

# Intel<sup>®</sup> Atom<sup>™</sup> Z8000 Processor Series

Datasheet (Volume 1 of 2)

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## Revision History

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| Document Number | Revision Number | Description  | Revision Date |
|-----------------|-----------------|--|---------------|
| 332065          | 001             | <ul style="list-style-type: none"><li>Initial release</li></ul>  | March 2015    |
| 332065          | 002             | <ul style="list-style-type: none"><li>Added<ul style="list-style-type: none"><li>Type3 SoC features and specifications included</li></ul></li><li>Updated<ul style="list-style-type: none"><li>Section 2.24, "Hardware Straps" strap pins updated.</li><li>Max. Imaging video resolution updated for T4 to 1080p30.</li><li>Table 124 VID values for all SKU's to match PRQ values.</li><li>Section 12.1, "SoC Storage Overview"</li></ul></li></ul> | June 2015     |
| 332065          | 003             | <ul style="list-style-type: none"><li>Added<ul style="list-style-type: none"><li>Intel® Atom™ processor X5-Z8350, Z8550, and Z8750.</li></ul></li><li>Updated Table 3, updated Table 124</li></ul>   | March 2016    |

§ §



# 1 Introduction

The **Intel® Atom™ Z8000 Processor Series Datasheet** is the Intel Architecture (IA) SoC that integrates the next generation Intel® processor core, Graphics, Memory Controller, and I/O interfaces into a single system-on-chip solution.

The figures below shows the system level block diagram of the SoC. Refer the subsequent chapters for detailed information on the functionality of the different interface blocks.

**Note:** Throughout this document Intel® Atom™ Z8000 Processor Series is referred as SoC.

[Section 1.3](#) lists the different features supported by the SoC packages.

## 1.1 References

Refer the following documents, which may be beneficial when reading this document or for additional information:

| Document   | Document Number   |
|--|---|
| 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 | <a href="http://www.intel.com/products/processor/manuals/index.htm">http://www.intel.com/products/processor/manuals/index.htm</a> |
| Intel® Atom™ Z8000 Processor Series Datasheet (Volume 2 of 2)  | 332066  |
| Intel® Atom™ Z8000 Processor Series Specification Update   | 332067  |

## 1.2 Terminology

| Term       | Description   |
|------------|---|
| ACPI       | Advanced Configuration and Power Interface  |
| Cold Reset | Full reset is when PWROK is de-asserted and all system rails except VCCRTC are powered down |
| DP         | Display Port  |
| DTS        | Digital Thermal Sensor  |
| EMI        | Electro Magnetic Interference   |
| eDP        | embedded Display Port   |



| Term       | Description   |
|------------|---|
| HDMI       | High Definition Multimedia Interface. HDMI supports standard, enhanced, or high-definition video, plus multi-channel digital audio on a single cable. HDMI transmits all Advanced Television Systems Committee (ATSC) HDTV standards and supports 8-channel digital audio, with bandwidth to spare for future requirements and enhancements (additional details available at <a href="http://www.hdmi.org/">http://www.hdmi.org/</a> ). |
| Intel® TXE | Intel® Trusted Execution Engine   |
| LPDDR      | Low Power Dual Data Rate memory technology.   |
| LPE        | Low Power Engine  |
| MIPI CSI   | MIPI Camera Interface Specification   |
| MIPI DSI   | MIPI Display Interface Specification  |
| MP         | Mega Pixel  |
| MPEG       | Moving Picture Experts Group  |
| MSI        | Message Signaled Interrupt. MSI is a transaction initiated outside the host, conveying interrupt information to the receiving agent through the same path that normally carries read and write commands.  |
| MSR        | Model Specific Register, as the name implies, is model-specific and may change from processor model number (n) to processor model number (n+1). An MSR is accessed by setting ECX to the register number and executing either the RDMSR or WRMSR instruction. The RDMSR instruction will place the 64 bits of the MSR in the EDX: EAX register pair. The WRMSR writes the contents of the EDX: EAX register pair into the MSR.          |
| PWM        | Pulse Width Modulation  |
| POSM       | Power on state machine  |
| Rank       | A unit of DRAM corresponding to the set of SDRAM devices that are accessed in parallel for a given transaction. For a 64-bit wide data bus using 8-bit (x8) wide SDRAM devices, a rank would be eight devices. Multiple ranks can be added to increase capacity without widening the data bus, at the cost of additional electrical loading.  |
| SCI        | System Control Interrupt. SCI is used in the ACPI protocol.   |
| SDRAM      | Synchronous Dynamic Random Access Memory  |
| SERR       | System Error. SERR is an indication that an unrecoverable error has occurred on an I/O bus.   |
| SMC        | System Management Controller or External Controller refers to a separate system management controller that handles reset sequences, sleep state transitions, and other system management tasks.   |
| SMI        | System Management Interrupt is used to indicate any of several system conditions (such as thermal sensor events, throttling activated, access to System Management RAM, chassis open, or other system state related activity).  |
| SIO        | Serial I/O  |
| TMDS       | Transition-Minimized Differential Signaling. TMDS is a serial signaling interface used in DVI and HDMI to send visual data to a display. TMDS is based on low-voltage differential signaling with 8/10b encoding for DC balancing.  |
| Warm Reset | Warm reset is when both PMC_PLTRST# and PMC_CORE_PWROK are asserted.  |





## 1.3 SoC Packages

**Table 1. SoC Packages (Sheet 1 of 2)**

| Interface          | Category                          | T4   | T3   |
|--------------------|-----------------------------------|--|--|
| CPU                | No. of Cores                      | 4  | 4  |
|                    | Burst Speed                       | 2.4 GHz  | 1.84 GHz <sup>[4]</sup>  |
| GPU                | Speed                             | Gen8-LP 12/16EU up to 600 MHz                                      | Gen8-LP 12EU up to 500 MHz   |
| Package Mechanical | Type                              | 17x17mm Type 4   | 17x17mm Type 3   |
|                    | IO count                          | 628  | 378  |
|                    | Ball count                        | 1380   | 592  |
|                    | ball pitch                        | 0.4mm  | 0.65mm   |
|                    | Z-height                          | 0.937mm  | 1.002mm  |
| Memory             | Interface, Max transfer data rate | Dual Channel 2x64 bit, LPDDR3 - 1600MT/S                           | Single Channel 1x32/64 DDR3L-RS - 1600MT/s                         |
|                    | Type                              | BGA  | BGA  |
|                    | Capacity                          | 2 - 8GB  | 1 - 2GB  |
| PCIe               | Number of ports                   | 2  | 1  |
|                    | Port Configuration                | 1x2, 2x1   | x1   |
| Imaging            | Number of lanes                   | 6  | 6  |
|                    | Lane configuration                | 4+2, 3+2, 2+2+2  | 4+2, 3+2, 2+2  |
|                    | Speed                             | 1.5 GHz  | 1.5 GHz  |
|                    | Still & Video                     | 13MP ZSL, 1080p30  | 8MP, 1080p30   |
| Media              | Media decode rate                 | H.263, MPEG4, H.264, H.265 (HEVC), VP8, VP9, MVC, MPEG2, VC1, JPEG | H.263, MPEG4, H.264, H.265 (HEVC), VP8, VP9, MVC, MPEG2, VC1, JPEG |
|                    | Media encode rate                 | H.264, H.263, VP8, MVC, JPEG                                       | H.264, H.263, VP8, MVC, JPEG                                       |
| Audio              | LPE (Low Power Engine)            | 3 I2S ports  | 3 I2S ports  |
| USB devices        | USB 3.0                           | 3  | Not Supported  |
|                    | USB 3.0 OTG                       | 1  | 1  |
|                    | USB 2.0                           | -  | 3  |
|                    | USB SSIC                          | 2  | Not Supported  |
|                    | USB HSIC                          | 2  | 2  |



**Table 1. SoC Packages (Sheet 2 of 2)**

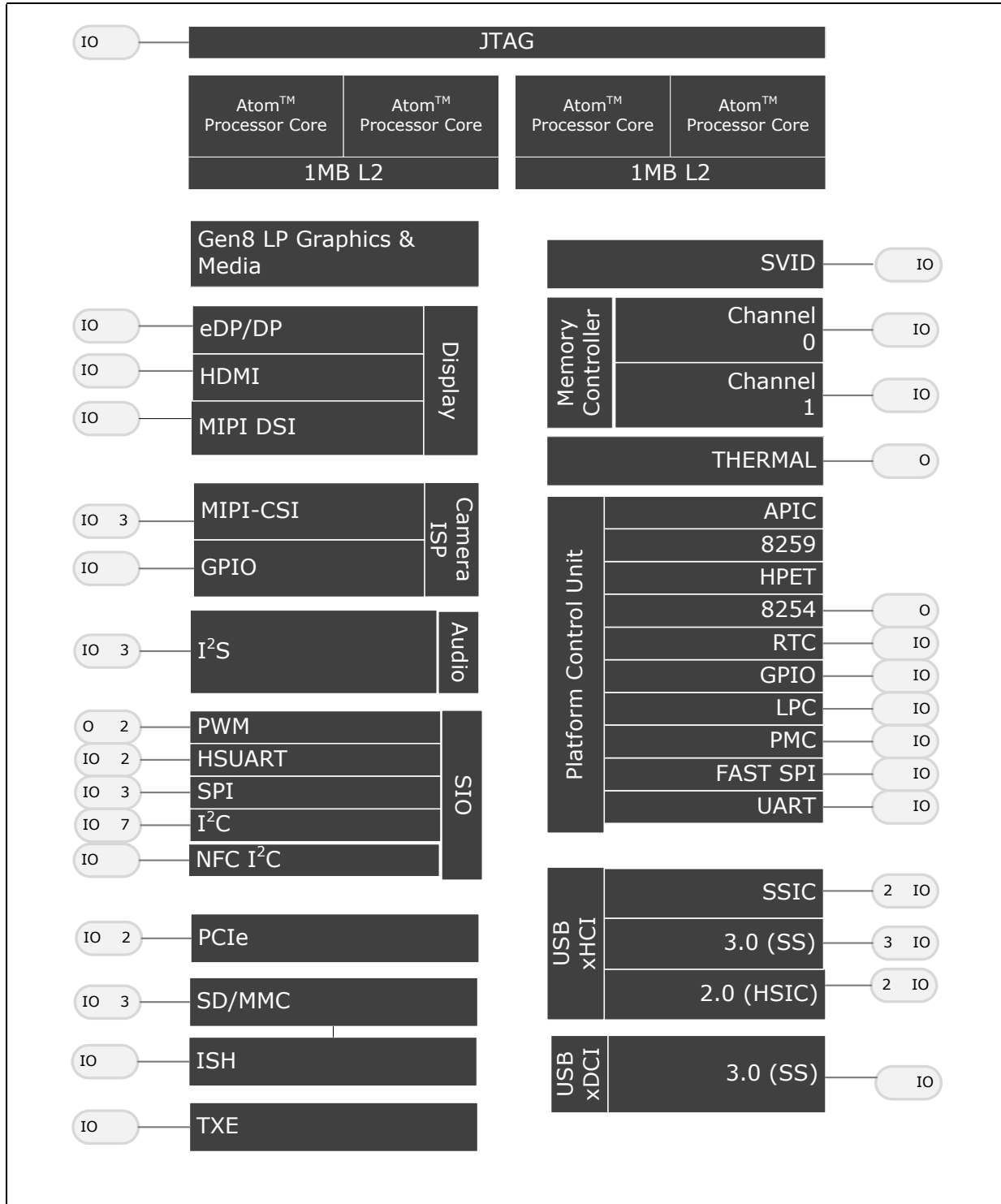
| Interface | Category                 | T4                       | T3                           |
|-----------|--------------------------|--------------------------|------------------------------|
| SIO       | LPC                      | YES                      | Not supported                |
|           | I2C                      | 7                        | 6                            |
|           | I2C Max Speed            | 1.7 MHz                  | 1.7 MHz                      |
|           | I2C NFC                  | 1                        | 1                            |
|           | I2C ISH                  | 1                        | 1                            |
|           | SPI                      | 3                        | Not supported <sup>[1]</sup> |
|           | SPI Speed                | Master Only up to 25 MHz | Master Only up to 25 MHz     |
|           | Fast SPI                 | Quad mode                | Dual mode                    |
| Storage   | SD Card                  | x1 SDR104                | x1 SDR104 <sup>[2]</sup>     |
|           | SDIO                     | x1 SDR104                | x1 SDR104                    |
|           | eMMC                     | 4.51                     | 4.51                         |
| Display   | DDI ports                | x3                       | x2                           |
|           | Max MIPI DSI Resolution  | 2560x1600 @60fps         | 1900x1200 @60fps             |
|           | MIPI-DSI ports           | 2x 4 Lanes @ 1Gbps       | 1x 4 Lanes @ 1Gbps           |
|           | Max eDP Resolution       | 2560x1600 @ 24bbp        | 1920x1080 @60fps             |
|           | eDP ports                | 2 (2x4 @2.7Gbps)         | 2 (2x4 @2.7Gbps)             |
|           | Max DP 1.1a Resolution   | 2560x1600 @60fps         | 2560x1600 @60fps             |
|           | Max HDMI 1.4b Resolution | 3840x2160 @30fps         | 1920x1080 @60fps             |

**NOTES:**

1. One SPI port is multiplexed with reference clock signal which is GPIO signal, and the usage will be dependent on the GPIO configurations on the platform.
2. Is limited to DDR50 due to PMIC power delivery limitation.
3. MPO available on Display Pipe B only.
4. The Burst Speed mentioned is for 2 Cores.This is PRE-SMT package height.



Figure 1. SoC Block Diagram





## 1.4 Feature Overview

### 1.4.1 Processor Core

- Up to four IA-compatible low power Intel® processor cores
  - One thread per core
- Two-wide instruction decode, out of order execution.
- On-die, 32 KB 8-way L1 instruction cache and 24 KB 6-way L1 data cache per core.
- On-die, 1 MB, 16-way L2 cache, shared per two cores.
- 36-bit physical address, 48-bit linear address size support.
- Supported C-states: C0, C1, C6C, C6, C7.
- Supports Intel® Virtualization Technology (Intel® VT-x2).

### 1.4.2 System Memory Controller

- Memory Controller supports dual-channel DDR3L-RS/LPDDR3.
- Up to two ranks per channel (4 ranks in total).
- 32 Bit or 64 Bit data bus.
- Supports DDR3L-RS/LPDDR3 with 1600 MT/s data rate.
- Supports x32 LPDDR3 DRAM device data widths.
- Supports x16 DDR3L-RS DRAM device data widths.
- Total memory bandwidth supported is 12.8GB/s (for 1600 MT/s single-channel) to 25.6GB/s (for 1600 MT/s dual-channel).
- Supports different physical mappings of bank addresses to optimize performance.
- Supports Dynamic Voltage and Frequency Scaling.
- Out-of-order request processing to increase performance.
- Aggressive power management to reduce power consumption.
- Proactive page closing policies to close unused pages.

### 1.4.3 Display Controller

- Supports up to 3 Display pipes.
- Supports 2 MIPI DSI ports.
- Supports 3 DDI ports to configure eDP 1.3/DP 1.1a/DVI/HDMI 1.4b.
- Supports 2 panel power sequence for 2 eDP ports.
- Supports Audio on DP/HDMI.
- Supports Intel® Display Power Saving Technology (DPST) 6.0, Panel Self Refresh (PSR) and Display Refresh Rate Switching Technology (DRRS).



#### 1.4.4 Graphics and Media Engine

- Intel's 8th generation (Gen 8) LP graphics and media encode/decode engine.
- Supports 3D rendering, media compositing and video encoding.
- Graphics Burst enabled through energy counters.
- Supports DX\*11.1, OpenGL 4.3, OGL ES 3.0, OpenCL 1.2.
- 4x anti-aliasing.
- Full HW acceleration for decode of H.263, MPEG4, H.264, H.265 (HEVC), VP8, VP9, MVC, MPEG2, VC1, JPEG.
- Full HW acceleration for encode of H.264, H.263, VP8, MVC, JPEG.
- Supports Content protection using PAVP2.0, HDCP 1.4 (wired)/2.2 (wireless) and Media Vault DRM.

#### 1.4.5 Image Signal Processor

- Supports up to three MIPI CSI ports.
- Supports up to 13MP sensors.

#### 1.4.6 Power Management

- Supports ACPI 5.0.
- Processor Core states: C0, C1, C1E, C6C, C6 and C7.
- Display and Graphics device states: D0, D3.
- System sleep states: S0, S0ix, S4, S5.
- Support CPU and GfX Burst for selected SKUs.
- Dynamic I/O power reductions (disabling sense amps on input buffers, tristating output buffers).
- Dynamic memory self-refresh.

#### 1.4.7 PCI Express\*

- Supports x2 PCIe 2.0 compliant controller.
- Supports both Gen1 and Gen2 data rates.
- The controller provides a max data payload of 128B with the capability of splitting the request at 64B granularity.
- Supports autonomous up-configuration and autonomous down-configuration as target.



## 1.4.8 USB Controller

### 1.4.8.1 USB xHCI Controller

USB Host Controller supports:

- Two (2) Super Speed Inter-Chip (SSIC) port.
- Three (3) Super Speed (SS) ports [Backward Compatible of USB 2.0 HS/FS/LS].
- Two (2) High Speed Inter-Chip (HSIC) ports.

**Note:** SoC can support the 4<sup>th</sup> SS port when OTG port is in Host mode.

### 1.4.8.2 USB xDCI Controller

The SoC implements OTG block for device-mode functionality:

- Supports one USB 3.0 Super Speed port with backward compatibility of USB 2.0 High Speed and Low/Full Speed.
- Supports SuperSpeed OTG v3.0 device.
- Supports USB3 Debug Device Class Specification [USB3-debug].

## 1.4.9 Low Power Engine (LPE) Audio Controller

- Support 3 I2S ports.
- I2S and DDI with dedicated DMA.
- Supports MP3, AAC, AC3/DD+, WMA9, PCM (WAV).
- Provides HW acceleration for common audio and voice functions such as codecs, acoustic echo cancellation, noise cancellation.

## 1.4.10 Storage

### 1.4.10.1 Storage Control Cluster (eMMC, SDIO, SD)

- Supports one eMMC 4.51 controller
  - 200 MB/s Data rate
- Supports one SDIO 3.0 interface
  - 800 Mb/s Data rate
- Supports one SDXC controller
  - 800 Mb/s Data rate

### 1.4.11 Intel® Trusted Execution Engine (Intel® TXE)

Intel TXE is responsible for supporting and handling security related features.

