SA_CS#) to define the SDRAM Commands. | O<br>DDR3 |
| SA_RAS# | **RAS Control Signal:** Used with SA_CAS# and SA_WE# (along with SA_CS#) to define the SRAM Commands. | O<br>DDR3 |
| SA_CAS# | **CAS Control Signal:** Used with SA_RAS# and SA_WE# (along with SA_CS#) to define the SRAM Commands. | O<br>DDR3 |
| SA_DQS[7:0]<br>SA_DQS#[7:0] | **Data Strobes:** SA_DQS[7:0] and its complement signal group make up a differential strobe pair. The data is captured at the crossing point of SA_DQS[7:0] and its SA_DQS#[7:0] during read and write transactions. | I/O<br>DDR3 |
| SA_DQS[8]<br>SA_DQS#[8] | **Data Strobes:** SA_DQS[8] is the data strobe for the ECC check data bits SA_DQ[71:64]. SA_DQS#[8] is the complement strobe for the ECC check data bits SA_DQ[71:64]<br>The data is captured at the crossing point of SA_DQS[8:0] and its SA_DQS#[8:0] during read and write transactions.<br>**Note:** Not required for non-ECC mode | I/O<br>DDR3 |
| SA_DQ[63:0] | **Data Bus:** Channel A data signal interface to the SDRAM data bus. | I/O<br>DDR3 |
| SA_ECC_CB[7:0] | **ECC Data Lines:** Data Lines for ECC Check Byte for Channel A.<br>**Note:** Not required for non-ECC mode | I/O<br>DDR3 |
| SA_MA[15:0] | **Memory Address:** These signals are used to provide the multiplexed row and column address to the SDRAM. | O<br>DDR3 |
| SA_CK[3:0] | **SDRAM Differential Clock:** Channel A SDRAM Differential clock signal pair. The crossing of the positive edge of SA_CK and the negative edge of its complement SA_CK# are used to sample the command and control signals on the SDRAM.<br>Signals 3:2 are used only for two DPC system. | O<br>DDR3 |
| SA_CK#[3:0] | **SDRAM Inverted Differential Clock:** Channel A SDRAM Differential clock signal-pair complement.<br>Signals 3:2 are used only for two DPC system. | O<br>DDR3 |

## Table 8-2. Memory Channel A (Sheet 2 of 2)

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| SA_CKE[3:0] | **Clock Enable:** (one per rank) Used to:<br>• Initialize the SDRAMs during power-up.<br>• Power-down SDRAM ranks.<br>• Place all SDRAM ranks into and out of self-refresh during STR.<br>Signals 3:2 are used only for two DPC system. | O<br>DDR3 |
| SA_CS#[3:0] | **Chip Select:** (one per rank) Used to select particular SDRAM components during the active state. There is one Chip Select for each SDRAM rank.<br>Signals 3:2 are used only for two DPC system. | O<br>DDR3 |
| SA_ODT[3:0] | **On Die Termination:** Active Termination Control.<br>Signals 3:2 are used only for two DPC system. | O<br>DDR3 |

## Table 8-3. Memory Channel B (Sheet 1 of 2)

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| SB_BS[2:0] | **Bank Select:** These signals define which banks are selected within each SDRAM rank. | O<br>DDR3 |
| SB_WE# | **Write Enable Control Signal:** Used with SB_RAS# and SB_CAS# (along with SB_CS#) to define the SDRAM Commands. | O<br>DDR3 |
| SB_RAS# | **RAS Control Signal:** Used with SB_CAS# and SB_WE# (along with SB_CS#) to define the SRAM Commands. | O<br>DDR3 |
| SB_CAS# | **CAS Control Signal:** Used with SB_RAS# and SB_WE# (along with SB_CS#) to define the SRAM Commands. | O<br>DDR3 |
| SB_DQS[7:0]<br>SB_DQS#[7:0] | **Data Strobes:** SB_DQS[7:0] and its complement signal group make up a differential strobe pair. The data is captured at the crossing point of SB_DQS[7:0] and its SB_DQS#[7:0] during read and write transactions. | I/O<br>DDR3 |
| SB_DQS[8]<br>SB_DQS#[8] | **Data Strobes:** SB_DQS[8] is the data strobe for the ECC check data bits SB_DQ[71:64].<br>SB_DQS#[8] is the complement strobe for the ECC check data bits SB_DQ[71:64]<br>The data is captured at the crossing point of SB_DQS[8:0] and its SB_DQS#[8:0] during read and write transactions.<br>**Note:** Not required for non-ECC mode | I/O<br>DDR3 |
| SB_DQ[63:0] | **Data Bus:** Channel B data signal interface to the SDRAM data bus. | I/O<br>DDR3 |
| SB_ECC_CB[7:0] | **ECC Data Lines:** Data Lines for ECC Check Byte for Channel B.<br>**Note:** Not required for non-ECC mode | I/O<br>DDR3 |
| SB_MA[15:0] | **Memory Address:** These signals are used to provide the multiplexed row and column address to the SDRAM. | O<br>DDR3 |

### Table 8-3. Memory Channel B (Sheet 2 of 2)

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| SB_CK[3:0] | **SDRAM Differential Clock:** Channel B SDRAM Differential clock signal pair. The crossing of the positive edge of SB_CK and the negative edge of its complement SB_CK# are used to sample the command and control signals on the SDRAM.<br>Signals 3:2 are used for two DPC system. | O<br>DDR3 |
| SB_CK#[3:0] | **SDRAM Inverted Differential Clock:** Channel B SDRAM Differential clock signal-pair complement.<br>Signals 3:2 are used for two DPC system. | O<br>DDR3 |
| SB_CKE[3:0] | **Clock Enable:** (1 per rank) Used to:<br>• Initialize the SDRAMs during power-up.<br>• Power-down SDRAM ranks.<br>• Place all SDRAM ranks into and out of self-refresh during STR.<br>Signals 3:2 are used for two DPC system. | O<br>DDR3 |
| SB_CS#[3:0] | **Chip Select:** (1 per rank) Used to select particular SDRAM components during the active state. There is one Chip Select for each SDRAM rank.<br>Bits [3:2] are used only for two DPC system. | O<br>DDR3 |
| SB_ODT[3:0] | **On Die Termination:** Active Termination Control.<br>Bits [3:2] are used only for two DPC system. | O<br>DDR3 |

## 8.2 Memory Reference and Compensation

### Table 8-4. Memory Reference and Compensation

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| SM_RCOMP[2:0] | **System Memory Impedance Compensation:**<br>• SM_RCOMP[0] Pull Down to VSS via 140 Ω ±1%<br>• SM_RCOMP[1] Pull Down to VSS via 25.5 Ω ±1%<br>• SM_RCOMP[2] Pull Down to VSS via 200 Ω ±1% | I/Analog |
| SM_VREF | **DDR3 Reference Voltage:** This provides reference voltage to the DDR3 interface and is defined as VDDQ/2 | I/Analog |
| SA_DIMM_VREFDQ<br>SB_DIMM_VREFDQ | **Memory Channel A/B DIMM DQ Voltage Reference:** These pins are not connected and are not supported. | O/Analog |

## 8.3 Reset and Miscellaneous Signals

### Table 8-5. Reset and Miscellaneous Signals

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| CFG[17:0] | **Configuration Signals:**<br>The CFG signals have a default value of '1' if not terminated on the board.<br>• **CFG[1:0]:** Reserved configuration ball. A test point may be placed on the board for this ball.<br>• **CFG[2]:** PCI Express* Static x16 Lane (Port1) Numbering Reversal.<br>— 1 = Normal operation (default)<br>— 0 = Lane numbers reversed<br>• **CFG[3]:** PCI Express* Static x4 Lane (Port2) Numbering Reversal.<br>— 1 = Normal operation (default)<br>— 0 = Lane numbers reversed<br>• **CFG[4]:** Reserved configuration ball. A test point may be placed on the board for this ball.<br>• **CFG[6:5]:** PCI Express* Bifurcation:<br>— 00 = 1 x8, 2 x4 PCI Express*<br>— 01 = reserved<br>— 10 = 2 x8 PCI Express*<br>— 11 = 1 x16 PCI Express*<br>**CFG[17:7]:** Reserved configuration balls. A test point may be placed on the board for these balls.<br>***Note:*** These strap values are read upon power up and the pre-boot software enables the appropriate number of controllers and lane orientation. See Section 3.2.5, "Configuring PCIe* Lanes" and Section 3.2.6, "Lane Reversal on PCIe* Interface". | I<br>CMOS |
| PM_SYNC | **Power Management Sync**: A sideband signal to communicate power management status from the platform to the processor. | I<br>CMOS |
| RESET# | Platform Reset pin driven by the PCH | I<br>CMOS |
| SM_DRAMRST# | **DDR3 DRAM Reset:** Reset signal from processor to DRAM devices. One common to all channels. | 0<br>CMOS |
| RSVD_[21:1],RSVD_[32:23], RSVD_[43:34],RSVD_[57:45] | **RESERVED:** All signals in this group are RSVD pins which must be left unconnected. | No Connect |
| RSVD_22, RSVD_33, RSVD_44 | **Terminated RESERVED:** These pins must be shorted together and tied to VCCP through 24.9 Ω ±1% resistor. | I<br>CMOS |

## 8.4 PCI Express* Based Interface Signals

### Table 8-6. PCI Express* Interface Signals

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| PCIE_ICOMPI<br>PCIE_ICOMPO<br>PCIE_RCOMPO | PCI Express* Compensation.<br>These pins must be shorted together and tied to VCCIO through 24.9 Ω ±1% resistor. | I/Analog |
| PCIE1_RX[15:0]<br>PCIE1_RX#[15:0] | PCI Express* Receive Differential Pair. | I/PCI Express* |
| PCIE1_TX[15:0]<br>PCIE1_TX#[15:0] | PCI Express* Transmit Differential Pair. | O/PCI Express* |
| PCIE2_RX[3:0]<br>PCIE2_RX#[3:0] | PCI Express* Receive Differential Pair.<br>x4 Port | I/PCI Express* |
| PCIE2_TX[3:0]<br>PCIE2_TX#[3:0] | PCI Express* Transmit Differential Pair.<br>x4 Port | O/PCI Express* |

## 8.5 DMI

### Table 8-7. DMI - Processor to PCH Serial Interface

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| DMI_RX[3:0]<br>DMI_RX#[3:0] | **DMI Input from PCH:** Direct Media Interface receive differential pair. | I<br>DMI |
| DMI_TX[3:0]<br>DMI_TX#[3:0] | **DMI Output to PCH:** Direct Media Interface transmit differential pair. | O<br>DMI |

## 8.6 PLL Signals

### Table 8-8. PLL Signals

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| BCLK<br>BCLK# | Differential bus clock input to the processor and PCI Express*. | I<br>Diff Clk |

## 8.7 TAP Signals

### Table 8-9. TAP Signals

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| BPM#[7:0] | **Breakpoint and Performance Monitor Signals:** Outputs from the processor that indicate the status of breakpoints and programmable counters used for monitoring processor performance. | I/O<br>CMOS |
| PRDY# | **PRDY#** is a processor output used by debug tools to determine processor debug readiness. | O<br>Asynchronous CMOS |
| PREQ# | **PREQ#** is used by debug tools to request debug operation of the processor. | I<br>Asynchronous CMOS |
| TCK | **TCK (Test Clock):** Provides the clock input for the processor Test Bus (also known as the Test Access Port). TCK must be driven low or allowed to float during power on Reset. | I<br>CMOS |
| TDI | **TDI (Test Data In):** Transfers serial test data into the processor. TDI provides the serial input needed for JTAG specification support. | I<br>CMOS |
| TDO | **TDO (Test Data Out)** transfers serial test data out of the processor. TDO provides the serial output needed for JTAG specification support. | O<br>Open Drain |
| TMS | **TMS (Test Mode Select):** A JTAG specification support signal used by debug tools. | I<br>CMOS |
| TRST# | T**RST# (Test Reset)** resets the Test Access Port (TAP) logic. TRST# must be driven low during power on Reset. | I<br>CMOS |

## 8.8 Error and Thermal Protection

### Table 8-10. Error and Thermal Protection

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| CATERR# | **Catastrophic Error:** This signal indicates that the system has experienced a catastrophic error and cannot continue to operate. The processor sets this for non-recoverable machine check errors or other unrecoverable internal errors. External agents are allowed to assert this pin which causes the processor to take a machine check exception.<br>CATERR# is used for signaling the following types of errors:<br>• Legacy MCERR's, CATERR# is asserted for 16 BCLKs.<br>• Legacy IERR's, CATERR# remains asserted until warm or cold reset. | O<br>CMOS |
| PECI | **PECI (Platform Environment Control Interface):** A serial sideband interface to the processor, it is used primarily for thermal, power, and error management. | I/O<br>Asynchronous |
| PROCHOT# | **Processor Hot:** PROCHOT# goes active when the processor temperature monitoring sensor(s) detects that the processor has reached its maximum safe operating temperature. This indicates that the processor Thermal Control Circuit (TCC) has been activated, if enabled. This signal can also be driven to the processor to activate the TCC. | CMOS Input/<br>Open-Drain Output |
| THERMTRIP# | **Thermal Trip:** The processor protects itself from catastrophic overheating by use of an internal thermal sensor. This sensor is set well above the normal operating temperature to ensure that there are no false trips. The processor stops all execution when the junction temperature exceeds approximately 130°C. This is signaled to the system by the THERMTRIP# pin. | O<br>Asynchronous CMOS |

## 8.9 Power Sequencing

### Table 8-11. Power Sequencing

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| SM_DRAMPWROK | **SM_DRAMPWROK Processor Input**: Connects to PCH DRAMPWROK. | I<br>Asynchronous<br>CMOS |
| UNCOREPWRGOOD | The processor requires this input signal to be a clean indication that the VCCSA, VCCIO, and VDDQ, power supplies are stable and within specifications. This requirement applies regardless of the S-state of the processor. 'Clean' implies that the signal remains low (capable of sinking leakage current), without glitches, from the time that the power supplies are turned on until they come within specification. The signal must then transition monotonically to a high state. This is connected to the PCH PROCPWRGD signal. | I<br>Asynchronous<br>CMOS |
| PROC_DETECT# | **PROC_DETECT (Processor Detect):** pulled to ground on the processor package. There is no connection to the processor silicon for this signal. System board designers may use this signal to determine if the processor is present. | N/A |
| PROC_SELECT# | **Processor Select:** This signal is an output that indicates if the processor used is 2nd Generation Intel® Core™ processor family or 3rd Generation Intel® Core™ processor family. For 2nd Generation Intel® Core™ processor family, the output will be high. For 3rd Generation Intel® Core™ processor family the output will be low. | O |

## 8.10 Processor Power and Ground Signals

### Table 8-12. Processor Power Signals (Sheet 1 of 2)

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| VCC | Processor core power rail | Ref |
| VCCIO | Processor power for I/O | Ref |
| VDDQ | Processor I/O supply voltage for DDR3. | Ref |
| VCCPLL | VCCPLL provides isolated power for internal processor PLLs. | Ref |
| VCCSA | System Agent power supply | Ref |
| VIDSOUT<br>VIDSCLK<br>VIDALERT# | VIDALERT#, VIDSCLK, and VIDSOUT comprise a three signal serial synchronous interface used to transfer power management information between the processor and the voltage regulator controllers. This serial VID (SVID) interface replaces the parallel VID interface on previous processors. | I/O<br>O<br>I<br>CMOS |

### Table 8-12. Processor Power Signals (Sheet 2 of 2)

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| VCCSA_VID | **Voltage selection for VCCSA**: For 2nd Generation Intel® Core™ processor family, the output will be low. For 3rd Generation Intel® Core™ processor family, the output may be high or low, and may change dynamically. | O<br>CMOS |
| VSS | Processor ground node | GND |

***Note:*** The VCCSA_VID can toggle at most once in 500 µS; The slew rate of VCCSA_VID is 1 V/nS.

## 8.11 Sense Pins

### Table 8-13. Sense Pins

| Signal Name | Description | Direction/Buffer Type |
|---|---|---|
| VCC_SENSE<br>VSS_SENSE | VCC_SENSE and VSS_SENSE provide an isolated, low impedance connection to the processor core voltage and ground. They can be used to sense or measure voltage near the silicon. | O<br>Analog |
| VCCIO_SENSE<br>VSS_SENSE_VCCIO | VCCIO_SENSE and VSS_SENSE_VCCIO provide an isolated, low impedance connection to the processor VCCIO voltage and ground. They can be used to sense or measure voltage near the silicon. | O<br>Analog |
| VCCSA_VCCSENCE<br>VCCSA_VSSSENCE | VCCSA_VCCSENCE and VCCSA_VSSSENCE provide an isolated, low impedance connection to the processor system agent voltage. It can be used to sense or measure voltage near the silicon. | O<br>Analog |

## 8.12 Processor Internal Pull Up/Pull Down

### Table 8-14. Processor Internal Pull Up/Pull Down

| Signal Name | Pull Up/Pull Down | Rail | Value |
|---|---|---|---|
| BPM[7:0] | Pull Up | VCCIO | 65-165 Ω |
| PRDY# | Pull Up | VCCIO | 65-165 Ω |
| PREQ# | Pull Up | VCCIO | 65-165 Ω |
| TCK | Pull Down | VSS | 5-15 kΩ |
| TDI | Pull Up | VCCIO | 5-15 kΩ |
| TMS | Pull Up | VCCIO | 5-15 kΩ |
| TRST# | Pull Up | VCCIO | 5-15 kΩ |
| CFG[17:0] | Pull Up | VCCIO | 5-15 kΩ |

§ §

# 9.0 Electrical Specifications

## 9.1 Power and Ground Pins

The processor has $V_{CC}$, $V_{CCIO}$, $V_{DDQ}$, $V_{CCPLL}$, $V_{CCSA}$ and $V_{SS}$ (ground) inputs for on-chip power distribution. All power pins must be connected to their respective processor power planes, while all $V_{SS}$ pins must be connected to the system ground plane. Use of multiple power and ground planes is recommended to reduce I*R drop. The $V_{CC}$ pins must be supplied with the voltage determined by the processor Serial Voltage IDentification (SVID) interface. Table 9-1 specifies the voltage level for the various VIDs.

## 9.2 Decoupling Guidelines

Due to its large number of transistors and high internal clock speeds, the processor is capable of generating large current swings between low- and full-power states. To keep voltages within specification, output decoupling must be properly designed.

***Caution:*** Design the board to ensure that the voltage provided to the processor remains within the specifications listed in Table 9-5. Failure to do so can result in timing violations or reduced lifetime of the processor.

### 9.2.1 Voltage Rail Decoupling

The voltage regulator solution must:

- Provide sufficient decoupling to compensate for large current swings generated during different power mode transitions.
- Provide low parasitic resistance from the regulator to the socket.
- Meet voltage and current specifications as defined in Table 9-5.

## 9.3 Processor Clocking (BCLK, BCLK#)

The processor utilizes a differential clock to generate the processor core(s) operating frequency, memory controller frequency, and other internal clocks. The processor core frequency is determined by multiplying the processor core ratio by 100 MHz. Clock multiplying within the processor is provided by an internal phase locked loop (PLL), which requires a constant frequency input, with exceptions for Spread Spectrum Clocking (SSC).

The processor's maximum core frequency is configured during power-on reset by using its manufacturing default value. This value is the highest core multiplier at which the processor can operate. If lower maximum speeds are desired, the appropriate ratio can be configured via the FLEX_RATIO MSR.

### 9.3.1 PLL Power Supply

An on-die PLL filter solution is implemented on the processor.

## 9.4 Serial Voltage Identification (SVID)

The SVID specifications for the processor VCC is defined in the VR12 / IMVP7 SVID Protocol. The processor uses three signals for the serial voltage identification interface to support automatic selection of voltages. Table 9-1 specifies the voltage level corresponding to the eight bit VID value transmitted over serial VID. A '1' in this table refers to a high voltage level and a '0' refers to a low voltage level. If the voltage regulation circuit cannot supply the voltage that is requested, the voltage regulator must disable itself. VID signals are CMOS push/pull drivers. The VID codes change due to temperature and/or current load changes in order to minimize the power of the part. A voltage range is provided in Table 9-1. The specifications are set so that one voltage regulator can operate with all supported frequencies.

Individual processor VID values may be set during manufacturing so that two devices at the same core frequency may have different default VID settings. This is shown in the VID range values in Table 9-5. The processor provides the ability to operate while transitioning to an adjacent VID and its associated voltage. This represents a DC shift in the loadline.

*Note:* Transitions above the maximum specified VID are not permitted. Table 9-5 includes VID step sizes and DC shift ranges. Minimum and maximum voltages must be maintained. At condition outside functional operation condition limits, neither functionality nor long term reliability can be expected. If a device is returned to conditions within functional operation limits after having been subjected to conditions outside these limits, but within the absolute maximum and minimum ratings, the device may be functional, but with its lifetime degraded on exposure to conditions exceeding the functional operation condition limits.

The VR utilized must be capable of regulating its output to the value defined by the new VID values issued. DC specifications for dynamic VID transitions are included in Table 9-5.

**Table 9-1. IMVP7 Voltage Identification Definition (Sheet 1 of 8)**

| VID7 | VID6 | VID5 | VID4 | VID3 | VID2 | VID1 | VID0 | HEX | | $V_{CC_MAX}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00000 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.25000 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0.25500 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 3 | 0.26000 |

## Table 9-1. IMVP7 Voltage Identification Definition (Sheet 2 of 8)

| VID7 | VID6 | VID5 | VID4 | VID3 | VID2 | VID1 | VID0 | HEX | | $V_{CC_MAX}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 0.26500 |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 0.27000 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 6 | 0.27500 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 7 | 0.28000 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 8 | 0.28500 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 9 | 0.29000 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | A | 0.29500 |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | B | 0.30000 |
| 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | C | 0.30500 |
| 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | D | 0.31000 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | E | 0.31500 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | F | 0.32000 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0.32500 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0.33000 |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 0.33500 |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 3 | 0.34000 |
| 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 4 | 0.34500 |
| 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 5 | 0.35000 |
| 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 6 | 0.35500 |
| 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 7 | 0.36000 |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 8 | 0.36500 |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 9 | 0.37000 |
| 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | A | 0.37500 |
| 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | B | 0.38000 |
| 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | C | 0.38500 |
| 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | D | 0.39000 |
| 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | E | 0.39500 |
| 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | F | 0.40000 |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0.40500 |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 0.41000 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 0.41500 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 0.42000 |
| 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 4 | 0.42500 |
| 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 5 | 0.43000 |
| 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 2 | 6 | 0.43500 |
| 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 7 | 0.44000 |
| 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 8 | 0.44500 |
| 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 2 | 9 | 0.45000 |
| 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 2 | A | 0.45500 |
| 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 2 | B | 0.46000 |

## Table 9-1. IMVP7 Voltage Identification Definition (Sheet 3 of 8)

| VID7 | VID6 | VID5 | VID4 | VID3 | VID2 | VID1 | VID0 | HEX | | $V_{CC_MAX}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 2 | C | 0.46500 |
| 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 2 | D | 0.47000 |
| 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 2 | E | 0.47500 |
| 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 2 | F | 0.48000 |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0.48500 |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 3 | 1 | 0.49000 |
| 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 3 | 2 | 0.49500 |
| 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 3 | 3 | 0.50000 |
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 3 | 4 | 0.50500 |
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 3 | 5 | 0.51000 |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 3 | 6 | 0.51500 |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 3 | 7 | 0.52000 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 3 | 8 | 0.52500 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 9 | 0.53000 |
| 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 3 | A | 0.53500 |
| 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 3 | B | 0.54000 |
| 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 3 | C | 0.54500 |
| 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 3 | D | 0.55000 |
| 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 3 | E | 0.55500 |
| 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | F | 0.56000 |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0.56500 |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 1 | 0.57000 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 2 | 0.57500 |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 3 | 0.58000 |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 4 | 0.58500 |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 4 | 5 | 0.59000 |
| 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 4 | 6 | 0.59500 |
| 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 4 | 7 | 0.60000 |
| 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 8 | 0.60500 |
| 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 4 | 9 | 0.61000 |
| 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 4 | A | 0.61500 |
| 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 4 | B | 0.62000 |
| 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 4 | C | 0.62500 |
| 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 4 | D | 0.63000 |
| 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 4 | E | 0.63500 |
| 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 4 | F | 0.64000 |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 0 | 0.64500 |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 5 | 1 | 0.65000 |
| 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 2 | 0.65500 |
| 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 5 | 3 | 0.66000 |

## Table 9-1. IMVP7 Voltage Identification Definition (Sheet 4 of 8)

| VID7 | VID6 | VID5 | VID4 | VID3 | VID2 | VID1 | VID0 | HEX | | $V_{CC_MAX}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 5 | 4 | 0.66500 |
| 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 5 | 5 | 0.67000 |
| 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 5 | 6 | 0.67500 |
| 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 5 | 7 | 0.68000 |
| 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 5 | 8 | 0.68500 |
| 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 5 | 9 | 0.69000 |
| 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 5 | A | 0.69500 |
| 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 5 | B | 0.70000 |
| 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 5 | C | 0.70500 |
| 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 5 | D | 0.71000 |
| 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 5 | E | 0.71500 |
| 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 5 | F | 0.72000 |
| 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0.72500 |
| 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 6 | 1 | 0.73000 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 6 | 2 | 0.73500 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 6 | 3 | 0.74000 |
| 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 6 | 4 | 0.74500 |
| 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 6 | 5 | 0.75000 |
| 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 6 | 6 | 0.75500 |
| 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 6 | 7 | 0.76000 |
| 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 6 | 8 | 0.76500 |
| 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 6 | 9 | 0.77000 |
| 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 6 | A | 0.77500 |
| 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 6 | B | 0.78000 |
| 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 6 | C | 0.78500 |
| 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 6 | D | 0.79000 |
| 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 6 | E | 0.79500 |
| 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 6 | F | 0.80000 |
| 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 7 | 0 | 0.80500 |
| 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 7 | 1 | 0.81000 |
| 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 7 | 2 | 0.81500 |
| 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 7 | 3 | 0.82000 |
| 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 7 | 4 | 0.82500 |
| 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 7 | 5 | 0.83000 |
| 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 7 | 6 | 0.83500 |
| 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 7 | 7 | 0.84000 |
| 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 7 | 8 | 0.84500 |
| 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 7 | 9 | 0.85000 |
| 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 7 | A | 0.85500 |
| 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 7 | B | 0.86000 |