- Supports MediaVault with OMA-DRM and One Time Password.
- Isolated execution environment for crypto operations.
- Supports secure boot - with customer programmable keys to secure code.



### 1.4.12 Serial I/O (SIO)

- Controller for external devices via SPI, UART, I<sup>2</sup>C or PWM.
- Each port is multiplexed with general purpose I/O for configurations flexibility.
- Supports up to 7 I<sup>2</sup>C, NFC I<sup>2</sup>C, ISH I<sup>2</sup>C, 2 HSUART, 2 PWM, 3 SPI interface.

### 1.4.13 Platform Control Unit (PCU)

Platform controller unit is a collection of HW blocks, including UART, debug/boot SPI and Intel legacy block (iLB), that are critical to implement a Windows\* compatible platform. Some of its key features are:

- Universal Asynchronous Receiver/Transmitter (UART) with COM1 interface.
- A Fast Serial Peripheral Interface (SPI) for Flash only - stores boot FW and system configuration data.
- Intel Legacy Block (iLB) supports legacy PC platform features
  - RTC, Interrupts, Timers and Peripheral interface (LPC for TPM) blocks.

### 1.4.14 Intel<sup>®</sup> Sensor Hub

Intel<sup>®</sup> Sensor Hub Supports:

- Acquisition / sampling of sensor data.
- The ability to combine data from individual sensors to create a more complex Virtual sensor that can be directly used by the firmware/OS.
- Low power operation through clock gating and power gating of parts of the ISH together with the ability to turn sensors off.
- The ability to operate independently when the host platform is in low power state.

### 1.4.15 Package

This SoC is packaged in a Flip-Chip Ball Grid Array (FCBGA) package.

The following table summarizes the package attributes for different SoC SKUs.

**Table 2. Package Attributes**

|         | Category   | T4             | T3             |
|---------|------------|----------------|----------------|
| Package | Type       | 17x17mm Type 4 | 17x17mm Type 3 |
|         | IO count   | 628            | 378            |
|         | Ball count | 1380           | 592            |
|         | ball pitch | 0.4mm          | 0.65mm         |
|         | Z-height   | 0.937mm        | 1.002mm        |



### 1.4.16 SKU List

Table 3. SoC SKU List

| Processor Number | Stepping | Package Type | SDP(W) | Core LFM (MHz)/HFM (GHz) | Core max Burst (GHz) | Tjmax (°C) | TDP/SDP Tj(°C) | GFx Normal/Burst (MHz) | No. of Graphics EU | Memory Channel | Memory Speed (MT/s) |
|------------------|----------|--------------|--------|--------------------------|----------------------|------------|----------------|------------------------|--------------------|----------------|---------------------|
| Z8750            | D-1      | T4           | 2.0    | 480/1.6                  | 2.56                 | 90         | 70             | 400/600                | 16                 | 2x64           | LPDDR3-1600         |
| Z8550            | D-1      | T4           | 2.0    | 480/1.44                 | 2.4                  | 90         | 70             | 400/600                | 12                 | 2x64           | LPDDR3-1600         |
| Z8350            | D-1      | T3           | 2.0    | 480/1.44                 | 1.92                 | 90         | 70             | 400/500                | 12                 | 1x64           | DDR3L/LPDDR3-1600   |
| Z8700            | C-0      | T4           | 2.0    | 480/1.6                  | 2.4                  | 90         | 70             | 400/600                | 16                 | 2x64           | LPDDR3-1600         |
| Z8500            | C-0      | T4           | 2.0    | 480/1.44                 | 2.24                 | 90         | 70             | 400/600                | 12                 | 2x64           | LPDDR3-1600         |
| Z8300            | C-0      | T3           | 2.0    | 480/1.44                 | 1.84                 | 90         | 70             | 400/500                | 12                 | 1x32/64        | DDR3L-1600          |

|                             |  |
|-----------------------------|--|
| <b>Issue</b>                | XHCI controller stuck in reset during warm reboot cycles   |
| <b>Stepping</b>             | BXT Ax/Bx, APL Ax  |
| <b>Workaround</b>           | BIOS should program USB Host Controller Misc Reg 2 bit2 =1, set Bit5 for A0 stepping and clear for all other steppings |
| <b>Impact of Workaround</b> |  |
| <b>Notes</b>                | USB  |

| Pad Name           | GPIO#    | Net Name     |
|--------------------|----------|--------------|
| GP187_DDI0_DDC_SDA | GPIO_187 | HDMI_DDC_SDA |
| GP188_DDI0_DDC_SCL | GPIO_188 | HDMI_DDC_SCL |
| GP193_PNL0_VDDEN   | GPIO_193 | DISP0_VDDEN  |

§





## 2 Physical Interfaces

Many interfaces contain physical pins. These groups of pins make up the physical interfaces. Because of the large number of interfaces and the small size of the package, Some interfaces share their pins with GPIOs, while others use dedicated physical pins. This chapter summarizes the physical interfaces, including the diversity in GPIO multiplexing options.

### 2.1 Pin States

This section describes the states of each signal before, during and directly after reset. Additionally, Some signals have internal pull-up/pull-down termination resistors, and their values are also provided. All signals with the "" symbol are muxed and may not be available without configuration.

**Table 4. Platform Power Well Definitions**

| Power Type  | Voltage Range (V)               | Power Well Description                                       |
|-------------|---------------------------------|--|
| VCC0/1      | Refer <a href="#">Table 118</a> | Variable voltage rail for core                               |
| VGG         | Refer <a href="#">Table 118</a> | Variable voltage rail for Graphics Core                      |
| VNN         | Refer <a href="#">Table 118</a> | Variable voltage rail for SoC.                               |
| V1P15       | 1.15                            | Fixed voltage rail for SoC, Graphics, camera                 |
| V1P05A      | 1.05                            | Fixed voltage rail for P-unit, LPE, TXE,I/O's, PLL's and ISH |
| V1P2A       | 1.24                            | Fixed voltage rail for I/O's and PLL's.                      |
| VDDQ        | 1.24/1.35                       | Fixed voltage rail for DDR PHY                               |
| VDDQG       | 1.24/1.35                       | Fixed voltage rail for DDR PHY                               |
| V1P8A       | 1.8                             | Fixed voltage rail for I/O's.                                |
| V3P3A       | 3.3                             | Fixed voltage rail for I/O's.                                |
| V3P3A_V1P8A | 1.8/3.3                         | Fixed voltage rail for SDIO.                                 |
| V3P3RTC     | 3.3                             | Voltage rai For RTC clock.                                   |

**Table 5. Buffer Type Definitions (Sheet 1 of 2)**

| Buffer Type | Buffer Description   |
|-------------|--|
| MIPI-DPHY   | 1.24 V tolerant MIPI DPHY buffer type                            |
| USB3 PHY    | 1.0 V tolerant USB3 PHY buffer type                              |
| USB2 PHY    | 1.8 V tolerant USB3 PHY buffer type                              |
| SSIC PHY    | 1.2 V tolerant SSIC PHY buffer type                              |
| HSIC PHY    | 1.2 V tolerant HSIC PHY buffer type                              |
| GPIO        | GPIO buffer type. This can be of the following types: 1.8/3.3 V. |



**Table 5. Buffer Type Definitions (Sheet 2 of 2)**

| Buffer Type       | Buffer Description  |
|-------------------|---|
| MODPHY            | 1.0 V tolerant MODPHY buffer type   |
| DDR3              | 1.5 V tolerant DDR3 buffer type   |
| Analog            | Analog pins that do not have specific digital requirements. Often used for circuit calibration or monitoring. |
| GPIOMV, HS        | GPIO Buffer type, Medium Voltage(1.8V),High Speed (FMAX~208Mhz)   |
| GPIOMV, MS        | GPIO Buffer type, Medium Voltage(1.8V),Medium Speed (FMAX~60Mhz)  |
| GPIOMV, MS, CLK   | GPIO Buffer type, Medium Voltage(1.8V),Medium Speed (FMAX~60Mhz), Clock                                       |
| GPIOMV, HS, CLK   | GPIO Buffer type, Medium Voltage(1.8V),High Speed (FMAX~208Mhz), Clock  |
| GPIOMV, HS, RCOMP | GPIO Buffer type, Medium Voltage(1.8V),High Speed (FMAX~208Mhz), RCOMP  |
| GPIOMV, MS, I2C   | GPIO Buffer type, Medium Voltage(1.8V),Medium Speed (FMAX~60Mhz), I2C   |
| GPIOHV, HS        | GPIO Buffer type, High Voltage(1.8V/3.3V),High Speed (FMAX~208Mhz)  |
| GPIOHV, HS, RCOMP | GPIO Buffer type, High Voltage(1.8V/3.3V),High Speed (FMAX~208Mhz), RCOMP                                     |

**NOTE:** GPIO mode, where register controlled will not hit FMAX speeds. It only matters when functionally used.

**Table 6. Default Buffer State Definitions (Sheet 1 of 2)**

| Buffer State    | Description   |
|-----------------|---|
| Z               | The SoC places this output in a high-impedance state. For inputs, external drivers are not expected.  |
| Do Not Care     | The state of the input (driven or tristated) does not affect the processor. For outputs, it is assumed that the output buffer is in a high-impedance state. |
| V <sub>OH</sub> | The SoC drives this signal high with a termination of 50 Ω.   |
| V <sub>OL</sub> | The SoC drives this signal low with a termination of 50 Ω.  |
| Unknown         | The processor drives or expects an indeterminate value.   |
| V <sub>IH</sub> | The SoC expects/requires the signal to be driven high.  |
| V <sub>IL</sub> | The SoC expects/requires the signal to be driven low.   |
| "P" 1.1V        | USB low speed Single ended 1.   |
| Pull-up         | This signal is pulled high by a pull-up resistor (internal or external — internal value specified in "Term" column).  |
| Pull-down       | This signal is pulled low by a pull-down resistor (internal or external — internal value specified in "Term" column).                                       |
| Running         | The clock is toggling, or the signal is transitioning.  |
| Off             | The power plane for this signal is powered down. The processor does not drive outputs, and inputs should not be driven to the processor. (VSS on output)    |



Table 6. Default Buffer State Definitions (Sheet 2 of 2)

| Buffer State | Description   |
|--------------|---|
| 1            | Buffer drives V <sub>OH</sub>   |
| 0            | Buffer drives V <sub>OL</sub>   |
| H            | Buffer Hi Z, weak PU, default to 20K, unless explicitly specified otherwise |
| L            | Buffer Hi Z, weak PD, default to 20K, unless explicitly specified otherwise |
| Input H      | Input enable, weak PU   |
| Output L     | Output enable, weak PU  |
| Pgm          | Programmable  |
| Retain       | retain configuration/data prior to standby                                  |

## 2.2 System Memory Controller Interface Signals

### 2.2.1 DDR3L-RS

Table 7. DDR3L-RS System Memory Signals (Sheet 1 of 2)

| Signal Name       | Dir | Plat. Power | Type | Default Buffer State |                         |      |
|-------------------|-----|-------------|------|----------------------|-------------------------|------|
|                   |     |             |      | Pwrgood Assert State | Resetout Deassert State | S0ix |
| DDR3_M0_MA[15:0]  | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_CK[1,0]_P | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_CK[1,0]_N | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_CKE[3:0]  | O   | V1P35       | DDR  | Weak 0               | 0                       | 0    |
| DDR3_M0_CS[1,0]_N | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_CAS_N     | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_RAS_N     | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_WE_N      | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_BS[2:0]   | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_DRAMRST_N | O   | V1P35       | DDR  | Weak 0               | 0                       | 1    |
| DDR3_M0_ODT[1,0]  | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_DQ[63:0]  | I/O | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_DM[7:0]   | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_DQSP[7:0] | I/O | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_DQSN[7:0] | I/O | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_OCAVREF   | O   | V1P35       | DDR  | Z                    | Z                       | Z    |
| DDR3_M0_ODQVREF   | O   | V1P35       | DDR  | Z                    | Z                       | Z    |



**Table 7. DDR3L-RS System Memory Signals (Sheet 2 of 2)**

| Signal Name        | Dir | Plat. Power | Type | Default Buffer State |                         |       |
|--------------------|-----|-------------|------|----------------------|-------------------------|-------|
|                    |     |             |      | Pwrgood Assert State | Resetout Deassert State | S0ix  |
| DDR3_M0_RCOMPDP    | I   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_MA[15:0]   | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_CK[1,0]_P  | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_CK[1,0]_N  | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_CKE[3:0]   | O   | V1P35       | DDR  | Weak 0               | 0                       | 0     |
| DDR3_M1_CS[1,0]_N  | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_CAS_N      | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_RAS_N      | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_WE_N       | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_BS[2:0]    | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_DRAMRST_N  | O   | V1P35       | DDR  | Weak 0               | 0                       | 1     |
| DDR3_M1_ODT[1,0]   | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_DQ[63:0]   | I/O | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_DM[7:0]    | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_DQS[7:0]_P | I/O | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_DQS[7:0]_N | I/O | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_OCAVREF    | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_ODQVREF    | O   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_M1_RCOMPDP    | I   | V1P35       | DDR  | Z                    | Z                       | Z     |
| DDR3_DRAM_PWROK    | I   | V1P35       | DDR  | Input                | Input                   | Input |
| DDR3_CORE_PWROK    | I   | V1P35       | DDR  | Input                | Input                   | Input |

## 2.2.2 LPDDR3

**Table 8. LPDDR3 System Memory Signals (Sheet 1 of 2)**

| Signal Name        | Dir | Plat. Power | Type | Default Buffer State |                         |      |
|--------------------|-----|-------------|------|----------------------|-------------------------|------|
|                    |     |             |      | Pwrgood Assert State | Resetout Deassert State | S0ix |
| LPDDR3_M0_CA[9:0]  | O   | V1P24       | DDR  | Z                    | Z                       | Z    |
| LPDDR3_M0_CK_P_A/B | O   | V1P24       | DDR  | Z                    | Z                       | Z    |
| LPDDR3_M0_CK_N_A/B | O   | V1P24       | DDR  | Z                    | Z                       | Z    |



Table 8. LPDDR3 System Memory Signals (Sheet 2 of 2)

| Signal Name              | Dir | Plat. Power | Type | Default Buffer State |                         |       |
|--------------------------|-----|-------------|------|----------------------|-------------------------|-------|
|                          |     |             |      | Pwrgood Assert State | Resetout Deassert State | S0ix  |
| LPDDR3_M0_CKE[1:0]_A/B   | O   | V1P24       | DDR  | Weak 0               | 0                       | 0     |
| LPDDR3_M0_CS[1:0]_N      | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M0_ODT_A/B        | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M0_DQ[31:0]_A/B   | I/O | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M0_DM[3:0]_A/B    | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M0_DQS[3:0]_P_A/B | I/O | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M0_DQS[3:0]_N_A/B | I/O | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M0_OCAVREF        | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M0_ODQVREF        | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M0_RCOMPPD        | I   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_CA[9:0]        | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_CK_P_A/B       | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_CK_N_A/B       | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_CKE[1:0]_A/B   | O   | V1P24       | DDR  | Weak 0               | 0                       | 0     |
| LPDDR3_M0_CS[1:0]_N      | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M0_ODT_A/B        | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_DQ[31:0]_A/B   | I/O | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_DM[3:0]_A/B    | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_DQS[3:0]_P_A/B | I/O | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_DQS[3:0]_N_A/B | I/O | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_OCAVREF        | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_ODQVREF        | O   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_M1_RCOMPPD        | I   | V1P24       | DDR  | Z                    | Z                       | Z     |
| LPDDR3_DRAM_PWROK        | I   | V1P24       | DDR  | Input                | Input                   | Input |
| LPDDR3_CORE_PWROK        | I   | V1P24       | DDR  | Input                | Input                   | Input |



## 2.3 USB Controller Interface Signals

### 2.3.1 USB2.0 Interface Signals

Table 9. USB2.0 Interface Signals

| Signal Name   | Dir | Plat. Power | Type       | Default Buffer State |                         |                   |
|---------------|-----|-------------|------------|----------------------|-------------------------|-------------------|
|               |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix              |
| USB_DN[3:0]   | I/O | V1P8        | USB2 PHY   | "P" 1.1V             | "P" 1.1V                | S0i3 <sup>1</sup> |
| USB_DP[3:0]   | I/O | V1P8        | USB2 PHY   | "P" 1.1V             | "P" 1.1V                | S0i3 <sup>1</sup> |
| USB_OTG_ID    | I/O | V1P8        | USB2 PHY   | Input, weak pull up  | Input, weak pull up     | Input             |
| USB_VBUSSENS  | I/O | V1P8        | USB2 PHY   | Input                | Input                   | Input             |
| USB_RCOMP     | O   | V1P8        | USB2 PHY   | Output               | Output                  | Output            |
| USB_OC[1:0]_N | I/O | V1P8        | GPIOMV, MS | Input (20k PU)       | Input (20k PU)          | Input (20k PU)    |

**NOTES:**

- <sup>1</sup>Depends on USB2 Mode.
- USB 2.0 Port 0 is the OTG port.

### 2.3.2 USB HSIC Interface Signals

Table 10. USB 2.0 HSIC Interface Signals

| Signal Name      | Dir | Plat. Power | Type        | Default Buffer State |                         |        |
|------------------|-----|-------------|-------------|----------------------|-------------------------|--------|
|                  |     |             |             | Pwrgood Assert State | Resetout Deassert State | S0ix   |
| USB_HSIC0_DATA   | I/O | V1P2        | HSIC Buffer | Weak 0               | Weak 0                  | Weak 0 |
| USB_HSIC0_STROBE | I/O | V1P2        | HSIC Buffer | Weak 1               | Weak 1                  | Weak 1 |
| USB_HSIC1_DATA   | I/O | V1P2        | HSIC Buffer | Weak 0               | Weak 0                  | Weak 0 |
| USB_HSIC1_STROBE | I/O | V1P2        | HSIC Buffer | Weak 1               | Weak 1                  | Weak 1 |
| USB_HSIC_RCOMP   | I   | V1P2        | HSIC Buffer | Z                    | Z                       | Z      |

**NOTE:** The HSIC should be reset after SoC.



## 2.3.3 USB3.0 Interface Signals

### 2.3.3.1 USB 3.0 Interface Signals

**Table 11. USB 3.0 Interface Signals**

| Signal Name   | Dir | Plat. Power | Type | Default Buffer State |                         |        |
|---------------|-----|-------------|------|----------------------|-------------------------|--------|
|               |     |             |      | Pwrgood Assert State | Resetout Deassert State | S0ix   |
| USB3_TXN[3:0] | O   | V1P05A      | USB3 | X                    | Z                       | Output |
| USB3_TXP[3:0] | O   | V1P05A      | USB3 | X                    | Z                       | Output |
| USB3_RXN[3:0] | I   | V1P05A      | USB3 | X                    | Z                       | Input  |
| USB3_RXP[3:0] | I   | V1P05A      | USB3 | X                    | Z                       | Input  |
| USB3_RCOMP_N  | I   | V1P05A      | USB3 | X                    | Output                  | Off    |
| USB3_RCOMP_P  | I   | V1P05A      | USB3 | X                    | Output                  | Off    |

**NOTE:** USB3.0 Port 0 is the OTG port.

### 2.3.3.2 USB SSIC Interface Signals

**Table 12. USB SSIC Interface Signals**

| Signal Name        | Dir | Plat. Power | Type     | Default Buffer State |                         |        |
|--------------------|-----|-------------|----------|----------------------|-------------------------|--------|
|                    |     |             |          | Pwrgood Assert State | Resetout Deassert State | S0ix   |
| USB_SSIC_RX_N[0,1] | I/O | V1P24       | SSIC PHY | Input                | Input                   | Input  |
| USB_SSIC_RX_P[0,1] | I/O | V1P24       | SSIC PHY | Input                | Input                   | Input  |
| USB_SSIC_TX_N[0,1] | I/O | V1P24       | SSIC PHY | Z                    | Output                  | Output |
| USB_SSIC_TX_P[0,1] | I/O | V1P24       | SSIC PHY | Z                    | Output                  | Output |
| USB_SSIC_RCOMP_N   | O   | V1P24       | SSIC PHY | Output               | Output                  | Output |
| USB_SSIC_RCOMP_P   | O   | V1P24       | SSIC PHY | Output               | Output                  | Output |



## 2.4 Integrated Clock Interface Signals

Table 13. Integrated Clock Interface Signals

| Signal Name | Dir | Plat. Power | Type               | Default Buffer State |                         |                  |
|-------------|-----|-------------|--------------------|----------------------|-------------------------|------------------|
|             |     |             |                    | Pwrgood Assert State | Resetout Deassert State | S0ix             |
| ICLK_OSCIN  | I   | V1P0        | Crystal Oscillator | Input (Crystal)      | Input (Crystal)         | Input (Crystal)  |
| ICLK_OSCOUT | O   | V1P0        | Crystal Oscillator | Output (Crystal)     | Output (Crystal)        | Output (Crystal) |
| ICLK_ICOMP  | O   | Analog      | Analog             | Input                | Input                   | Input            |
| ICLK_RCOMP  | O   | Analog      | Analog             | Input                | Input                   | Input            |

## 2.5 Display - Digital Display Interface (DDI) Signals

Table 14. Digital Display Interface Signals (Sheet 1 of 2)

| Signal Name   | Dir | Plat. Power | Type            | Default Buffer State |                         |                |
|---------------|-----|-------------|-----------------|----------------------|-------------------------|----------------|
|               |     |             |                 | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| DDI0_TXP[3:0] | O   | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI0_TXN[3:0] | O   | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI0_AUXP     | I/O | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI0_AUXN     | I/O | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI0_BKLTCTL  | I/O | V1P8        | GPIOMV, MS      | 0                    | 0                       | 0              |
| DDI0_BKLTEN   | I/O | V1P8        | GPIOMV, MS      | 0                    | 0                       | 0              |
| DDI0_DDC_CLK  | I/O | V1P8        | GPIOMV, MS, CLK | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| DDI0_DDC_DATA | I/O | V1P8        | GPIOMV, MS      | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| DDI0_HPD      | I/O | V1P8        | GPIOMV, MS      | Input (20k PD)       | Input (20k PD)          | Input (20k PD) |
| DDI0_VDDEN    | I/O | V1P8        | GPIOMV, MS      | 0                    | 0                       | 0              |
| DDI0_RCOMP_N  | O   | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI0_RCOMP_P  | O   | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI1_TXP[3:0] | O   | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI1_TXN[3:0] | O   | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI1_AUXP     | I/O | V1P24       | DDI             | Z                    | Output                  | Output         |





Table 14. Digital Display Interface Signals (Sheet 2 of 2)

| Signal Name   | Dir | Plat. Power | Type            | Default Buffer State |                         |                |
|---------------|-----|-------------|-----------------|----------------------|-------------------------|----------------|
|               |     |             |                 | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| DDI1_AUXN     | I/O | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI1_BKLTCTL  | I/O | V1P8        | GPIOMV, MS      | 0                    | 0                       | 0              |
| DDI1_BKLTEN   | I/O | V1P8        | GPIOMV, MS      | 0                    | 0                       | 0              |
| DDI1_DDC_CLK  | I/O | V1P8        | GPIOMV, MS, CLK | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| DDI1_DDC_DATA | I/O | V1P8        | GPIOMV, MS      | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| DDI1_HPD      | I/O | V1P8        | GPIOMV, MS      | Input (20k PD)       | Input (20k PD)          | Input (20k PD) |
| DDI1_VDDEN    | I/O | V1P8        | GPIOMV, MS      | 0                    | 0                       | 0              |
| DDI1_RCOMP_N  | O   | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI1_RCOMP_P  | O   | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI2_DDC_CLK  | I/O | V1P8        | DDI             | Z                    | Output                  | Output         |
| DDI2_DDC_DATA | I/O | V1P8        | DDI             | Z                    | Output                  | Output         |
| DDI2_TXP[3:0] | O   | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI2_TXN[3:0] | O   | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI2_AUXP     | I/O | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI2_AUXN     | I/O | V1P24       | DDI             | Z                    | Output                  | Output         |
| DDI2_HPD      | I/O | V1P8        | GPIOMV, MS      | Input (20k PD)       | Input (20k PD)          | Input (20k PD) |

## 2.6 MIPI DSI Interface Signals

Table 15. MIPI DSI Interface Signals (Sheet 1 of 2)

| Signal Name    | Dir | Plat. Power | Type      | Default Buffer State |                         |      |
|----------------|-----|-------------|-----------|----------------------|-------------------------|------|
|                |     |             |           | Pwrgood Assert State | Resetout Deassert State | S0ix |
| MDSI_A_CLKN    | O   | V1P24       | MIPI-DPHY | 0                    | 0                       | 0    |
| MDSI_A_CLKP    | O   | V1P24       | MIPI-DPHY | 0                    | 0                       | 0    |
| MDSI_A_DN[3:0] | I/O | V1P24       | MIPI-DPHY | 0                    | 0                       | 0    |
| MDSI_A_DP[3:0] | I/O | V1P24       | MIPI-DPHY | 0                    | 0                       | 0    |
| MDSI_C_CLKN    | O   | V1P24       | MIPI-DPHY | 0                    | 0                       | 0    |
| MDSI_C_CLKP    | O   | V1P24       | MIPI-DPHY | 0                    | 0                       | 0    |

**Table 15. MIPI DSI Interface Signals (Sheet 2 of 2)**

| Signal Name    | Dir | Plat. Power | Type      | Default Buffer State |                         |      |
|----------------|-----|-------------|-----------|----------------------|-------------------------|------|
|                |     |             |           | Pwrgood Assert State | Resetout Deassert State | S0ix |
| MDSI_C_DN[3:0] | I/O | V1P24       | MIPI-DPHY | 0                    | 0                       | 0    |
| MDSI_C_DP[3:0] | I/O | V1P24       | MIPI-DPHY | 0                    | 0                       | 0    |
| MDSI_RCOMP     | I/O | V1P24       | MIPI-DPHY | 0                    | 0                       | 0    |

## 2.7 MIPI Camera Serial Interface (CSI) and ISP Interface Signals

**Table 16. MIPI CSI Interface Signals**

| Signal Name    | Dir | Plat. Power | Type      | Default Buffer State |                         |       |
|----------------|-----|-------------|-----------|----------------------|-------------------------|-------|
|                |     |             |           | Pwrgood Assert State | Resetout Deassert State | S0ix  |
| MCSI_1_CLKN    | I   | V1P24       | MIPI-DPHY | Input                | Input                   | Input |
| MCSI_1_CLKP    | I   | V1P24       | MIPI-DPHY | Input                | Input                   | Input |
| MCSI_1_DN[0:3] | I   | V1P24       | MIPI-DPHY | Input                | Input                   | Input |
| MCSI_1_DP[0:3] | I   | V1P24       | MIPI-DPHY | Input                | Input                   | Input |
| MCSI_2_CLKN    | I   | V1P24       | MIPI-DPHY | Input                | Input                   | Input |
| MCSI_2_CLKP    | I   | V1P24       | MIPI-DPHY | Input                | Input                   | Input |
| MCSI_2_DN[0:1] | I   | V1P24       | MIPI-DPHY | Input                | Input                   | Input |
| MCSI_2_DP[0:1] | I   | V1P24       | MIPI-DPHY | Input                | Input                   | Input |
| MCSI_3_CLKN    | I   | V1P24       | MIPI-DPHY | Input                | Input                   | Input |
| MCSI_3_CLKP    | I   | V1P24       | MIPI-DPHY | Input                | Input                   | Input |
| MCSI_RCOMP     | I/O | V1P24       | MIPI-DPHY | Input                | Input                   | Input |



## 2.8 PCI Express Signals

Table 17. PCIe Signals and Clocks

| Signal Name        | Dir | Plat. Power | Type       | Default Buffer State |                         |        |
|--------------------|-----|-------------|------------|----------------------|-------------------------|--------|
|                    |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix   |
| PCIE_RXN[0:1]      | I   | V1P05       | PCIe PHY   | X                    | Weak Pull Down          | Input  |
| PCIE_RXP[0:1]      | I   | V1P05       | PCIe PHY   | X                    | Weak Pull Down          | Input  |
| PCIE_TXN[0:1]      | O   | V1P05       | PCIe PHY   | X                    | Z                       | Output |
| PCIE_TXP[0:1]      | O   | V1P05       | PCIe PHY   | X                    | Z                       | Output |
| P_RCOMP_N          | IO  | X           | PCIe PHY   | X                    |                         | Off    |
| P_RCOMP_P          | IO  | X           | PCIe PHY   | X                    |                         | Off    |
| PCIE_CLKREQ[0:1]_N | IO  | V1P8        | GPIOMV, MS | X                    | Input (20k PU)          | Prg    |

## 2.9 Low Power Engine (LPE) for Audio (I<sup>2</sup>S) Interface Signals

Table 18. LPE Interface Signals

| Signal Name          | Dir | Plat. Power | Type        | Default Buffer State |                         |       |
|----------------------|-----|-------------|-------------|----------------------|-------------------------|-------|
|                      |     |             |             | Pwrgood Assert State | Resetout Deassert State | S0ix  |
| LPE_I2S[2:0]_CLK     | I/O | V1P8        | GPIOM V, MS | Input (20k PD)       | Input (20k PD)          | 0     |
| LPE_I2S[2:0]_FRM     | I/O | V1P8        | GPIOM V, MS | Input (20k PD)       | Input (20k PD)          | 1     |
| LPE_I2S[2:0]_DATAOUT | I/O | V1P8        | GPIOM V, MS | 0 (20k PD)           | 0 (20k PD)              | 0     |
| LPE_I2S[2:0]_DATAIN  | I/O | V1P8        | GPIOM V, MS | Input (20k PD)       | Input (20k PD)          | Input |



## 2.10 Storage Interface Signals

### 2.10.1 Storage Controller (eMMC, SDIO, SD)

Table 19. Storage Controller (eMMC, SDIO, SD) Interface Signals

| Signal Name   | Dir | Plat. Power   | Type              | Default Buffer State |                         |                |
|---------------|-----|---------------|-------------------|----------------------|-------------------------|----------------|
|               |     |               |                   | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| MMC1_D[7:0]   | I/O | V1P8          | GPIOMV, HS        | Z (20k PU)           | Z (20k PU)              | Z (20k PU)     |
| MMC1_CMD      | I/O | V1P8          | GPIOMV, HS        | Z (20k PU)           | Z (20k PU)              | Z (20k PU)     |
| MMC1_CLK      | I/O | V1P8          | GPIOMV, HS, CLK   | 0 (20k PD)           | 0 (20k PD)              | 0 (20k PD)     |
| MMC1_RCLK     | I/O | V1P8          | GPIOMV, HS        | Z (20k PD)           | Z                       | Z              |
| MMC1_RESET_N  | I/O | V1P8          | GPIOMV, HS        | Z                    | Z                       | Z              |
| MMC1_RCOMP    | I/O | V1P8          | GPIOMV, HS, RCOMP | Z                    | Z                       | Z              |
| SD2_D[2:0]    | I/O | V1P8          | GPIOMV, HS        | Z (20k PU)           | Z (20k PU)              | Z (20k PU)     |
| SD2_D[3]_CD_N | I/O | V1P8          | GPIOMV, HS        | Z (20k PU)           | Z (20k PU)              | Z (20k PU)     |
| SD2_CMD       | I/O | V1P8          | GPIOMV, HS        | Z (20k PU)           | Z (20k PU)              | Z (20k PU)     |
| SD2_CLK       | I/O | V1P8          | GPIOMV, HS, CLK   | 0 (20k PD)           | 0                       | 0              |
| SD3_D[3:0]    | I/O | V1P8/<br>V3P3 | GPIOHV, HS        | Z (20k PU)           | Z (20k PU)              | Z (20k PU)     |
| SD3_CMD       | I/O | V1P8/<br>V3P3 | GPIOHV, HS        | Z (20k PU)           | Z (20k PU)              | Z (20k PU)     |
| SD3_PWREN_N   | I/O | V1P8          | GPIOMV, HS        | 1 (20k PD)           | 1                       | -              |
| SD3_CLK       | I/O | V1P8/<br>V3P3 | GPIOHV, HS, CLK   | 0 (20k PD)           | 0                       | 0              |
| SD3_RCOMP     | I/O | V1P8/<br>V3P3 | GPIOHV, HS, RCOMP | Z                    | Z                       | Z              |
| SD3_1P8_EN    | I/O | V1P8          | GPIOMV, HS        | 0 (20k PD)           | 0                       | -              |
| SD3_CD_N      | I/O | V1P8          | GPIOMV, HS        | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |



## 2.11 High Speed UART Interface Signals

Table 20. High Speed UART Interface Signals

| Signal Name   | Dir | Plat. Power | Type       | Default Buffer State |                         |                |
|---------------|-----|-------------|------------|----------------------|-------------------------|----------------|
|               |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| UART1_DATAIN  | I/O | V1P8        | GPIOMV, MS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| UART1_DATAOUT | I/O | V1P8        | GPIOMV, MS | 1 (20k PU)           | 1                       | 1              |
| UART1_RTS_N   | I/O | V1P8        | GPIOMV, MS | 1 (20k PU)           | 1                       | 1              |
| UART1_CTS_N   | I/O | V1P8        | GPIOMV, MS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| UART2_DATAIN  | I/O | V1P8        | GPIOMV, MS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| UART2_DATAOUT | I/O | V1P8        | GPIOMV, MS | 1 (20k PU)           | 1                       | 1              |
| UART2_RTS_N   | I/O | V1P8        | GPIOMV, MS | 1 (20k PU)           | 1                       | 1              |
| UART2_CTS_N   | I/O | V1P8        | GPIOMV, MS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |



## 2.12 I<sup>2</sup>C Interface Signals

Table 21. I<sup>2</sup>C Interface Signals

| Signal Name | Dir | Plat. Power | Type            | Default Buffer State |                         |                |
|-------------|-----|-------------|-----------------|----------------------|-------------------------|----------------|
|             |     |             |                 | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| I2C0_DATA   | I/O | V1P8        | GPIOMV, MS, I2C | Z (1k PU, OD)        | Z (1k PU, OD)           | Z (1k PU, OD)  |
| I2C0_CLK    | I/O | V1P8        | GPIOMV, MS, I2C | Z (1k PU, OD)        | Z (1k PU, OD)           | Z (1k PU, OD)  |
| I2C1_DATA   | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C1_CLK    | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C2_DATA   | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C2_CLK    | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C3_DATA   | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C3_CLK    | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C4_DATA   | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C4_CLK    | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C5_DATA   | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C5_CLK    | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C6_DATA   | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| I2C6_CLK    | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |



## 2.13 NFC I<sup>2</sup>C Interface Signals

Table 22. NFC I<sup>2</sup>C Interface Signals

| Signal Name  | Dir | Plat. Power | Type            | Default Buffer State |                         |                |
|--------------|-----|-------------|-----------------|----------------------|-------------------------|----------------|
|              |     |             |                 | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| NFC_I2C_DATA | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| NFC_I2C_CLK  | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| GPIO_ALERT   | I/O | V1P8        | GPIOMV, MS      | 0 (20k PU)           | 0                       | 0              |

## 2.14 PCU- Fast Serial Peripheral Interface (SPI) Signals

Table 23. PCU- Fast Serial Peripheral Interface (SPI) Signals

| Signal Name     | Dir | Plat. Power | Type       | Default Buffer State |                         |                |
|-----------------|-----|-------------|------------|----------------------|-------------------------|----------------|
|                 |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| FST_SPI_CLK     | I/O | V1P8        | GPIOMV, HS | 0 (20k PU)           | Output                  | Output         |
| FST_SPI_CS[0]_N | I/O | V1P8        | GPIOMV, HS | 1 (20k PU)           | Output                  | Output         |
| FST_SPI_CS[1]_N | I/O | V1P8        | GPIOMV, HS | Input (20k PU)       | Output                  | Output         |
| FST_SPI_CS[2]_N | I/O | V1P8        | GPIOMV, HS | 1 (20k PU)           | Output                  | Output         |
| FST_SPI_D[3:0]  | I/O | V1P8        | GPIOMV, HS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |



## 2.15 PCU - Real Time Clock (RTC) Interface Signals

Table 24. PCU - Real Time Clock (RTC) Interface Signals

| Signal Name | Dir | Plat. Power | Type    | Default Buffer State |                         |                  |
|-------------|-----|-------------|---------|----------------------|-------------------------|------------------|
|             |     |             |         | Pwrgood Assert State | Resetout Deassert State | S0ix             |
| RTC_X1      | I   | V3P3        | RTC PHY | Input (Crystal)      | Input (Crystal)         | Input (Crystal)  |
| RTC_X2      | O   | V3P3        | RTC PHY | Output (Crystal)     | Output (Crystal)        | Output (Crystal) |
| RTC_RST_N   | I   | V3P3        | RTC PHY | Input                | Input                   | Input            |
| RTC_TEST_N  | I   | V3P3        | RTC PHY | Input                | Input                   | Input            |
| RTC_EXTPAD  | O   | V3P3        | RTC PHY | Input                | Input                   | Input            |