## Table 9-1. IMVP7 Voltage Identification Definition (Sheet 5 of 8)

| VID7 | VID6 | VID5 | VID4 | VID3 | VID2 | VID1 | VID0 | HEX | | $V_{CC_MAX}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 7 | C | 0.86500 |
| 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 7 | D | 0.87000 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 7 | E | 0.87500 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 | F | 0.88000 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0.88500 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 1 | 0.89000 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 8 | 2 | 0.89500 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 8 | 3 | 0.90000 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 8 | 4 | 0.90500 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 8 | 5 | 0.91000 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 8 | 6 | 0.91500 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 8 | 7 | 0.92000 |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 8 | 0.92500 |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 8 | 9 | 0.93000 |
| 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 8 | A | 0.93500 |
| 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 8 | B | 0.94000 |
| 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 8 | C | 0.94500 |
| 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 8 | D | 0.95000 |
| 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 8 | E | 0.95500 |
| 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 8 | F | 0.96000 |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 9 | 0 | 0.96500 |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 9 | 1 | 0.97000 |
| 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 9 | 2 | 0.97500 |
| 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 9 | 3 | 0.98000 |
| 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 9 | 4 | 0.98500 |
| 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 9 | 5 | 0.99000 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 9 | 6 | 0.99500 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 9 | 7 | 1.00000 |
| 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 9 | 8 | 1.00500 |
| 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 9 | 9 | 1.01000 |
| 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 9 | A | 1.01500 |
| 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 9 | B | 1.02000 |
| 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 9 | C | 1.02500 |
| 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 9 | D | 1.03000 |
| 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 9 | E | 1.03500 |
| 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 9 | F | 1.04000 |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | A | 0 | 1.04500 |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | A | 1 | 1.05000 |
| 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | A | 2 | 1.05500 |
| 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | A | 3 | 1.06000 |

## Table 9-1. IMVP7 Voltage Identification Definition (Sheet 6 of 8)

| VID7 | VID6 | VID5 | VID4 | VID3 | VID2 | VID1 | VID0 | HEX | | $V_{CC_MAX}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | A | 4 | 1.06500 |
| 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | A | 5 | 1.07000 |
| 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | A | 6 | 1.07500 |
| 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | A | 7 | 1.08000 |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | A | 8 | 1.08500 |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | A | 9 | 1.09000 |
| 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | A | A | 1.09500 |
| 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | A | B | 1.10000 |
| 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | A | C | 1.10500 |
| 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | A | D | 1.11000 |
| 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | A | E | 1.11500 |
| 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | A | F | 1.12000 |
| 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | B | 0 | 1.12500 |
| 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | B | 1 | 1.13000 |
| 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | B | 2 | 1.13500 |
| 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | B | 3 | 1.14000 |
| 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | B | 4 | 1.14500 |
| 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | B | 5 | 1.15000 |
| 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | B | 6 | 1.15500 |
| 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | B | 7 | 1.16000 |
| 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | B | 8 | 1.16500 |
| 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | B | 9 | 1.17000 |
| 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | B | A | 1.17500 |
| 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | B | B | 1.18000 |
| 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | B | C | 1.18500 |
| 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | B | D | 1.19000 |
| 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | B | E | 1.19500 |
| 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | B | F | 1.20000 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | C | 0 | 1.20500 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | C | 1 | 1.21000 |
| 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | C | 2 | 1.21500 |
| 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | C | 3 | 1.22000 |
| 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | C | 4 | 1.22500 |
| 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | C | 5 | 1.23000 |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | C | 6 | 1.23500 |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | C | 7 | 1.24000 |
| 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | C | 8 | 1.24500 |
| 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | C | 9 | 1.25000 |
| 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | C | A | 1.25500 |
| 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | C | B | 1.26000 |

## Table 9-1. IMVP7 Voltage Identification Definition (Sheet 7 of 8)

| VID7 | VID6 | VID5 | VID4 | VID3 | VID2 | VID1 | VID0 | HEX | | $V_{CC_MAX}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | C | C | 1.26500 |
| 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | C | D | 1.27000 |
| 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | C | E | 1.27500 |
| 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | C | F | 1.28000 |
| 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | D | 0 | 1.28500 |
| 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | D | 1 | 1.29000 |
| 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | D | 2 | 1.29500 |
| 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | D | 3 | 1.30000 |
| 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | D | 4 | 1.30500 |
| 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | D | 5 | 1.31000 |
| 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | D | 6 | 1.31500 |
| 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | D | 7 | 1.32000 |
| 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | D | 8 | 1.32500 |
| 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | D | 9 | 1.33000 |
| 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | D | A | 1.33500 |
| 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | D | B | 1.34000 |
| 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | D | C | 1.34500 |
| 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | D | D | 1.35000 |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | D | E | 1.35500 |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | D | F | 1.36000 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | E | 0 | 1.36500 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | E | 1 | 1.37000 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | E | 2 | 1.37500 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | E | 3 | 1.38000 |
| 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | E | 4 | 1.38500 |
| 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | E | 5 | 1.39000 |
| 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | E | 6 | 1.39500 |
| 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | E | 7 | 1.40000 |
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | E | 8 | 1.40500 |
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | E | 9 | 1.41000 |
| 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | E | A | 1.41500 |
| 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | E | B | 1.42000 |
| 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | E | C | 1.42500 |
| 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | E | D | 1.43000 |
| 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | E | E | 1.43500 |
| 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | E | F | 1.44000 |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | F | 0 | 1.44500 |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | F | 1 | 1.45000 |
| 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | F | 2 | 1.45500 |
| 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | F | 3 | 1.46000 |

**Table 9-1. IMVP7 Voltage Identification Definition (Sheet 8 of 8)**

| VID7 | VID6 | VID5 | VID4 | VID3 | VID2 | VID1 | VID0 | HEX | | $V_{CC_MAX}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | F | 4 | 1.46500 |
| 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | F | 5 | 1.47000 |
| 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | F | 6 | 1.47500 |
| 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | F | 7 | 1.48000 |
| 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | F | 8 | 1.48500 |
| 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | F | 9 | 1.49000 |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | F | A | 1.49500 |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | F | B | 1.50000 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | F | C | 1.50500 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | F | D | 1.51000 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | F | E | 1.51500 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | F | F | 1.52000 |

## 9.5 System Agent (SA) Vcc VID

The VccSA is configured by the processor output pin VCCSA_VID and PROC_SELECT#. VCCSA_VID output may be a logic state “0” or “1”.

*Note:* During boot, VCCSA is 0.8 volts.

Table 9-2 specifies the different VCCSA_VID configurations.

**Table 9-2. VCCSA Configuration**

| VCCSA_VID | PROC_SELECT# | Selected VCCSA |
|---|---|---|
| 0 | 0 | 0.8 V |
| 1 | 0 | 0.8 V |

***Note:***

## 9.6 Reserved or Unused Signals

The following are the general types of reserved (RSVD) signals and connection guidelines:

- RSVD_22, RSVD_33 and RSVD_44 - These pins must be shorted together and tied to VCCP through 24.9 ohm 1% resistor.
- RSVD_[21:1], RSVD_[32:23], RSVD_[43:34] and RSVD_[57:45] - these signals should not be connected.

Arbitrary connection of these signals to $V_{CC}$, $V_{CCIO}$, $V_{DDQ}$, $V_{CCPLL}$, $V_{CCSA}$, $V_{SS}$, or to any other signal (including each other) may result in component malfunction or incompatibility with future processors. See Chapter 8.0, "Signal Description" for a pin listing of the processor and the location of all reserved signals.

For reliable operation, always connect unused inputs or bi-directional signals to an appropriate signal level. Unused active high inputs should be connected through a resistor to ground ($V_{SS}$). Unused outputs maybe left unconnected; however, this may interfere with some Test Access Port (TAP) functions, complicate debug probing, and prevent boundary scan testing. A resistor must be used when tying bi-directional signals to power or ground. When tying any signal to power or ground, a resistor will also allow for system testability. Resistor values should be within ±20% of the impedance of the baseboard trace, unless otherwise noted in the appropriate platform design guidelines. For details, see Table 8-14, "Processor Internal Pull Up/Pull Down".

## 9.7 Signal Groups

Signals are grouped by buffer type and similar characteristics as listed in Table 9-3. The buffer type indicates which signaling technology and specifications apply to the signals. All the differential signals, and selected DDR3 and Control Sideband signals have On-Die Termination (ODT) resistors. Some signals do not have ODT and must be terminated on the board.

**Table 9-3. Signal Groups (Sheet 1 of 3)**

| Signal Group[1] | Type | Signals |
|---|---|---|
| **System Reference Clock** | | |
| Differential | CMOS Input | BCLK, BCLK# |
| **DDR3 Reference Clocks[2]** | | |
| Differential | DDR3 Output | SA_CK[3:0], SA_CK#[3:0]<br>SB_CK[3:0], SB_CK#[3:0] |
| **DDR3 Command Signals[2]** | | |
| Single Ended | DDR3 Output | SA_BS[2:0], SB_BS[2:0]<br>SA_WE#, SB_WE#<br>SA_RAS#, SB_RAS#<br>SA_CAS#, SB_CAS#<br>SA_MA[15:0], SB_MA[15:0] |
| **DDR3 Control Signals[2]** | | |
| Single Ended | DDR3 Output | SA_CS#[3:0], SB_CS#[3:0]<br>SA_ODT[3:0], SB_ODT[3:0]<br>SA_CKE[3:0], SB_CKE[3:0]<br>SM_DRAMRST# |

## Table 9-3. Signal Groups (Sheet 2 of 3)

| Signal Group[1] | Type | Signals |
|---|---|---|
| **DDR3 Data Signals[2]** | | |
| Single ended | DDR3 Bi-directional | SA_DQ[63:0], SB_DQ[63:0]<br>SA_ECC_CB[7:0],<br>SB_ECC_CB[7:0] |
| Differential | DDR3 Bi-directional | SA_DQS[8:0], SA_DQS#[8:0]<br>SB_DQS[8:0], SB_DQS#[8:0] |
| **DDR3 Compensation** | | |
| | Analog Bi-directional | SM_RCOMP[2:0] |
| **DDR3 Reference** | | |
| | Analog Input | SM_VREF |
| **TAP (ITP/XDP)** | | |
| Single Ended | CMOS Input | TCK, TDI, TMS, TRST# |
| Single Ended | CMOS Open-Drain Output | TDO |
| Single Ended | Asynchronous CMOS Bi-directional | BPM#[7:0] |
| Single Ended | Asynchronous CMOS Output | PRDY# |
| Single Ended | Asynchronous CMOS Input | PREQ# |
| **Control Sideband[3]** | | |
| Single Ended | CMOS Input | CFG[17:0] |
| Single Ended | Asynchronous CMOS/Open Drain Bi-directional | PROCHOT# |
| Single Ended | Asynchronous CMOS Output | THERMTRIP#, CATERR# |
| Single Ended | Asynchronous CMOS Input | SM_DRAMPWROK, UNCOREPWRGOOD[4], PM_SYNC, RESET# |
| Single Ended | Asynchronous Bi-directional | PECI |
| **Voltage Regulator** | | |
| Single Ended | CMOS Input | VIDALERT# |
| Single Ended | Open Drain Output | VIDSCLK |
| Single Ended | CMOS Output | VCCSA_VID |
| Single Ended | Bi-directional CMOS Input/Open Drain Output | VIDSOUT |
| Single Ended | Analog Output | VCCSA_VCCSENCE, VCCSA_VSSSENCE, |
| Differential | Analog Output | VCC_SENSE, VSS_SENSE, VCCIO_SENSE, VSS_SENSE_VCCIO, |
| **Power/Ground/Other** | | |
| Single Ended | Power | $V_{CC}$, $V_{CCIO}$, $V_{CCSA}$, $V_{CCPLL}$, $V_{DDQ}$ |
| | Ground | $V_{SS}$ |
| | No Connect /Test Point | RSVD |
| | Other | PROC_DETECT# |

**Table 9-3. Signal Groups (Sheet 3 of 3)**

| Signal Group[1] | Type | Signals |
|---|---|---|
| **PCI Express*** | | |
| Differential | PCI Express* Input | PCIE_RX[15:0], PCIE_RX#[15:0]<br>PE_RX[3:0], PE_RX#[3:0] |
| Differential | PCI Express* Output | PCIE_TX[15:0], PCIE_TX#[15:0]<br>PE_TX[3:0], PE_TX#[3:0] |
| Single Ended | Analog Input | PCIE_ICOMP0, PCIE_ICOMPI,<br>PCIE_RCOMP0 |
| **DMI** | | |
| Differential | DMI Input | DMI_RX[3:0], DMI_RX#[3:0] |
| Differential | DMI Output | DMI_TX[3:0], DMI_TX#[3:0] |

***Notes:***
1. See Chapter 8.0 for signal description details.
2. SA and SB see DDR3 Channel A and DDR3 Channel B.
3. All Control Sideband Asynchronous signals are required to be asserted/deasserted for at least **10 BCLKs** with a maximum Trise/Tfall of 6 ns for the processor to recognize the proper signal state. See Chapter 9.10 for the DC specifications.
4. The maximum rise/fall time of UNCOREPWRGOOD is 20 ns.

## 9.8 Test Access Port (TAP) Connection

Due to the voltage levels supported by other components in the Test Access Port (TAP) logic, Intel recommends the processor be first in the TAP chain, followed by any other components within the system. A translation buffer should be used to connect to the rest of the chain unless one of the other components is capable of accepting an input of the appropriate voltage. Two copies of each signal may be required with each driving a different voltage level.

The processor supports Boundary Scan (JTAG) IEEE 1149.1-2001 and IEEE 1149.6-2003 standards. Some small portion of the I/O pins may support only one of these standards.

*Note:* Some of the I/O pins may support only one of these standards.

## 9.9 Storage Conditions Specifications

Environmental storage condition limits define the temperature and relative humidity to which the device is exposed to while being stored in a moisture barrier bag. The specified storage conditions are for component level prior to board attach.

Table 9-4 specifies absolute maximum and minimum storage temperature limits which represent the maximum or minimum device condition beyond which damage, latent or otherwise, may occur. The table also specifies sustained storage temperature, relative humidity, and time-duration limits. These limits specify the maximum or minimum device storage conditions for a sustained period of time. Failure to adhere to the following specifications can affect long term reliability of the processor.

### Table 9-4. Storage Condition Ratings

| Symbol | Parameter | Min | Max | Notes |
|---|---|---|---|---|
| $T_{absolute\ storage}$ | Device storage temperature when exceeded for any length of time | -25 °C | 125 °C | 1,2,3,4 |
| $T_{short\ term\ storage}$ | The ambient storage temperature and time for up to 72 hours | -25 °C | 85 °C | 5,6,7 |
| $T_{sustained\ storage\ time\ and\ temp}$ | The ambient storage temperature and time for up to 30 months | -5 °C | 40 °C | |
| $RH_{sustained\ storage}$ | The maximum device storage relative humidity for up to 30 months. | 60% @ 24 °C | | 6,7 |

***Notes:***
1. Refers to a component device that is not assembled in a board or socket and is not electrically connected to a voltage re fence or I/O signal.
2. Specified temperatures are not to exceed values based on data collected. Exceptions for surface mount reflow are specified by the applicable JEDEC standard. Non-adherence may affect processor reliability.
3. $T_{absolute\ storage}$ applies to the unassembled component only and does not apply to the shipping media, moisture barrier bags, or desiccant.
4. Component product device storage temperature qualification methods may follow JESD22-A119 (low temp) and JESD22-A103 (high temp) standards when applicable for volatile memory.
5. Intel® branded products are specified and certified to meet the following temperature and humidity limits that are given as a example only (Non-Operating Temperature Limit: -40 °C to 70 °C and Humidity: 50% to 90%, non-condensing with a maximum wet bulb of 28 °C.) Post board attach storage temperature limits are not specified for non-Intel branded boards.
6. The JEDEC J-JSTD-020 moisture level rating and associated handling practices apply to all moisture sensitive devices removed from the moisture barrier bag.
7. Nominal temperature and humidity conditions and durations are given and tested within the constraints imposed by $T_{sustaind\ storage}$ and customer shelf life in applicable Intel boxes and bags.

## 9.10 DC Specifications

The processor DC specifications in this section are defined at the processor pins, unless noted otherwise. See Chapter 10.0 for the processor pin listings and Chapter 8.0 for signal definitions.

The DC specifications for the DDR3 signals are listed in Table 9-10. Control Sideband and Test Access Port (TAP) are listed in Table 9-11.

Table 9-5 through Table 9-9 list the DC specifications for the processor and are valid only while meeting specifications for junction temperature, clock frequency, and input voltages. Read all notes associated with each parameter.

AC tolerances for all DC rails include dynamic load currents at switching frequencies up to 1 MHz.

### 9.10.1 Voltage and Current Specifications

*Note:* Noise measurements on SENSE pins for all voltage supplies should be made with a 20-MHz bandwidth oscilloscope.

*Note:* Noise measurements on SENSE pins for all voltage supplies should be made with a 20-MHz bandwidth oscilloscope.

## Table 9-5. Processor Core (VCC) DC Voltage and Current Specifications (Sheet 1 of 2)

| Symbol | Parameter | SKU | Min | Typ | Max | Unit | Note |
|---|---|---|---|---|---|---|---|
| HFM_VID | VID Range for Highest Frequency Mode | **E3-1125C v2**<br>**E3-1105C v2**<br>**i3-3115C**<br>**B925C** | 0.8<br>0.8<br>0.75<br>0.70 | | 1.35<br>1.35<br>1.3<br>1.2 | V | 1,2,7,9 |
| LFM_VID | VID Range for Lowest Frequency Mode | **E3-1125C v2**<br>**E3-1105C v2**<br>**i3-3115C**<br>**B925C** | 0.65<br>0.65<br>0.65<br>0.65 | | 0.95<br>0.95<br>0.90<br>0.90 | V | 1,2,9 |
| $V_{CC}$ | $V_{CC}$ for processor core | | 0.3-1.52 | | | V | 2, 3, 4 |
| $I_{CCMAX}$ | Maximum Processor Core $I_{CC}$ | **E3-1125C v2**<br>**E3-1105C v2**<br>**i3-3115C**<br>**B925C** | | | 57<br>33<br>30<br>23 | A | 1,5,7,9 |
| $I_{CC_TDC}$ | Thermal Design $I_{CC}$ | **E3-1125C v2**<br>**E3-1105C v2**<br>**i3-3115C**<br>**B925C** | | | 35<br>22<br>18<br>13 | A | 1,6,7, 9,14 |
| $I_{CC_LFM}$ | $I_{CC}$ at LFM | **E3-1125C v2**<br>**E3-1105C v2**<br>**i3-3115C**<br>**B925C** | | | 28<br>28<br>15<br>15 | A | 6 |
| $TDC_{_LFM}$ | TDC at LFM | **E3-1125C v2**<br>**E3-1105C v2**<br>**i3-3115C**<br>**B925C** | | | 22<br>22<br>12<br>12 | A | 1,6 |
| Icc_Dyn_VID1 | Dynamic Current step size in VID1 | **E3-1125C v2**<br>**E3-1105C v2**<br>**i3-3115C**<br>**B925C** | | | 46<br>26<br>24<br>18 | A | 11, 12 |
| didt | VCC ICC Slew Time | | 150 | | | nS | 13 |
| $TOL_{VCC}$ | Voltage Tolerance | PS0 | | | +/- 15 | mV | 8, 10 |
| | | PS1 | | | +/- 12 | | |
| | | PS2, PS3 | | | +/- 11.5 | | |
| Ripple | Ripple Tolerance | PS0 & Icc > TDC+30% | | | +/- 15 | mV | 8,10 |
| | | PS0 & Icc <= TDC+30% | | | +/- 10 | | |
| | | PS1 | | | +/- 13 | | |
| | | PS2 | | | - 7.5/+18.5 | | |
| | | PS3 | | | - 7.5/+27.5 | | |

## Table 9-5. Processor Core (VCC) DC Voltage and Current Specifications (Sheet 2 of 2)

| Symbol | Parameter | SKU | Min | Typ | Max | Unit | Note |
|---|---|---|---|---|---|---|---|
| VR Step | VID resolution | | | 5 | | mV | |
| $SLOPE_{LL}$ | Processor Loadline Slope | **E3-1125C v2**<br>**E3-1105C v2**<br>**i3-3115C**<br>**B925C** | | -1.9<br>-1.9<br>-2.9<br>-2.9 | | mΩ | |

***Notes:***

1. Unless otherwise noted, all specifications in this table are based on post-silicon estimates and simulations or empirical data.
2. Each processor is programmed with a maximum valid voltage identification value (VID), which is set at manufacturing and cannot be altered. Individual maximum SVID values are calibrated during manufacturing such that two processors at the same frequency may have different settings within the SVID range. This differs from the SVID employed by the processor during a power or thermal management event (Intel Adaptive Thermal Monitor, Enhanced Intel SpeedStep Technology, or Low Power States).
3. The voltage specification requirements are measured across $V_{CC_SENSE}$ and $V_{SS_SENSE}$ balls at the socket with a 100-MHz bandwidth oscilloscope, 1.5 pF maximum probe capacitance, and 1-MΩ minimum impedance. The maximum length of ground wire on the probe should be less than 5 mm. Ensure external noise from the system is not coupled into the oscilloscope probe.
4. The processor should not be subjected to any $V_{CC}$ and $I_{CC}$ combination wherein $V_{CC}$ exceeds $V_{CC_MAX}$ for a given current.
5. Processor core VR to be designed to electrically support this current
6. Processor core VR to be designed to thermally support this current indefinitely.
7. Measured at $V_{CC_SENSE}$ and $V_{SS_SENSE}$ processor pins.
8. Long term reliability cannot be assured if tolerance, ripple, and core noise parameters are violated
9. Long term reliability cannot be assured in conditions above or below Max/Min functional limits.
10. PSx refers to the voltage regulator power state as set by the SVID protocol.
11. Step is done in 150 ns
12. Slew time for any transient step size.
13. Simulated at platform processor pads. This parameter is not tested.

## Table 9-6. Processor Uncore ($V_{CCIO}$) Supply DC Voltage and Current Specifications

| Symbol | Parameter | Min | Typ | Max | Unit | Note |
|---|---|---|---|---|---|---|
| $V_{CCIO}$ | Voltage for the memory controller and shared cache defined at the motherboard $V_{CCIO_SENSE}$ and $V_{SS_SENSE_VCCIO}$ | - | 1.05 | - | V | |
| $TOL_{CCIO}$ | $V_{CCIO}$ Tolerance defined across $V_{CCIO_SENSE}$ and $V_{SS_SENSE_VCCIO}$ | DC: ±2% including ripple<br>AC: ±3% | | | % | 1 |
| $I_{CCMAX_VCCIO}$ | Max Current for $V_{CCIO}$ Rail | | - | 8.5 | A | 1 |
| $I_{CCTDC_VCCIO}$ | Thermal Design Current (TDC) for $V_{CCIO}$ Rail | | - | 8.5 | A | 1 |
| di/dt | Step current | 2 | | | A | 2, 3 |
| Slew Rate | Voltage Ramp rate (dV/dT) | 0.5 | | 10 | mV/uS | 1 |

***Notes:***
1. Long term reliability cannot be assured in conditions above or below Max/Min functional limits.
2. Step is done in 100 nS.
3. di/dt values are for platform testing only. This parameter is not tested on Intel silicon. Testing should go up to and include IccMax.

## Table 9-7. Memory Controller ($V_{DDQ}$) Supply DC Voltage and Current Specifications

| Symbol | Parameter | Min | Typ | Max | Unit | Note |
|---|---|---|---|---|---|---|
| $V_{DDQ}$(DC+AC) DDR3 | Processor I/O supply voltage for DDR3 (DC + AC specification) | - | 1.5 | - | V | |
| $V_{DDQ}$(DC + AC) DDR3L | Processor I/O supply voltage for DDR3L (DC + AC specification) | | 1.35 | | V | |
| $TOL_{DDQ}$ | $V_{DDQ}$ Tolerance | DC= ±3%<br>AC= ±2%<br>AC+DC= ±5% | | | % | 3 |
| $I_{CCMAX_VDDQ}$ | Max Current for $V_{DDQ}$ Rail | | - | 5 | A | 1,2 |
| $I_{CCTDC_VDDQ}$ | Thermal Design Current (TDC) for $V_{DDQ}$ Rail | | | 5 | A | 1 |
| $I_{CCAVG_VDDQ\ (Standby)}$ | Average Current for $V_{DDQ}$ Rail during Standby | | 66 | 133 | mA | 2 |
| Slew Rate | Voltage Ramp rate (dV/dT) | 0.5 | | 10 | mV/uS | |
| di/dt | Step current | 7.5 | | | A | 3,4 |

***Notes:***
1. The current supplied to the DIMM modules is not included in this specification.
2. Long term reliability cannot be assured in conditions above or below Max/Min functional limits.
3. Step current between 1 amp through 8.5 amps is done in 150nS
4. di/dt values are for platform testing only. This parameter is not tested on Intel silicon. Testing should go up to and include IccMax.

## Table 9-8. System Agent ($V_{CCSA}$) Supply DC Voltage and Current Specifications (Sheet 1 of 2)

| Symbol | Parameter | Min | Typ | Max | Unit | Note |
|---|---|---|---|---|---|---|
| $V_{CCSA}$ | Voltage for the System Agent and VCCSA_VCCSENCE | - | 0.80 | - | V | 1 |
| $TOL_{CCSA}$ | $V_{CCSA}$ Tolerance | AC + DC = ± 5% | | | % | 1 |
| $I_{CCMAX_VCCSA}$ | Max Current for $V_{CCSA}$ Rail | | - | 6 | A | 1 |
| $I_{CCTDC_VCCSA}$ | Thermal Design Current (TDC) for $V_{CCSA}$ Rail | | - | 6 | A | 1 |

### Table 9-8. System Agent ($V_{CCSA}$) Supply DC Voltage and Current Specifications (Sheet 2 of 2)

| Symbol | Parameter | Min | Typ | Max | Unit | Note |
|---|---|---|---|---|---|---|
| Slew Rate | Voltage Ramp rate (dV/dT) | 0.5 | | 10 | mV/uS | 1 |
| di/dt | Step current | 2 | | | A | 2,3 |

***Notes:***
1. Long term reliability cannot be assured in conditions above or below Max/Min functional limits.
2. Step current is done in 100nS
3. di/dt values are for platform testing only. This parameter is not tested on Intel silicon. Testing should go up to and include IccMax.