## 2.16 PCU - Low Pin Count (LPC) Bridge Interface Signals

Table 25. PCU - LPC Bridge Interface Signals

| Signal Name   | Dir | Plat. Power | Type       | Default Buffer State |                         |                |
|---------------|-----|-------------|------------|----------------------|-------------------------|----------------|
|               |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| LPC_AD[3:0]   | I/O | V3P3/V1P8   | GPIOHV, HS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| LPC_FRAME_N   | I/O | V3P3/V1P8   | GPIOHV, HS | 1 (20k PU)           | 1                       | 1              |
| LPC_SERIRQ    | I/O | V1P8        | GPIOHV, HS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| LPC_CLKRUN_N  | I/O | V3P3/V1P8   | GPIOHV, HS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| LPC_CLKOUT[0] | I/O | V3P3/V1P8   | GPIOHV, HS | 0 (20k PU)           | Clock                   | 0              |
| LPC_CLKOUT[1] | I/O | V3P3/V1P8   | GPIOHV, HS | Input (20k PD)       | Input                   | Input          |
| LPC_RCOMP     | I/O | V3P3/V1P8   | GPIOHV, HS | Z                    | Z                       | Z              |





## 2.17 PCU - Power Management Controller (PMC) Interface Signals

Table 26. PCU - Power Management Controller (PMC) Interface Signals

| Signal Name     | Dir | Plat. Power | Type       | Default Buffer State |                         |                |
|-----------------|-----|-------------|------------|----------------------|-------------------------|----------------|
|                 |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| PMC_PLTRST_N    | I/O | V1P8        | GPIOMV, MS | 0 (20k PU)           | 1                       | 1              |
| PMC_PWRBTN_N    | I   | V1P8        | GPIOMV, MS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| PMC_RSTBTN_N    | I/O | V1P8        | GPIOMV, MS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| PMC_SUSPWRDNACK | I/O | V1P8        | GPIOMV, MS | 0 (20k PD)           | 0 (20k PD)              | 0 (20k PD)     |
| PMC_SUS_STAT_N  | I/O | V1P8        | GPIOMV, MS | 0 (20k PU)           | 1                       | 0              |
| PMC_SUSCLK[0]   | I/O | V1P8        | GPIOMV, MS | 0 (20k PD)           | 32 KHz Clock            | 32 KHz Clock   |
| PMC_SLP_S4_N    | I/O | V1P8        | GPIOMV, MS | 0 (20k PU)           | 1                       | 1              |
| PMC_SLP_S0ix_N  | I/O | V1P8        | GPIOMV, MS | 0 (20k PU)           | 1                       | 0 at S0ix2     |
| PMC_ACPRESENT   | I/O | V1P8        | GPIOMV, MS | Input (20k PD)       | Input (20k PD)          | Input (20k PD) |
| PMC_BATLOW_N    | I/O | V1P8        | GPIOMV, MS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| PMC_WAKE_N      | I/O | V1P8        | GPIOMV, MS | Input (20k PU)       | Input (20k PU)          | Input (20k PU) |
| PMC_CORE_PWROK  | I   | V3P3        | RTC PHY    | Input                | Input                   | Input          |
| PMC_RSMRST_N    | I   | V3P3        | RTC PHY    | Input                | Input                   | Input          |



## 2.18 Serial Peripheral Interface (SPI) Signals

Table 27. Serial Peripheral Interface (SPI) Signals

| Signal Name          | Dir | Plat. Power | Type       | Default Buffer State |                         |       |
|----------------------|-----|-------------|------------|----------------------|-------------------------|-------|
|                      |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix  |
| SPI[1,2,3]_CLK       | I/O | V1P8        | GPIOMV, HS | 0 (20k PU)           | 0                       | 0     |
| SPI[1,2,3]_CS[0:1]_N | I/O | V1P8        | GPIOMV, HS | 1 (20k PU)           | 1                       | 1     |
| SPI[1,2,3]_MOSI      | I/O | V1P8        | GPIOMV, HS | 0 (20k PU)           | 0                       | 0     |
| SPI[1,2,3]_MISO      | I/O | V1P8        | GPIOMV, HS | Input (20k PU)       | Input (20k PD)          | Input |

## 2.19 JTAG Interface Signals

Table 28. JTAG Interface Signals

| Signal Name | Dir | Plat. Power | Type       | Default Buffer State |                         |                   |
|-------------|-----|-------------|------------|----------------------|-------------------------|-------------------|
|             |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix              |
| JTAG_TCK    | I/O | V1P8        | GPIOMV, MS | Input (5k PD)        | Input (5k PD)           | Input (5k PD)     |
| JTAG_TDI    | I/O | V1P8        | GPIOMV, MS | Input (5k PU)        | Input (5k PU)           | Input (5k PU)     |
| JTAG_TDO    | I/O | V1P8        | GPIOMV, MS | Z                    | Z                       | Z                 |
| JTAG_TMS    | I/O | V1P8        | GPIOMV, MS | Input (5k PU)        | Input (5k PU)           | Input (5k PU)     |
| JTAG_TRST_N | I/O | V1P8        | GPIOMV, MS | Input (5k PU)        | Input (5k PU)           | Input (5k PU)     |
| JTAG_PRDY_N | I/O | V1P8        | GPIOMV, MS | Z (5k PU, OD)        | Output (5k PU, OD)      | Z (5k PU, OD)     |
| JTAG_PREQ_N | I/O | V1P8        | GPIOMV, MS | Input (5k PU, OD)    | Input (5k PU, OD)       | Input (5k PU, OD) |

## 2.20 Integrated Sensor Hub Interface Signals

Table 29. Integrated Sensor Hub Interface Signals (Sheet 1 of 2)

| Signal Name   | Dir | Plat. Power | Type       | Default Buffer State |                         |            |
|---------------|-----|-------------|------------|----------------------|-------------------------|------------|
|               |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix       |
| ISH_GPIO[7:0] | I/O | V1P8        | GPIOMV, MS | Input (20k PD)       | Z (20k PU)              | Z (20k PU) |



Table 29. Integrated Sensor Hub Interface Signals (Sheet 2 of 2)

| Signal Name  | Dir | Plat. Power | Type            | Default Buffer State |                         |                |
|--------------|-----|-------------|-----------------|----------------------|-------------------------|----------------|
|              |     |             |                 | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| ISH_GPIO[8]  | I/O | V1P8        | GPIOMV, MS      | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| ISH_GPIO[9]  | I/O | V1P8        | GPIOMV, MS      | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| ISH_I2C1_SDA | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |
| ISH_I2C1_CLK | I/O | V1P8        | GPIOMV, MS, I2C | Input (20k PU)       | Z (20k PU, OD)          | Z (20k PU, OD) |

## 2.21 PWM Interface Signals

Table 30. PWM Interface Signal

| Signal Name | Dir | Plat. Power | Type       | Default Buffer State |                         |      |
|-------------|-----|-------------|------------|----------------------|-------------------------|------|
|             |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix |
| PWM[0]      | I/O | V1P8        | GPIOMV, MS | 0 (20k PD)           | 0                       | 0    |
| PWM[1]      | I/O | V1P8        | GPIOMV, MS | 0 (20k PU)           | 0                       | 0    |

## 2.22 SVID Interface Signals

Table 31. SVID Interface Signal

| Signal Name  | Dir | Plat. Power | Type       | Default Buffer State |                         |        |
|--------------|-----|-------------|------------|----------------------|-------------------------|--------|
|              |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix   |
| SVID_DATA    | I/O | V1P8        | GPIOMV, MS | 0                    | 0                       | 1 or Z |
| SVID_CLK     | I/O | V1P8        | GPIOMV, MS | 0                    | 1 or Z                  | 1 or Z |
| SVID_ALERT_N | I/O | V1P8        | GPIOMV, MS | Input                | Input                   | Input  |

## 2.23 Miscellaneous Signals

**Table 32. Miscellaneous Signals and Clocks**

| Signal Name  | Dir | Plat. Power | Type       | Default Buffer State |                         |                |
|--------------|-----|-------------|------------|----------------------|-------------------------|----------------|
|              |     |             |            | Pwrgood Assert State | Resetout Deassert State | S0ix           |
| PLT_CLK[0:5] | I/O | V1P8        | GPIOMV, MS | 0 (20k PD)           | Clock (20k PD)          | 0 <sup>1</sup> |
| PROCHOT_N    | I/O | V1P8        | GPIOMV, MS | Z                    | Z                       | Z              |

**NOTE:** '0' in S0i2 or below.

## 2.24 Hardware Straps

All straps are sampled on the rising edge of **PMC\_RSMRST\_N**.

While **PMC\_RSMRST\_N** is low all strap pins are in input mode. Weak pull ups or downs keep straps from floating during this time. Strap values can be changed by driving the strap pins or using stronger pull resistors.

**Table 33. Straps (Sheet 1 of 2)**

| Signal Name              | Purpose                            | Pull up/Pull Down              | Strap Description   |
|--------------------------|------------------------------------|--------------------------------|---|
| GPIO_SUS[0] <sup>1</sup> | DDI0 Detect                        | Weak internal pull down of 20K | DDI0 Detect<br>0 = DDI0 not enabled<br>1 = DDI0 enabled                           |
| GPIO_SUS[1]              | DDI1 Detect                        | Weak internal pull down of 20K | DDI1 Detect<br>0 = DDI1 not enabled<br>1 = DDI1 enabled                           |
| GPIO_SUS[2]              | A16 swap overdrive                 | Weak internal pull up of 20K   | Top Swap (A16 Override)<br>0 = Change Boot Loader address<br>1 = Normal Operation |
| GPIO_SUS[3]              | DSI Display Detect                 | Weak internal pull down of 20K | MIPI DSI Detect<br>0 = DSI not enabled<br>1 = DSI enabled                         |
| GPIO_SUS[4]              | Boot BIOS Strap BBS                | Weak internal pull up of 20K   | BIOS Boot Selection<br>0 = Default<br>1 = SPI                                     |
| GPIO_SUS[5]              | Flash Descriptor Security Override | Weak internal pull up of 20K   | Security Flash Descriptors<br>0 = Override<br>1 = Normal Operation                |



Table 33. Straps (Sheet 2 of 2)

| Signal Name     | Purpose                              | Pull up/Pull Down                 | Strap Description   |
|-----------------|--------------------------------------|-----------------------------------|---|
| GPIO_SUS[8]     | ICLK, USB2, DDI SFR<br>Supply Select | Weak internal pull<br>up of 20K   | 0 = Supply is 1.25V<br>1 = Supply is 1.35V<br><br>This strap also contains PLL<br>LDO<br>0: supply is 1.25V<br>1: supply is 1.35V.<br><br>Selects supply voltage for<br>LDOs used for PLLs,<br>thermal oscillators, USB2,<br>iCLK and DDI |
| GPIO_SUS[9]     | ICLK, USB2, DDI SFR<br>Bypass        | Weak internal pull<br>down of 20K | Bypasses LDOs for ICLK<br>0 = Use LDOs<br>1 = Bypass LDOs<br>(Supply 1.05V on power<br>pins)  |
| GPIO_SUS[10]    | POSM Select                          | Weak internal pull<br>down of 20K | Selects which POSM<br>(power on state machine)<br>will be observed at time 0<br>0 = Fuse controller<br>1 = PMC  |
| GPIO_CAMERASB08 | ICLK Xtal OSC Bypass                 | Weak internal pull<br>down of 20K | 0 = No Bypass<br>1 = Bypass   |
| GPIO_CAMERASB09 | CCU SUS RO Bypass                    | Weak internal pull<br>down of 20K | 0 = No Bypass<br>1 = Bypass   |
| GPIO_CAMERASB11 | RTC OSC Bypass                       | Weak internal pull<br>down of 20K | 0 = No Bypass<br>1 = Bypass   |

**NOTE:**

1. Ignore this strap and use a software mechanism to detect the relevant DDI port. This signal can be used as a GPIO.



## 2.25 SoC RCOMP List

Table 34. RCOMP's List (Sheet 1 of 2)

| Interface Name | RCOMP Name                     | Bias                                     | Remarks  |
|----------------|--------------------------------|--|--|
| DDR3           | DDR3_M0_RCOMP/ LPDDR3_M0_RCOMP | 182 Ohm $\pm 1\%$ to Ground              | RCOMP pins for DDR3  |
|                | DDR3_M1_RCOMP/ LPDDR3_M1_RCOMP | 182 Ohm $\pm 1\%$ to Ground              |  |
| MIPI DSI       | MDSI_RCOMP                     | 150 Ohm $\pm 1\%$ to Ground              | RCOMP pin for MIPI DSI   |
| MIPI CSI       | MCSI_RCOMP                     | 150 Ohm $\pm 1\%$ to Ground              | RCOMP pin for MIPI CSI   |
| eMMC           | MMC1_RCOMP                     | 100 Ohm $\pm 1\%$ to Ground              | eMMC, SDIO, FST_SPI RCOMP  |
| SD Card        | SD3_RCOMP                      | 80.6 Ohm $\pm 1\%$ to Ground             | SD Card contains its own RCOMP as it can be either 1.8V or 3.3V. Special care is needed to perform an RCOMP any time a card is inserted. |
| LPC            | LPC_RCOMP                      | 100 Ohm $\pm 1\%$ to Ground              | LPC has its own RCOMP because it can operate at 1.8V or 3.3V.  |
| iCLK           | ICLK_ICOMP                     | 2.5k Ohm $\pm 1\%$ to Ground             | The calibration will be handled inside the iCLK.   |
|                | ICLK_RCOMP                     | 50 Ohm $\pm 1\%$ to Ground               |  |
| USB2           | USB_RCOMP                      | 113 Ohm $\pm 1\%$ to Ground              | The calibration will be handled inside USB   |
| HSIC           | USB_HSIC_RCOMP                 | 45 Ohm $\pm 1\%$ to Ground               | The calibration is handled inside the USB HSIC.  |
| SSIC           | USB_SSIC_RCOMP_P               | 90 Ohm $\pm 1\%$ Between SSIC RCOMP pads | The calibration is handled inside the USB SSIC.  |
|                | USB_SSIC_RCOMP_N               |  |  |
| USB3           | USB3_RCOMP_N                   | 402 Ohm 1% between RCOMP pads            | The calibration is handled inside the USB3.  |
|                | USB3_RCOMP_P                   |  |  |
| GPIO           | GPIO0_RCOMP                    | 100 Ohm to Ground                        | Will be shared across all GPIO buffers on the north side of the chip.  |
| PCIE           | PCIE_RCOMP_N                   | 402 Ohm 1% between RCOMP pads            | The Calibration is handled in PCIE.  |
|                | PCIE_RCOMP_P                   |  |  |



Table 34. RCOMP's List (Sheet 2 of 2)

| Interface Name | RCOMP Name   | Bias                                | Remarks                           |
|----------------|--------------|-------------------------------------|-----------------------------------|
| DDI            | DDI0_RCOMP_N | 402 Ohm 1%<br>between RCOMP<br>pads | The calibration is handled in DDI |
|                | DDI0_RCOMP_P |                                     |                                   |
|                | DDI1_RCOMP_N | 402 Ohm 1%<br>between RCOMP<br>pads |                                   |
|                | DDI1_RCOMP_P |                                     |                                   |

## 2.26 GPIO Muxing

Not all interfaces can be active at the same time. To provide flexibility, these shared interfaces are muxed with GPIOs.

**Note:** All GPIOs default to function as GPIO name at boot. BIOS is responsible for enabling proper configuration.

GPIO Number= GPIO pin location

GPIO mode= GPIO mode in which the pin operates

Table 35. Multiplexed Functions - T4 SoC (Sheet 1 of 11)

| GPIO Pin Name  | Package Ball # | GPIO # | Mode 0 | Mode 1         | Mode 2          | Mode 3          | Mode 4       | Mode 5 | Mode 6 |
|--|----------------|--------|--------|----------------|-----------------|-----------------|--------------|--------|--------|
| ISH_GPIO[8]/<br>ISH_SPI_CS[0]_N/<br>I2S5_CLK                         | BL9            | E23    |        | ISH_GPIO[8]    | ISH_SPI_CS[0]_N | I2S5_CLK        |              |        |        |
| LPC_AD[2]/<br>ISH_GPIO[14]/<br>ISH_I2C0_DATA                         | BP20           | SE45   |        | LPC_AD[2]      | ISH_GPIO[14]    | ISH_I2C0_DATA   |              |        |        |
| I2C4_CLK/<br>DDI0_DDC_CLK/<br>DDI2_DDC_CLK/<br>MDSI_DDC_CLK          | BP34           | SW52   |        | I2C4_CLK       | DDI0_DC_CLK     | DDI2_DDC_CLK    | MDSI_DDC_CLK |        |        |
| LPC_AD[3]/<br>ISH_GPIO[15]/<br>ISH_I2C0_CLK/<br>SPI2_MOSI            | BR21           | SE50   |        | LPC_AD[3]      | ISH_GPIO[15]    | ISH_I2C0_CLK    | SPI2_MOSI    |        |        |
| PMC_PLT_CLK[4]/<br>ISH_GPIO[14]/<br>ISH_I2C0_DATA/<br>SPI2_MISO      | BR7            | SE3    |        | PMC_PLT_CLK[4] | ISH_GPIO[14]    | ISH_I2C0_DATA   | SPI2_MISO    |        |        |
| PMC_PLT_CLK[1]/<br>ISH_GPIO[11]/<br>ISH_UART_DATAIN/<br>SPI2_CS[1]_N | BR9            | SE2    |        | PMC_PLT_CLK[1] | ISH_GPIO[11]    | ISH_UART_DATAIN | SPI2_CS[1]_N |        |        |