### Table 9-9. Processor PLL ($V_{CCPLL}$) Supply DC Voltage and Current Specifications

| Symbol | Parameter | Min | Typ | Max | Unit | Note |
|---|---|---|---|---|---|---|
| $V_{CCPLL}$ | PLL supply voltage (DC + AC specification) | - | 1.8 | - | V | |
| $TOL_{CCPLL}$ | $V_{CCPLL}$ Tolerance | AC + DC = ± 5% | | | % | |
| $I_{CCMAX_VCCPLL}$ | Max Current for $V_{CCPLL}$ Rail | | - | 1.2 | A | |
| $I_{CCTDC_VCCPLL}$ | Thermal Design Current (TDC) for $V_{CCPLL}$ Rail | | - | 1.2 | A | 3 |

***Note:*** Long term reliability cannot be assured in conditions above or below Max/Min functional limits.

### Table 9-10. DDR3/DDR3L Signal Group DC Specifications (Sheet 1 of 2)

| Symbol | Parameter | Min | Typ | Max | Units | Notes[1] |
|---|---|---|---|---|---|---|
| $V_{IL}$ | Input Low Voltage | — | — | SM_VREF -0.1 | V | 2, 4, 11 |
| $V_{IH}$ | Input High Voltage | SM_VREF + 0.1 | — | — | V | 3, 11 |
| $V_{IL}$ | Input Low Voltage (SM_DRAMPWROK) | — | — | $V_{DDQ}$*0.55 -0.1 | V | 10 |
| $V_{IH}$ | Input High Voltage (SM_DRAMPWROK) | $V_{DDQ}$*0.55 +0.1 | — | — | V | 10 |
| $V_{OL}$ | Output Low Voltage | — | ($V_{DDQ}$ / 2)* ($R_{ON}$ / ($R_{ON}$+$R_{TERM}$)) | — | | 6 |
| $V_{OH}$ | Output High Voltage | — | $V_{DDQ}$ - (($V_{DDQ}$ / 2)* ($R_{ON}$/($R_{ON}$+$R_{TERM}$)) | — | V | 4, 6 |
| $R_{ON_UP(DQ)}$ | DDR3 Data Buffer pull-up Resistance | 20 | 28.6 | 40 | Ω | 5 |
| $R_{ON_DN(DQ)}$ | DDR3 Data Buffer pull-down Resistance | 20 | 28.6 | 40 | Ω | 5 |
| $R_{ODT(DQ)}$ | DDR3 On-die termination equivalent resistance for data signals | 40 | 50 | 60 | Ω | |
| $V_{ODT(DC)}$ | DDR3 On-die termination DC working point (driver set to receive mode) | 0.4*$V_{DDQ}$ | 0.5*$V_{DDQ}$ | 0.6*$V_{DDQ}$ | V | |
| $R_{ON_UP(CK)}$ | DDR3 Clock Buffer pull-up Resistance | 20 | 26 | 40 | Ω | 5 |

## Table 9-10. DDR3/DDR3L Signal Group DC Specifications (Sheet 2 of 2)

| Symbol | Parameter | Min | Typ | Max | Units | Notes[1] |
|---|---|---|---|---|---|---|
| $R_{ON_DN(CK)}$ | DDR3 Clock Buffer pull-down Resistance | 20 | 26 | 40 | Ω | 5 |
| $R_{ON_UP(CMD)}$ | DDR3 Command Buffer pull-up Resistance | 15 | 20 | 25 | Ω | 5 |
| $R_{ON_DN(CMD)}$ | DDR3 Command Buffer pull-down Resistance | 15 | 20 | 27 | Ω | 5 |
| $R_{ON_UP(CTL)}$ | DDR3 Control Buffer pull-up Resistance | 15 | 20 | 25 | Ω | 5 |
| $R_{ON_DN(CTL)}$ | DDR3 Control Buffer pull-down Resistance | 15 | 20 | 27 | Ω | 5 |
| $I_{LI}$ | Input Leakage Current (DQ, CK)<br>0V<br>$0.2*V_{DDQ}$<br>$0.8*V_{DDQ}$<br>$V_{DDQ}$ | — | — | <br>± 0.75<br>± 0.55<br>± 0.9<br>± 1.4 | mA | |
| $I_{LI}$ | Input Leakage Current (CMD, CTL)<br>0V<br>$0.2*V_{DDQ}$<br>$0.8*V_{DDQ}$<br>$V_{DDQ}$ | — | — | <br>± 0.85<br>± 0.65<br>± 1.10<br>± 1.65 | mA | |
| SM_RCOMP0 | Command COMP Resistance | 138.6 | 140 | 141.4 | Ω | 8 |
| SM_RCOMP1 | Data COMP Resistance | 25.245 | 25.5 | 25.755 | Ω | 8 |
| SM_RCOMP2 | ODT COMP Resistance | 198 | 200 | 202 | Ω | 8 |

***Notes:***
1. Unless otherwise noted, all specifications in this table apply to all processor frequencies.
2. $V_{IL}$ is defined as the maximum voltage level at a receiving agent that will be interpreted as a logical low value.
3. $V_{IH}$ is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value.
4. $V_{IH}$ and $V_{OH}$ may experience excursions above $V_{DDQ}$. However, input signal drivers must comply with the signal quality specifications.
5. This is the pull-up/pull-down driver resistance.
6. $R_{TERM}$ is the termination on the DIMM and in not controlled by the processor.
7. The minimum and maximum values for these signals are programmable by BIOS to one of the two sets.
8. SM_RCOMPx resistance must be provided on the system board with 1% resistors. SM_RCOMPx resistors are to $V_{SS}$.
9. SM_DRAMPWROK must have a maximum of 15 ns rise or fall time over $V_{DDQ}$ * 0.55± 200 mV and the edge must be monotonic.
10. SM_VREF is defined as $V_{DDQ}/2$.
11. $R_{on}$ tolerance is preliminary and might be subject to change.

## Table 9-11.Control Sideband and TAP Signal Group DC Specifications

| Symbol | Parameter | Min | Max | Units | Notes |
|---|---|---|---|---|---|
| $V_{IL}$ | Input Low Voltage | | $V_{CCIO}*0.3$ | V | 2 |
| $V_{IH}$ | Input High Voltages | $V_{CCIO}*0.7$ | | V | 2, |
| $V_{OL}$ | Output Low Voltage | | $V_{CCIO}*0.1$ | V | 2 |

| Symbol | Parameter | Min | Max | Units | Notes |
|---|---|---|---|---|---|
| $V_{OH}$ | Output High Voltage | $V_{CCIO}$*0.9 | | V | 2, |
| $V_{ON}$ | Buffer on Resistance | 23 | 73 | Ω | |
| $I_{LI}$ | Input Leakage Currents | | ±200 | µA | |

***Notes:***
1. Unless otherwise noted, all specifications in this table apply to all processor frequencies.
2. The $V_{CCIO}$ referred to in these specifications refers to instantaneous $V_{CCIO}$.
3. For $V_{IN}$ between "0" V and $V_{CCIO}$. Measured when the driver is tristated.
4. $V_{IH}$ and $V_{OH}$ may experience excursions above $V_{CCIO}$. However, input signal drivers must comply with the signal quality specifications

## Table 9-12. PCI Express* DC Specifications

| Symbol | Parameter | Min | Typ | Max | Units | Notes[1] |
|---|---|---|---|---|---|---|
| $Z_{TX-DIFF-DC}$ | DC Differential Tx Impedance (Gen 1 Only) | 80 | | 120 | Ω | 1, |
| $Z_{TX-DIFF-DC}$ | DC Differential Tx Impedance (Gen 2 and Gen 3) | - | - | 120 | Ω | 1, |
| $Z_{RX-DC}$ | DC Common Mode Rx Impedance | 40 | | 60 | Ω | 1,, |
| $Z_{RX-DIFF-DC}$ | DC Differential Rx Impedance (Gen1 Only) | 80 | | 120 | Ω | 1 |
| $V_{RX-DIFFp-p}$ | Differential Rx Input Peak-to-Peak Voltage (Gen 1 only) | 0.175 | | 1.2 | V | 1, |
| $V_{RX_CM-AC-p}$ | Rx AC Peak Common Mode Input Voltage | | | 150 | mV | 1, |
| PCIE_ICOMPO | Comp Resistance | 24.75 | 25 | 25.25 | Ω | , |
| PCIE_ICOMPI | Comp Resistance | 24.75 | 25 | 25.25 | Ω | , |
| PCIE_RCOMPO | Comp Resistance | 24.75 | 25 | 25.25 | Ω | , |

***Notes:***
1. See the *PCI Express* Base Specification* for details.
2. $V_{TX-AC-CM-PP}$ and $V_{TX-AC-CM-P}$ are defined in the *PCI Express Base Specification*. Measurement is made over at least 10^6 UI.
3. As measured with compliance test load. Defined as $2*|V_{TXD+} - V_{TXD-}|$.
4. RMS value.
5. Measured at Rx pins into a pair of 50-Ω terminations into ground. Common mode peak voltage is defined by the expression: max{|(Vd+ - Vd-) - V-CMDC|}.
6. DC impedance limits are needed to guarantee Receiver detect.
7. The Rx DC Common Mode Impedance must be present when the Receiver terminations are first enabled to ensure that the Receiver Detect occurs properly. Compensation of this impedance can start immediately and the 15 Rx Common Mode Impedance (constrained by RLRX-CM to 50 Ω ±20%) must be within the specified range by the time Detect is entered.
8. Low impedance defined during signaling. Parameter is captured for 5.0 GHz by RLTX-DIFF.
9. This specification is the same as $V_{RX-EYE}$.

## 9.10.2 Platform Environmental Control Interface DC Specifications

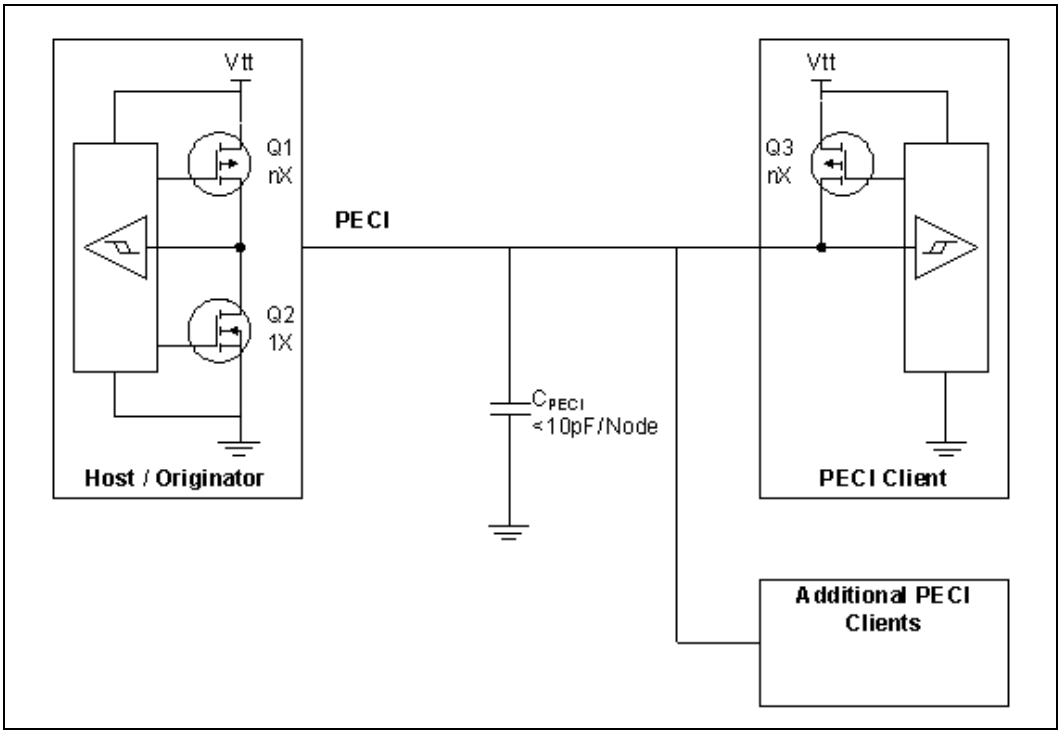
Platform Environmental Control Interface (PECI) is an Intel proprietary interface that provides a communication channel between Intel processors and chipset components to external Adaptive Thermal Monitor devices. The processor contains a Digital Thermal Sensor (DTS) that reports a relative die temperature as an offset from Thermal Control Circuit (TCC) activation temperature. Temperature sensors located throughout the die are implemented as analog-to-digital converters calibrated at the factory. PECI provides an interface for external devices to read the DTS temperature for thermal management and fan speed control.

### 9.10.2.1 PECI Bus Architecture

The PECI architecture is based on a wired-OR bus, which the processor PECI can pull up high (with strong drive strength). The idle state on the bus is near zero.

Figure 9-1 demonstrates PECI design and connectivity. The host/originator can be a third-party PECI host, with one of the PECI clients being the processor PECI device.

**Figure 9-1. Example of PECI Host-Client Connection**



### 9.10.2.2 PECI DC Characteristics

The PECI interface operates at a nominal voltage set by $V_{CCIO}$. The set of DC electrical specifications shown in Table 9-13 are used with devices normally operating from a $V_{CCIO}$ interface supply. $V_{CCIO}$ nominal levels will vary between processor families. All PECI devices will operate at the $V_{CCIO}$ level determined by the processor installed in the system.

**Table 9-13. PECI DC Electrical Limits**

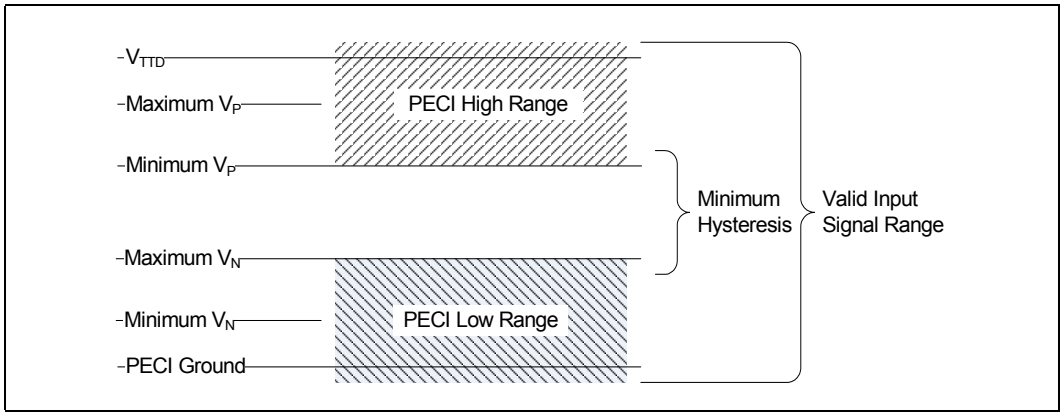
| Symbol | Definition and Conditions | Min | Max | Units | Notes[1] |
|---|---|---|---|---|---|
| Rup | Output resistance | 15 | 45 | Ohm | 3 |
| $V_{in}$ | Input Voltage Range | -0.15 | $V_{CCIO}$ | V | |
| $V_{hysteresis}$ | Hysteresis | 0.1 * $V_{CCIO}$ | N/A | V | |
| $V_n$ | Negative-Edge Threshold Voltage | 0.275 * $V_{CCIO}$ | 0.500 * $V_{CCIO}$ | V | |
| $V_p$ | Positive-Edge Threshold Voltage | 0.550 * $V_{CCIO}$ | 0.725 * $V_{CCIO}$ | V | |
| $C_{bus}$ | Bus Capacitance per Node | N/A | 10 | pF | |
| $C_{pad}$ | Pad Capacitance | 0.7 | 1.8 | pF | |
| Ileak000 | leakage current @ 0V | - | 0.6 | mA | |
| Ileak025 | leakage current @ 0.25*$V_{CCIO}$ | - | 0.4 | mA | |
| Ileak050 | leakage current @ 0.50*$V_{CCIO}$ | - | 0.2 | mA | |
| Ileak075 | leakage current @ 0.75*$V_{CCIO}$ | - | 0.13 | mA | |
| Ileak100 | leakage current @ $V_{CCIO}$ | - | 0.10 | mA | |

***Notes:***
1. $V_{CCIO}$ supplies the PECI interface. PECI behavior does not affect $V_{TT}$ min/max specifications.
2. The leakage specification applies to powered devices on the PECI bus.
3. The PECI buffer internal pull up resistance measured at 0.75*$V_{CCIO}$

### 9.10.2.3 Input Device Hysteresis

The input buffers in both client and host models must use a Schmitt-triggered input design for improved noise immunity. Use Figure 9-2 as a guide for input buffer design.

**Figure 9-2. Input Device Hysteresis**

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# 10.0 Processor Ball and Package Information

## 10.1 Processor Ball Assignments

- Table 10-1 lists all processor pins ordered alphabetically by ball name.
- Table 10-2 lists all processor pins ordered alphabetically by ball number.
- Figure 10-1, Figure 10-2, Figure 10-3, and Figure 10-4 show the bottom view of the processor ballmap.

## Table 10-1. Alphabetical Ball Listing

| Ball | Signal |
|---|---|
| A3 | VSS |
| A4 | VSS |
| A5 | PCIE1_RX[6] |
| A6 | PCIE1_RX#[6] |
| A7 | VSS |
| A8 | PCIE1_RX#[1] |
| A9 | PCIE1_RX[1] |
| A10 | VSS |
| A11 | PCIE2_RX#[3] |
| A12 | PCIE2_RX[3] |
| A13 | VSS |
| A14 | VCC |
| A15 | VCC |
| A16 | VSS |
| A17 | VCC |
| A18 | VCC |
| A19 | VSS |
| A20 | VCC |
| A21 | VCC |
| A22 | VSS |
| A23 | VCC |
| A24 | VCC |
| A25 | VSS |
| A26 | BPM#[4] |
| A27 | VSS |
| A28 | RSVD_14 |
| A29 | RSVD_31 |
| A30 | RSVD_13 |
| A31 | RSVD_30 |
| A32 | VSS |
| A33 | RSVD_33 |
| A34 | RSVD_54 |
| B2 | VSS |
| B3 | VSS |
| B4 | PCIE1_RX[9] |
| B5 | PCIE1_RX#[9] |
| B6 | VSS |
| B7 | PCIE1_RX[4] |
| B8 | PCIE1_RX#[4] |

| Ball | Signal |
|---|---|
| B9 | VSS |
| B10 | PCIE2_RX#[2] |
| B11 | PCIE2_RX[2] |
| B12 | VSS |
| B13 | VSS |
| B14 | VCC |
| B15 | VCC |
| B16 | VSS |
| B17 | VCC |
| B18 | VCC |
| B19 | VSS |
| B20 | VCC |
| B21 | VCC |
| B22 | VSS |
| B23 | VCC |
| B24 | VCC |
| B25 | VSS |
| B26 | BPM#[5] |
| B27 | RSVD_22 |
| B28 | VSS |
| B29 | VSS |
| B30 | RSVD_12 |
| B31 | VSS |
| B32 | RSVD_53 |
| B33 | VSS |
| B34 | RSVD_28 |
| B35 | RSVD_52 |
| C1 | VSS |
| C2 | VSS |
| C3 | PCIE1_RX#[10] |
| C4 | PCIE1_RX[10] |
| C5 | VSS |
| C6 | PCIE1_RX[5] |
| C7 | PCIE1_RX#[5] |
| C8 | VSS |
| C9 | PCIE1_RX[0] |
| C10 | PCIE1_RX#[0] |
| C11 | VSS |
| C12 | PCIE_RCOMPO |

| Ball | Signal |
|---|---|
| C13 | VSS |
| C14 | VCC |
| C15 | VCC |
| C16 | VSS |
| C17 | VCC |
| C18 | VCC |
| C19 | VSS |
| C20 | VCC |
| C21 | VCC |
| C22 | VSS |
| C23 | VCC |
| C24 | VCC |
| C25 | VSS |
| C26 | BPM#[2] |
| C27 | BPM#[1] |
| C28 | RSVD_42 |
| C29 | VSS |
| C30 | VSS |
| C31 | RSVD_29 |
| C32 | RSVD_27 |
| C33 | RSVD_21 |
| C34 | VSS |
| C35 | RSVD_26 |
| C36 | RSVD_23 |
| D1 | VSS |
| D2 | PCIE1_RX#[11] |
| D3 | PCIE1_RX[11] |
| D4 | VSS |
| D5 | PCIE1_RX[7] |
| D6 | PCIE1_RX#[7] |
| D7 | VSS |
| D8 | PCIE1_RX#[2] |
| D9 | PCIE1_RX[2] |
| D10 | PCIE2_RX#[0] |
| D11 | PCIE2_RX#[1] |
| D12 | PCIE2_RX[1] |
| D13 | VSS |
| D14 | VCC |
| D15 | VCC |

| Ball | Signal |
|---|---|
| D16 | VSS |
| D17 | VCC |
| D18 | VCC |
| D19 | VSS |
| D20 | VCC |
| D21 | VCC |
| D22 | VSS |
| D23 | VCC |
| D24 | VCC |
| D25 | VSS |
| D26 | BPM#[3] |
| D27 | VSS |
| D28 | BPM#[0] |
| D29 | RSVD_44 |
| D30 | TCK |
| D31 | VSS |
| D32 | VSS |
| D33 | RSVD_39 |
| D34 | RSVD_20 |
| D35 | VSS |
| D36 | RSVD_40 |
| E1 | PCIE1_RX#[12] |
| E2 | PCIE1_RX[12] |
| E3 | VSS |
| E4 | PCIE1_RX[8] |
| E5 | PCIE1_RX#[8] |
| E6 | VSS |
| E7 | PCIE1_RX[3] |
| E8 | PCIE1_RX#[3] |
| E9 | VSS |
| E10 | VSS |
| E11 | PCIE2_RX[0] |
| E12 | VSS |
| E13 | VSS |
| E14 | VCC |
| E15 | VCC |
| E16 | VSS |
| E17 | VCC |
| E18 | VCC |
| E19 | VSS |
| E20 | VCC |

| Ball | Signal |
|---|---|
| E21 | VCC |
| E22 | VSS |
| E23 | VCC |
| E24 | VCC |
| E25 | VSS |
| E26 | BPM#[6] |
| E27 | RSVD_41 |
| E28 | PM_SYNC |
| E29 | VIDSCLK |
| E30 | TDI |
| E31 | VIDALERT# |
| E32 | RSVD_37 |
| E33 | VSS |
| E34 | RSVD_38 |
| E35 | RSVD_18 |
| E36 | VSS |
| F1 | PCIE_ICOMPO |
| F2 | VSS |
| F3 | PCIE1_RX#[13] |
| F4 | PCIE1_RX[13] |
| F5 | VSS |
| F6 | VSS |
| F7 | VSS |
| F8 | VSS |
| F9 | VSS |
| F10 | VSS |
| F11 | VSS |
| F12 | VSS |
| F13 | VSS |
| F14 | VCC |
| F15 | VCC |
| F16 | VSS |
| F17 | VCC |
| F18 | VCC |
| F19 | VSS |
| F20 | VCC |
| F21 | VCC |
| F22 | VSS |
| F23 | VCC |
| F24 | VCC |
| F25 | VSS |

| Ball | Signal |
|---|---|
| F26 | BPM#[7] |
| F27 | RSVD_43 |
| F28 | PROC_DETECT# |
| F29 | VSS |
| F30 | TMS |
| F31 | VSS |
| F32 | RSVD_19 |
| F33 | RSVD_16 |
| F34 | VSS |
| F35 | RSVD_36 |
| F36 | RSVD_17 |
| G1 | PCIE1_RX[15] |
| G2 | PCIE1_RX#[14] |
| G3 | PCIE1_RX[14] |
| G4 | VSS |
| G5 | VSS |
| G6 | PCIE1_TX[7] |
| G7 | VSS |
| G8 | PCIE1_TX#[4] |
| G9 | PCIE1_TX[4] |
| G10 | VSS |
| G11 | PCIE1_TX#[0] |
| G12 | PCIE1_TX[0] |
| G13 | VSS |
| G14 | VCC |
| G15 | VCC |
| G16 | VSS |
| G17 | VCC |
| G18 | VCC |
| G19 | VSS |
| G20 | VCC |
| G21 | VCC |
| G22 | VSS |
| G23 | VCC |
| G24 | VCC |
| G25 | VSS |
| G26 | VIDSOUT |
| G27 | VSS |
| G28 | VSS |
| G29 | PREQ# |
| G30 | RSVD_11 |

| Ball | Signal |
|---|---|
| G31 | THERMTRIP# |
| G32 | VSS |
| G33 | RSVD_34 |
| G34 | RSVD_32 |
| G35 | VSS |
| G36 | RSVD_35 |
| H1 | PCIE1_RX#[15] |
| H2 | VSS |
| H3 | VSS |
| H4 | VSS |
| H5 | PCIE1_TX#[7] |
| H6 | VSS |
| H7 | PCIE1_TX#[5] |
| H8 | PCIE1_TX[5] |
| H9 | VSS |
| H10 | PCIE1_TX[1] |
| H11 | PCIE1_TX#[1] |
| H12 | VSS |
| H13 | VSS |
| H14 | VCC |
| H15 | VCC |
| H16 | VSS |
| H17 | VCC |
| H18 | VCC |
| H19 | VSS |
| H20 | VCC |
| H21 | VCC |
| H22 | VSS |
| H23 | VCC |
| H24 | VCC |
| H25 | VSS |
| H26 | TRST# |
| H27 | PROC_SELECT# |
| H28 | CATERR# |
| H29 | UNCOREPWRGOOD |
| H30 | VSS |
| H31 | RESET# |
| H32 | PROCHOT# |
| H33 | VSS |
| H34 | RSVD_15 |
| H35 | RSVD_51 |

| Ball | Signal |
|---|---|
| H36 | VSS |
| J1 | PCIE_ICOMPI |
| J2 | VSS |
| J3 | PCIE1_TX[10] |
| J4 | PCIE1_TX#[8] |
| J5 | PCIE1_TX[8] |
| J6 | PCIE1_TX#[6] |
| J7 | PCIE1_TX[6] |
| J8 | VSS |
| J9 | PCIE1_TX#[2] |
| J10 | PCIE1_TX[2] |
| J11 | VSS |
| J12 | RSVD_7 |
| J13 | VSS |
| J14 | VCC |
| J15 | VCC |
| J16 | VSS |
| J17 | VCC |
| J18 | VCC |
| J19 | VSS |
| J20 | VCC |
| J21 | VCC |
| J22 | VSS |
| J23 | VCC |
| J24 | VCC |
| J25 | VSS |
| J26 | VCCSA_VID |
| J27 | RSVD_48 |
| J28 | VSS |
| J29 | RSVD_47 |
| J30 | RSVD_57 |
| J31 | RSVD_45 |
| J32 | VSS |
| J33 | PECI |
| J34 | VSS |
| J35 | RSVD_25 |
| J36 | RSVD_50 |
| K1 | VSS |
| K2 | PCIE1_TX[13] |
| K3 | PCIE1_TX#[10] |
| K4 | VSS |

| Ball | Signal |
|---|---|
| K5 | PCIE1_TX#[9] |
| K6 | PCIE1_TX[9] |
| K7 | VSS |
| K8 | PCIE1_TX#[3] |
| K9 | PCIE1_TX[3] |
| K10 | VSS |
| K11 | PCIE2_TX#[3] |
| K12 | PCIE2_TX[3] |
| K13 | VSS |
| K14 | VCC |
| K15 | VCC |
| K16 | VSS |
| K17 | VCC |
| K18 | VCC |
| K19 | VSS |
| K20 | VCC |
| K21 | VCC |
| K22 | VSS |
| K23 | VCC |
| K24 | VCC |
| K25 | VSS |
| K26 | PRDY# |
| K27 | VSS |
| K28 | RSVD_46 |
| K29 | VSS |
| K30 | CFG[0] |
| K31 | VSS |
| K32 | CFG[7] |
| K33 | VSS |
| K34 | CFG[10] |
| K35 | VSS |
| K36 | RSVD_24 |
| L1 | PCIE1_TX#[14] |
| L2 | PCIE1_TX#[13] |
| L3 | VSS |
| L4 | PCIE1_TX#[11] |
| L5 | PCIE1_TX[11] |
| L6 | VSS |
| L7 | PCIE2_TX[1] |
| L8 | PCIE2_TX#[1] |
| L9 | VSS |

| Ball | Signal |
|---|---|
| L10 | PCIE2_TX#[2] |
| L11 | PCIE2_TX[2] |
| L12 | RSVD_8 |
| L13 | VSS |
| L14 | VCC |
| L15 | VCC |
| L16 | VSS |
| L17 | VCC |
| L18 | VCC |
| L19 | VSS |
| L20 | VCC |
| L21 | VCC |
| L22 | VSS |
| L23 | VCC |
| L24 | VCC |
| L25 | VSS |
| L26 | RSVD_55 |
| L27 | RSVD_56 |
| L28 | RSVD_49 |
| L29 | TDO |
| L30 | CFG[1] |
| L31 | CFG[4] |
| L32 | CFG[5] |
| L33 | CFG[16] |
| L34 | CFG[9] |
| L35 | CFG[13] |
| L36 | VSS |
| M1 | PCIE1_TX[14] |
| M2 | VSS |
| M3 | PCIE1_TX[15] |
| M4 | VSS |
| M5 | VSS |
| M6 | PCIE2_TX[0] |
| M7 | PCIE2_TX#[0] |
| M8 | VSS |
| M9 | VCCSA_VSSSENSE |
| M10 | VCCSA_VCCSENSE |
| M11 | VCCIO |
| M12 | VCCIO |
| M13 | VSS |
| M14 | VCC |

| Ball | Signal |
|---|---|
| M15 | VCC |
| M16 | VSS |
| M17 | VCC |
| M18 | VCC |
| M19 | VSS |
| M20 | VCC |
| M21 | VCC |
| M22 | VSS |
| M23 | VCC |
| M24 | VCC |
| M25 | VSS |
| M26 | VCC_SENSE |
| M27 | VSS_SENSE |
| M28 | VSS |
| M29 | VSS |
| M30 | VSS |
| M31 | VSS |
| M32 | CFG[17] |
| M33 | VSS |
| M34 | CFG[11] |
| M35 | VSS |
| M36 | CFG[14] |
| N1 | VSS |
| N2 | RSVD_6 |
| N3 | PCIE1_TX#[15] |
| N4 | PCIE1_TX#[12] |
| N5 | PCIE1_TX[12] |
| N6 | VSS |
| N7 | VSS |
| N8 | VCCIO |
| N9 | VCCSA |
| N10 | VCCIO |
| N11 | VSS |
| N12 | VCC |
| N13 | VSS |
| N14 | VCC |
| N15 | VCC |
| N16 | VSS |
| N17 | VCC |
| N18 | VCC |
| N19 | VSS |

| Ball | Signal |
|---|---|
| N20 | VCC |
| N21 | VCC |
| N22 | VSS |
| N23 | VCC |
| N24 | VCC |
| N25 | VSS |
| N26 | VCC |
| N27 | VSS |
| N28 | VCCIO |
| N29 | VCCIO |
| N30 | VSS |
| N31 | CFG[3] |
| N32 | CFG[6] |
| N33 | CFG[8] |
| N34 | CFG[2] |
| N35 | CFG[12] |
| N36 | CFG[15] |
| P1 | DMI_TX[0] |
| P2 | VSS |
| P3 | VSS |
| P4 | VSS |
| P5 | VSS |
| P6 | BCLK |
| P7 | BCLK# |
| P8 | VSS |
| P9 | VCCSA |
| P10 | VSS |
| P11 | VCCSA |
| P12 | VCC |
| P13 | VSS |
| P14 | VCC |
| P15 | VCC |
| P16 | VSS |
| P17 | VCC |
| P18 | VCC |
| P19 | VSS |
| P20 | VCC |
| P21 | VCC |
| P22 | VSS |
| P23 | VCC |
| P24 | VCC |

| Ball | Signal |
|---|---|
| P25 | VSS |
| P26 | VCC |
| P27 | VSS |
| P28 | VCCIO |
| P29 | VCCIO |
| P30 | VSS |
| P31 | VSS |
| P32 | VSS |
| P33 | VSS |
| P34 | VSS |
| P35 | VSS |
| P36 | VSS |
| R1 | DMI_TX#[0] |
| R2 | VSS |
| R3 | DMI_RX[0] |
| R4 | DMI_RX[1] |
| R5 | VSS |
| R6 | RSVD_9 |
| R7 | VCCIO |
| R8 | VCCIO |
| R9 | VCCSA |
| R10 | VSS |
| R11 | VCCSA |
| R12 | VCC |
| R13 | VSS |
| R14 | VCC |
| R15 | VCC |
| R16 | VSS |
| R17 | VCC |
| R18 | VCC |
| R19 | VSS |
| R20 | VCC |
| R21 | VCC |
| R22 | VSS |
| R23 | VCC |
| R24 | VCC |
| R25 | VSS |
| R26 | VCC |
| R27 | VCCIO |
| R28 | VSS |
| R29 | VCCIO |

| Ball | Signal |
|---|---|
| R30 | VSS |
| R31 | VSS |
| R32 | SA_DQS[7] |
| R33 | SA_DQ[59] |
| R34 | SA_DQ[58] |
| R35 | SA_DQ[62] |
| R36 | SA_DQ[63] |
| T1 | DMI_TX#[1] |
| T2 | VSS |
| T3 | DMI_RX#[0] |
| T4 | DMI_RX#[1] |
| T5 | VSS |
| T6 | RSVD_10 |
| T7 | VCCIO |
| T8 | VCCSA |
| T9 | VSS |
| T10 | VCCIO |
| T11 | VCCSA |
| T12 | VCC |
| T13 | VSS |
| T14 | VCC |
| T15 | VCC |
| T16 | VSS |
| T17 | VCC |
| T18 | VCC |
| T19 | VSS |
| T20 | VCC |
| T21 | VCC |
| T22 | VSS |
| T23 | VCC |
| T24 | VCC |
| T25 | VSS |
| T26 | VCC |
| T27 | VCCIO |
| T28 | VSS |
| T29 | VCCIO |
| T30 | VSS |
| T31 | VSS |
| T32 | SA_DQS#[7] |
| T33 | SA_DQ[60] |
| T34 | SA_DQ[61] |

| Ball | Signal |
|---|---|
| T35 | SA_DQ[57] |
| T36 | SA_DQ[56] |
| U1 | DMI_TX[1] |
| U2 | DMI_TX[2] |
| U3 | VSS |
| U4 | DMI_RX[2] |
| U5 | VSS |
| U6 | VSS |
| U7 | VCCIO |
| U8 | VCCIO |
| U9 | VCCSA |
| U10 | VSS |
| U11 | VSS |
| U12 | VCC |
| U13 | VSS |
| U14 | VCC |
| U15 | VCC |
| U16 | VSS |
| U17 | VCC |
| U18 | VCC |
| U19 | VSS |
| U20 | VCC |
| U21 | VCC |
| U22 | VSS |
| U23 | VCC |
| U24 | VCC |
| U25 | VSS |
| U26 | VCC |
| U27 | VSS |
| U28 | VCCIO |
| U29 | VCCIO |
| U30 | VSS |
| U31 | VSS |
| U32 | VSS |
| U33 | VSS |
| U34 | VSS |
| U35 | VSS |
| U36 | VSS |
| V1 | DMI_TX#[3] |
| V2 | DMI_TX#[2] |
| V3 | VSS |

| Ball | Signal |
|---|---|
| V4 | DMI_RX#[2] |
| V5 | DMI_RX[3] |
| V6 | VSS |
| V7 | VCCIO |
| V8 | VCCIO |
| V9 | VCCSA |
| V10 | VSS |
| V11 | VCCSA |
| V12 | VCC |
| V13 | VSS |
| V14 | VCC |
| V15 | VCC |
| V16 | VSS |
| V17 | VCC |
| V18 | VCC |
| V19 | VSS |
| V20 | VCC |
| V21 | VCC |
| V22 | VSS |
| V23 | VCC |
| V24 | VCC |
| V25 | VSS |
| V26 | VCC |
| V27 | VSS |
| V28 | VCCIO |
| V29 | VCCIO |
| V30 | VCCIO |
| V31 | VSS |
| V32 | SA_DQS[6] |
| V33 | SA_DQ[51] |
| V34 | SA_DQ[50] |
| V35 | SA_DQ[54] |
| V36 | SA_DQ[55] |
| W1 | DMI_TX[3] |
| W2 | VSS |
| W3 | VSS |
| W4 | VSS |
| W5 | DMI_RX#[3] |
| W6 | VSS |
| W7 | VCCIO |
| W8 | VCCSA |

| Ball | Signal |
|---|---|
| W9 | VSS |
| W10 | VCCIO |
| W11 | VCCSA |
| W12 | VCC |
| W13 | VSS |
| W14 | VCC |
| W15 | VCC |
| W16 | VSS |
| W17 | VCC |
| W18 | VCC |
| W19 | VSS |
| W20 | VCC |
| W21 | VCC |
| W22 | VSS |
| W23 | VCC |
| W24 | VCC |
| W25 | VSS |
| W26 | VCC |
| W27 | VCCIO |
| W28 | VSS |
| W29 | VCCIO |
| W30 | VCCIO |
| W31 | VSS |
| W32 | SA_DQS#[6] |
| W33 | SA_DQ[52] |
| W34 | SA_DQ[53] |
| W35 | SA_DQ[49] |
| W36 | SA_DQ[48] |
| Y1 | VCCIO |
| Y2 | VCCIO |
| Y3 | VCCIO |
| Y4 | VCCIO |
| Y5 | VCCIO |
| Y6 | VCCIO |
| Y7 | VCCIO |
| Y8 | VCCIO |
| Y9 | VCCSA |
| Y10 | VSS |
| Y11 | VCCSA |
| Y12 | VCC |
| Y13 | VSS |

| Ball | Signal |
|---|---|
| Y14 | VCC |
| Y15 | VCC |
| Y16 | VSS |
| Y17 | VCC |
| Y18 | VCC |
| Y19 | VSS |
| Y20 | VCC |
| Y21 | VCC |
| Y22 | VSS |
| Y23 | VCC |
| Y24 | VCC |
| Y25 | VSS |
| Y26 | VCC |
| Y27 | VCCIO |
| Y28 | VSS |
| Y29 | VCCIO |
| Y30 | VCCIO |
| Y31 | VSS |
| Y32 | VSS |
| Y33 | VSS |
| Y34 | VSS |
| Y35 | VSS |
| Y36 | VSS |
| AA1 | VCCIO |
| AA2 | VCCIO |
| AA3 | VCCIO |
| AA4 | VCCIO |
| AA5 | VCCIO |
| AA6 | VCCIO |
| AA7 | VCCIO |
| AA8 | VSS |
| AA9 | VCCSA |
| AA10 | VSS |
| AA11 | VSS |
| AA12 | VCC |
| AA13 | VSS |
| AA14 | VCC |
| AA15 | VCC |
| AA16 | VSS |
| AA17 | VCC |
| AA18 | VCC |

| Ball | Signal |
|---|---|
| AA19 | VSS |
| AA20 | VCC |
| AA21 | VCC |
| AA22 | VSS |
| AA23 | VCC |
| AA24 | VCC |
| AA25 | VSS |
| AA26 | VCC |
| AA27 | VSS |
| AA28 | VCCIO |
| AA29 | VCCIO |
| AA30 | VCCIO |
| AA31 | VSS |
| AA32 | SA_DQS[5] |
| AA33 | SA_DQ[43] |
| AA34 | SA_DQ[42] |
| AA35 | SA_DQ[46] |
| AA36 | SA_DQ[47] |
| AB1 | VSS |
| AB2 | VSS |
| AB3 | VSS |
| AB4 | VSS |
| AB5 | VSS |
| AB6 | VSS |
| AB7 | VCCIO |
| AB8 | VCCIO |
| AB9 | VCCSA |
| AB10 | VCCIO |
| AB11 | VSS |
| AB12 | VCCIO |
| AB13 | VSS |
| AB14 | VCCIO |
| AB15 | VCCIO |
| AB16 | VSS |
| AB17 | VCCIO |
| AB18 | VCCIO |
| AB19 | VSS |
| AB20 | VCCIO |
| AB21 | VCCIO |
| AB22 | VSS |
| AB23 | VCCIO |

| Ball | Signal |
|---|---|
| AB24 | VCCIO |
| AB25 | VSS |
| AB26 | VCCIO |
| AB27 | VCCIO |
| AB28 | VCCIO |
| AB29 | VCCIO |
| AB30 | VCCIO |
| AB31 | VSS |
| AB32 | SA_DQS#[5] |
| AB33 | SA_DQ[44] |
| AB34 | SA_DQ[45] |
| AB35 | SA_DQ[41] |
| AB36 | SA_DQ[40] |
| AC1 | SB_DQ[1] |
| AC2 | SB_DQ[5] |
| AC3 | SB_DQ[0] |
| AC4 | SB_DQ[4] |
| AC5 | SB_DQS#[0] |
| AC6 | VSS |
| AC7 | VCCIO |
| AC8 | VCCIO |
| AC9 | VCCIO |
| AC10 | VCCIO |
| AC11 | VCCIO |
| AC12 | VCCIO |
| AC13 | VCCIO |
| AC14 | VCCIO |
| AC15 | VCCIO |
| AC16 | VCCIO |
| AC17 | VCCIO |
| AC18 | VCCIO |
| AC19 | VCCIO |
| AC20 | VCCIO |
| AC21 | VCCIO |
| AC22 | VCCIO |
| AC23 | VCCIO |
| AC24 | VCCIO |
| AC25 | VCCIO |
| AC26 | VCCIO |
| AC27 | VCCIO |
| AC28 | VCCIO |

| Ball | Signal |
|---|---|
| AC29 | VCCIO |
| AC30 | VCCIO |
| AC31 | VSS |
| AC32 | VSS |
| AC33 | VSS |
| AC34 | VSS |
| AC35 | VSS |
| AC36 | VSS |
| AD1 | SB_DQ[6] |
| AD2 | SB_DQ[7] |
| AD3 | SB_DQ[2] |
| AD4 | SB_DQ[3] |
| AD5 | SB_DQS[0] |
| AD6 | VSS |
| AD7 | VSS |
| AD8 | VSS |
| AD9 | VSS |
| AD10 | VCCIO |
| AD11 | VCCIO |
| AD12 | VSS |
| AD13 | VDDQ |
| AD14 | VDDQ |
| AD15 | VDDQ |
| AD16 | VSS |
| AD17 | VDDQ |
| AD18 | VDDQ |
| AD19 | VSS |
| AD20 | VSS |
| AD21 | VDDQ |
| AD22 | VSS |
| AD23 | VSS |
| AD24 | VSS |
| AD25 | VDDQ |
| AD26 | VSS |
| AD27 | VSS |
| AD28 | VCCIO_SENSE |
| AD29 | VSS_SENSE_VCCIO |
| AD30 | VSS |
| AD31 | SB_DQ[60] |
| AD32 | SB_DQS[7] |
| AD33 | SB_DQ[59] |

| Ball | Signal |
|---|---|
| AD34 | SB_DQ[58] |
| AD35 | SB_DQ[62] |
| AD36 | SB_DQ[63] |
| AE1 | VSS |
| AE2 | VSS |
| AE3 | VSS |
| AE4 | VSS |
| AE5 | VSS |
| AE6 | VSS |
| AE7 | VSS |
| AE8 | VSS |
| AE9 | VSS |
| AE10 | VSS |
| AE11 | VSS |
| AE12 | VSS |
| AE13 | VSS |
| AE14 | VSS |
| AE15 | VDDQ |
| AE16 | VDDQ |
| AE17 | VDDQ |
| AE18 | VDDQ |
| AE19 | VDDQ |
| AE20 | VDDQ |
| AE21 | VDDQ |
| AE22 | VDDQ |
| AE23 | VDDQ |
| AE24 | VDDQ |
| AE25 | VDDQ |
| AE26 | VDDQ |
| AE27 | VDDQ |
| AE28 | VDDQ |
| AE29 | VSS |
| AE30 | VSS |
| AE31 | VSS |
| AE32 | SB_DQS#[7] |
| AE33 | SB_DQ[61] |
| AE34 | SB_DQ[56] |
| AE35 | SB_DQ[57] |
| AE36 | VSS |
| AF1 | SA_DQ[1] |
| AF2 | SA_DQ[5] |

| Ball | Signal |
|---|---|
| AF3 | SA_DQ[0] |
| AF4 | SA_DQ[4] |
| AF5 | SA_DQS#[0] |
| AF6 | VSS |
| AF7 | SB_DQ[12] |
| AF8 | SB_DQ[13] |
| AF9 | VSS |
| AF10 | SA_DQ[20] |
| AF11 | SA_DQ[21] |
| AF12 | VSS |
| AF13 | SB_ECC_CB[4] |
| AF14 | SB_ECC_CB[5] |
| AF15 | VSS |
| AF16 | SB_CKE[2] |
| AF17 | VDDQ |
| AF18 | RSVD_1 |
| AF19 | SM_DRAMPWROK |
| AF20 | VDDQ |
| AF21 | SA_MA[4] |
| AF22 | SA_MA[2] |
| AF23 | VDDQ |
| AF24 | VDDQ |
| AF25 | VSS |
| AF26 | VDDQ |
| AF27 | VSS |
| AF28 | VSS |
| AF29 | VSS |
| AF30 | SA_DQ[34] |
| AF31 | SA_DQ[35] |
| AF32 | VSS |
| AF33 | VSS |
| AF34 | VSS |
| AF35 | VSS |
| AF36 | SB_DQ[51] |
| AG1 | SA_DQ[6] |
| AG2 | SA_DQ[7] |
| AG3 | SA_DQ[2] |
| AG4 | SA_DQ[3] |
| AG5 | SA_DQS[0] |
| AG6 | VSS |
| AG7 | SB_DQ[8] |

| Ball | Signal |
|---|---|
| AG8 | SB_DQ[9] |
| AG9 | VSS |
| AG10 | SA_DQ[16] |
| AG11 | SA_DQ[17] |
| AG12 | VSS |
| AG13 | SB_ECC_CB[0] |
| AG14 | SB_ECC_CB[1] |
| AG15 | VSS |
| AG16 | SB_CKE[1] |
| AG17 | VSS |
| AG18 | SB_MA[11] |
| AG19 | SB_MA[7] |
| AG20 | VSS |
| AG21 | SB_CK[3] |
| AG22 | SB_CK#[3] |
| AG23 | VSS |
| AG24 | SB_WE# |
| AG25 | SB_CS#[0] |
| AG26 | VSS |
| AG27 | SB_ODT[1] |
| AG28 | SB_ODT[3] |
| AG29 | VSS |
| AG30 | SA_DQ[38] |
| AG31 | SA_DQ[39] |
| AG32 | VSS |
| AG33 | SB_DQS[6] |
| AG34 | SB_DQ[50] |
| AG35 | SB_DQ[55] |
| AG36 | SB_DQ[54] |
| AH1 | VSS |
| AH2 | VSS |
| AH3 | VSS |
| AH4 | VSS |
| AH5 | VSS |
| AH6 | VSS |
| AH7 | SB_DQS#[1] |
| AH8 | SB_DQS[1] |
| AH9 | VSS |
| AH10 | SA_DQS#[2] |
| AH11 | SA_DQS[2] |
| AH12 | VSS |

| Ball | Signal |
|---|---|
| AH13 | SB_DQS#[8] |
| AH14 | SB_DQS[8] |
| AH15 | VSS |
| AH16 | SB_BS[2] |
| AH17 | VDDQ |
| AH18 | SB_MA[6] |
| AH19 | SB_MA[4] |
| AH20 | VDDQ |
| AH21 | SB_CK[0] |
| AH22 | SB_CK#[0] |
| AH23 | VDDQ |
| AH24 | SB_MA[10] |
| AH25 | SB_RAS# |
| AH26 | VDDQ |
| AH27 | SB_CS#[1] |
| AH28 | SB_CS#[3] |
| AH29 | VSS |
| AH30 | SA_DQS#[4] |
| AH31 | SA_DQS[4] |
| AH32 | VSS |
| AH33 | SB_DQS#[6] |
| AH34 | SB_DQ[53] |
| AH35 | SB_DQ[48] |
| AH36 | SB_DQ[49] |
| AJ1 | SA_DQ[9] |
| AJ2 | SA_DQ[8] |
| AJ3 | SA_DQ[13] |
| AJ4 | SA_DQ[12] |
| AJ5 | SA_DQS#[1] |
| AJ6 | VSS |
| AJ7 | SB_DQ[15] |
| AJ8 | SB_DQ[14] |
| AJ9 | VSS |
| AJ10 | SA_DQ[22] |
| AJ11 | SA_DQ[23] |
| AJ12 | VSS |
| AJ13 | SB_ECC_CB[6] |
| AJ14 | SB_ECC_CB[7] |
| AJ15 | VSS |
| AJ16 | SB_MA[15] |
| AJ17 | VSS |

| Ball | Signal |
|---|---|
| AJ18 | SB_MA[8] |
| AJ19 | SB_MA[5] |
| AJ20 | VSS |
| AJ21 | SB_CK[1] |
| AJ22 | SB_CK#[2] |
| AJ23 | VSS |
| AJ24 | SB_BS[1] |
| AJ25 | SB_BS[0] |
| AJ26 | VSS |
| AJ27 | SB_ODT[0] |
| AJ28 | SB_MA[13] |
| AJ29 | VSS |
| AJ30 | SA_DQ[33] |
| AJ31 | SA_DQ[37] |
| AJ32 | VSS |
| AJ33 | VSS |
| AJ34 | VSS |
| AJ35 | VSS |
| AJ36 | SB_DQ[52] |
| AK1 | SA_DQ[14] |
| AK2 | SA_DQ[15] |
| AK3 | SA_DQ[10] |
| AK4 | SA_DQ[11] |
| AK5 | SA_DQS[1] |
| AK6 | VSS |
| AK7 | SB_DQ[11] |
| AK8 | SB_DQ[10] |
| AK9 | VSS |
| AK10 | SA_DQ[18] |
| AK11 | SA_DQ[19] |
| AK12 | VSS |
| AK13 | SB_ECC_CB[2] |
| AK14 | SB_ECC_CB[3] |
| AK15 | VSS |
| AK16 | SB_DIMM_VREFDQ |
| AK17 | VDDQ |
| AK18 | SA_CKE[2] |
| AK19 | SA_MA[11] |
| AK20 | VDDQ |
| AK21 | SB_CK#[1] |
| AK22 | SB_CK[2] |

| Ball | Signal |
|---|---|
| AK23 | VDDQ |
| AK24 | SA_WE# |
| AK25 | SA_CS#[0] |
| AK26 | VDDQ |
| AK27 | SA_CS#[3] |
| AK28 | SA_ODT[3] |
| AK29 | VSS |
| AK30 | SA_DQ[32] |
| AK31 | SA_DQ[36] |
| AK32 | VSS |
| AK33 | SB_DQ[43] |
| AK34 | SB_DQ[42] |
| AK35 | SB_DQ[47] |
| AK36 | VSS |
| AL1 | VSS |
| AL2 | VSS |
| AL3 | VSS |
| AL4 | VSS |
| AL5 | VSS |
| AL6 | VSS |
| AL7 | VSS |
| AL8 | VSS |
| AL9 | VSS |
| AL10 | VSS |
| AL11 | VSS |
| AL12 | VSS |
| AL13 | VSS |
| AL14 | VSS |
| AL15 | SB_CKE[0] |
| AL16 | SA_DIMM_VREFDQ |
| AL17 | VSS |
| AL18 | SA_MA[14] |
| AL19 | SA_MA[8] |
| AL20 | VSS |
| AL21 | VSS |
| AL22 | SA_CK#[0] |
| AL23 | VSS |
| AL24 | SA_CK[3] |
| AL25 | SA_MA[10] |
| AL26 | VSS |
| AL27 | SA_ODT[0] |