**Table 35. Multiplexed Functions - T4 SoC (Sheet 2 of 11)**

| GPIO Pin Name  | Package Ball # | GPIO # | Mode 0 | Mode 1         | Mode 2        | Mode 3         | Mode 4        | Mode 5     | Mode 6     |
|--|----------------|--------|--------|----------------|---------------|----------------|---------------|------------|------------|
| I2C4_DATA/<br>DDI2_DDC_DATA/<br>DDI2_DDC_DATA/<br>MDSI_DDC_DATA                  | BT32           | SW46   |        | I2C4_DATA      |               | DDI2_DDC_DATA  | MDSI_DDC_DATA |            |            |
| PMC_PLT_CLK[5]/<br>ISH_GPIO[15]/<br>ISH_I2C0_CLK/<br>SPI2_MOSI                   | BT6            | SE6    |        | PMC_PLT_CLK[5] | ISH_GPIO[15]  | ISH_I2C0_CLK   | SPI2_MOSI     |            |            |
| MMC1_RCLK/<br>MMC1_RESET_N   | BU13           | SE69   |        | MMC1_RCLK      | MMC1_RESET_N  |                |               |            |            |
| PMC_PLT_CLK[2]/<br>ISH_GPIO[12]/<br>ISH_UART_CTS_N/<br>SPI2_CS[0]_N              | BU7            | SE7    |        | PMC_PLT_CLK[2] | ISH_GPIO[12]  | ISH_UART_CTS_N | SPI2_CS[0]_N  |            |            |
| PMC_PLT_CLK[3]/<br>ISH_GPIO[13]/<br>ISH_UART_RTS_N/<br>SPI2_CLK                  | BU9            | SE4    |        | PMC_PLT_CLK[3] | ISH_GPIO[13]  | ISH_UART_RTS_N | SPI2_CLK      |            |            |
| DDI2_DDC_CLK/<br>DDI1_DDC_CLK/<br>UART0_DATAOUT/<br>MDSI_DDC_CLK/<br>MDSI_A_TE   | E21            | N67    |        | DDI2_DDC_CLK   | DDI1_DDC_CLK  | UART0_DATAOUT  | MDSI_DDC_CLK  | MDSI_A_TE  |            |
| GPIO_N1/<br>C0_BPM3_TX/<br>C1_BPM3_TX  | E39            | N1     |        |                |               |                |               | C0_BPM3_TX | C1_BPM3_TX |
| DDI2_DDC_DATA/<br>DDI1_DDC_DATA/<br>UART0_DATAIN/<br>MDSI_DDC_DATA/<br>MDSI_C_TE | F20            | N62    |        | DDI2_DDC_DATA  | DDI1_DDC_DATA | UART0_DATAIN   | MDSI_DDC_DATA | MDSI_C_TE  |            |
| DDI0_DDC_CLK/<br>DDI1_DDC_CLK/<br>MDSI_DDC_CLK                                   | F26            | N71    |        | DDI0_DDC_CLK   | DDI1_DDC_CLK  | MDSI_DDC_CLK   |               |            |            |
| GPIO_N2/<br>C0_BPM2_TX/<br>C1_BPM2_TX  | F38            | N2     |        |                |               |                |               | C0_BPM2_TX | C1_BPM2_TX |
| GPIO_N4/<br>C0_BPM0_TX/<br>C1_BPM0_TX  | G39            | N4     |        |                |               |                |               | C0_BPM0_TX | C1_BPM0_TX |
| DDI0_DDC_DATA/<br>DDI1_DDC_DATA/<br>MDSI_DDC_DATA                                | H26            | N66    |        | DDI0_DDC_DATA  | DDI1_DDC_DATA | MDSI_DDC_DATA  |               |            |            |
| JTAG2_TMS  | J37            | N24    |        | JTAG2_TMS      |               |                |               |            |            |





Table 35. Multiplexed Functions - T4 SoC (Sheet 3 of 11)

| GPIO Pin Name                              | Package Ball # | GPIO # | Mode 0 | Mode 1          | Mode 2 | Mode 3 | Mode 4       | Mode 5     | Mode 6     |
|--|----------------|--------|--------|-----------------|--------|--------|--------------|------------|------------|
| GPIO_N6/<br>C0_BPM3_TX/<br>C1_BPM3_TX      | J39            | N6     |        |                 |        |        |              | C0_BPM3_TX | C1_BPM3_TX |
| GPIO_N8/<br>C0_BPM1_TX/<br>C1_BPM1_TX      | K40            | N8     |        |                 |        |        |              | C0_BPM1_TX | C1_BPM1_TX |
| GPIO_N3/<br>C0_BPM1_TX/<br>C1_BPM1_TX      | B38            | N3     |        |                 |        |        |              | C0_BPM1_TX | C1_BPM1_TX |
| ISH_GPIO[13]/<br>C0_BPM2_TX/<br>C1_BPM2_TX | C39            | N7     |        |                 |        |        | ISH_GPIO[13] | C0_BPM2_TX | C1_BPM2_TX |
| GPIO_N0/<br>C0_BPM0_TX/<br>C1_BPM0_TX      | D40            | N0     |        |                 |        |        |              | C0_BPM0_TX | C1_BPM0_TX |
| GPIO_CAMERASB03                            | B28            | N51    |        | GPIO_CAMERASB03 |        |        |              |            |            |
| JTAG_TMS                                   | B34            | N34    |        | JTAG_TMS        |        |        |              |            |            |
| PMC_PWRBTN_N                               | BH10           | E8     |        | PMC_PWRBTN_N    |        |        |              |            |            |
| SD3_D[2]                                   | BH18           | SE33   |        | SD3_D[2]        |        |        |              |            |            |
| PMC_RSTBTN_N                               | BH24           | SE76   |        | PMC_RSTBTN_N    |        |        |              |            |            |
| UART2_RTS_N                                | BH26           | SW19   |        | UART2_RTS_N     |        |        |              |            |            |
| UART2_DATAIN                               | BH28           | SW17   |        | UART2_DATAIN    |        |        |              |            |            |
| LPE_I2S0_CLK                               | BH32           | SW31   |        | LPE_I2S0_CLK    |        |        |              |            |            |
| I2C6_CLK/NMI_N                             | BH34           | SW53   |        | I2C6_CLK        | NMI_N  |        |              |            |            |
| I2C2_DATA                                  | BH36           | SW62   |        | I2C2_DATA       |        |        |              |            |            |
| PMC_BATLOW_N                               | BH4            | E1     |        | PMC_BATLOW_N    |        |        |              |            |            |
| LPE_I2S2_FRM                               | BH40           | SW96   |        | LPE_I2S2_FRM    |        |        |              |            |            |
| PMC_SUS_STAT_N                             | BH6            | E2     |        | PMC_SUS_STAT_N  |        |        |              |            |            |



**Table 35. Multiplexed Functions - T4 SoC (Sheet 4 of 11)**

| GPIO Pin Name  | Package Ball # | GPIO # | Mode 0 | Mode 1           | Mode 2        | Mode 3           | Mode 4            | Mode 5 | Mode 6 |
|--|----------------|--------|--------|------------------|---------------|------------------|-------------------|--------|--------|
| MMC1_CMD   | BJ15           | SE23   |        | MMC1_CM D        |               |                  |                   |        |        |
| LPC_FRAME_N/<br>UART0_DATAIN/<br>SPI2_MISO           | BJ19           | SE48   |        | LPC_FRAM E_N     | UART0_ DATAIN |                  | SPI2_MISO         |        |        |
| GPIO_ALERT/<br>ISH_GPIO[11]/<br>ISH_UART_DATAIN      | BJ21           | SE77   |        | GPIO_ALE RT      | ISH_GPI O[11] | ISH_UART_ DATAIN |                   |        |        |
| FST_SPI_D[2]   | BJ25           | SW0    |        | FST_SPI_ D[2]    |               |                  |                   |        |        |
| PMC_SLP_S3_N   | BJ3            | E0     |        | PMC_SLP_ S3_N    |               |                  |                   |        |        |
| LPE_I2S1_DATAIN                                      | BJ30           | SW37   |        | LPE_I2S1_ DATAIN |               |                  |                   |        |        |
| NFC_I2C_CLK  | BJ33           | SW54   |        | NFC_I2C_ CLK     |               |                  |                   |        |        |
| UART0_DATAIN   | BJ37           | SW77   |        |                  | UART0_ DATAIN |                  |                   |        |        |
| PMC_PLTRST_N   | BJ5            | E5     |        | PMC_PLTR ST_N    |               |                  |                   |        |        |
| PMC_WAKE_N   | BJ7            | E10    |        | PMC_WAK E_N      |               |                  |                   |        |        |
| PMC_SLP_S4_N   | BJ9            | E9     |        | PMC_SLP_ S4_N    |               |                  |                   |        |        |
| ISH_GPIO[6]/<br>I2S4_DATAOUT                         | BK10           | E25    |        | ISH_GPIO[ 6]     |               | I2S4_DATA OUT    |                   |        |        |
| MMC1_D[3]  | BK12           | SE26   |        | MMC1_D[3 ]       |               |                  |                   |        |        |
| MMC1_D[1]  | BK14           | SE24   |        | MMC1_D[1 ]       |               |                  |                   |        |        |
| SD3_D[0]   | BK16           | SE35   |        | SD3_D[0]         |               |                  |                   |        |        |
| SPI1_MOSI  | BK18           | SE64   |        | SPI1_MOS I       |               |                  |                   |        |        |
| LPC_CLKOUT[0]/<br>ISH_GPIO[10]/<br>ISH_UART_DATAO UT | BK20           | SE51   |        | LPC_CLKO UT[0]   | ISH_GPI O[10] |                  | ISH_UART _DATAOUT |        |        |
| PMC_SUSPWRDNCK                                       | BK22           | SE83   |        | PMC_SUSP WRDNACK |               |                  |                   |        |        |



Table 35. Multiplexed Functions - T4 SoC (Sheet 5 of 11)

| GPIO Pin Name                               | Package Ball # | GPIO # | Mode 0 | Mode 1           | Mode 2        | Mode 3        | Mode 4   | Mode 5 | Mode 6 |
|---|----------------|--------|--------|------------------|---------------|---------------|----------|--------|--------|
| FST_SPI_D[1]                                | BK26           | SW5    |        | FST_SPI_D[1]     |               |               |          |        |        |
| UART2_DATAOUT                               | BK28           | SW21   |        | UART2_DATAOUT    |               |               |          |        |        |
| LPE_I2S0_FRM                                | BK32           | SW35   |        | LPE_I2S0_FRM     |               |               |          |        |        |
| I2C5_CLK                                    | BK34           | SW50   |        | I2C5_CLK         |               |               |          |        |        |
| SPI3_MOSI                                   | BK36           | SW82   |        |                  | SPI3_MOSI     |               |          |        |        |
| LPE_I2S2_CLK                                | BK38           | SW92   |        | LPE_I2S2_CLK     |               |               |          |        |        |
| PMC_ACPRESENT                               | BK4            | E4     |        | PMC_ACPRESENT    |               |               |          |        |        |
| LPE_I2S2_DATAOUT                            | BK40           | SW97   |        | LPE_I2S2_DATAOUT |               |               |          |        |        |
| ISH_GPIO[9]/<br>ISH_SPI_MISO/<br>I2S5_FS    | BK8            | E20    |        | ISH_GPIO[9]      | ISH_SPI_MISO  | I2S5_FS       |          |        |        |
| SD2_CLK                                     | BL11           | SE19   |        | SD2_CLK          |               |               |          |        |        |
| SD3_D[3]                                    | BL15           | SE32   |        | SD3_D[3]         |               |               |          |        |        |
| SD3_CLK                                     | BL17           | SE31   |        | SD3_CLK          |               |               |          |        |        |
| SPI1_MISO                                   | BL19           | SE60   |        | SPI1_MISO        |               |               |          |        |        |
| LPC_CLKRUN_N/<br>UART0_DATAOUT/<br>SPI2_CLK | BL21           | SE46   |        | LPC_CLKRUN_N     | UART0_DATAOUT |               | SPI2_CLK |        |        |
| FST_SPI_D[3]                                | BL25           | SW3    |        | FST_SPI_D[3]     |               |               |          |        |        |
| UART2_CTS_N                                 | BL27           | SW22   |        | UART2_CTS_N      |               |               |          |        |        |
| PMC_SLP_S0IX_N                              | BL3            | E3     |        | PMC_SLP_S0IX_N   |               |               |          |        |        |
| I2C6_DATA/<br>SD3_WP                        | BL33           | SW49   |        | I2C6_DATA        | SD3_WP        |               |          |        |        |
| I2C2_CLK                                    | BL35           | SW66   |        | I2C2_CLK         |               |               |          |        |        |
| UART0_DATAOUT/<br>SPI3_CLK                  | BL37           | SW79   |        |                  | SPI3_CLK      | UART0_DATAOUT |          |        |        |



**Table 35. Multiplexed Functions - T4 SoC (Sheet 6 of 11)**

| GPIO Pin Name                                      | Package Ball # | GPIO # | Mode 0 | Mode 1           | Mode 2       | Mode 3       | Mode 4          | Mode 5 | Mode 6 |
|--|----------------|--------|--------|------------------|--------------|--------------|-----------------|--------|--------|
| LPE_I2S2_DATAIN                                    | BL39           | SW94   |        | LPE_I2S2_DATAIN  |              |              |                 |        |        |
| MMC1_D[0]  | BM12           | SE17   |        | MMC1_D[0]        |              |              |                 |        |        |
| MMC1_D[2]  | BM14           | SE20   |        | MMC1_D[2]        |              |              |                 |        |        |
| ISH_GPIO[7]/<br>I2S4_DATAIN                        | BM2            | E16    |        | ISH_GPIO[7]      |              | I2S4_DATAIN  |                 |        |        |
| LPC_CLKOUT[1]/<br>ISH_GPIO[11]/<br>ISH_UART_DATAIN | BM20           | SE49   |        | LPC_CLKOUT[1]    | ISH_GPIO[11] |              | ISH_UART_DATAIN |        |        |
| LPC_SERIRQ/<br>SPI2_CS[0]_N                        | BM24           | SE79   |        | LPC_SERIRQ       |              |              | SPI2_CS[0]_N    |        |        |
| LPE_I2S0_DATAOUT                                   | BM32           | SW30   |        | LPE_I2S0_DATAOUT |              |              |                 |        |        |
| SPI3_CS[0]_N                                       | BM38           | SW76   |        |                  |              | SPI3_CS[0]_N |                 |        |        |
| ISH_GPIO[3]/<br>I2S3_DATAIN                        | BM4            | E15    |        | ISH_GPIO[3]      |              | I2S3_DATAIN  |                 |        |        |
| PMC_SUSCLK[0]                                      | BM6            | E6     |        | PMC_SUSCLK[0]    |              |              |                 |        |        |
| ISH_I2C1_DATA/<br>ISH_SPI_MOSI/<br>I2S5_DATAOUT    | BM8            | E26    |        | ISH_I2C1_DATA    | ISH_SPI_MOSI | I2S5_DATAOUT |                 |        |        |
| SD2_CMD  | BN11           | SE22   |        | SD2_CMD          |              |              |                 |        |        |
| MMC1_CLK   | BN15           | SE16   |        | MMC1_CLK         |              |              |                 |        |        |
| SPI1_CLK   | BN19           | SE62   |        | SPI1_CLK         |              |              |                 |        |        |
| FST_SPI_D[0]                                       | BN25           | SW1    |        | FST_SPI_D[0]     |              |              |                 |        |        |
| ISH_I2C1_CLK/<br>ISH_SPI_CLK/<br>I2S5_DATAIN       | BN3            | E17    |        | ISH_I2C1_CLK     | ISH_SPI_CLK  | I2S5_DATAIN  |                 |        |        |
| NFC_I2C_DATA                                       | BN33           | SW51   |        | NFC_I2C_DATA     |              |              |                 |        |        |
| SPI3_MISO  | BN37           | SW81   |        |                  | SPI3_MISO    |              |                 |        |        |
| ISH_GPIO[1]/<br>I2S3_FS                            | BN5            | E18    |        | ISH_GPIO[1]      |              | I2S3_FS      |                 |        |        |
| SD2_D[3]_CD_N                                      | BP12           | SE15   |        | SD2_D[3]_CD_N    |              |              |                 |        |        |
| MMC1_D[6]  | BP14           | SE63   |        | MMC1_D[6]        |              |              |                 |        |        |



Table 35. Multiplexed Functions - T4 SoC (Sheet 7 of 11)

| GPIO Pin Name  | Package Ball # | GPIO # | Mode 0 | Mode 1           | Mode 2       | Mode 3           | Mode 4         | Mode 5 | Mode 6 |
|--|----------------|--------|--------|------------------|--------------|------------------|----------------|--------|--------|
| SD3_D[1]   | BP16           | SE30   |        | SD3_D[1]         |              |                  |                |        |        |
| USB_OC[0]_N  | BP22           | SE80   |        | USB_OC[0]_N      |              |                  |                |        |        |
| FST_SPI_CLK  | BP24           | SW2    |        | FST_SPI_CLK      |              |                  |                |        |        |
| LPE_I2S1_DATAOUT                                     | BP28           | SW34   |        | LPE_I2S1_DATAOUT |              |                  |                |        |        |
| I2C1_CLK   | BP36           | SW63   |        | I2C1_CLK         |              |                  |                |        |        |
| GPIO_SW93  | BP38           | SW93   |        |                  |              |                  |                |        |        |
| ISH_GPIO[5]/<br>I2S4_FS                              | BP4            | E19    |        | ISH_GPIO[5]      |              | I2S4_FS          |                |        |        |
| PMC_PLT_CLK[0]/<br>ISH_GPIO[10]/<br>ISH_UART_DATAOUT | BP8            | SE0    |        | PMC_PLT_CLK[0]   | ISH_GPIO[10] | ISH_UART_DATAOUT |                |        |        |
| SD2_D[1]   | BR11           | SE18   |        | SD2_D[1]         |              |                  |                |        |        |
| MMC1_D[4]  | BR13           | SE67   |        | MMC1_D[4]        |              |                  |                |        |        |
| SD3_CMD  | BR15           | SE34   |        | SD3_CMD          |              |                  |                |        |        |
| SPI1_CS[1]_N   | BR17           | SE66   |        | SPI1_CS[1]_N     |              |                  |                |        |        |
| LPC_AD[1]/<br>ISH_GPIO[13]/<br>ISH_UART_RTS_N        | BR19           | SE52   |        | LPC_AD[1]        | ISH_GPIO[13] |                  | ISH_UART_RTS_N |        |        |
| FST_SPI_CS[1]_N                                      | BR23           | SW4    |        | FST_SPI_CS[1]_N  |              |                  |                |        |        |
| UART1_RTS_N  | BR25           | SW15   |        | UART1_RTS_N      |              |                  |                |        |        |
| UART1_CTS_N  | BR27           | SW18   |        | UART1_CTS_N      |              |                  |                |        |        |
| ISH_GPIO[0]/<br>I2S3_CLK                             | BR3            | E21    |        | ISH_GPIO[0]      |              | I2S3_CLK         |                |        |        |
| LPE_I2S1_CLK   | BR30           | SW32   |        | LPE_I2S1_CLK     |              |                  |                |        |        |
| I2C5_DATA  | BR33           | SW45   |        | I2C5_DATA        |              |                  |                |        |        |
| I2C1_DATA  | BR35           | SW60   |        | I2C1_DATA        |              |                  |                |        |        |