| Ball | Signal |
|---|---|
| AL28 | SA_ODT[1] |
| AL29 | VSS |
| AL30 | VSS |
| AL31 | VSS |
| AL32 | VSS |
| AL33 | SB_DQ[46] |
| AL34 | SB_DQ[45] |
| AL35 | SB_DQ[41] |
| AL36 | SB_DQS[5] |
| AM1 | SB_DQ[20] |
| AM2 | SB_DQ[17] |
| AM3 | SB_DQ[16] |
| AM4 | SB_DQS#[2] |
| AM5 | SB_DQ[21] |
| AM6 | VSS |
| AM7 | SB_DQS#[3] |
| AM8 | SB_DQS[3] |
| AM9 | VSS |
| AM10 | SA_DQS#[3] |
| AM11 | SA_DQS[3] |
| AM12 | VSS |
| AM13 | SA_DQS#[8] |
| AM14 | SA_DQS[8] |
| AM15 | VSS |
| AM16 | SA_CKE[3] |
| AM17 | VDDQ |
| AM18 | SA_BS[2] |
| AM19 | SA_MA[9] |
| AM20 | VDDQ |
| AM21 | SA_MA[1] |
| AM22 | SA_CK[0] |
| AM23 | VDDQ |
| AM24 | SA_CK#[3] |
| AM25 | SA_BS[1] |
| AM26 | VDDQ |
| AM27 | SA_ODT[2] |
| AM28 | SA_MA[13] |
| AM29 | VDDQ |
| AM30 | VSS |
| AM31 | SB_DQS#[4] |
| AM32 | SB_DQS[4] |

| Ball | Signal |
|---|---|
| AM33 | VSS |
| AM34 | VSS |
| AM35 | VSS |
| AM36 | SB_DQS#[5] |
| AN1 | VSS |
| AN2 | SB_DQ[22] |
| AN3 | SB_DQ[23] |
| AN4 | SB_DQS[2] |
| AN5 | SB_DQ[19] |
| AN6 | VSS |
| AN7 | SB_DQ[28] |
| AN8 | SB_DQ[27] |
| AN9 | VSS |
| AN10 | SA_DQ[28] |
| AN11 | SA_DQ[27] |
| AN12 | VSS |
| AN13 | SA_ECC_CB[4] |
| AN14 | SA_ECC_CB[3] |
| AN15 | VSS |
| AN16 | SM_DRAMRST# |
| AN17 | VSS |
| AN18 | SA_MA[12] |
| AN19 | SA_MA[7] |
| AN20 | VSS |
| AN21 | SA_CK[1] |
| AN22 | SA_CK#[1] |
| AN23 | VSS |
| AN24 | SA_CK[2] |
| AN25 | SA_MA[0] |
| AN26 | VSS |
| AN27 | SA_CAS# |
| AN28 | SA_CS#[1] |
| AN29 | VSS |
| AN30 | VSS |
| AN31 | SB_DQ[36] |
| AN32 | SB_DQ[35] |
| AN33 | VSS |
| AN34 | SB_DQ[44] |
| AN35 | SB_DQ[40] |
| AN36 | VSS |
| AP1 | VSS |

| Ball | Signal |
|---|---|
| AP2 | VSS |
| AP3 | SB_DQ[18] |
| AP4 | VSS |
| AP5 | VSS |
| AP6 | VSS |
| AP7 | SB_DQ[29] |
| AP8 | SB_DQ[26] |
| AP9 | VSS |
| AP10 | SA_DQ[29] |
| AP11 | SA_DQ[26] |
| AP12 | VSS |
| AP13 | SA_ECC_CB[5] |
| AP14 | SA_ECC_CB[2] |
| AP15 | VSS |
| AP16 | SM_VREF |
| AP17 | VDDQ |
| AP18 | SA_CKE[1] |
| AP19 | SA_MA[15] |
| AP20 | VDDQ |
| AP21 | SA_MA[6] |
| AP22 | SA_MA[3] |
| AP23 | VDDQ |
| AP24 | SA_CK#[2] |
| AP25 | VSS |
| AP26 | VDDQ |
| AP27 | SA_RAS# |
| AP28 | SA_CS#[2] |
| AP29 | VDDQ |
| AP30 | VSS |
| AP31 | SB_DQ[32] |
| AP32 | SB_DQ[34] |
| AP33 | VSS |
| AP34 | VSS |
| AP35 | VSS |
| AP36 | VSS |
| AR2 | VSS |
| AR3 | VSS |
| AR4 | VCCPLL |
| AR5 | VCCPLL |
| AR6 | VSS |
| AR7 | SB_DQ[24] |

| Ball | Signal |
|---|---|
| AR8 | SB_DQ[31] |
| AR9 | VSS |
| AR10 | SA_DQ[24] |
| AR11 | SA_DQ[31] |
| AR12 | VSS |
| AR13 | SA_ECC_CB[0] |
| AR14 | SA_ECC_CB[7] |
| AR15 | VSS |
| AR16 | SM_VREF |
| AR17 | VSS |
| AR18 | SA_CKE[0] |
| AR19 | SB_MA[9] |
| AR20 | VSS |
| AR21 | SA_MA[5] |
| AR22 | SB_MA[1] |
| AR23 | VSS |
| AR24 | SB_MA[0] |
| AR25 | VSS |
| AR26 | VSS |
| AR27 | SA_BS[0] |
| AR28 | SB_ODT[2] |
| AR29 | VSS |
| AR30 | RSVD_3 |
| AR31 | SB_DQ[33] |
| AR32 | SB_DQ[38] |
| AR33 | RSVD_2 |
| AR34 | VSS |
| AR35 | VSS |
| AT3 | VSS |
| AT4 | VCCPLL |
| AT5 | VCCPLL |
| AT6 | VSS |
| AT7 | SB_DQ[25] |
| AT8 | SB_DQ[30] |
| AT9 | VSS |
| AT10 | SA_DQ[25] |
| AT11 | SA_DQ[30] |
| AT12 | VSS |
| AT13 | SA_ECC_CB[1] |
| AT14 | SA_ECC_CB[6] |
| AT15 | VSS |

| Ball | Signal |
|---|---|
| AT16 | SB_CKE[3] |
| AT17 | VDDQ |
| AT18 | SB_MA[14] |
| AT19 | SB_MA[12] |
| AT20 | VDDQ |
| AT21 | SB_MA[3] |
| AT22 | SB_MA[2] |
| AT23 | VDDQ |
| AT24 | SM_RCOMP[1] |
| AT25 | VDDQ |
| AT26 | VDDQ |
| AT27 | SB_CS#[2] |
| AT28 | SB_CAS# |
| AT29 | SM_RCOMP[0] |
| AT30 | SM_RCOMP[2] |
| AT31 | SB_DQ[37] |
| AT32 | SB_DQ[39] |
| AT33 | VSS |
| AT34 | VSS |

## Table 10-2. Alphabetical Signal Listing

| Signal | Ball |
|---|---|
| BCLK | P6 |
| BCLK# | P7 |
| BPM#[0] | D28 |
| BPM#[1] | C27 |
| BPM#[2] | C26 |
| BPM#[3] | D26 |
| BPM#[4] | A26 |
| BPM#[5] | B26 |
| BPM#[6] | E26 |
| BPM#[7] | F26 |
| CATERR# | H28 |
| CFG[0] | K30 |
| CFG[1] | L30 |
| CFG[10] | K34 |
| CFG[11] | M34 |
| CFG[12] | N35 |
| CFG[13] | L35 |
| CFG[14] | M36 |
| CFG[15] | N36 |
| CFG[16] | L33 |
| CFG[17] | M32 |
| CFG[2] | N34 |
| CFG[3] | N31 |
| CFG[4] | L31 |
| CFG[5] | L32 |
| CFG[6] | N32 |
| CFG[7] | K32 |
| CFG[8] | N33 |
| CFG[9] | L34 |
| DMI_RX[0] | R3 |
| DMI_RX[1] | R4 |
| DMI_RX[2] | U4 |
| DMI_RX[3] | V5 |
| DMI_RX#[0] | T3 |
| DMI_RX#[1] | T4 |
| DMI_RX#[2] | V4 |
| DMI_RX#[3] | W5 |
| DMI_TX[0] | P1 |
| DMI_TX[1] | U1 |
| DMI_TX[2] | U2 |
| DMI_TX[3] | W1 |
| DMI_TX#[0] | R1 |
| DMI_TX#[1] | T1 |
| DMI_TX#[2] | V2 |
| DMI_TX#[3] | V1 |
| PCIE_ICOMPI | J1 |
| PCIE_ICOMPO | F1 |
| PCIE_RCOMPO | C12 |
| PCIE1_RX[0] | C9 |
| PCIE1_RX[1] | A9 |
| PCIE1_RX[10] | C4 |
| PCIE1_RX[11] | D3 |
| PCIE1_RX[12] | E2 |
| PCIE1_RX[13] | F4 |
| PCIE1_RX[14] | G3 |
| PCIE1_RX[15] | G1 |
| PCIE1_RX[2] | D9 |
| PCIE1_RX[3] | E7 |
| PCIE1_RX[4] | B7 |
| PCIE1_RX[5] | C6 |
| PCIE1_RX[6] | A5 |
| PCIE1_RX[7] | D5 |
| PCIE1_RX[8] | E4 |
| PCIE1_RX[9] | B4 |
| PCIE1_RX#[0] | C10 |
| PCIE1_RX#[1] | A8 |
| PCIE1_RX#[10] | C3 |
| PCIE1_RX#[11] | D2 |
| PCIE1_RX#[12] | E1 |
| PCIE1_RX#[13] | F3 |
| PCIE1_RX#[14] | G2 |
| PCIE1_RX#[15] | H1 |
| PCIE1_RX#[2] | D8 |
| PCIE1_RX#[3] | E8 |
| PCIE1_RX#[4] | B8 |
| PCIE1_RX#[5] | C7 |
| PCIE1_RX#[6] | A6 |
| PCIE1_RX#[7] | D6 |
| PCIE1_RX#[8] | E5 |
| PCIE1_RX#[9] | B5 |
| PCIE1_TX[0] | G12 |
| PCIE1_TX[1] | H10 |
| PCIE1_TX[10] | J3 |
| PCIE1_TX[11] | L5 |
| PCIE1_TX[12] | N5 |
| PCIE1_TX[13] | K2 |
| PCIE1_TX[14] | M1 |
| PCIE1_TX[15] | M3 |
| PCIE1_TX[2] | J10 |
| PCIE1_TX[3] | K9 |
| PCIE1_TX[4] | G9 |
| PCIE1_TX[5] | H8 |
| PCIE1_TX[6] | J7 |
| PCIE1_TX[7] | G6 |
| PCIE1_TX[8] | J5 |
| PCIE1_TX[9] | K6 |
| PCIE1_TX#[0] | G11 |
| PCIE1_TX#[1] | H11 |
| PCIE1_TX#[10] | K3 |
| PCIE1_TX#[11] | L4 |
| PCIE1_TX#[12] | N4 |
| PCIE1_TX#[13] | L2 |
| PCIE1_TX#[14] | L1 |
| PCIE1_TX#[15] | N3 |
| PCIE1_TX#[2] | J9 |
| PCIE1_TX#[3] | K8 |
| PCIE1_TX#[4] | G8 |
| PCIE1_TX#[5] | H7 |
| PCIE1_TX#[6] | J6 |
| PCIE1_TX#[7] | H5 |
| PCIE1_TX#[8] | J4 |
| PCIE1_TX#[9] | K5 |
| PCIE2_RX[0] | E11 |
| PCIE2_RX[1] | D12 |
| PCIE2_RX[2] | B11 |
| PCIE2_RX[3] | A12 |
| PCIE2_RX#[0] | D10 |
| PCIE2_RX#[1] | D11 |
| PCIE2_RX#[2] | B10 |
| PCIE2_RX#[3] | A11 |
| PCIE2_TX[0] | M6 |
| PCIE2_TX[1] | L7 |
| PCIE2_TX[2] | L11 |

| Signal | Ball |
|---|---|
| PCIE2_TX[3] | K12 |
| PCIE2_TX#[0] | M7 |
| PCIE2_TX#[1] | L8 |
| PCIE2_TX#[2] | L10 |
| PCIE2_TX#[3] | K11 |
| PECI | J33 |
| PM_SYNC | E28 |
| PRDY# | K26 |
| PREQ# | G29 |
| PROC_DETECT# | F28 |
| PROC_SELECT# | H27 |
| PROCHOT# | H32 |
| RESET# | H31 |
| RSVD_1 | AF18 |
| RSVD_10 | T6 |
| RSVD_11 | G30 |
| RSVD_12 | B30 |
| RSVD_13 | A30 |
| RSVD_14 | A28 |
| RSVD_15 | H34 |
| RSVD_16 | F33 |
| RSVD_17 | F36 |
| RSVD_18 | E35 |
| RSVD_19 | F32 |
| RSVD_2 | AR33 |
| RSVD_20 | D34 |
| RSVD_21 | C33 |
| RSVD_22 | B27 |
| RSVD_23 | C36 |
| RSVD_24 | K36 |
| RSVD_25 | J35 |
| RSVD_26 | C35 |
| RSVD_27 | C32 |
| RSVD_28 | B34 |
| RSVD_29 | C31 |
| RSVD_3 | AR30 |
| RSVD_30 | A31 |
| RSVD_31 | A29 |
| RSVD_32 | G34 |
| RSVD_33 | A33 |
| RSVD_34 | G33 |

| Signal | Ball |
|---|---|
| RSVD_35 | G36 |
| RSVD_36 | F35 |
| RSVD_37 | E32 |
| RSVD_38 | E34 |
| RSVD_39 | D33 |
| RSVD_40 | D36 |
| RSVD_41 | E27 |
| RSVD_42 | C28 |
| RSVD_43 | F27 |
| RSVD_44 | D29 |
| RSVD_45 | J31 |
| RSVD_46 | K28 |
| RSVD_47 | J29 |
| RSVD_48 | J27 |
| RSVD_49 | L28 |
| RSVD_50 | J36 |
| RSVD_51 | H35 |
| RSVD_52 | B35 |
| RSVD_53 | B32 |
| RSVD_54 | A34 |
| RSVD_55 | L26 |
| RSVD_56 | L27 |
| RSVD_57 | J30 |
| RSVD_6 | N2 |
| RSVD_7 | J12 |
| RSVD_8 | L12 |
| RSVD_9 | R6 |
| SA_BS[0] | AR27 |
| SA_BS[1] | AM25 |
| SA_BS[2] | AM18 |
| SA_CAS# | AN27 |
| SA_CK[0] | AM22 |
| SA_CK[1] | AN21 |
| SA_CK[2] | AN24 |
| SA_CK[3] | AL24 |
| SA_CK#[0] | AL22 |
| SA_CK#[1] | AN22 |
| SA_CK#[2] | AP24 |
| SA_CK#[3] | AM24 |
| SA_CKE[0] | AR18 |
| SA_CKE[1] | AP18 |

| Signal | Ball |
|---|---|
| SA_CKE[2] | AK18 |
| SA_CKE[3] | AM16 |
| SA_CS#[0] | AK25 |
| SA_CS#[1] | AN28 |
| SA_CS#[2] | AP28 |
| SA_CS#[3] | AK27 |
| SA_DIMM_VREFDQ | AL16 |
| SA_DQ[0] | AF3 |
| SA_DQ[1] | AF1 |
| SA_DQ[10] | AK3 |
| SA_DQ[11] | AK4 |
| SA_DQ[12] | AJ4 |
| SA_DQ[13] | AJ3 |
| SA_DQ[14] | AK1 |
| SA_DQ[15] | AK2 |
| SA_DQ[16] | AG10 |
| SA_DQ[17] | AG11 |
| SA_DQ[18] | AK10 |
| SA_DQ[19] | AK11 |
| SA_DQ[2] | AG3 |
| SA_DQ[20] | AF10 |
| SA_DQ[21] | AF11 |
| SA_DQ[22] | AJ10 |
| SA_DQ[23] | AJ11 |
| SA_DQ[24] | AR10 |
| SA_DQ[25] | AT10 |
| SA_DQ[26] | AP11 |
| SA_DQ[27] | AN11 |
| SA_DQ[28] | AN10 |
| SA_DQ[29] | AP10 |
| SA_DQ[3] | AG4 |
| SA_DQ[30] | AT11 |
| SA_DQ[31] | AR11 |
| SA_DQ[32] | AK30 |
| SA_DQ[33] | AJ30 |
| SA_DQ[34] | AF30 |
| SA_DQ[35] | AF31 |
| SA_DQ[36] | AK31 |
| SA_DQ[37] | AJ31 |
| SA_DQ[38] | AG30 |
| SA_DQ[39] | AG31 |

| Signal | Ball |
|---|---|
| SA_DQ[4] | AF4 |
| SA_DQ[40] | AB36 |
| SA_DQ[41] | AB35 |
| SA_DQ[42] | AA34 |
| SA_DQ[43] | AA33 |
| SA_DQ[44] | AB33 |
| SA_DQ[45] | AB34 |
| SA_DQ[46] | AA35 |
| SA_DQ[47] | AA36 |
| SA_DQ[48] | W36 |
| SA_DQ[49] | W35 |
| SA_DQ[5] | AF2 |
| SA_DQ[50] | V34 |
| SA_DQ[51] | V33 |
| SA_DQ[52] | W33 |
| SA_DQ[53] | W34 |
| SA_DQ[54] | V35 |
| SA_DQ[55] | V36 |
| SA_DQ[56] | T36 |
| SA_DQ[57] | T35 |
| SA_DQ[58] | R34 |
| SA_DQ[59] | R33 |
| SA_DQ[6] | AG1 |
| SA_DQ[60] | T33 |
| SA_DQ[61] | T34 |
| SA_DQ[62] | R35 |
| SA_DQ[63] | R36 |
| SA_DQ[7] | AG2 |
| SA_DQ[8] | AJ2 |
| SA_DQ[9] | AJ1 |
| SA_DQS[0] | AG5 |
| SA_DQS[1] | AK5 |
| SA_DQS[2] | AH11 |
| SA_DQS[3] | AM11 |
| SA_DQS[4] | AH31 |
| SA_DQS[5] | AA32 |
| SA_DQS[6] | V32 |
| SA_DQS[7] | R32 |
| SA_DQS[8] | AM14 |
| SA_DQS#[0] | AF5 |
| SA_DQS#[1] | AJ5 |

| Signal | Ball |
|---|---|
| SA_DQS#[2] | AH10 |
| SA_DQS#[3] | AM10 |
| SA_DQS#[4] | AH30 |
| SA_DQS#[5] | AB32 |
| SA_DQS#[6] | W32 |
| SA_DQS#[7] | T32 |
| SA_DQS#[8] | AM13 |
| SA_ECC_CB[0] | AR13 |
| SA_ECC_CB[1] | AT13 |
| SA_ECC_CB[2] | AP14 |
| SA_ECC_CB[3] | AN14 |
| SA_ECC_CB[4] | AN13 |
| SA_ECC_CB[5] | AP13 |
| SA_ECC_CB[6] | AT14 |
| SA_ECC_CB[7] | AR14 |
| SA_MA[0] | AN25 |
| SA_MA[1] | AM21 |
| SA_MA[10] | AL25 |
| SA_MA[11] | AK19 |
| SA_MA[12] | AN18 |
| SA_MA[13] | AM28 |
| SA_MA[14] | AL18 |
| SA_MA[15] | AP19 |
| SA_MA[2] | AF22 |
| SA_MA[3] | AP22 |
| SA_MA[4] | AF21 |
| SA_MA[5] | AR21 |
| SA_MA[6] | AP21 |
| SA_MA[7] | AN19 |
| SA_MA[8] | AL19 |
| SA_MA[9] | AM19 |
| SA_ODT[0] | AL27 |
| SA_ODT[1] | AL28 |
| SA_ODT[2] | AM27 |
| SA_ODT[3] | AK28 |
| SA_RAS# | AP27 |
| SA_WE# | AK24 |
| SB_BS[0] | AJ25 |
| SB_BS[1] | AJ24 |
| SB_BS[2] | AH16 |
| SB_CAS# | AT28 |

| Signal | Ball |
|---|---|
| SB_CK[0] | AH21 |
| SB_CK[1] | AJ21 |
| SB_CK[2] | AK22 |
| SB_CK[3] | AG21 |
| SB_CK#[0] | AH22 |
| SB_CK#[1] | AK21 |
| SB_CK#[2] | AJ22 |
| SB_CK#[3] | AG22 |
| SB_CKE[0] | AL15 |
| SB_CKE[1] | AG16 |
| SB_CKE[2] | AF16 |
| SB_CKE[3] | AT16 |
| SB_CS#[0] | AG25 |
| SB_CS#[1] | AH27 |
| SB_CS#[2] | AT27 |
| SB_CS#[3] | AH28 |
| SB_DIMM_VREFDQ | AK16 |
| SB_DQ[0] | AC3 |
| SB_DQ[1] | AC1 |
| SB_DQ[10] | AK8 |
| SB_DQ[11] | AK7 |
| SB_DQ[12] | AF7 |
| SB_DQ[13] | AF8 |
| SB_DQ[14] | AJ8 |
| SB_DQ[15] | AJ7 |
| SB_DQ[16] | AM3 |
| SB_DQ[17] | AM2 |
| SB_DQ[18] | AP3 |
| SB_DQ[19] | AN5 |
| SB_DQ[2] | AD3 |
| SB_DQ[20] | AM1 |
| SB_DQ[21] | AM5 |
| SB_DQ[22] | AN2 |
| SB_DQ[23] | AN3 |
| SB_DQ[24] | AR7 |
| SB_DQ[25] | AT7 |
| SB_DQ[26] | AP8 |
| SB_DQ[27] | AN8 |
| SB_DQ[28] | AN7 |
| SB_DQ[29] | AP7 |
| SB_DQ[3] | AD4 |

| Signal | Ball |
|---|---|
| SB_DQ[30] | AT8 |
| SB_DQ[31] | AR8 |
| SB_DQ[32] | AP31 |
| SB_DQ[33] | AR31 |
| SB_DQ[34] | AP32 |
| SB_DQ[35] | AN32 |
| SB_DQ[36] | AN31 |
| SB_DQ[37] | AT31 |
| SB_DQ[38] | AR32 |
| SB_DQ[39] | AT32 |
| SB_DQ[4] | AC4 |
| SB_DQ[40] | AN35 |
| SB_DQ[41] | AL35 |
| SB_DQ[42] | AK34 |
| SB_DQ[43] | AK33 |
| SB_DQ[44] | AN34 |
| SB_DQ[45] | AL34 |
| SB_DQ[46] | AL33 |
| SB_DQ[47] | AK35 |
| SB_DQ[48] | AH35 |
| SB_DQ[49] | AH36 |
| SB_DQ[5] | AC2 |
| SB_DQ[50] | AG34 |
| SB_DQ[51] | AF36 |
| SB_DQ[52] | AJ36 |
| SB_DQ[53] | AH34 |
| SB_DQ[54] | AG36 |
| SB_DQ[55] | AG35 |
| SB_DQ[56] | AE34 |
| SB_DQ[57] | AE35 |
| SB_DQ[58] | AD34 |
| SB_DQ[59] | AD33 |
| SB_DQ[6] | AD1 |
| SB_DQ[60] | AD31 |
| SB_DQ[61] | AE33 |
| SB_DQ[62] | AD35 |
| SB_DQ[63] | AD36 |
| SB_DQ[7] | AD2 |
| SB_DQ[8] | AG7 |
| SB_DQ[9] | AG8 |
| SB_DQS[0] | AD5 |

| Signal | Ball |
|---|---|
| SB_DQS[1] | AH8 |
| SB_DQS[2] | AN4 |
| SB_DQS[3] | AM8 |
| SB_DQS[4] | AM32 |
| SB_DQS[5] | AL36 |
| SB_DQS[6] | AG33 |
| SB_DQS[7] | AD32 |
| SB_DQS[8] | AH14 |
| SB_DQS#[0] | AC5 |
| SB_DQS#[1] | AH7 |
| SB_DQS#[2] | AM4 |
| SB_DQS#[3] | AM7 |
| SB_DQS#[4] | AM31 |
| SB_DQS#[5] | AM36 |
| SB_DQS#[6] | AH33 |
| SB_DQS#[7] | AE32 |
| SB_DQS#[8] | AH13 |
| SB_ECC_CB[0] | AG13 |
| SB_ECC_CB[1] | AG14 |
| SB_ECC_CB[2] | AK13 |
| SB_ECC_CB[3] | AK14 |
| SB_ECC_CB[4] | AF13 |
| SB_ECC_CB[5] | AF14 |
| SB_ECC_CB[6] | AJ13 |
| SB_ECC_CB[7] | AJ14 |
| SB_MA[0] | AR24 |
| SB_MA[1] | AR22 |
| SB_MA[10] | AH24 |
| SB_MA[11] | AG18 |
| SB_MA[12] | AT19 |
| SB_MA[13] | AJ28 |
| SB_MA[14] | AT18 |
| SB_MA[15] | AJ16 |
| SB_MA[2] | AT22 |
| SB_MA[3] | AT21 |
| SB_MA[4] | AH19 |
| SB_MA[5] | AJ19 |
| SB_MA[6] | AH18 |
| SB_MA[7] | AG19 |
| SB_MA[8] | AJ18 |
| SB_MA[9] | AR19 |

| Signal | Ball |
|---|---|
| SB_ODT[0] | AJ27 |
| SB_ODT[1] | AG27 |
| SB_ODT[2] | AR28 |
| SB_ODT[3] | AG28 |
| SB_RAS# | AH25 |
| SB_WE# | AG24 |
| SM_DRAMPWROK | AF19 |
| SM_DRAMRST# | AN16 |
| SM_RCOMP[0] | AT29 |
| SM_RCOMP[1] | AT24 |
| SM_RCOMP[2] | AT30 |
| SM_VREF | AP16 |
| SM_VREF | AR16 |
| TCK | D30 |
| TDI | E30 |
| TDO | L29 |
| THERMTRIP# | G31 |
| TMS | F30 |
| TRST# | H26 |
| UNCOREPWRGOOD | H29 |
| VCC | A14 |
| VCC | A15 |
| VCC | A17 |
| VCC | A18 |
| VCC | A20 |
| VCC | A21 |
| VCC | A23 |
| VCC | A24 |
| VCC | B14 |
| VCC | B15 |
| VCC | B17 |
| VCC | B18 |
| VCC | B20 |
| VCC | B21 |
| VCC | B23 |
| VCC | B24 |
| VCC | C14 |
| VCC | C15 |
| VCC | C17 |
| VCC | C18 |
| VCC | C20 |

| Signal | Ball |
|---|---|
| VCC | C21 |
| VCC | C23 |
| VCC | C24 |
| VCC | D14 |
| VCC | D15 |
| VCC | D17 |
| VCC | D18 |
| VCC | D20 |
| VCC | D21 |
| VCC | D23 |
| VCC | D24 |
| VCC | E14 |
| VCC | E15 |
| VCC | E17 |
| VCC | E18 |
| VCC | E20 |
| VCC | E21 |
| VCC | E23 |
| VCC | E24 |
| VCC | F14 |
| VCC | F15 |
| VCC | F17 |
| VCC | F18 |
| VCC | F20 |
| VCC | F21 |
| VCC | F23 |
| VCC | F24 |
| VCC | G14 |
| VCC | G15 |
| VCC | G17 |
| VCC | G18 |
| VCC | G20 |
| VCC | G21 |
| VCC | G23 |
| VCC | G24 |
| VCC | H14 |
| VCC | H15 |
| VCC | H17 |
| VCC | H18 |
| VCC | H20 |
| VCC | H21 |

| Signal | Ball |
|---|---|
| VCC | H23 |
| VCC | H24 |
| VCC | J14 |
| VCC | J15 |
| VCC | J17 |
| VCC | J18 |
| VCC | J20 |
| VCC | J21 |
| VCC | J23 |
| VCC | J24 |
| VCC | K14 |
| VCC | K15 |
| VCC | K17 |
| VCC | K18 |
| VCC | K20 |
| VCC | K21 |
| VCC | K23 |
| VCC | K24 |
| VCC | L14 |
| VCC | L15 |
| VCC | L17 |
| VCC | L18 |
| VCC | L20 |
| VCC | L21 |
| VCC | L23 |
| VCC | L24 |
| VCC | M14 |
| VCC | M15 |
| VCC | M17 |
| VCC | M18 |
| VCC | M20 |
| VCC | M21 |
| VCC | M23 |
| VCC | M24 |
| VCC | N12 |
| VCC | N14 |
| VCC | N15 |
| VCC | N17 |
| VCC | N18 |
| VCC | N20 |
| VCC | N21 |

| Signal | Ball |
|---|---|
| VCC | N23 |
| VCC | N24 |
| VCC | N26 |
| VCC | P12 |
| VCC | P14 |
| VCC | P15 |
| VCC | P17 |
| VCC | P18 |
| VCC | P20 |
| VCC | P21 |
| VCC | P23 |
| VCC | P24 |
| VCC | P26 |
| VCC | R12 |
| VCC | R14 |
| VCC | R15 |
| VCC | R17 |
| VCC | R18 |
| VCC | R20 |
| VCC | R21 |
| VCC | R23 |
| VCC | R24 |
| VCC | R26 |
| VCC | T12 |
| VCC | T14 |
| VCC | T15 |
| VCC | T17 |
| VCC | T18 |
| VCC | T20 |
| VCC | T21 |
| VCC | T23 |
| VCC | T24 |
| VCC | T26 |
| VCC | U12 |
| VCC | U14 |
| VCC | U15 |
| VCC | U17 |
| VCC | U18 |
| VCC | U20 |
| VCC | U21 |
| VCC | U23 |

| Signal | Ball |
|---|---|
| VCC | U24 |
| VCC | U26 |
| VCC | V12 |
| VCC | V14 |
| VCC | V15 |
| VCC | V17 |
| VCC | V18 |
| VCC | V20 |
| VCC | V21 |
| VCC | V23 |
| VCC | V24 |
| VCC | V26 |
| VCC | W12 |
| VCC | W14 |
| VCC | W15 |
| VCC | W17 |
| VCC | W18 |
| VCC | W20 |
| VCC | W21 |
| VCC | W23 |
| VCC | W24 |
| VCC | W26 |
| VCC | Y12 |
| VCC | Y14 |
| VCC | Y15 |
| VCC | Y17 |
| VCC | Y18 |
| VCC | Y20 |
| VCC | Y21 |
| VCC | Y23 |
| VCC | Y24 |
| VCC | Y26 |
| VCC | AA12 |
| VCC | AA14 |
| VCC | AA15 |
| VCC | AA17 |
| VCC | AA18 |
| VCC | AA20 |
| VCC | AA21 |
| VCC | AA23 |
| VCC | AA24 |

| Signal | Ball |
|---|---|
| VCC | AA26 |
| VCC_SENSE | M26 |
| VCCIO | M11 |
| VCCIO | M12 |
| VCCIO | N8 |
| VCCIO | N10 |
| VCCIO | N28 |
| VCCIO | N29 |
| VCCIO | P28 |
| VCCIO | P29 |
| VCCIO | R7 |
| VCCIO | R8 |
| VCCIO | R27 |
| VCCIO | R29 |
| VCCIO | T7 |
| VCCIO | T10 |
| VCCIO | T27 |
| VCCIO | T29 |
| VCCIO | U7 |
| VCCIO | U8 |
| VCCIO | U28 |
| VCCIO | U29 |
| VCCIO | V7 |
| VCCIO | V8 |
| VCCIO | V28 |
| VCCIO | V29 |
| VCCIO | V30 |
| VCCIO | W7 |
| VCCIO | W10 |
| VCCIO | W27 |
| VCCIO | W29 |
| VCCIO | W30 |
| VCCIO | Y1 |
| VCCIO | Y2 |
| VCCIO | Y3 |
| VCCIO | Y4 |
| VCCIO | Y5 |
| VCCIO | Y6 |
| VCCIO | Y7 |
| VCCIO | Y8 |
| VCCIO | Y27 |

| Signal | Ball |
|---|---|
| VCCIO | Y29 |
| VCCIO | Y30 |
| VCCIO | AA1 |
| VCCIO | AA2 |
| VCCIO | AA3 |
| VCCIO | AA4 |
| VCCIO | AA5 |
| VCCIO | AA6 |
| VCCIO | AA7 |
| VCCIO | AA28 |
| VCCIO | AA29 |
| VCCIO | AA30 |
| VCCIO | AB7 |
| VCCIO | AB8 |
| VCCIO | AB10 |
| VCCIO | AB12 |
| VCCIO | AB14 |
| VCCIO | AB15 |
| VCCIO | AB17 |
| VCCIO | AB18 |
| VCCIO | AB20 |
| VCCIO | AB21 |
| VCCIO | AB23 |
| VCCIO | AB24 |
| VCCIO | AB26 |
| VCCIO | AB27 |
| VCCIO | AB28 |
| VCCIO | AB29 |
| VCCIO | AB30 |
| VCCIO | AC7 |
| VCCIO | AC8 |
| VCCIO | AC9 |
| VCCIO | AC10 |
| VCCIO | AC11 |
| VCCIO | AC12 |
| VCCIO | AC13 |
| VCCIO | AC14 |
| VCCIO | AC15 |
| VCCIO | AC16 |
| VCCIO | AC17 |
| VCCIO | AC18 |

| Signal | Ball |
|---|---|
| VCCIO | AC19 |
| VCCIO | AC20 |
| VCCIO | AC21 |
| VCCIO | AC22 |
| VCCIO | AC23 |
| VCCIO | AC24 |
| VCCIO | AC25 |
| VCCIO | AC26 |
| VCCIO | AC27 |
| VCCIO | AC28 |
| VCCIO | AC29 |
| VCCIO | AC30 |
| VCCIO | AD10 |
| VCCIO | AD11 |
| VCCIO_SENSE | AD28 |
| VCCPLL | AR4 |
| VCCPLL | AR5 |
| VCCPLL | AT4 |
| VCCPLL | AT5 |
| VCCSA | N9 |
| VCCSA | P9 |
| VCCSA | P11 |
| VCCSA | R9 |
| VCCSA | R11 |
| VCCSA | T8 |
| VCCSA | T11 |
| VCCSA | U9 |
| VCCSA | V9 |
| VCCSA | V11 |
| VCCSA | W8 |
| VCCSA | W11 |
| VCCSA | Y9 |
| VCCSA | Y11 |
| VCCSA | AA9 |
| VCCSA | AB9 |
| VCCSA_VCCSENSE | M10 |
| VCCSA_VID | J26 |
| VCCSA_VSSSENSE | M9 |
| VDDQ | AD13 |
| VDDQ | AD14 |
| VDDQ | AD15 |

| Signal | Ball |
|---|---|
| VDDQ | AD17 |
| VDDQ | AD18 |
| VDDQ | AD21 |
| VDDQ | AD25 |
| VDDQ | AE15 |
| VDDQ | AE16 |
| VDDQ | AE17 |
| VDDQ | AE18 |
| VDDQ | AE19 |
| VDDQ | AE20 |
| VDDQ | AE21 |
| VDDQ | AE22 |
| VDDQ | AE23 |
| VDDQ | AE24 |
| VDDQ | AE25 |
| VDDQ | AE26 |
| VDDQ | AE27 |
| VDDQ | AE28 |
| VDDQ | AF17 |
| VDDQ | AF20 |
| VDDQ | AF23 |
| VDDQ | AF24 |
| VDDQ | AF26 |
| VDDQ | AH17 |
| VDDQ | AH20 |
| VDDQ | AH23 |
| VDDQ | AH26 |
| VDDQ | AK17 |
| VDDQ | AK20 |
| VDDQ | AK23 |
| VDDQ | AK26 |
| VDDQ | AM17 |
| VDDQ | AM20 |
| VDDQ | AM23 |
| VDDQ | AM26 |
| VDDQ | AM29 |
| VDDQ | AP17 |
| VDDQ | AP20 |
| VDDQ | AP23 |
| VDDQ | AP26 |
| VDDQ | AP29 |

| Signal | Ball |
|---|---|
| VDDQ | AT17 |
| VDDQ | AT20 |
| VDDQ | AT23 |
| VDDQ | AT25 |
| VDDQ | AT26 |
| VIDALERT# | E31 |
| VIDSCLK | E29 |
| VIDSOUT | G26 |
| VSS | A3 |
| VSS | A4 |
| VSS | A7 |
| VSS | A10 |
| VSS | A13 |
| VSS | A16 |
| VSS | A19 |
| VSS | A22 |
| VSS | A25 |
| VSS | A27 |
| VSS | A32 |
| VSS | B2 |
| VSS | B3 |
| VSS | B6 |
| VSS | B9 |
| VSS | B12 |
| VSS | B13 |
| VSS | B16 |
| VSS | B19 |
| VSS | B22 |
| VSS | B25 |
| VSS | B28 |
| VSS | B29 |
| VSS | B31 |
| VSS | B33 |
| VSS | C1 |
| VSS | C2 |
| VSS | C5 |
| VSS | C8 |
| VSS | C11 |
| VSS | C13 |
| VSS | C16 |
| VSS | C19 |

| Signal | Ball |
|---|---|
| VSS | C22 |
| VSS | C25 |
| VSS | C29 |
| VSS | C30 |
| VSS | C34 |
| VSS | D1 |
| VSS | D4 |
| VSS | D7 |
| VSS | D13 |
| VSS | D16 |
| VSS | D19 |
| VSS | D22 |
| VSS | D25 |
| VSS | D27 |
| VSS | D31 |
| VSS | D32 |
| VSS | D35 |
| VSS | E3 |
| VSS | E6 |
| VSS | E9 |
| VSS | E10 |
| VSS | E12 |
| VSS | E13 |
| VSS | E16 |
| VSS | E19 |
| VSS | E22 |
| VSS | E25 |
| VSS | E33 |
| VSS | E36 |
| VSS | F2 |
| VSS | F5 |
| VSS | F6 |
| VSS | F7 |
| VSS | F8 |
| VSS | F9 |
| VSS | F10 |
| VSS | F11 |
| VSS | F12 |
| VSS | F13 |
| VSS | F16 |
| VSS | F19 |

| Signal | Ball |
|---|---|
| VSS | F22 |
| VSS | F25 |
| VSS | F29 |
| VSS | F31 |
| VSS | F34 |
| VSS | G4 |
| VSS | G5 |
| VSS | G7 |
| VSS | G10 |
| VSS | G13 |
| VSS | G16 |
| VSS | G19 |
| VSS | G22 |
| VSS | G25 |
| VSS | G27 |
| VSS | G28 |
| VSS | G32 |
| VSS | G35 |
| VSS | H2 |
| VSS | H3 |
| VSS | H4 |
| VSS | H6 |
| VSS | H9 |
| VSS | H12 |
| VSS | H13 |
| VSS | H16 |
| VSS | H19 |
| VSS | H22 |
| VSS | H25 |
| VSS | H30 |
| VSS | H33 |
| VSS | H36 |
| VSS | J2 |
| VSS | J8 |
| VSS | J11 |
| VSS | J13 |
| VSS | J16 |
| VSS | J19 |
| VSS | J22 |
| VSS | J25 |
| VSS | J28 |

| Signal | Ball |
|---|---|
| VSS | J32 |
| VSS | J34 |
| VSS | K1 |
| VSS | K4 |
| VSS | K7 |
| VSS | K10 |
| VSS | K13 |
| VSS | K16 |
| VSS | K19 |
| VSS | K22 |
| VSS | K25 |
| VSS | K27 |
| VSS | K29 |
| VSS | K31 |
| VSS | K33 |
| VSS | K35 |
| VSS | L3 |
| VSS | L6 |
| VSS | L9 |
| VSS | L13 |
| VSS | L16 |
| VSS | L19 |
| VSS | L22 |
| VSS | L25 |
| VSS | L36 |
| VSS | M2 |
| VSS | M4 |
| VSS | M5 |
| VSS | M8 |
| VSS | M13 |
| VSS | M16 |
| VSS | M19 |
| VSS | M22 |
| VSS | M25 |
| VSS | M28 |
| VSS | M29 |
| VSS | M30 |
| VSS | M31 |
| VSS | M33 |
| VSS | M35 |
| VSS | N1 |

| Signal | Ball |
|---|---|
| VSS | N6 |
| VSS | N7 |
| VSS | N11 |
| VSS | N13 |
| VSS | N16 |
| VSS | N19 |
| VSS | N22 |
| VSS | N25 |
| VSS | N27 |
| VSS | N30 |
| VSS | P2 |
| VSS | P3 |
| VSS | P4 |
| VSS | P5 |
| VSS | P8 |
| VSS | P10 |
| VSS | P13 |
| VSS | P16 |
| VSS | P19 |
| VSS | P22 |
| VSS | P25 |
| VSS | P27 |
| VSS | P30 |
| VSS | P31 |
| VSS | P32 |
| VSS | P33 |
| VSS | P34 |
| VSS | P35 |
| VSS | P36 |
| VSS | R2 |
| VSS | R5 |
| VSS | R10 |
| VSS | R13 |
| VSS | R16 |
| VSS | R19 |
| VSS | R22 |
| VSS | R25 |
| VSS | R28 |
| VSS | R30 |
| VSS | R31 |
| VSS | T2 |

| Signal | Ball |
|---|---|
| VSS | T5 |
| VSS | T9 |
| VSS | T13 |
| VSS | T16 |
| VSS | T19 |
| VSS | T22 |
| VSS | T25 |
| VSS | T28 |
| VSS | T30 |
| VSS | T31 |
| VSS | U3 |
| VSS | U5 |
| VSS | U6 |
| VSS | U10 |
| VSS | U11 |
| VSS | U13 |
| VSS | U16 |
| VSS | U19 |
| VSS | U22 |
| VSS | U25 |
| VSS | U27 |
| VSS | U30 |
| VSS | U31 |
| VSS | U32 |
| VSS | U33 |
| VSS | U34 |
| VSS | U35 |
| VSS | U36 |
| VSS | V3 |
| VSS | V6 |
| VSS | V10 |
| VSS | V13 |
| VSS | V16 |
| VSS | V19 |
| VSS | V22 |
| VSS | V25 |
| VSS | V27 |
| VSS | V31 |
| VSS | W2 |
| VSS | W3 |
| VSS | W4 |

| Signal | Ball |
|---|---|
| VSS | W6 |
| VSS | W9 |
| VSS | W13 |
| VSS | W16 |
| VSS | W19 |
| VSS | W22 |
| VSS | W25 |
| VSS | W28 |
| VSS | W31 |
| VSS | Y10 |
| VSS | Y13 |
| VSS | Y16 |
| VSS | Y19 |
| VSS | Y22 |
| VSS | Y25 |
| VSS | Y28 |
| VSS | Y31 |
| VSS | Y32 |
| VSS | Y33 |
| VSS | Y34 |
| VSS | Y35 |
| VSS | Y36 |
| VSS | AA8 |
| VSS | AA10 |
| VSS | AA11 |
| VSS | AA13 |
| VSS | AA16 |
| VSS | AA19 |
| VSS | AA22 |
| VSS | AA25 |
| VSS | AA27 |
| VSS | AA31 |
| VSS | AB1 |
| VSS | AB2 |
| VSS | AB3 |
| VSS | AB4 |
| VSS | AB5 |
| VSS | AB6 |
| VSS | AB11 |
| VSS | AB13 |
| VSS | AB16 |

| Signal | Ball |
|---|---|
| VSS | AB19 |
| VSS | AB22 |
| VSS | AB25 |
| VSS | AB31 |
| VSS | AC6 |
| VSS | AC31 |
| VSS | AC32 |
| VSS | AC33 |
| VSS | AC34 |
| VSS | AC35 |
| VSS | AC36 |
| VSS | AD6 |
| VSS | AD7 |
| VSS | AD8 |
| VSS | AD9 |
| VSS | AD12 |
| VSS | AD16 |
| VSS | AD19 |
| VSS | AD20 |
| VSS | AD22 |
| VSS | AD23 |
| VSS | AD24 |
| VSS | AD26 |
| VSS | AD27 |
| VSS | AD30 |
| VSS | AE1 |
| VSS | AE2 |
| VSS | AE3 |
| VSS | AE4 |
| VSS | AE5 |
| VSS | AE6 |
| VSS | AE7 |
| VSS | AE8 |
| VSS | AE9 |
| VSS | AE10 |
| VSS | AE11 |
| VSS | AE12 |
| VSS | AE13 |
| VSS | AE14 |
| VSS | AE29 |
| VSS | AE30 |

| Signal | Ball |
|---|---|
| VSS | AE31 |
| VSS | AE36 |
| VSS | AF6 |
| VSS | AF9 |
| VSS | AF12 |
| VSS | AF15 |
| VSS | AF25 |
| VSS | AF27 |
| VSS | AF28 |
| VSS | AF29 |
| VSS | AF32 |
| VSS | AF33 |
| VSS | AF34 |
| VSS | AF35 |
| VSS | AG6 |
| VSS | AG9 |
| VSS | AG12 |
| VSS | AG15 |
| VSS | AG17 |
| VSS | AG20 |
| VSS | AG23 |
| VSS | AG26 |
| VSS | AG29 |
| VSS | AG32 |
| VSS | AH1 |
| VSS | AH2 |
| VSS | AH3 |
| VSS | AH4 |
| VSS | AH5 |
| VSS | AH6 |
| VSS | AH9 |
| VSS | AH12 |
| VSS | AH15 |
| VSS | AH29 |
| VSS | AH32 |
| VSS | AJ6 |
| VSS | AJ9 |
| VSS | AJ12 |
| VSS | AJ15 |
| VSS | AJ17 |
| VSS | AJ20 |

| Signal | Ball |
|---|---|
| VSS | AJ23 |
| VSS | AJ26 |
| VSS | AJ29 |
| VSS | AJ32 |
| VSS | AJ33 |
| VSS | AJ34 |
| VSS | AJ35 |
| VSS | AK6 |
| VSS | AK9 |
| VSS | AK12 |
| VSS | AK15 |
| VSS | AK29 |
| VSS | AK32 |
| VSS | AK36 |
| VSS | AL1 |
| VSS | AL2 |
| VSS | AL3 |
| VSS | AL4 |
| VSS | AL5 |
| VSS | AL6 |
| VSS | AL7 |
| VSS | AL8 |
| VSS | AL9 |
| VSS | AL10 |
| VSS | AL11 |
| VSS | AL12 |
| VSS | AL13 |
| VSS | AL14 |
| VSS | AL17 |
| VSS | AL20 |
| VSS | AL21 |
| VSS | AL23 |
| VSS | AL26 |
| VSS | AL29 |
| VSS | AL30 |
| VSS | AL31 |
| VSS | AL32 |
| VSS | AM6 |
| VSS | AM9 |
| VSS | AM12 |
| VSS | AM15 |

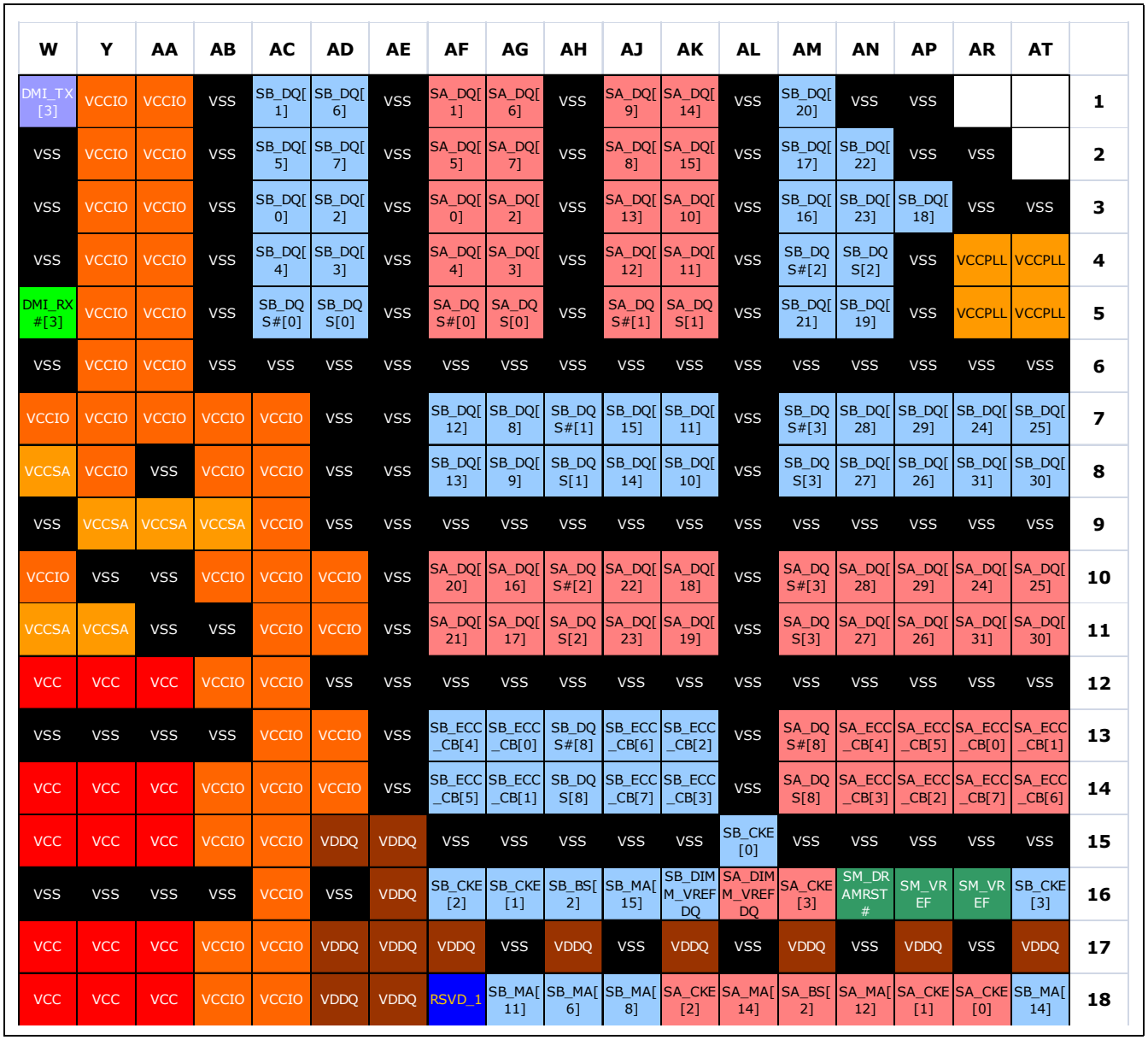
| Signal | Ball |
|---|---|
| VSS | AM30 |
| VSS | AM33 |
| VSS | AM34 |
| VSS | AM35 |
| VSS | AN1 |
| VSS | AN6 |
| VSS | AN9 |
| VSS | AN12 |
| VSS | AN15 |
| VSS | AN17 |
| VSS | AN20 |
| VSS | AN23 |
| VSS | AN26 |
| VSS | AN29 |
| VSS | AN30 |
| VSS | AN33 |
| VSS | AN36 |
| VSS | AP1 |
| VSS | AP2 |
| VSS | AP4 |
| VSS | AP5 |
| VSS | AP6 |
| VSS | AP9 |
| VSS | AP12 |
| VSS | AP15 |
| VSS | AP25 |
| VSS | AP30 |
| VSS | AP33 |
| VSS | AP34 |
| VSS | AP35 |
| VSS | AP36 |
| VSS | AR2 |
| VSS | AR3 |
| VSS | AR6 |
| VSS | AR9 |
| VSS | AR12 |
| VSS | AR15 |
| VSS | AR17 |
| VSS | AR20 |
| VSS | AR23 |
| VSS | AR25 |

| Signal | Ball |
|---|---|
| VSS | AR26 |
| VSS | AR29 |
| VSS | AR34 |
| VSS | AR35 |
| VSS | AT3 |
| VSS | AT6 |
| VSS | AT9 |
| VSS | AT12 |
| VSS | AT15 |
| VSS | AT33 |
| VSS | AT34 |
| VSS_SENSE | M27 |
| VSS_SENSE_VCCIO | AD29 |