**Table 35. Multiplexed Functions - T4 SoC (Sheet 8 of 11)**

| GPIO Pin Name                                 | Package Ball # | GPIO # | Mode 0 | Mode 1           | Mode 2        | Mode 3         | Mode 4         | Mode 5 | Mode 6 |
|---|----------------|--------|--------|------------------|---------------|----------------|----------------|--------|--------|
| ISH_GPIO[12]/<br>ISH_UART_CTS_N               | BR37           | SW75   |        |                  | ISH_GPIO[12]  | ISH_UART_CTS_N |                |        |        |
| PCIE_CLKREQ[0]_N                              | BR39           | SW90   |        | PCIE_CLKREQ[0]_N |               |                |                |        |        |
| SD2_D[0]                                      | BT10           | SE25   |        | SD2_D[0]         |               |                |                |        |        |
| MMC1_D[7]                                     | BT14           | SE68   |        | MMC1_D[7]        |               |                |                |        |        |
| SPI1_CS[0]_N                                  | BT18           | SE61   |        | SPI1_CS[0]_N     |               |                |                |        |        |
| ISH_GPIO[2]/<br>I2S3_DATAOUT                  | BT2            | E24    |        | ISH_GPIO[2]      |               | I2S3_DATAOUT   |                |        |        |
| SD3_1P8_EN                                    | BT22           | SE85   |        | SD3_1P8_EN       |               |                |                |        |        |
| UART1_DATAIN/<br>UART0_DATAIN                 | BT26           | SW16   |        | UART1_DATAIN     | UART0_DATAIN  |                |                |        |        |
| I2C0_CLK                                      | BT36           | SW65   |        | I2C0_CLK         |               |                |                |        |        |
| ISH_GPIO[4]/<br>I2S4_CLK                      | BT4            | E22    |        | ISH_GPIO[4]      |               | I2S4_CLK       |                |        |        |
| SD3_WP  | BT40           | SW95   |        |                  | SD3_WP        |                |                |        |        |
| SD2_D[2]                                      | BU11           | SE21   |        | SD2_D[2]         |               |                |                |        |        |
| MMC1_D[5]                                     | BU15           | SE65   |        | MMC1_D[5]        |               |                |                |        |        |
| SD3_CD_N                                      | BU17           | SE81   |        | SD3_CD_N         |               |                |                |        |        |
| LPC_AD[0]/<br>ISH_GPIO[12]/<br>ISH_UART_CTS_N | BU19           | SE47   |        | LPC_AD[0]        | ISH_GPIO[12]  |                | ISH_UART_CTS_N |        |        |
| USB_OC[1]_N                                   | BU21           | SE75   |        | USB_OC[1]_N      |               |                |                |        |        |
| SD3_PWREN_N                                   | BU23           | SE78   |        | SD3_PWREN_N      |               |                |                |        |        |
| FST_SPI_CS[0]_N                               | BU25           | SW6    |        | FST_SPI_CS[0]_N  |               |                |                |        |        |
| UART1_DATAOUT/<br>UART0_DATAOUT               | BU27           | SW20   |        | UART1_DATAOUT    | UART0_DATAOUT |                |                |        |        |
| LPE_I2S0_DATAIN                               | BU30           | SW33   |        | LPE_I2S0_DATAIN  |               |                |                |        |        |
| I2C3_DATA                                     | BU33           | SW64   |        | I2C3_DATA        |               |                |                |        |        |



Table 35. Multiplexed Functions - T4 SoC (Sheet 9 of 11)

| GPIO Pin Name                                | Package Ball # | GPIO # | Mode 0    | Mode 1           | Mode 2       | Mode 3           | Mode 4 | Mode 5 | Mode 6 |
|--|----------------|--------|-----------|------------------|--------------|------------------|--------|--------|--------|
| I2C0_DATA                                    | BU35           | SW61   |           | I2C0_DATA        |              |                  |        |        |        |
| GPIO_SW78                                    | BU37           | SW78   |           |                  |              |                  |        |        |        |
| PCIE_CLKREQ[1]_N                             | BU39           | SW91   |           | PCIE_CLKREQ[1]_N |              |                  |        |        |        |
| PWM[1]/<br>ISH_GPIO[10]/<br>ISH_UART_DATAOUT | BU5            | SE1    |           | PWM[1]           | ISH_GPIO[10] | ISH_UART_DATAOUT |        |        |        |
| FST_SPI_CS[2]_N                              | BV24           | SW7    |           | FST_SPI_CS[2]_N  |              |                  |        |        |        |
| LPE_I2S1_FRM                                 | BV28           | SW36   |           | LPE_I2S1_FRM     |              |                  |        |        |        |
| I2C3_CLK                                     | BV34           | SW67   |           | I2C3_CLK         |              |                  |        |        |        |
| MMC1_RESET_N/<br>SPI3_CS[1]_N                | BV38           | SW80   |           |                  | MMC1_RESET_N | SPI3_CS[1]_N     |        |        |        |
| PWM[0]                                       | BV4            | SE5    |           | PWM[0]           |              |                  |        |        |        |
| DDI2_HPD                                     | C21            | N68    |           | DDI2_HPD         |              |                  |        |        |        |
| GPIO_CAMERASB07                              | C27            | N54    |           | GPIO_CAMERASB07  |              |                  |        |        |        |
| GPIO_CAMERASB04                              | C30            | N56    |           | GPIO_CAMERASB04  |              |                  |        |        |        |
| SVID_ALERT_N                                 | C33            | N38    |           | SVID_ALERT_N     |              |                  |        |        |        |
| GPIO_SUS5/<br>PMC_SUSCLK[1]                  | C35            | N20    |           | PMC_SUSCLK[1]    |              |                  |        |        |        |
| GPIO_SUS3/<br>JTAG2_TDI                      | C37            | N17    |           | JTAG2_TDI        |              |                  |        |        |        |
| GPIO_CAMERASB10                              | D26            | N50    |           | GPIO_CAMERASB10  |              |                  |        |        |        |
| SVID_DATA                                    | D32            | N33    | SVID_DATA |                  |              |                  |        |        |        |
| GPIO_SUS6/<br>PMC_SUSCLK[2]                  | D36            | N25    |           | PMC_SUSCLK[2]    |              |                  |        |        |        |
| DDI1_HPD                                     | E25            | N64    |           | DDI1_HPD         |              |                  |        |        |        |
| GPIO_CAMERASB06                              | E27            | N49    |           | GPIO_CAMERASB06  |              |                  |        |        |        |
| GPIO_CAMERASB02                              | E30            | N46    |           | GPIO_CAMERASB02  |              |                  |        |        |        |
| JTAG_TDI                                     | E33            | N41    |           | JTAG_TDI         |              |                  |        |        |        |



**Table 35. Multiplexed Functions - T4 SoC (Sheet 10 of 11)**

| GPIO Pin Name                            | Package Ball # | GPIO # | Mode 0 | Mode 1          | Mode 2        | Mode 3    | Mode 4    | Mode 5 | Mode 6 |
|--|----------------|--------|--------|-----------------|---------------|-----------|-----------|--------|--------|
| JTAG_TRST_N                              | E35            | N30    |        | JTAG_TRST_N     |               |           |           |        |        |
| GPIO_SUS0                                | E37            | N15    |        |                 |               |           |           |        |        |
| DDIO_VDDEN                               | F22            | N72    |        | DDIO_VDDEN      |               |           |           |        |        |
| GPIO_CAMERASB11                          | F28            | N55    |        | GPIO_CAMERASB11 |               |           |           |        |        |
| SVID_CLK                                 | F32            | N40    |        | SVID_CLK        |               |           |           |        |        |
| JTAG_TCK                                 | F34            | N31    |        | JTAG_TCK        |               |           |           |        |        |
| GPIO_SUS8                                | F36            | N23    |        | GPIO_SUS8       |               |           |           |        |        |
| GPIO_CAMERASB05                          | G27            | N45    |        | GPIO_CAMERASB05 |               |           |           |        |        |
| JTAG_PRDY_N                              | G33            | N37    |        | JTAG_PRDY_N     |               |           |           |        |        |
| GPIO_SUS4/<br>JTAG2_TDO                  | G37            | N22    |        | JTAG2_TDO       |               |           |           |        |        |
| DDI1_VDDEN/<br>MDSI_DDC_DATA             | H22            | N69    |        | DDI1_VDDEN      | MDSI_DDC_DATA |           |           |        |        |
| PROCHOT_N                                | H32            | N32    |        | PROCHOT_N       |               |           |           |        |        |
| JTAG_PREQ_N                              | H34            | N26    |        | JTAG_PREQ_N     |               |           |           |        |        |
| GPIO_DFX4                                | H38            | N5     |        |                 |               |           |           |        |        |
| DDI1_BKLTEN/<br>MDSI_DDC_CLK             | J21            | N70    |        | DDI1_BKLTEN     | MDSI_DDC_CLK  |           |           |        |        |
| GPIO_CAMERASB09                          | J27            | N52    |        | GPIO_CAMERASB09 |               |           |           |        |        |
| GPIO_CAMERASB00                          | J30            | N48    |        | GPIO_CAMERASB00 |               |           |           |        |        |
| JTAG_TDO                                 | J33            | N39    |        | JTAG_TDO        |               |           |           |        |        |
| GPIO_SUS9                                | J35            | N27    |        | GPIO_SUS9       |               |           |           |        |        |
| DDI1_BKLTCTL/<br>MDSI_A_TE/<br>MDSI_C_TE | K20            | N63    |        | DDI1_BKLTCTL    |               | MDSI_A_TE | MDSI_C_TE |        |        |
| DDIO_BKLTCTL                             | K22            | N65    |        | DDIO_BKLTCTL    |               |           |           |        |        |
| DDIO_HPD                                 | K26            | N61    |        | DDIO_HPD        |               |           |           |        |        |
| GPIO_CAMERASB08                          | K28            | N47    |        | GPIO_CAMERASB08 |               |           |           |        |        |





Table 35. Multiplexed Functions - T4 SoC (Sheet 11 of 11)

| GPIO Pin Name               | Package Ball # | GPIO # | Mode 0 | Mode 1          | Mode 2 | Mode 3 | Mode 4 | Mode 5 | Mode 6 |
|-----------------------------|----------------|--------|--------|-----------------|--------|--------|--------|--------|--------|
| GPIO_CAMERASB01             | K32            | N53    |        | GPIO_CAMERASB01 |        |        |        |        |        |
| GPIO_SUS10                  | K34            | N16    |        | GPIO_SUS10      |        |        |        |        |        |
| GPIO_SUS7/<br>PMC_SUSCLK[3] | K36            | N18    |        | PMC_SUSCLK[3]   |        |        |        |        |        |
| GPIO_SUS1/<br>JTAG2_TCK     | K38            | N19    |        | JTAG2_TCK       |        |        |        |        |        |
| DDIO_BKLTEN                 | L21            | N60    |        | DDIO_BKLTEN     |        |        |        |        |        |

Table 36. Multiplexed Functions - T3 SoC (Sheet 1 of 9)

| GPIO Pin Name   | Package Ball # | GPIO # | Mode 0 | Mode 1         | Mode 2        | Mode 3         | Mode 4        | Mode 5 | Mode 6 |
|---|----------------|--------|--------|----------------|---------------|----------------|---------------|--------|--------|
| DDIO_DDC_CLK/<br>DDI1_DDC_CLK/<br>MDSI_DDC_CLK                      | A10            | N71    |        | DDIO_DDC_CLK   | DDI1_DDC_CLK  | MDSI_DDC_CLK   |               |        |        |
| GPIO_SE79   | AA13           | SE79   |        |                |               |                |               |        |        |
| I2C4_CLK/<br>DDI1_DDC_CLK/<br>DDI2_DDC_CLK/<br>MDSI_DDC_CLK         | AB17           | SW52   |        | I2C4_CLK       | DDI1_DDC_CLK  | DDI2_DDC_CLK   | MDSI_DDC_CLK  |        |        |
| I2C4_DATA/<br>DDI1_DDC_DATA/<br>DDI2_DDC_DATA/<br>MDSI_DDC_DATA     | AB18           | SW46   |        | I2C4_DATA      | DDI1_DDC_DATA | DDI2_DDC_DATA  | MDSI_DDC_DATA |        |        |
| PMC_PLT_CLK[3]/<br>ISH_GPIO[13]/<br>ISH_UART_RTS_N/<br>SPI2_CLK     | AB4            | SE4    |        | PMC_PLT_CLK[3] | ISH_GPIO[13]  | ISH_UART_RTS_N | SPI2_CLK      |        |        |
| PMC_PLT_CLK[4]/<br>ISH_GPIO[14]/<br>ISH_I2C0_DATA/<br>SPI2_MISO     | AC3            | SE3    |        | PMC_PLT_CLK[4] | ISH_GPIO[14]  | ISH_I2C0_DATA  | SPI2_MISO     |        |        |
| PMC_PLT_CLK[2]/<br>ISH_GPIO[12]/<br>ISH_UART_CTS_N/<br>SPI2_CS[0]_N | AC4            | SE7    |        | PMC_PLT_CLK[2] | ISH_GPIO[12]  | ISH_UART_CTS_N | SPI2_CS[0]_N  |        |        |
| PMC_PLT_CLK[5]/<br>ISH_GPIO[15]/<br>ISH_I2C0_CLK/<br>SPI2_MOSI      | AE3            | SE6    |        | PMC_PLT_CLK[5] | ISH_GPIO[15]  | ISH_I2C0_CLK   | SPI2_MOSI     |        |        |



**Table 36. Multiplexed Functions - T3 SoC (Sheet 2 of 9)**

| GPIO Pin Name  | Package Ball # | GPIO # | Mode 0 | Mode 1            | Mode 2            | Mode 3            | Mode 4            | Mode 5         | Mode 6         |
|--|----------------|--------|--------|-------------------|-------------------|-------------------|-------------------|----------------|----------------|
| MMC1_RCLK/<br>MMC1_RESET_N   | AE8            | SE69   |        | MMC1_R<br>CLK     | MMC1_R<br>ESET_N  |                   |                   |                |                |
| PMC_SUSCLK[3]  | B12            | N18    |        | PMC_SUS<br>CLK[3] |                   |                   |                   |                |                |
| JTAG2_TDI  | B14            | N17    |        | JTAG2_T<br>DI     |                   |                   |                   |                |                |
| DDI0_DDC_DATA/<br>DDI1_DDC_DATA/<br>MDSI_DDC_DATA                                | C10            | N66    |        | DDI0_DD<br>C_DATA | DDI1_DD<br>C_DATA | MDSI_D<br>DC_DATA |                   |                |                |
| PMC_SUSCLK[2]  | C14            | N25    |        | PMC_SUS<br>CLK[2] |                   |                   |                   |                |                |
| JTAG2_TCK  | C15            | N19    |        | JTAG2_TC<br>K     |                   |                   |                   |                |                |
| GPIO_N3/<br>C0_BPM1_TX/<br>C1_BPM1_TX  | C17            | N3     |        |                   |                   |                   |                   | C0_BPM<br>1_TX | C1_BPM1<br>_TX |
| DDI2_DDC_DATA/<br>DDI1_DDC_DATA/<br>UART0_DATAIN/<br>MDSI_DDC_DATA/<br>MDSI_C_TE | C9             | N62    |        | DDI2_DD<br>C_DATA | DDI1_DD<br>C_DATA | UART0_D<br>ATAIN  | MDSI_DDC<br>_DATA | MDSI_C<br>_TE  |                |
| JTAG2_TDO  | D14            | N22    |        | JTAG2_T<br>DO     |                   |                   |                   |                |                |
| JTAG2_TMS  | D15            | N24    |        | JTAG2_T<br>MS     |                   |                   |                   |                |                |
| DDI1_BKLTCTL/<br>MDSI_A_TE/<br>MDSI_C_TE   | D8             | N63    |        | DDI1_BK<br>LTCTL  |                   | MDSI_A_<br>TE     | MDSI_C_T<br>E     |                |                |
| DDI2_DDC_CLK/<br>DDI1_DDC_CLK/<br>UART0_DATAOUT/<br>MDSI_DDC_CLK/<br>MDSI_A_TE   | E10            | N67    |        | DDI2_DD<br>C_CLK  | DDI1_DD<br>C_CLK  | UART0_D<br>ATAOUT | MDSI_DDC<br>_CLK  | MDSI_A<br>_TE  |                |
| GPIO_N4/<br>C0_BPM0_TX/<br>C1_BPM0_TX  | E16            | N4     |        |                   |                   |                   |                   | C0_BPM<br>0_TX | C1_BPM0<br>_TX |
| GPIO_N0/<br>C0_BPM0_TX/<br>C1_BPM0_TX  | E17            | N0     |        |                   |                   |                   |                   | C0_BPM<br>0_TX | C1_BPM0<br>_TX |
| GPIO_N2/<br>C0_BPM2_TX/<br>C1_BPM2_TX  | F16            | N2     |        |                   |                   |                   |                   | C0_BPM<br>2_TX | C1_BPM2<br>_TX |