## Figure 10-1. Ball Map (Bottom View, Upper Left Side)

| | A | B | C | D | E | F | G | H | J | K | L | M | N | P | R | T | U | V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | VSS | VSS | PCIE1_RX#[12] | PCIE_ICOMPO | PCIE1_RX[15] | PCIE1_RX#[15] | PCIE_ICOMPI | VSS | PCIE1_TX#[14] | PCIE1_TX[14] | VSS | DMI_TX[0] | DMI_TX#[0] | DMI_TX#[1] | DMI_TX[1] | DMI_TX#[3] |
| 2 | | VSS | VSS | PCIE1_RX#[11] | PCIE1_RX[12] | VSS | PCIE1_RX#[14] | VSS | VSS | PCIE1_TX[13] | PCIE1_TX#[13] | VSS | RSVD_6 | VSS | VSS | VSS | DMI_TX[2] | DMI_TX#[2] |
| 3 | VSS | VSS | PCIE1_RX#[10] | PCIE1_RX[11] | VSS | PCIE1_RX#[13] | PCIE1_RX[14] | VSS | PCIE1_TX[10] | PCIE1_TX#[10] | VSS | PCIE1_TX[15] | PCIE1_TX#[15] | VSS | DMI_RX[0] | DMI_RX#[0] | VSS | VSS |
| 4 | VSS | PCIE1_RX[9] | PCIE1_RX[10] | VSS | PCIE1_RX[8] | PCIE1_RX[13] | VSS | VSS | PCIE1_TX#[8] | VSS | PCIE1_TX#[11] | VSS | PCIE1_TX#[12] | VSS | DMI_RX[1] | DMI_RX#[1] | DMI_RX[2] | DMI_RX#[2] |
| 5 | PCIE1_RX[6] | PCIE1_RX#[9] | VSS | PCIE1_RX[7] | PCIE1_RX#[8] | VSS | VSS | PCIE1_TX#[7] | PCIE1_TX[8] | PCIE1_TX#[9] | PCIE1_TX[11] | VSS | PCIE1_TX[12] | VSS | VSS | VSS | VSS | DMI_RX[3] |
| 6 | PCIE1_RX#[6] | VSS | PCIE1_RX[5] | PCIE1_RX#[7] | VSS | VSS | PCIE1_TX[7] | VSS | PCIE1_TX#[6] | PCIE1_TX[9] | VSS | PCIE2_TX[0] | VSS | BCLK# | RSVD_9 | RSVD_10 | VSS | VSS |
| 7 | VSS | PCIE1_RX[4] | PCIE1_RX#[5] | VSS | PCIE1_RX[3] | VSS | VSS | PCIE1_TX#[5] | PCIE1_TX[6] | VSS | PCIE2_TX[1] | PCIE2_TX#[0] | VSS | BCLK | VCCIO | VCCIO | VCCIO | VCCIO |
| 8 | PCIE1_RX#[1] | PCIE1_RX#[4] | VSS | PCIE1_RX#[2] | PCIE1_RX#[3] | VSS | PCIE1_TX#[4] | PCIE1_TX[5] | VSS | PCIE1_TX#[3] | PCIE2_TX#[1] | VSS | VCCIO | VSS | VCCIO | VCCSA | VCCIO | VCCIO |
| 9 | PCIE1_RX[1] | VSS | PCIE1_RX[0] | PCIE1_RX[2] | VSS | VSS | PCIE1_TX[4] | VSS | PCIE1_TX#[2] | PCIE1_TX[3] | VSS | VCCSA_VSSSENSE | VCCSA | VCCSA | VCCSA | VSS | VCCSA | VCCSA |
| 10 | VSS | PCIE2_RX#[2] | PCIE1_RX#[0] | PCIE2_RX#[0] | VSS | VSS | VSS | PCIE1_TX[1] | PCIE1_TX[2] | VSS | PCIE2_TX#[2] | VCCSA_VCCSENSE | VCCIO | VSS | VSS | VCCIO | VSS | VSS |
| 11 | PCIE2_RX#[3] | PCIE2_RX[2] | VSS | PCIE2_RX#[1] | PCIE2_RX[0] | VSS | PCIE1_TX#[0] | PCIE1_TX#[1] | VSS | PCIE2_TX#[3] | PCIE2_TX[2] | VCC | VSS | VCCSA | VCCSA | VCCSA | VSS | VCCSA |
| 12 | PCIE2_RX[3] | VSS | PCIE_RCOMPO | PCIE2_RX[1] | VSS | VSS | PCIE1_TX[0] | VSS | RSVD_7 | PCIE2_TX[3] | RSVD_8 | VCC | VCC | VCC | VCC | VCC | VCC | VCC |
| 13 | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS |
| 14 | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC |
| 15 | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC |
| 16 | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS |
| 17 | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC |
| 18 | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC |

## Figure 10-2. Ball Map (Bottom View, Upper Right Side)

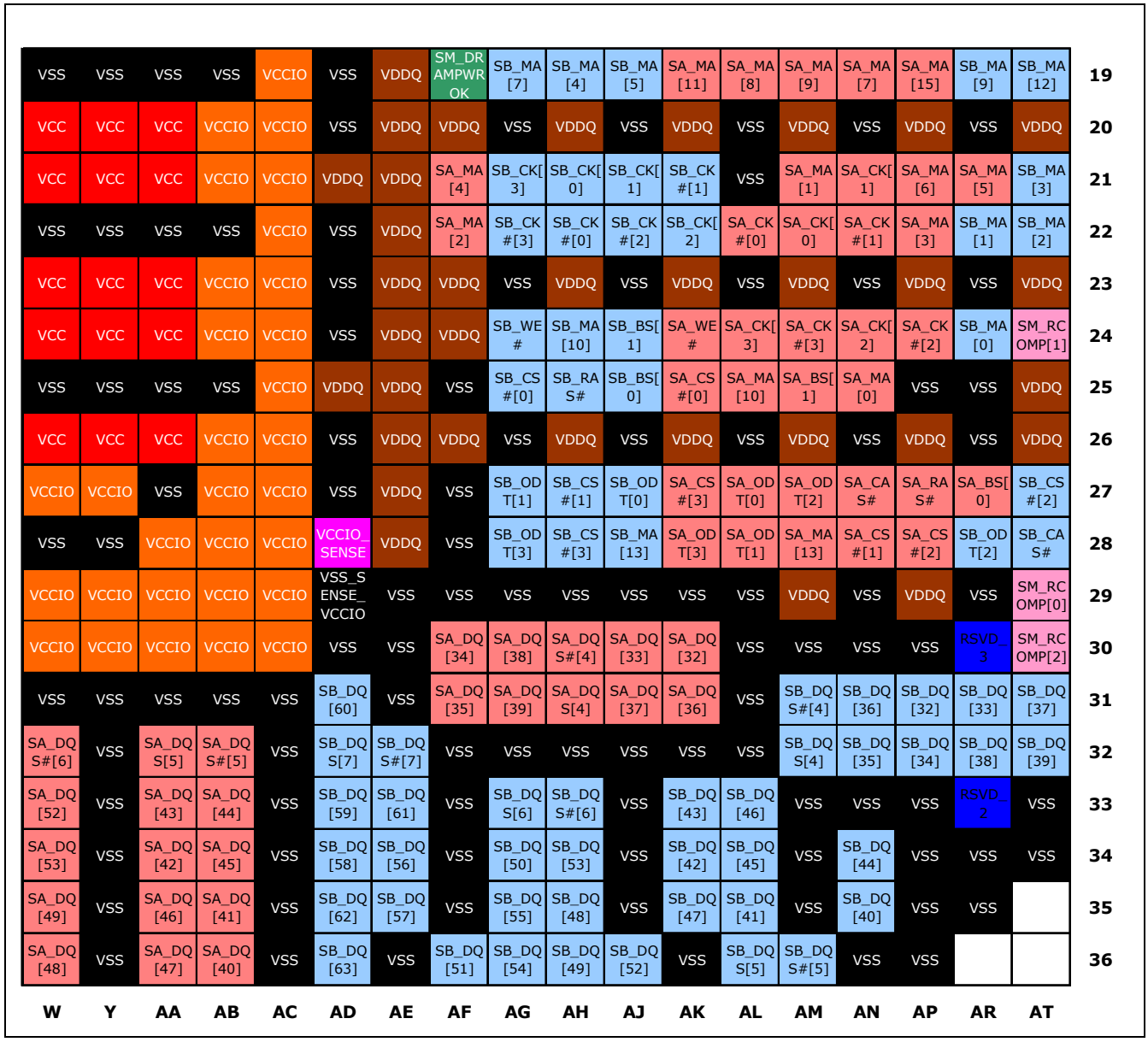


| W | Y | AA | AB | AC | AD | AE | AF | AG | AH | AJ | AK | AL | AM | AN | AP | AR | AT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DMI_TX[3] | VCCIO | VCCIO | VSS | SB_DQ[1] | SB_DQ[6] | VSS | SA_DQ[1] | SA_DQ[6] | VSS | SA_DQ[9] | SA_DQ[14] | VSS | SB_DQ[20] | VSS | VSS | | | 1 |
| VSS | VCCIO | VCCIO | VSS | SB_DQ[5] | SB_DQ[7] | VSS | SA_DQ[5] | SA_DQ[7] | VSS | SA_DQ[8] | SA_DQ[15] | VSS | SB_DQ[17] | SB_DQ[22] | VSS | VSS | | 2 |
| VSS | VCCIO | VCCIO | VSS | SB_DQ[0] | SB_DQ[2] | VSS | SA_DQ[0] | SA_DQ[2] | VSS | SA_DQ[13] | SA_DQ[10] | VSS | SB_DQ[16] | SB_DQ[23] | SB_DQ[18] | VSS | VSS | 3 |
| VSS | VCCIO | VCCIO | VSS | SB_DQ[4] | SB_DQ[3] | VSS | SA_DQ[4] | SA_DQ[3] | VSS | SA_DQ[12] | SA_DQ[11] | VSS | SB_DQS#[2] | SB_DQS[2] | VSS | VCCPLL | VCCPLL | 4 |
| DMI_RX#[3] | VCCIO | VCCIO | VSS | SB_DQS#[0] | SB_DQS[0] | VSS | SA_DQS#[0] | SA_DQS[0] | VSS | SA_DQS#[1] | SA_DQS[1] | VSS | SB_DQ[21] | SB_DQ[19] | VSS | VCCPLL | VCCPLL | 5 |
| VSS | VCCIO | VCCIO | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | 6 |
| VCCIO | VCCIO | VCCIO | VCCIO | VCCIO | VSS | VSS | SB_DQ[12] | SB_DQ[8] | SB_DQS#[1] | SB_DQ[15] | SB_DQ[11] | VSS | SB_DQS#[3] | SB_DQ[28] | SB_DQ[29] | SB_DQ[24] | SB_DQ[25] | 7 |
| VCCSA | VCCIO | VSS | VCCIO | VCCIO | VSS | VSS | SB_DQ[13] | SB_DQ[9] | SB_DQS[1] | SB_DQ[14] | SB_DQ[10] | VSS | SB_DQS[3] | SB_DQ[27] | SB_DQ[26] | SB_DQ[31] | SB_DQ[30] | 8 |
| VSS | VCCSA | VCCSA | VCCSA | VCCIO | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | 9 |
| VCCIO | VSS | VSS | VCCIO | VCCIO | VCCIO | VSS | SA_DQ[20] | SA_DQ[16] | SA_DQS#[2] | SA_DQ[22] | SA_DQ[18] | VSS | SA_DQS#[3] | SA_DQ[28] | SA_DQ[29] | SA_DQ[24] | SA_DQ[25] | 10 |
| VCCSA | VCCSA | VSS | VSS | VCCIO | VCCIO | VSS | SA_DQ[21] | SA_DQ[17] | SA_DQS[2] | SA_DQ[23] | SA_DQ[19] | VSS | SA_DQS[3] | SA_DQ[27] | SA_DQ[26] | SA_DQ[31] | SA_DQ[30] | 11 |
| VCC | VCC | VCC | VCCIO | VCCIO | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | 12 |
| VSS | VSS | VSS | VSS | VCCIO | VCCIO | VSS | SB_ECC_CB[4] | SB_ECC_CB[0] | SB_DQS#[8] | SB_ECC_CB[6] | SB_ECC_CB[2] | VSS | SA_DQS#[8] | SA_ECC_CB[4] | SA_ECC_CB[5] | SA_ECC_CB[0] | SA_ECC_CB[1] | 13 |
| VCC | VCC | VCC | VCCIO | VCCIO | VCCIO | VSS | SB_ECC_CB[5] | SB_ECC_CB[1] | SB_DQS[8] | SB_ECC_CB[7] | SB_ECC_CB[3] | VSS | SA_DQS[8] | SA_ECC_CB[3] | SA_ECC_CB[2] | SA_ECC_CB[7] | SA_ECC_CB[6] | 14 |
| VCC | VCC | VCC | VCCIO | VCCIO | VDDQ | VDDQ | VSS | VSS | VSS | VSS | VSS | SB_CKE[0] | VSS | VSS | VSS | VSS | VSS | 15 |
| VSS | VSS | VSS | VSS | VCCIO | VSS | VDDQ | SB_CKE[2] | SB_CKE[1] | SB_BS[2] | SB_MA[15] | SB_DIMM_VREFDQ | SA_DIMM_VREFDQ | SA_CKE[3] | SM_DRAMRST# | SM_VREF | SM_VREF | SB_CKE[3] | 16 |
| VCC | VCC | VCC | VCCIO | VCCIO | VDDQ | VDDQ | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | 17 |
| VCC | VCC | VCC | VCCIO | VCCIO | VDDQ | VDDQ | RSVD_1 | SB_MA[11] | SB_MA[6] | SB_MA[8] | SA_CKE[2] | SA_MA[14] | SA_BS[2] | SA_MA[12] | SA_CKE[1] | SA_CKE[0] | SB_MA[14] | 18 |

## Figure 10-3. Ball Map (Bottom View, Lower Left Side)

| | A | B | C | D | E | F | G | H | J | K | L | M | N | P | R | T | U | V |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS |
| 20 | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC |
| 21 | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC |
| 22 | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS |
| 23 | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC |
| 24 | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC | VCC |
| 25 | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VSS |
| 26 | BPM#[4] | BPM#[5] | BPM#[2] | BPM#[3] | BPM#[6] | BPM#[7] | VIDSOUT | TRST# | VCCSA_VID | PRDY# | RSVD_55 | VCC_SENSE | VCC | VCC | VCC | VCC | VCC | VCC |
| 27 | VSS | RSVD_22 | BPM#[1] | VSS | RSVD_41 | RSVD_43 | VSS | PROC_SELECT# | RSVD_48 | VSS | RSVD_56 | VSS_SENSE | VSS | VSS | VCCIO | VCCIO | VSS | VSS |
| 28 | RSVD_14 | VSS | RSVD_42 | BPM#[0] | PM_SYNC | PROC_DETECT# | VSS | CATERR# | VSS | RSVD_46 | RSVD_49 | VSS | VCCIO | VCCIO | VSS | VSS | VCCIO | VCCIO |
| 29 | RSVD_31 | VSS | VSS | RSVD_44 | VIDSCLK | VSS | PREQ# | UNCOREPWRGOOD | RSVD_47 | VSS | TDO | VSS | VCCIO | VCCIO | VCCIO | VCCIO | VCCIO | VCCIO |
| 30 | RSVD_13 | RSVD_12 | VSS | TCK | TDI | TMS | RSVD_11 | VSS | RSVD_57 | CFG[0] | CFG[1] | VSS | VSS | VSS | VSS | VSS | VSS | VCCIO |
| 31 | RSVD_30 | VSS | RSVD_29 | VSS | VIDALERT# | VSS | THERMTRIP# | RESET# | RSVD_45 | VSS | CFG[4] | VSS | CFG[3] | VSS | VSS | VSS | VSS | VSS |
| 32 | VSS | RSVD_53 | RSVD_27 | VSS | RSVD_37 | RSVD_19 | VSS | PROCHOT# | VSS | CFG[7] | CFG[5] | CFG[17] | CFG[6] | VSS | SA_DQS[7] | SA_DQS#[7] | VSS | SA_DQS[6] |
| 33 | RSVD_33 | VSS | RSVD_21 | RSVD_39 | VSS | RSVD_16 | RSVD_34 | VSS | PECI | VSS | CFG[16] | VSS | CFG[8] | VSS | SA_DQ[59] | SA_DQ[60] | VSS | SA_DQ[51] |
| 34 | RSVD_54 | RSVD_28 | VSS | RSVD_20 | RSVD_38 | VSS | RSVD_32 | RSVD_15 | VSS | CFG[10] | CFG[9] | CFG[11] | CFG[2] | VSS | SA_DQ[58] | SA_DQ[61] | VSS | SA_DQ[50] |
| 35 | | RSVD_52 | RSVD_26 | VSS | RSVD_18 | RSVD_36 | VSS | RSVD_51 | RSVD_25 | VSS | CFG[13] | VSS | CFG[12] | VSS | SA_DQ[62] | SA_DQ[57] | VSS | SA_DQ[54] |
| 36 | | | RSVD_23 | RSVD_40 | VSS | RSVD_17 | RSVD_35 | VSS | RSVD_50 | RSVD_24 | VSS | CFG[14] | CFG[15] | VSS | SA_DQ[63] | SA_DQ[56] | VSS | SA_DQ[55] |

## Figure 10-4. Ball Map (Bottom View, Lower Right Side)



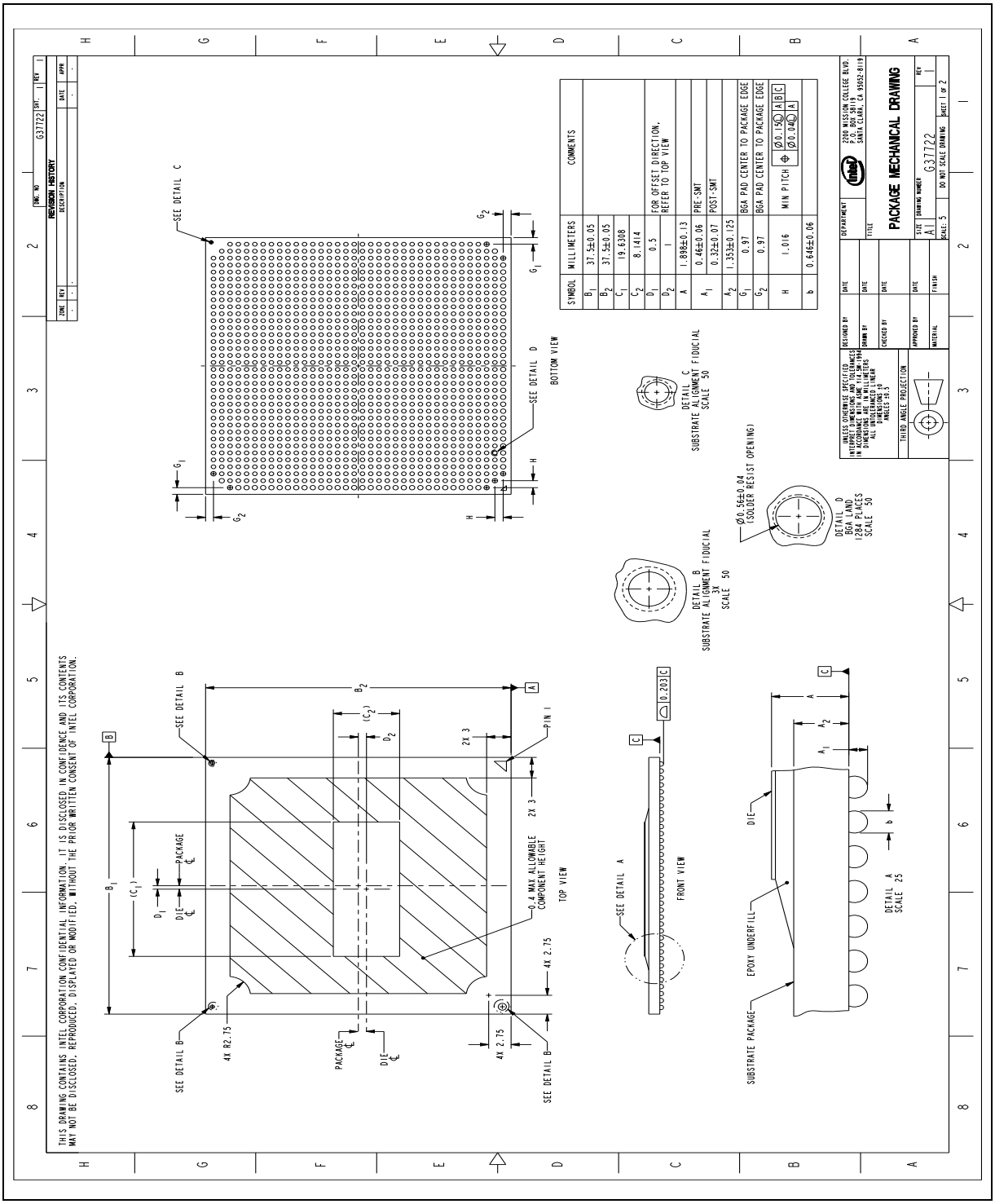
| W | Y | AA | AB | AC | AD | AE | AF | AG | AH | AJ | AK | AL | AM | AN | AP | AR | AT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VSS | VSS | VSS | VSS | VCCIO | VSS | VDDQ | SM_DRAMPWROK | SB_MA[7] | SB_MA[4] | SB_MA[5] | SA_MA[11] | SA_MA[8] | SA_MA[9] | SA_MA[7] | SA_MA[15] | SB_MA[9] | SB_MA[12] | 19 |
| VCC | VCC | VCC | VCCIO | VCCIO | VSS | VDDQ | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | 20 |
| VCC | VCC | VCC | VCCIO | VCCIO | VDDQ | VDDQ | SA_MA[4] | SB_CK[3] | SB_CK[0] | SB_CK[1] | SB_CK#[1] | VSS | SA_MA[1] | SA_CK[1] | SA_MA[6] | SA_MA[5] | SB_MA[3] | 21 |
| VSS | VSS | VSS | VSS | VCCIO | VSS | VDDQ | SA_MA[2] | SB_CK#[3] | SB_CK#[0] | SB_CK#[2] | SB_CK[2] | SA_CK#[0] | SA_CK[0] | SA_CK#[1] | SA_MA[3] | SB_MA[1] | SB_MA[2] | 22 |
| VCC | VCC | VCC | VCCIO | VCCIO | VSS | VDDQ | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | 23 |
| VCC | VCC | VCC | VCCIO | VCCIO | VSS | VDDQ | VDDQ | SB_WE# | SB_MA[10] | SB_BS[1] | SA_WE# | SA_CK[3] | SA_CK#[3] | SA_CK[2] | SA_CK#[2] | SB_MA[0] | SM_RCOMP[1] | 24 |
| VSS | VSS | VSS | VSS | VCCIO | VDDQ | VDDQ | VSS | SB_CS#[0] | SB_RAS# | SB_BS[0] | SA_CS#[0] | SA_MA[10] | SA_BS[1] | SA_MA[0] | VSS | VSS | VDDQ | 25 |
| VCC | VCC | VCC | VCCIO | VCCIO | VSS | VDDQ | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | VSS | VDDQ | 26 |
| VCCIO | VCCIO | VSS | VCCIO | VCCIO | VSS | VDDQ | VSS | SB_ODT[1] | SB_CS#[1] | SB_ODT[0] | SA_CS#[3] | SA_ODT[0] | SA_ODT[2] | SA_CAS# | SA_RAS# | SA_BS[0] | SB_CS#[2] | 27 |
| VSS | VSS | VCCIO | VCCIO | VCCIO | VCCIO_SENSE | VDDQ | VSS | SB_ODT[3] | SB_CS#[3] | SB_MA[13] | SA_ODT[3] | SA_ODT[1] | SA_MA[13] | SA_CS#[1] | SA_CS#[2] | SB_ODT[2] | SB_CAS# | 28 |
| VCCIO | VCCIO | VCCIO | VCCIO | VCCIO | VSS_SENSE_VCCIO | VSS | VSS | VSS | VSS | VSS | VSS | VSS | VDDQ | VSS | VDDQ | VSS | SM_RCOMP[0] | 29 |
| VCCIO | VCCIO | VCCIO | VCCIO | VCCIO | VSS | VSS | SA_DQ[34] | SA_DQ[38] | SA_DQS#[4] | SA_DQ[33] | SA_DQ[32] | VSS | VSS | VSS | VSS | RSVD_3 | SM_RCOMP[2] | 30 |
| VSS | VSS | VSS | VSS | VSS | SB_DQ[60] | VSS | SA_DQ[35] | SA_DQ[39] | SA_DQS[4] | SA_DQ[37] | SA_DQ[36] | VSS | SB_DQS#[4] | SB_DQ[36] | SB_DQ[32] | SB_DQ[33] | SB_DQ[37] | 31 |
| SA_DQS#[6] | VSS | SA_DQS[5] | SA_DQS#[5] | VSS | SB_DQS[7] | SB_DQS#[7] | VSS | VSS | VSS | VSS | VSS | VSS | SB_DQS[4] | SB_DQ[35] | SB_DQ[34] | SB_DQ[38] | SB_DQ[39] | 32 |
| SA_DQ[52] | VSS | SA_DQ[43] | SA_DQ[44] | VSS | SB_DQ[59] | SB_DQ[61] | VSS | SB_DQS[6] | SB_DQS#[6] | VSS | SB_DQ[43] | SB_DQ[46] | VSS | VSS | VSS | RSVD_2 | VSS | 33 |
| SA_DQ[53] | VSS | SA_DQ[42] | SA_DQ[45] | VSS | SB_DQ[58] | SB_DQ[56] | VSS | SB_DQ[50] | SB_DQ[53] | VSS | SB_DQ[42] | SB_DQ[45] | VSS | SB_DQ[44] | VSS | VSS | VSS | 34 |
| SA_DQ[49] | VSS | SA_DQ[46] | SA_DQ[41] | VSS | SB_DQ[62] | SB_DQ[57] | VSS | SB_DQ[55] | SB_DQ[48] | VSS | SB_DQ[47] | SB_DQ[41] | VSS | SB_DQ[40] | VSS | VSS | | 35 |
| SA_DQ[48] | VSS | SA_DQ[47] | SA_DQ[40] | VSS | SB_DQ[63] | VSS | SB_DQ[51] | SB_DQ[54] | SB_DQ[49] | SB_DQ[52] | VSS | SB_DQS[5] | SB_DQS#[5] | VSS | VSS | | | 36 |

## 10.2 Package Mechanical Information

The following section contains the mechanical drawings for the processor. The processor utilizes a 37.5 x 37.5 mm, FC-BGA package.