Table 36. Multiplexed Functions - T3 SoC (Sheet 3 of 9)

| GPIO Pin Name                                | Package Ball # | GPIO # | Mode 0 | Mode 1           | Mode 2        | Mode 3      | Mode 4       | Mode 5     | Mode 6     |
|--|----------------|--------|--------|------------------|---------------|-------------|--------------|------------|------------|
| GPIO_N1/<br>C0_BPM3_TX/<br>C1_BPM3_TX        | F17            | N1     |        |                  |               |             |              | C0_BPM3_TX | C1_BPM3_TX |
| UART0_DATAIN                                 | V13            | SE48   |        |                  | UART0_DATAIN  |             |              |            |            |
| PMC_SLP_S0IX_N                               | W4             | E3     |        | PMC_SLP_S0IX_N   |               |             |              |            |            |
| UART0_DATAOUT                                | Y12            | SE46   |        |                  | UART0_DATAOUT |             |              |            |            |
| GPIO_N6/<br>C0_BPM3_TX/<br>C1_BPM3_TX        | C16            | N6     |        |                  |               |             |              | C0_BPM3_TX | C1_BPM3_TX |
| GPIO_N8/<br>C0_BPM1_TX/<br>C1_BPM1_TX        | D16            | N8     |        |                  |               |             |              | C0_BPM1_TX | C1_BPM1_TX |
| ISH_GPIO[13]/<br>C0_BPM2_TX/<br>C1_BPM2_TX   | D17            | N7     |        |                  |               |             | ISH_GPIO[13] | C0_BPM2_TX | C1_BPM2_TX |
| GPIO_SUS9                                    | A13            | N27    |        | GPIO_SUS9        |               |             |              |            |            |
| GPIO_SUS0                                    | A14            | N15    |        |                  |               |             |              |            |            |
| DDI0_VDDEN                                   | A9             | N72    |        | DDI0_VDDEN       |               |             |              |            |            |
| SD3_CMD                                      | AA10           | SE34   |        | SD3_CMD          |               |             |              |            |            |
| FST_SPI_CS[0]_N                              | AA12           | SW6    |        | FST_SPI_CS[0]_N  |               |             |              |            |            |
| LPE_I2S1_FRM                                 | AA14           | SW36   |        | LPE_I2S1_FRM     |               |             |              |            |            |
| LPE_I2S0_DATAOUT                             | AA15           | SW30   |        | LPE_I2S0_DATAOUT |               |             |              |            |            |
| LPE_I2S0_CLK                                 | AA16           | SW31   |        | LPE_I2S0_CLK     |               |             |              |            |            |
| I2C2_CLK                                     | AA17           | SW66   |        | I2C2_CLK         |               |             |              |            |            |
| ISH_I2C1_CLK/<br>ISH_SPI_CLK/<br>I2S5_DATAIN | AA3            | E17    |        | ISH_I2C1_CLK     | ISH_SPI_CLK   | I2S5_DATAIN |              |            |            |



**Table 36. Multiplexed Functions - T3 SoC (Sheet 4 of 9)**

| <b>GPIO Pin Name</b>                            | <b>Package Ball #</b> | <b>GPIO #</b> | <b>Mode 0</b> | <b>Mode 1</b>    | <b>Mode 2</b> | <b>Mode 3</b> | <b>Mode 4</b> | <b>Mode 5</b> | <b>Mode 6</b> |
|---|-----------------------|---------------|---------------|------------------|---------------|---------------|---------------|---------------|---------------|
| ISH_GPIO[9]/<br>ISH_SPI_MISO/<br>I2S5_FS        | AA4                   | E20           |               | ISH_GPIO[9]      | ISH_SPI_MISO  | I2S5_FS       |               |               |               |
| ISH_I2C1_DATA/<br>ISH_SPI_MOSI/<br>I2S5_DATAOUT | AA5                   | E26           |               | ISH_I2C1_DATA    | ISH_SPI_MOSI  | I2S5_DATAOUT  |               |               |               |
| MMC1_CMD  | AA6                   | SE23          |               | MMC1_CMD         |               |               |               |               |               |
| MMC1_D[7]                                       | AA7                   | SE68          |               | MMC1_D[7]        |               |               |               |               |               |
| MMC1_D[0]                                       | AA8                   | SE17          |               | MMC1_D[0]        |               |               |               |               |               |
| SD3_PWREN_N                                     | AA9                   | SE78          |               | SD3_PWREN_N      |               |               |               |               |               |
| SD3_D[2]  | AB10                  | SE33          |               | SD3_D[2]         |               |               |               |               |               |
| FST_SPI_D[0]                                    | AB11                  | SW1           |               | FST_SPI_D[0]     |               |               |               |               |               |
| FST_SPI_CLK                                     | AB12                  | SW2           |               | FST_SPI_CLK      |               |               |               |               |               |
| UART2_DATAOUT                                   | AB13                  | SW21          |               | UART2_DATAOUT    |               |               |               |               |               |
| LPE_I2S1_CLK                                    | AB14                  | SW32          |               | LPE_I2S1_CLK     |               |               |               |               |               |
| LPE_I2S0_DATAIN                                 | AB15                  | SW33          |               | LPE_I2S0_DATAIN  |               |               |               |               |               |
| I2C5_CLK  | AB16                  | SW50          |               | I2C5_CLK         |               |               |               |               |               |
| LPE_I2S2_CLK                                    | AB19                  | SW92          |               | LPE_I2S2_CLK     |               |               |               |               |               |
| ISH_GPIO[0]/<br>I2S3_CLK                        | AB2                   | E21           |               | ISH_GPIO[0]      |               | I2S3_CLK      |               |               |               |
| PCIE_CLKREQ[0]_N                                | AB20                  | SW90          |               | PCIE_CLKREQ[0]_N |               |               |               |               |               |
| ISH_GPIO[2]/<br>I2S3_DATAOUT                    | AB3                   | E24           |               | ISH_GPIO[2]      |               | I2S3_DATAOUT  |               |               |               |
| SD2_CMD   | AB5                   | SE22          |               | SD2_CMD          |               |               |               |               |               |
| MMC1_D[2]                                       | AB6                   | SE20          |               | MMC1_D[2]        |               |               |               |               |               |



Table 36. Multiplexed Functions - T3 SoC (Sheet 5 of 9)

| GPIO Pin Name                   | Package Ball # | GPIO # | Mode 0 | Mode 1        | Mode 2        | Mode 3      | Mode 4 | Mode 5 | Mode 6 |
|---------------------------------|----------------|--------|--------|---------------|---------------|-------------|--------|--------|--------|
| MMC1_D[6]                       | AB7            | SE63   |        | MMC1_D[6]     |               |             |        |        |        |
| SD3_1P8_EN                      | AB8            | SE85   |        | SD3_1P8_EN    |               |             |        |        |        |
| SD3_D[1]                        | AB9            | SE30   |        | SD3_D[1]      |               |             |        |        |        |
| ISH_GPIO[7]/<br>I2S4_DATAIN     | AC1            | E16    |        | ISH_GPIO[7]   |               | I2S4_DATAIN |        |        |        |
| SD3_D[0]                        | AC10           | SE35   |        | SD3_D[0]      |               |             |        |        |        |
| FST_SPI_D[1]                    | AC11           | SW5    |        | FST_SPI_D[1]  |               |             |        |        |        |
| UART2_RTS_N                     | AC12           | SW19   |        | UART2_RTS_N   |               |             |        |        |        |
| UART1_CTS_N                     | AC13           | SW18   |        | UART1_CTS_N   |               |             |        |        |        |
| UART1_DATAOUT/<br>UART0_DATAOUT | AC14           | SW20   |        | UART1_DATAOUT | UART0_DATAOUT |             |        |        |        |
| NFC_I2C_DATA                    | AC15           | SW51   |        | NFC_I2C_DATA  |               |             |        |        |        |
| NFC_I2C_CLK                     | AC16           | SW54   |        | NFC_I2C_CLK   |               |             |        |        |        |
| I2C2_DATA                       | AC17           | SW62   |        | I2C2_DATA     |               |             |        |        |        |
| GPIO_SW78                       | AC18           | SW78   |        |               |               |             |        |        |        |
| LPE_I2S2_FRM                    | AC19           | SW96   |        | LPE_I2S2_FRM  |               |             |        |        |        |
| ISH_GPIO[4]/<br>I2S4_CLK        | AC2            | E22    |        | ISH_GPIO[4]   |               | I2S4_CLK    |        |        |        |
| GPIO_SW93                       | AC20           | SW93   |        |               |               |             |        |        |        |
| MMC1_D[3]                       | AC6            | SE26   |        | MMC1_D[3]     |               |             |        |        |        |
| MMC1_D[4]                       | AC7            | SE67   |        | MMC1_D[4]     |               |             |        |        |        |



**Table 36. Multiplexed Functions - T3 SoC (Sheet 6 of 9)**

| GPIO Pin Name                                | Package Ball # | GPIO # | Mode 0 | Mode 1        | Mode 2       | Mode 3           | Mode 4 | Mode 5 | Mode 6 |
|--|----------------|--------|--------|---------------|--------------|------------------|--------|--------|--------|
| MMC1_D[5]                                    | AC8            | SE65   |        | MMC1_D[5]     |              |                  |        |        |        |
| SD3_CLK                                      | AC9            | SE31   |        | SD3_CLK       |              |                  |        |        |        |
| SD3_D[3]                                     | AD10           | SE32   |        | SD3_D[3]      |              |                  |        |        |        |
| UART2_CTS_N                                  | AD12           | SW22   |        | UART2_CTS_N   |              |                  |        |        |        |
| UART1_DATAIN/<br>UART0_DATAIN                | AD14           | SW16   |        | UART1_DATAIN  | UART0_DATAIN |                  |        |        |        |
| I2C6_DATA/<br>SD3_WP                         | AD16           | SW49   |        | I2C6_DATA     | SD3_WP       |                  |        |        |        |
| MMC1_RESET_N                                 | AD18           | SW80   |        |               | MMC1_RESET_N |                  |        |        |        |
| PWM[1]/<br>ISH_GPIO[10]/<br>ISH_UART_DATAOUT | AD2            | SE1    |        | PWM[1]        | ISH_GPIO[10] | ISH_UART_DATAOUT |        |        |        |
| SD3_WP                                       | AD20           | SW95   |        |               | SD3_WP       |                  |        |        |        |
| PWM[0]                                       | AD3            | SE5    |        | PWM[0]        |              |                  |        |        |        |
| SD2_D[0]                                     | AD4            | SE25   |        | SD2_D[0]      |              |                  |        |        |        |
| SD2_CLK                                      | AD5            | SE19   |        | SD2_CLK       |              |                  |        |        |        |
| SD2_D[3]_CD_N                                | AD6            | SE15   |        | SD2_D[3]_CD_N |              |                  |        |        |        |
| MMC1_CLK                                     | AD8            | SE16   |        | MMC1_CLK      |              |                  |        |        |        |
| UART2_DATAIN                                 | AE12           | SW17   |        | UART2_DATAIN  |              |                  |        |        |        |
| UART1_RTS_N                                  | AE13           | SW15   |        | UART1_RTS_N   |              |                  |        |        |        |
| I2C6_CLK/NMI_N                               | AE16           | SW53   |        | I2C6_CLK      | NMI_N        |                  |        |        |        |
| I2C5_DATA                                    | AE17           | SW45   |        | I2C5_DATA     |              |                  |        |        |        |
| UART0_DATAIN                                 | AE18           | SW77   |        |               | UART0_DATAIN |                  |        |        |        |



Table 36. Multiplexed Functions - T3 SoC (Sheet 7 of 9)

| GPIO Pin Name   | Package Ball # | GPIO # | Mode 0    | Mode 1          | Mode 2 | Mode 3 | Mode 4 | Mode 5 | Mode 6 |
|-----------------|----------------|--------|-----------|-----------------|--------|--------|--------|--------|--------|
| SD2_D[1]        | AE4            | SE18   |           | SD2_D[1]        |        |        |        |        |        |
| SD2_D[2]        | AE5            | SE21   |           | SD2_D[2]        |        |        |        |        |        |
| SD3_CD_N        | AE9            | SE81   |           | SD3_CD_N        |        |        |        |        |        |
| GPIO_CAMERASB10 | B10            | N50    |           | GPIO_CAMERASB10 |        |        |        |        |        |
| DDIO_BKLTCTL    | B8             | N65    |           | DDIO_BKLTCTL    |        |        |        |        |        |
| GPIO_CAMERASB11 | C11            | N55    |           | GPIO_CAMERASB11 |        |        |        |        |        |
| JTAG_TDI        | C12            | N41    |           | JTAG_TDI        |        |        |        |        |        |
| GPIO_SUS8       | C13            | N23    |           | GPIO_SUS8       |        |        |        |        |        |
| DDIO_BKLTEN     | C8             | N60    |           | DDIO_BKLTEN     |        |        |        |        |        |
| GPIO_CAMERASB09 | D10            | N52    |           | GPIO_CAMERASB09 |        |        |        |        |        |
| GPIO_CAMERASB08 | D11            | N47    |           | GPIO_CAMERASB08 |        |        |        |        |        |
| DDIO_HPDP       | D9             | N61    |           | DDIO_HPDP       |        |        |        |        |        |
| SVID_ALERT_N    | E12            | N38    |           | SVID_ALERT_N    |        |        |        |        |        |
| JTAG_TRST_N     | E13            | N30    |           | JTAG_TRST_N     |        |        |        |        |        |
| JTAG_TCK        | E14            | N31    |           | JTAG_TCK        |        |        |        |        |        |
| DDI2_HPDP       | E9             | N68    |           | DDI2_HPDP       |        |        |        |        |        |
| SVID_CLK        | F11            | N40    |           | SVID_CLK        |        |        |        |        |        |
| SVID_DATA       | F12            | N33    | SVID_DATA |                 |        |        |        |        |        |
| JTAG_TDO        | F13            | N39    |           | JTAG_TDO        |        |        |        |        |        |



**Table 36. Multiplexed Functions - T3 SoC (Sheet 8 of 9)**

| GPIO Pin Name           | Package Ball # | GPIO # | Mode 0 | Mode 1           | Mode 2 | Mode 3      | Mode 4 | Mode 5 | Mode 6 |
|-------------------------|----------------|--------|--------|------------------|--------|-------------|--------|--------|--------|
| JTAG_TMS                | F14            | N34    |        | JTAG_TMS         |        |             |        |        |        |
| GPIO_DFX4               | F18            | N5     |        |                  |        |             |        |        |        |
| PROCHOT_N               | F9             | N32    |        | PROCHOT_N        |        |             |        |        |        |
| LPE_I2S2_DATAIN         | U17            | SW94   |        | LPE_I2S2_DATAIN  |        |             |        |        |        |
| PMC_SUSPWRDNACK         | V12            | SE83   |        | PMC_SUSPWRDNACK  |        |             |        |        |        |
| LPE_I2S2_DATAOUT        | V18            | SW97   |        | LPE_I2S2_DATAOUT |        |             |        |        |        |
| PMC_SUS_STAT_N          | V5             | E2     |        | PMC_SUS_STAT_N   |        |             |        |        |        |
| I2C1_DATA               | W15            | SW60   |        | I2C1_DATA        |        |             |        |        |        |
| I2C1_CLK                | W16            | SW63   |        | I2C1_CLK         |        |             |        |        |        |
| PMC_PWRBTN_N            | W3             | E8     |        | PMC_PWRBTN_N     |        |             |        |        |        |
| ISH_GPIO[3]/I2S3_DATAIN | Y1             | E15    |        | ISH_GPIO[3]      |        | I2S3_DATAIN |        |        |        |
| LPE_I2S1_DATAIN         | Y13            | SW37   |        | LPE_I2S1_DATAIN  |        |             |        |        |        |
| LPE_I2S1_DATAOUT        | Y14            | SW34   |        | LPE_I2S1_DATAOUT |        |             |        |        |        |
| LPE_I2S0_FRM            | Y16            | SW35   |        | LPE_I2S0_FRM     |        |             |        |        |        |
| I2C0_CLK                | Y17            | SW65   |        | I2C0_CLK         |        |             |        |        |        |





Table 36. Multiplexed Functions - T3 SoC (Sheet 9 of 9)

| GPIO Pin Name           | Package Ball # | GPIO # | Mode 0 | Mode 1        | Mode 2 | Mode 3  | Mode 4 | Mode 5 | Mode 6 |
|-------------------------|----------------|--------|--------|---------------|--------|---------|--------|--------|--------|
| I2C0_DATA               | Y18            | SW61   |        | I2C0_DATA     |        |         |        |        |        |
| ISH_GPIO[1]/<br>I2S3_FS | Y2             | E18    |        | ISH_GPIO[1]   |        | I2S3_FS |        |        |        |
| PMC_WAKE_N              | Y3             | E10    |        | PMC_WAKE_N    |        |         |        |        |        |
| PMC_SUSCLK[0]           | Y4             | E6     |        | PMC_SUSCLK[0] |        |         |        |        |        |
| PMC_PLTRST_N            | Y5             | E5     |        | PMC_PLTRST_N  |        |         |        |        |        |
| MMC1_D[1]               | Y8             | SE24   |        | MMC1_D[1]     |        |         |        |        |        |
| USB_OC[0]_N             | Y9             | SE80   |        | USB_OC[1]_N   |        |         |        |        |        |

Table 37. Multiplexed Functions - T3 SoC (Sheet 1 of 9)

| GPIO Pin Name   | Package Ball # | GPIO # | Mode 0 | Mode 1         | Mode 2        | Mode 3         | Mode 4        | Mode 5 | Mode 6 |
|---|----------------|--------|--------|----------------|---------------|----------------|---------------|--------|--------|
| DDI0_DDC_CLK/<br>DDI1_DDC_CLK/<br>MDSI_DDC_CLK                  | A10            | N71    |        | DDI0_DDC_CLK   | DDI1_DDC_CLK  | MDSI_DDC_CLK   |               |        |        |
| GPIO_SE79   | AA13           | SE79   |        |                |               |                |               |        |        |
| I2C4_CLK/<br>DDI1_DDC_CLK/<br>DDI2_DDC_CLK/<br>MDSI_DDC_CLK     | AB17           | SW52   |        | I2C4_CLK       | DDI1_DDC_CLK  | DDI2_DDC_CLK   | MDSI_DDC_CLK  |        |        |
| I2C4_DATA/<br>DDI1_DDC_DATA/<br>DDI2_DDC_DATA/<br>MDSI_DDC_DATA | AB18           | SW46   |        | I2C4_DATA      | DDI1_DDC_DATA | DDI2_DDC_DATA  | MDSI_DDC_DATA |        |        |
| PMC_PLT_CLK[3]/<br>ISH_GPIO[13]/<br>ISH_UART_RTS_N/<br>SPI2_CLK | AB4            | SE4    |        | PMC_PLT_CLK[3] | ISH_GPIO[13]  | ISH_UART_RTS_N | SPI2_CLK      |        |        |