Figure 10-5 shows the die size and other mechanical details related to this processor.

## Figure 10-5. Processor Mechanical Package




§ §

# 11.0 Processor Configuration Registers

This section contains register information that is specific to the this processor. For other register details see the *Mobile 3rd Generation Intel® Core™ Processor Family, Intel® Pentium® Processor Family, and Intel® Celeron® Processor Family Datasheet, Volume 2 of 2*

*Note:* The processor does not include the Integrated Display Engine or the Graphics Processor Unit (GPU). Disregard references to graphics and Intel® Turbo Boost in the *Mobile 3rd Generation Intel® Core™ Processor Family, Intel® Pentium® Processor Family, and Intel® Celeron® Processor Family Datasheet*

Table 11-1 lists the register-related terminology and access attributes that are used in this chapter. Table 11-2 provides the attribute modifiers.

**Table 11-1. Register Terminology**

| Item | Description |
|---|---|
| RO | Read Only: These bits can only be read by software, writes have no effect. The value of the bits is determined by the hardware only. |
| RW | Read/Write: These bits can be read and written by software. |
| RW1C | Read / Write 1 to Clear: These bits can be read and cleared by software. Writing a '1' to a bit will clear it, while writing a '0' to a bit has no effect. Hardware sets these bits. |
| RW0C | Read/Write 0 to Clear: These bits can be read and cleared by software. Writing a '0' to a bit will clear it, while writing a '1' to a bit has no effect. Hardware sets these bits. |
| RW1S | Read / Write 1 to Set: These bits can be read and set by software. Writing a '1' to a bit will set it, while writing a '0' to a bit has no effect. Hardware clears these bits. |
| RsvdP | Reserved and Preserved: These bits are reserved for future RW implementations and their value must not be modified by software. When writing to these bits, software must preserve the value read. When SW updates a register that has RsvdP fields, it must read the register value first so that the appropriate merge between the RsvdP and updated fields will occur. |
| RsvdZ | Reserved and Zero: These bits are reserved for future RW1C implementations. SW must use 0 for writes. |
| WO | Write Only: These bits can only be written by software, reads return zero.<br>NOTE: Use of this attribute type is deprecated and can only be used to describe bits without persistent state. |
| RC | Read Clear: These bits can only be read by software, but a read causes the bits to be cleared. Hardware sets these bits.<br>NOTE: Use of this attribute type is only allowed on legacy functions, as side-effects on reads are not desirable |
| RSW1C | Read Set / Write 1 to Clear: These bits can be read and cleared by software. Reading a bit will set the bit to '1'. Writing a '1' to a bit will clear it, while writing a '0' to a bit has no effect. |
| RCW | Read Clear / Write: These bits can be read and written by software, but a read causes the bits to be cleared.<br>NOTE: Use of this attribute type is only allowed on legacy functions, as side-effects on reads are not desirable. |

Table 11-2 lists the modifiers used in conjunction with attributes that are included in the register tables throughout this chapter.

### Table 11-2. Register Terminology Attribute Modifiers

| Attribute Modifier | Applicable Attribute | Description |
|---|---|---|
| S | RO (w/ -V) | **Sticky**: These bits are only re-initialized to their Reset Value by a "Power Good Reset".<br>***Note:*** Does not apply to RO (constant) bits. |
| | RW | |
| | RW1C | |
| | RW1S | |
| -K | RW | **Key:** These bits control the ability to write other bits (identified with a 'Lock' modifier) |
| -L | RW | **Lock:** Hardware can make these bits "Read Only" using a separate configuration bit or other logic.<br>Mutually exclusive with 'Once' modifier. |
| | WO | |
| -O | RW | **Once:** After reset, these bits can only be written by software once, after which they become "Read Only".<br>Mutually exclusive with 'Lock' modifier and does not make sense with 'Variant' modifier. |
| | WO | |
| -FW | RO | **Firmware Write:** The value of these bits can be updated by firmware (PCU, TAP, and so on). |
| -V | RO | **Variant:** The value of these bits can be updated by hardware.<br>***Note:*** RW1C and RC bits are variant by definition and therefore do not need to be modified. |

## 11.1 ERRSTS - Error Status

This register is used to report various error conditions via the SERR DMI messaging mechanism. The SERR DMI message is generated on a zero to one transition of any of these flags (if enabled by the ERRCMD and PCICMD registers).

These bits are set regardless of whether or not the SERR is enabled and generated. After the error processing is complete, the error logging mechanism can be unlocked by clearing the appropriate status bit by software writing a '1' to it.

**Table 11-3. Error Status Register**

| | | | | |
|---|---|---|---|---|
| 15:2 | RO | 0h | | **Reserved (RSVD)** |
| 1 | RW1CS | 0b | Powergood | **Multiple-bit DRAM ECC Error Flag (DMERR)**<br>If this bit is set to 1, a memory read data transfer had an uncorrectable multiple-bit error. When this bit is set, the column, row, bank, and rank that caused the error, and the error syndrome, are logged in the ECC Error Log register in the channel where the error occurred. Once this bit is set, the ECCERRLOGx fields are locked until the processor clears this bit by writing a 1. Software uses bits [1:0] to detect whether the logged error address is for a Single-bit or a Multiple-bit error.<br>This bit is reset on PWROK. |
| 0 | RW1CS | 0b | Powergood | **Single-bit DRAM ECC Error Flag (DSERR)**<br>If this bit is set to 1, a memory read data transfer had a single-bit correctable error and the corrected data was returned to the requesting agent. When this bit is set the column, row, bank, and rank where the error occurred and the syndrome of the error are logged in the ECC Error Log register in the channel where the error occurred. Once this bit is set the ECCERRLOGx fields are locked to further single-bit error updates until the processor clears this bit by writing a 1. A multiple bit error that occurs after this bit is set will overwrite the ECCERRLOGx fields with the multiple-bit error signature and the DMERR bit will also be set. A single bit error that occurs after a multibit error will set this bit but will not overwrite the other fields.<br>This bit is reset on PWROK. |

## 11.2 ERRCMD - Error Command

This register controls the Host Bridge responses to various system errors. Since the Host Bridge does not have an SERR# signal, SERR messages are passed from the Processor to the PCH over DMI.

When a bit in this register is set, a SERR message will be generated on DMI whenever the corresponding flag is set in the ERRSTS register. The actual generation of the SERR message is globally enabled for Device 0 via the PCI Command register.

**Table 11-4. Error Command Registers**

| | | | | |
|---|---|---|---|---|
| 15:2 | RO | 0h | | **Reserved (RSVD)** |
| 1 | RW | 0b | Uncore | **SERR Multiple-Bit DRAM ECC Error (DMERR)**<br>1 = The Host Bridge generates an SERR message over DMI when it detects a multiple-bit error reported by the DRAM controller.<br>0 = Reporting of this condition using SERR messaging is disabled.<br>For systems not supporting ECC, this bit must be disabled. |
| 0 | RW | 0b | Uncore | **SERR on Single-bit ECC Error (DSERR)**<br>1 = The Host Bridge generates an SERR special cycle over DMI when the DRAM controller detects a single bit error.<br>0 = Reporting of this condition using SERR messaging is disabled.<br>For systems that do not support ECC, this bit must be disabled. |

## 11.3 SMICMD - SMI Command

This register enables various errors to generate an SMI DMI special cycle. When an error flag is set in the ERRSTS register, it can generate an SERR, SMI, or SCI DMI special cycle when enabled in the ERRCMD, SMICMD, or SCICMD registers, respectively.

*Note:* Only one message type can be enabled.

**Table 11-5. SMI Command Registers**

| | | | | |
|---|---|---|---|---|
| 15:2 | RO | 0h | | **Reserved (RSVD)** |
| 1 | RW | 0b | Uncore | **SMI on Multiple-Bit DRAM ECC Error (DMESMI)**<br>1 = The Host generates an SMI DMI message when it detects a multiple-bit error reported by the DRAM controller.<br>0 = Reporting of this condition using SMI messaging is disabled.<br>For systems not supporting ECC, this bit must be disabled. |
| 0 | RW | 0b | Uncore | **SMI on Single-bit ECC Error (DSESMI)**<br>1 = The Host generates an SMI DMI special cycle when the DRAM controller detects a single bit error.<br>0 = Reporting of this condition using SMI messaging is disabled.<br>For systems that do not support ECC, this bit must be disabled. |

## 11.4 SCICMD - SCI Command

This register enables various errors to generate an SMI DMI special cycle. When an error flag is set in the ERRSTS register, it can generate an SERR, SMI, or SCI DMI special cycle when enabled in the ERRCMD, SMICMD, or SCICMD registers, respectively.

*Note:* Only one message type can be enabled.

**Table 11-6. SCI Command Registers**

| | | | | |
|---|---|---|---|---|
| 15:2 | RO | 0h | | **Reserved (RSVD)** |
| 1 | RW | 0b | Uncore | **SCI on Multiple-Bit DRAM ECC Error (DMESCI)**<br>1 = The Host generates an SCI DMI message when it detects a multiple-bit error reported by the DRAM controller.<br>0 = Reporting of this condition using SCI messaging is disabled.<br>For systems not supporting ECC, this bit must be disabled. |
| 0 | RW | 0b | Uncore | **SCI on Single-bit ECC Error (DSESCI)**<br>1 = The Host generates an SCI DMI special cycle when the DRAM controller detects a single bit error.<br>0 = Reporting of this condition using SCI messaging is disabled.<br>For systems that do not support ECC, this bit must be disabled. |

## 11.5 ECCERRLOG0_C0 - ECC Error Log 0

This Channel 0 register is used to store the error status information in ECC enabled configurations, along with the error syndrome and the rank and bank address information of the address block of main memory of which an error (single bit or multi-bit error) has occurred. The address fields represent the address of the first single or the first multiple bit error occurrence after the error flag bits in the ERRSTS register have been cleared by software. A multiple bit error will overwrite a single bit error. Once the error flag bits are set as a result of an error, this bit field is locked and doesn't change as a result of a new error until the error flag is cleared by software. Same is the case with error syndrome field.

### Table 11-7. Channel 0 ECC Error Log 0

| | | | | |
|---|---|---|---|---|
| 31:29 | ROS-V | 000b | Powergood | **Error Bank (ERRBANK)**<br>This field holds the Bank Address of the read transaction that had the ECC error. |
| 28:27 | ROS-V | 00b | Powergood | **Error Rank (ERRRANK)**<br>This field holds the Rank ID of the read transaction that had the ECC error. |
| 26:24 | ROS-V | 000b | Powergood | **Error Chunk (ERRCHUNK)**<br>Holds the chunk number of the error stored in the register. |
| 23:16 | ROS-V | 00h | Powergood | **Error Syndrome (ERRSYND)**<br>This field contains the error syndrome. A value of FFh indicates that the error is due to poisoning.<br>**Note:** For ERRSYND definition see Table 11-13, "Error Syndrome - ERRSYND" |
| 15:2 | RO | 0h | | **Reserved (RSVD)** |
| 1 | ROS-V | 0b | Powergood | **Uncorrectable Error Status (MERRSTS)**<br>This bit is set when an uncorrectable multiple-bit error occurs on a memory read data transfer. When this bit is set, the address that caused the error and the error syndrome are also logged and they are locked until this bit is cleared.<br>This bit is cleared when the corresponding bit in 0.0.0.PCI.ERRSTS is cleared. |
| 0 | ROS-V | 0b | Powergood | **Correctable Error Status (CERRSTS)**<br>This bit is set when a correctable single-bit error occurs on a memory read data transfer. When this bit is set, the address that caused the error and the error syndrome are also logged and they are locked to further single bit errors, until this bit is cleared.<br>A multiple bit error that occurs after this bit is set will override the address/error syndrome information.<br>This bit is cleared when the corresponding bit in 0.0.0.PCI.ERRSTS is cleared. |

## 11.6 ECCERRLOG1_C0 - ECC Error Log 1

This register is used to store the error status information in ECC enabled configurations, along with the error syndrome and the row and column address information of the address block of main memory of which an error (single bit or multi-bit error) has occurred.

**Table 11-8. Channel 0 ECC Error Log 1**

| | | | | |
|---|---|---|---|---|
| 31:16 | ROS-V | 0000h | Powergood | **Error Column (ERRCOL)**<br>This field holds the DRAM column address of the read transaction that had the ECC error. |
| 15:0 | ROS-V | 0000h | Powergood | **Error Row (ERRROW)**<br>This field holds the DRAM row (page) address of the read transaction that had the ECC error. |

## 11.7 ECCERRLOG0_C1 - ECC Error Log 0

This Channel 1 register is used to store the error status information in ECC enabled configurations, along with the error syndrome and the rank and bank address information of the address block of main memory of which an error (single bit or multi-bit error) has occurred. The address fields represent the address of the first single or the first multiple bit error occurrence after the error flag bits in the ERRSTS register have been cleared by software. A multiple bit error will overwrite a single bit error. Once the error flag bits are set as a result of an error, this bit field is locked and doesn't change as a result of a new error until the error flag is cleared by software. Same is the case with error syndrome field.

**Table 11-9. Channel 1 ECC Error Log 0**

| | | | | |
|---|---|---|---|---|
| 31:29 | ROS-V | 000b | Powergood | **Error Bank (ERRBANK)**<br>This field holds the Bank Address of the read transaction that had the ECC error. |
| 28:27 | ROS-V | 00b | Powergood | **Error Rank (ERRRANK)**<br>This field holds the Rank ID of the read transaction that had the ECC error. |
| 26:24 | ROS-V | 000b | Powergood | **Error Chunk (ERRCHUNK)**<br>Holds the chunk number of the error stored in the register. |
| 23:16 | ROS-V | 00h | Powergood | **Error Syndrome (ERRSYND)**<br>This field contains the error syndrome. A value of FFh indicates that the error is due to poisoning.<br>For ERRSYND definition see Table 11-13, "Error Syndrome - ERRSYND" |

| | | | | |
|---|---|---|---|---|
| 15:2 | RO | 0h | | **Reserved (RSVD)** |
| 1 | ROS-V | 0b | Powergood | **Uncorrectable Error Status (MERRSTS)**<br>This bit is set when an uncorrectable multiple-bit error occurs on a memory read data transfer. When this bit is set, the address that caused the error and the error syndrome are also logged and they are locked until this bit is cleared.<br>This bit is cleared when the corresponding bit in 0.0.0.PCI.ERRSTS is cleared. |
| 0 | ROS-V | 0b | Powergood | **Correctable Error Status (CERRSTS)**<br>This bit is set when a correctable single-bit error occurs on a memory read data transfer. When this bit is set, the address that caused the error and the error syndrome are also logged and they are locked to further single bit errors, until this bit is cleared.<br>A multiple bit error that occurs after this bit is set will override the address/error syndrome information.<br>This bit is cleared when the corresponding bit in 0.0.0.PCI.ERRSTS is cleared. |

## 11.8 ECCERRLOG1_C1 - ECC Error Log 1

This register is used to store the error status information in ECC enabled configurations, along with the error syndrome and the row and column address information of the address block of main memory of which an error (single bit or multi-bit error) has occurred.

**Table 11-10. Channel 1 ECC Error Log 1**

| | | | | |
|---|---|---|---|---|
| 31:16 | ROS-V | 0000h | Powergood | **Error Column (ERRCOL)**<br>This field holds the DRAM column address of the read transaction that had the ECC error. |
| 15:0 | ROS-V | 0000h | Powergood | **Error Row (ERRROW)**<br>This field holds the DRAM row (page) address of the read transaction that had the ECC error. |

## 11.9 MAD_DIMM_CH0 - Address Decode Channel 0

This register defines channel characteristics - number of DIMMs, number of ranks, size, ECC, interleave options and ECC options.

**Table 11-11. Address Decode Channel 0**

**B/D/F/Type:** 0/0/0/MCHBAR_MCMAIN
**Address Offset:** 5004–5007h
**Reset Value:** 00600000h
**Access:** RW-L
**Size:** 32 bits
**BIOS Optimal Default** 00h

| Bit | Access | Reset Value | RST/ PWR | Description |
|---|---|---|---|---|
| 31:26 | RO | 0h | | **Reserved (RSVD)** |
| 23 | RO | 0h | | **Reserved (RSVD)** |
| 22 | RW-L | 1b | Uncore | **Enhanced Interleave mode (Enh_Interleave)**<br>0 = off<br>1 = on |

| | |
|---|---|
| **B/D/F/Type:** | **0/0/0/MCHBAR_MCMAIN** |
| **Address Offset:** | **5004–5007h** |
| **Reset Value:** | **00600000h** |
| **Access:** | **RW-L** |
| **Size:** | **32 bits** |
| **BIOS Optimal Default** | **00h** |

| Bit | Access | Reset Value | RST/ PWR | Description |
|---|---|---|---|---|
| 21 | RW-L | 1b | Uncore | **Rank Interleave (RI)**<br>0 = off<br>1 = on |
| 20 | RW-L | 0b | Uncore | **DIMM B DDR width (DBW)**<br>0 = X8 chips<br>1 = X16 chips |
| 19 | RW-L | 0b | Uncore | **DIMM A DDR width (DAW)**<br>0 = X8 chips<br>1 = X16 chips |
| 18 | RW-L | 0b | Uncore | **DIMM B number of ranks (DBNOR)**<br>0 = single rank<br>1 = dual rank |
| 17 | RW-L | 0b | Uncore | **DIMM A number of ranks (DANOR)**<br>0 = single rank<br>1 = dual rank |
| 16 | RW-L | 0b | Uncore | **DIMM A select (DAS)**<br>Selects which of the DIMMs is DIMM A – should be the larger DIMM:<br>0 = DIMM 0<br>1 = DIMM 1 |
| 15:8 | RW-L | 00h | Uncore | **Size of DIMM B (DIMM_B_Size)**<br>Size of DIMM B in 256 MB multiples |
| 7:0 | RW-L | 00h | Uncore | **Size of DIMM A (DIMM_A_Size)**<br>Size of DIMM A in 256 MB multiples |

## 11.10 MAD_DIMM_CH1 - Address Decode Channel 1

This register defines channel characteristics - number of DIMMs, number of ranks, size, ECC, interleave options and ECC options.

**Table 11-12. Address Decode Channel 1**

| | |
|---|---|
| **B/D/F/Type:** | **0/0/0/MCHBAR_MCMAIN** |
| **Address Offset:** | **5008–500Bh** |
| **Reset Value:** | **00600000h** |
| **Access:** | **RW-L** |
| **Size:** | **32 bits** |
| **BIOS Optimal Default** | **00h** |

| Bit | Access | Reset Value | RST/ PWR | Description |
|---|---|---|---|---|
| 31:26 | RO | 0h | | **Reserved (RSVD)** |
| 23 | RO | 0h | | **Reserved (RSVD)** |
| 22 | RW-L | 1b | Uncore | **Enhanced Interleave mode (Enh_Interleave)**<br>0 = off<br>1 = on |
| 21 | RW-L | 1b | Uncore | **Rank Interleave (RI)**<br>0 = off<br>1 = on |
| 20 | RW-L | 0b | Uncore | **DIMM B DDR width (DBW)**<br>0 = X8 chips<br>1 = X16 chips |
| 19 | RW-L | 0b | Uncore | **DIMM A DDR width (DAW)**<br>0 = X8 chips<br>1 = X16 chips |
| 18 | RW-L | 0b | Uncore | **DIMM B number of ranks (DBNOR)**<br>0 = single rank<br>1 = dual rank |
| 17 | RW-L | 0b | Uncore | **DIMM A number of ranks (DANOR)**<br>0 = single rank<br>1 = dual rank |
| 16 | RW-L | 0b | Uncore | **DIMM A select (DAS)**<br>Selects which of the DIMMs is DIMM A – should be the larger DIMM.<br>0 = DIMM 0<br>1 = DIMM 1 |
| 15:8 | RW-L | 00h | Uncore | **Size of DIMM B (DIMM_B_Size)**<br>Size of DIMM B in 256 MB multiples |
| 7:0 | RW-L | 00h | Uncore | **Size of DIMM A (DIMM_A_Size)**<br>Size of DIMM A in 256 MB multiples |

*Note:* This document supplements or overrides the *Mobile 3rd Generation Intel® Core™ Processor Family, Intel® Pentium® Processor Family, and Intel® Celeron® Processor Family Datasheet, Volume* . For additional information, see the *Mobile 3rd Generation Intel® Core™ Processor Family, Intel® Pentium® Processor Family, and Intel® Celeron® Processor Family Datasheet, Volume 2*.

## 11.11 Error Detection and Correction

If ECC is enabled and DIMMS with ECC are used, through an Error Correction Code algorithm the memory controller is able to detect and correct single bit errors or detect multiple bit errors. ECC increases the reliability of the DRAM devices by allowing single bit errors to be fixed and detecting multi-bit errors but it requires additional bits to

store the error correction code. The ECC algorithm requires an 8-bit error correction code. DIMMs with ECC are 72 bits wide, the first 64 bits are for data and the last 8 bits are for the Check Bits.

Detection of correctable or uncorrectable errors are reported in the "ERRSTS - Error Status" register. When either Single-bit correctable or Multi-bit uncorrectable errors are detected, the column, row, bank, and rank that caused the error, and the error syndrome, are logged in the ECC Error Log registers in the channel where the error occurred. Channel 0 and Channel 1 errors are detailed in Section 11.5, "ECCERRLOG0_C0 - ECC Error Log 0", Section 11.6, "ECCERRLOG1_C0 - ECC Error Log 1", Section 11.7, "ECCERRLOG0_C1 - ECC Error Log 0" and Section 11.8, "ECCERRLOG1_C1 - ECC Error Log 1" respectively. If an uncorrectable error occurs after a correctable error, then the address and syndrome information will be replaced with the uncorrectable error information.

During the write cycle, ECC check bits are generated 1 per 8 bits of data by XORing a particular combination of the written bits with an associated Check Bit. The result of this function creates a syndrome byte that is visible via "Error Syndrome (ERRSYND)", ("ECCERRLOG0_C0 - ECC Error Log 0" or "ECCERRLOG0_C1 - ECC Error Log 0").

Table 11-13 provides a lookup of the ERRSYND and defines the failing data bit.

**Table 11-13. Error Syndrome - ERRSYND (Sheet 1 of 3)**

| Syndrome (ERRSYND) | Bit Locator | DQ/CB Locator |
|---|---|---|
| 0x00 | No Error | |
| 0x01 | 64 | CB0 |
| 0x02 | 65 | CB1 |
| 0x04 | 66 | CB2 |
| 0x07 | 60 | DQ60 |
| 0x08 | 67 | CB3 |
| 0x0B | 36 | DQ36 |
| 0x0D | 27 | DQ27 |
| 0x0E | 3 | DQ3 |
| 0x10 | 68 | CB4 |
| 0x13 | 55 | DQ55 |
| 0x15 | 10 | DQ10 |
| 0x16 | 29 | DQ29 |
| 0x19 | 45 | DQ45 |
| 0x1A | 57 | DQ57 |
| 0x1C | 0 | DQ0 |
| 0x1F | 15 | DQ15 |
| 0x20 | 69 | CB5 |
| 0x23 | 39 | DQ39 |
| 0x25 | 26 | DQ26 |
| 0x26 | 46 | DQ46 |
| 0x29 | 61 | DQ61 |
| 0x2A | 9 | DQ9 |
| 0x2C | 16 | DQ16 |

## Table 11-13. Error Syndrome - ERRSYND (Sheet 2 of 3)

| Syndrome (ERRSYND) | Bit Locator | DQ/CB Locator |
|---|---|---|
| 0x2F | 23 | DQ23 |
| 0x31 | 63 | DQ63 |
| 0x32 | 47 | DQ47 |
| 0x34 | 14 | DQ14 |
| 0x38 | 30 | DQ30 |
| 0x40 | 70 | CB6 |
| 0x43 | 6 | DQ6 |
| 0x45 | 42 | DQ42 |
| 0x46 | 62 | DQ62 |
| 0x49 | 12 | DQ12 |
| 0x4A | 25 | DQ25 |
| 0x4C | 32 | DQ32 |
| 0x4F | 51 | DQ51 |
| 0x51 | 2 | DQ2 |
| 0x52 | 18 | DQ18 |
| 0x54 | 34 | DQ34 |
| 0x58 | 50 | DQ50 |
| 0x61 | 21 | DQ21 |
| 0x62 | 38 | DQ38 |
| 0x64 | 54 | DQ54 |
| 0x68 | 5 | DQ5 |
| 0x70 | 52 | DQ52 |
| 0x80 | 71 | CB7 |
| 0x83 | 22 | DQ22 |
| 0x85 | 58 | DQ58 |
| 0x86 | 13 | DQ13 |
| 0x89 | 28 | DQ28 |
| 0x8A | 41 | DQ41 |
| 0x8C | 48 | DQ48 |
| 0x8F | 43 | DQ43 |
| 0x91 | 37 | DQ37 |
| 0x92 | 53 | DQ53 |
| 0x94 | 4 | DQ4 |
| 0x98 | 20 | DQ20 |
| 0xA1 | 49 | DQ49 |
| 0xA2 | 1 | DQ1 |
| 0xA4 | 17 | DQ17 |
| 0xA8 | 33 | DQ33 |
| 0xB0 | 44 | DQ44 |
| 0xC1 | 8 | DQ8 |

## Table 11-13. Error Syndrome - ERRSYND (Sheet 3 of 3)

| Syndrome (ERRSYND) | Bit Locator | DQ/CB Locator |
|---|---|---|
| 0xC2 | 24 | DQ24 |
| 0xC4 | 40 | DQ40 |
| 0xC8 | 56 | DQ56 |
| 0xD0 | 19 | DQ19 |
| 0xE0 | 11 | DQ11 |
| 0xF1 | 7 | DQ7 |
| 0xF2 | 31 | DQ31 |
| 0xF4 | 59 | DQ59 |
| 0xF8 | 35 | DQ35 |
| 0xFF | Error reported is due to poisoning | |
| All Other Values | Unrecoverable Multi-bit errors | |

§ §

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