**Table 37. Multiplexed Functions - T3 SoC (Sheet 2 of 9)**

| GPIO Pin Name  | Package Ball # | GPIO # | Mode 0 | Mode 1         | Mode 2        | Mode 3         | Mode 4        | Mode 5     | Mode 6     |
|--|----------------|--------|--------|----------------|---------------|----------------|---------------|------------|------------|
| PMC_PLT_CLK[4]/<br>ISH_GPIO[14]/<br>ISH_I2C0_DATA/<br>SPI2_MISO                  | AC3            | SE3    |        | PMC_PLT_CLK[4] | ISH_GPIO[14]  | ISH_I2C0_DATA  | SPI2_MISO     |            |            |
| PMC_PLT_CLK[2]/<br>ISH_GPIO[12]/<br>ISH_UART_CTS_N/<br>SPI2_CS[0]_N              | AC4            | SE7    |        | PMC_PLT_CLK[2] | ISH_GPIO[12]  | ISH_UART_CTS_N | SPI2_CS[0]_N  |            |            |
| PMC_PLT_CLK[5]/<br>ISH_GPIO[15]/<br>ISH_I2C0_CLK/<br>SPI2_MOSI                   | AE3            | SE6    |        | PMC_PLT_CLK[5] | ISH_GPIO[15]  | ISH_I2C0_CLK   | SPI2_MOSI     |            |            |
| MMC1_RCLK/<br>MMC1_RESET_N   | AE8            | SE69   |        | MMC1_RCLK      | MMC1_RESET_N  |                |               |            |            |
| PMC_SUSCLK[3]  | B12            | N18    |        | PMC_SUSCLK[3]  |               |                |               |            |            |
| JTAG2_TDI  | B14            | N17    |        | JTAG2_TDI      |               |                |               |            |            |
| DDI0_DDC_DATA/<br>DDI1_DDC_DATA/<br>MDSI_DDC_DATA                                | C10            | N66    |        | DDI0_DDC_DATA  | DDI1_DDC_DATA | MDSI_DDC_DATA  |               |            |            |
| PMC_SUSCLK[2]  | C14            | N25    |        | PMC_SUSCLK[2]  |               |                |               |            |            |
| JTAG2_TCK  | C15            | N19    |        | JTAG2_TCK      |               |                |               |            |            |
| GPIO_N3/<br>C0_BPM1_TX/<br>C1_BPM1_TX  | C17            | N3     |        |                |               |                |               | C0_BPM1_TX | C1_BPM1_TX |
| DDI2_DDC_DATA/<br>DDI1_DDC_DATA/<br>UART0_DATAIN/<br>MDSI_DDC_DATA/<br>MDSI_C_TE | C9             | N62    |        | DDI2_DDC_DATA  | DDI1_DDC_DATA | UART0_DATAIN   | MDSI_DDC_DATA | MDSI_C_TE  |            |
| JTAG2_TDO  | D14            | N22    |        | JTAG2_TDO      |               |                |               |            |            |
| JTAG2_TMS  | D15            | N24    |        | JTAG2_TMS      |               |                |               |            |            |
| DDI1_BKLTCTL/<br>MDSI_A_TE/<br>MDSI_C_TE   | D8             | N63    |        | DDI1_BKLTCTL   |               | MDSI_A_TE      | MDSI_C_TE     |            |            |



Table 37. Multiplexed Functions - T3 SoC (Sheet 3 of 9)

| GPIO Pin Name  | Package Ball # | GPIO # | Mode 0 | Mode 1              | Mode 2           | Mode 3            | Mode 4           | Mode 5         | Mode 6         |
|--|----------------|--------|--------|---------------------|------------------|-------------------|------------------|----------------|----------------|
| DDI2_DDC_CLK/<br>DDI1_DDC_CLK/<br>UART0_DATAOUT/<br>MDSI_DDC_CLK/<br>MDSI_A_TE | E10            | N67    |        | DDI2_DD<br>C_CLK    | DDI1_DD<br>C_CLK | UART0_D<br>ATAOUT | MDSI_DDC<br>_CLK | MDSI_A<br>_TE  |                |
| GPIO_N4/<br>C0_BPM0_TX/<br>C1_BPM0_TX  | E16            | N4     |        |                     |                  |                   |                  | C0_BPM<br>0_TX | C1_BPM0<br>_TX |
| GPIO_N0/<br>C0_BPM0_TX/<br>C1_BPM0_TX  | E17            | N0     |        |                     |                  |                   |                  | C0_BPM<br>0_TX | C1_BPM0<br>_TX |
| GPIO_N2/<br>C0_BPM2_TX/<br>C1_BPM2_TX  | F16            | N2     |        |                     |                  |                   |                  | C0_BPM<br>2_TX | C1_BPM2<br>_TX |
| GPIO_N1/<br>C0_BPM3_TX/<br>C1_BPM3_TX  | F17            | N1     |        |                     |                  |                   |                  | C0_BPM<br>3_TX | C1_BPM3<br>_TX |
| UART0_DATAIN   | V13            | SE48   |        |                     |                  | UART0_D<br>ATAIN  |                  |                |                |
| PMC_SLP_S0IX_N   | W4             | E3     |        | PMC_SLP<br>_S0IX_N  |                  |                   |                  |                |                |
| UART0_DATAOUT  | Y12            | SE46   |        |                     |                  | UART0_D<br>ATAOUT |                  |                |                |
| GPIO_N6/<br>C0_BPM3_TX/<br>C1_BPM3_TX  | C16            | N6     |        |                     |                  |                   |                  | C0_BPM<br>3_TX | C1_BPM3<br>_TX |
| GPIO_N8/<br>C0_BPM1_TX/<br>C1_BPM1_TX  | D16            | N8     |        |                     |                  |                   |                  | C0_BPM<br>1_TX | C1_BPM1<br>_TX |
| ISH_GPIO[13]/<br>C0_BPM2_TX/<br>C1_BPM2_TX                                     | D17            | N7     |        |                     |                  |                   | ISH_GPIO[<br>13] | C0_BPM<br>2_TX | C1_BPM2<br>_TX |
| GPIO_SUS9  | A13            | N27    |        | GPIO_SU<br>S9       |                  |                   |                  |                |                |
| GPIO_SUS0  | A14            | N15    |        |                     |                  |                   |                  |                |                |
| DDIO_VDDEN   | A9             | N72    |        | DDIO_VD<br>DEN      |                  |                   |                  |                |                |
| SD3_CMD  | AA10           | SE34   |        | SD3_CM<br>D         |                  |                   |                  |                |                |
| FST_SPI_CS[0]_N  | AA12           | SW6    |        | FST_SPI_<br>CS[0]_N |                  |                   |                  |                |                |



**Table 37. Multiplexed Functions - T3 SoC (Sheet 4 of 9)**

| GPIO Pin Name                                   | Package Ball # | GPIO # | Mode 0 | Mode 1           | Mode 2       | Mode 3       | Mode 4 | Mode 5 | Mode 6 |
|---|----------------|--------|--------|------------------|--------------|--------------|--------|--------|--------|
| LPE_I2S1_FRM                                    | AA14           | SW36   |        | LPE_I2S1_FRM     |              |              |        |        |        |
| LPE_I2S0_DATAOUT                                | AA15           | SW30   |        | LPE_I2S0_DATAOUT |              |              |        |        |        |
| LPE_I2S0_CLK                                    | AA16           | SW31   |        | LPE_I2S0_CLK     |              |              |        |        |        |
| I2C2_CLK  | AA17           | SW66   |        | I2C2_CLK         |              |              |        |        |        |
| ISH_I2C1_CLK/<br>ISH_SPI_CLK/<br>I2S5_DATAIN    | AA3            | E17    |        | ISH_I2C1_CLK     | ISH_SPI_CLK  | I2S5_DATAIN  |        |        |        |
| ISH_GPIO[9]/<br>ISH_SPI_MISO/<br>I2S5_FS        | AA4            | E20    |        | ISH_GPIO[9]      | ISH_SPI_MISO | I2S5_FS      |        |        |        |
| ISH_I2C1_DATA/<br>ISH_SPI_MOSI/<br>I2S5_DATAOUT | AA5            | E26    |        | ISH_I2C1_DATA    | ISH_SPI_MOSI | I2S5_DATAOUT |        |        |        |
| MMC1_CMD  | AA6            | SE23   |        | MMC1_CMD         |              |              |        |        |        |
| MMC1_D[7]                                       | AA7            | SE68   |        | MMC1_D[7]        |              |              |        |        |        |
| MMC1_D[0]                                       | AA8            | SE17   |        | MMC1_D[0]        |              |              |        |        |        |
| SD3_PWREN_N                                     | AA9            | SE78   |        | SD3_PWREN_N      |              |              |        |        |        |
| SD3_D[2]  | AB10           | SE33   |        | SD3_D[2]         |              |              |        |        |        |
| FST_SPI_D[0]                                    | AB11           | SW1    |        | FST_SPI_D[0]     |              |              |        |        |        |
| FST_SPI_CLK                                     | AB12           | SW2    |        | FST_SPI_CLK      |              |              |        |        |        |
| UART2_DATAOUT                                   | AB13           | SW21   |        | UART2_DATAOUT    |              |              |        |        |        |
| LPE_I2S1_CLK                                    | AB14           | SW32   |        | LPE_I2S1_CLK     |              |              |        |        |        |
| LPE_I2S0_DATAIN                                 | AB15           | SW33   |        | LPE_I2S0_DATAIN  |              |              |        |        |        |
| I2C5_CLK  | AB16           | SW50   |        | I2C5_CLK         |              |              |        |        |        |



Table 37. Multiplexed Functions - T3 SoC (Sheet 5 of 9)

| GPIO Pin Name                   | Package Ball # | GPIO # | Mode 0 | Mode 1           | Mode 2        | Mode 3       | Mode 4 | Mode 5 | Mode 6 |
|---------------------------------|----------------|--------|--------|------------------|---------------|--------------|--------|--------|--------|
| LPE_I2S2_CLK                    | AB19           | SW92   |        | LPE_I2S2_CLK     |               |              |        |        |        |
| ISH_GPIO[0]/<br>I2S3_CLK        | AB2            | E21    |        | ISH_GPIO[0]      |               | I2S3_CLK     |        |        |        |
| PCIE_CLKREQ[0]_N                | AB20           | SW90   |        | PCIE_CLKREQ[0]_N |               |              |        |        |        |
| ISH_GPIO[2]/<br>I2S3_DATAOUT    | AB3            | E24    |        | ISH_GPIO[2]      |               | I2S3_DATAOUT |        |        |        |
| SD2_CMD                         | AB5            | SE22   |        | SD2_CMD          |               |              |        |        |        |
| MMC1_D[2]                       | AB6            | SE20   |        | MMC1_D[2]        |               |              |        |        |        |
| MMC1_D[6]                       | AB7            | SE63   |        | MMC1_D[6]        |               |              |        |        |        |
| SD3_1P8_EN                      | AB8            | SE85   |        | SD3_1P8_EN       |               |              |        |        |        |
| SD3_D[1]                        | AB9            | SE30   |        | SD3_D[1]         |               |              |        |        |        |
| ISH_GPIO[7]/<br>I2S4_DATAIN     | AC1            | E16    |        | ISH_GPIO[7]      |               | I2S4_DATAIN  |        |        |        |
| SD3_D[0]                        | AC10           | SE35   |        | SD3_D[0]         |               |              |        |        |        |
| FST_SPI_D[1]                    | AC11           | SW5    |        | FST_SPI_D[1]     |               |              |        |        |        |
| UART2_RTS_N                     | AC12           | SW19   |        | UART2_RTS_N      |               |              |        |        |        |
| UART1_CTS_N                     | AC13           | SW18   |        | UART1_CTS_N      |               |              |        |        |        |
| UART1_DATAOUT/<br>UART0_DATAOUT | AC14           | SW20   |        | UART1_DATAOUT    | UART0_DATAOUT |              |        |        |        |
| NFC_I2C_DATA                    | AC15           | SW51   |        | NFC_I2C_DATA     |               |              |        |        |        |
| NFC_I2C_CLK                     | AC16           | SW54   |        | NFC_I2C_CLK      |               |              |        |        |        |
| I2C2_DATA                       | AC17           | SW62   |        | I2C2_DATA        |               |              |        |        |        |



**Table 37. Multiplexed Functions - T3 SoC (Sheet 6 of 9)**

| GPIO Pin Name                        | Package Ball # | GPIO # | Mode 0 | Mode 1        | Mode 2       | Mode 3           | Mode 4 | Mode 5 | Mode 6 |
|--------------------------------------|----------------|--------|--------|---------------|--------------|------------------|--------|--------|--------|
| GPIO_SW78                            | AC18           | SW78   |        |               |              |                  |        |        |        |
| LPE_I2S2_FRM                         | AC19           | SW96   |        | LPE_I2S2_FRM  |              |                  |        |        |        |
| ISH_GPIO[4]/I2S4_CLK                 | AC2            | E22    |        | ISH_GPIO[4]   |              | I2S4_CLK         |        |        |        |
| GPIO_SW93                            | AC20           | SW93   |        |               |              |                  |        |        |        |
| MMC1_D[3]                            | AC6            | SE26   |        | MMC1_D[3]     |              |                  |        |        |        |
| MMC1_D[4]                            | AC7            | SE67   |        | MMC1_D[4]     |              |                  |        |        |        |
| MMC1_D[5]                            | AC8            | SE65   |        | MMC1_D[5]     |              |                  |        |        |        |
| SD3_CLK                              | AC9            | SE31   |        | SD3_CLK       |              |                  |        |        |        |
| SD3_D[3]                             | AD10           | SE32   |        | SD3_D[3]      |              |                  |        |        |        |
| UART2_CTS_N                          | AD12           | SW22   |        | UART2_CTS_N   |              |                  |        |        |        |
| UART1_DATAIN/UART0_DATAIN            | AD14           | SW16   |        | UART1_DATAIN  | UART0_DATAIN |                  |        |        |        |
| I2C6_DATA/SD3_WP                     | AD16           | SW49   |        | I2C6_DATA     | SD3_WP       |                  |        |        |        |
| MMC1_RESET_N                         | AD18           | SW80   |        |               | MMC1_RESET_N |                  |        |        |        |
| PWM[1]/ISH_GPIO[10]/ISH_UART_DATAOUT | AD2            | SE1    |        | PWM[1]        | ISH_GPIO[10] | ISH_UART_DATAOUT |        |        |        |
| SD3_WP                               | AD20           | SW95   |        |               | SD3_WP       |                  |        |        |        |
| PWM[0]                               | AD3            | SE5    |        | PWM[0]        |              |                  |        |        |        |
| SD2_D[0]                             | AD4            | SE25   |        | SD2_D[0]      |              |                  |        |        |        |
| SD2_CLK                              | AD5            | SE19   |        | SD2_CLK       |              |                  |        |        |        |
| SD2_D[3]_CD_N                        | AD6            | SE15   |        | SD2_D[3]_CD_N |              |                  |        |        |        |



Table 37. Multiplexed Functions - T3 SoC (Sheet 7 of 9)

| GPIO Pin Name   | Package Ball # | GPIO # | Mode 0 | Mode 1          | Mode 2       | Mode 3 | Mode 4 | Mode 5 | Mode 6 |
|-----------------|----------------|--------|--------|-----------------|--------------|--------|--------|--------|--------|
| MMC1_CLK        | AD8            | SE16   |        | MMC1_CLK        |              |        |        |        |        |
| UART2_DATAIN    | AE12           | SW17   |        | UART2_DATAIN    |              |        |        |        |        |
| UART1_RTS_N     | AE13           | SW15   |        | UART1_RTS_N     |              |        |        |        |        |
| I2C6_CLK/NMI_N  | AE16           | SW53   |        | I2C6_CLK        | NMI_N        |        |        |        |        |
| I2C5_DATA       | AE17           | SW45   |        | I2C5_DATA       |              |        |        |        |        |
| UART0_DATAIN    | AE18           | SW77   |        |                 | UART0_DATAIN |        |        |        |        |
| SD2_D[1]        | AE4            | SE18   |        | SD2_D[1]        |              |        |        |        |        |
| SD2_D[2]        | AE5            | SE21   |        | SD2_D[2]        |              |        |        |        |        |
| SD3_CD_N        | AE9            | SE81   |        | SD3_CD_N        |              |        |        |        |        |
| GPIO_CAMERASB10 | B10            | N50    |        | GPIO_CAMERASB10 |              |        |        |        |        |
| DDIO_BKLTCTL    | B8             | N65    |        | DDIO_BKLTCTL    |              |        |        |        |        |
| GPIO_CAMERASB11 | C11            | N55    |        | GPIO_CAMERASB11 |              |        |        |        |        |
| GPIO_SUS8       | C13            | N23    |        | GPIO_SUS8       |              |        |        |        |        |
| DDIO_BKLTEN     | C8             | N60    |        | DDIO_BKLTEN     |              |        |        |        |        |
| GPIO_CAMERASB09 | D10            | N52    |        | GPIO_CAMERASB09 |              |        |        |        |        |
| GPIO_CAMERASB08 | D11            | N47    |        | GPIO_CAMERASB08 |              |        |        |        |        |
| DDIO_HPDP       | D9             | N61    |        | DDIO_HPDP       |              |        |        |        |        |



**Table 37. Multiplexed Functions - T3 SoC (Sheet 8 of 9)**

| GPIO Pin Name           | Package Ball # | GPIO # | Mode 0    | Mode 1           | Mode 2 | Mode 3      | Mode 4 | Mode 5 | Mode 6 |
|-------------------------|----------------|--------|-----------|------------------|--------|-------------|--------|--------|--------|
| SVID_ALERT_N            | E12            | N38    |           | SVID_ALERT_N     |        |             |        |        |        |
| DDI2_HPD                | E9             | N68    |           | DDI2_HPD         |        |             |        |        |        |
| SVID_CLK                | F11            | N40    |           | SVID_CLK         |        |             |        |        |        |
| SVID_DATA               | F12            | N33    | SVID_DATA |                  |        |             |        |        |        |
| GPIO_DFX4               | F18            | N5     |           |                  |        |             |        |        |        |
| PROCHOT_N               | F9             | N32    |           | PROCHOT_N        |        |             |        |        |        |
| LPE_I2S2_DATAIN         | U17            | SW94   |           | LPE_I2S2_DATAIN  |        |             |        |        |        |
| PMC_SUSPWRDNACK         | V12            | SE83   |           | PMC_SUSPWRDNACK  |        |             |        |        |        |
| LPE_I2S2_DATAOUT        | V18            | SW97   |           | LPE_I2S2_DATAOUT |        |             |        |        |        |
| PMC_SUS_STAT_N          | V5             | E2     |           | PMC_SUS_STAT_N   |        |             |        |        |        |
| I2C1_DATA               | W15            | SW60   |           | I2C1_DATA        |        |             |        |        |        |
| I2C1_CLK                | W16            | SW63   |           | I2C1_CLK         |        |             |        |        |        |
| PMC_PWRBTN_N            | W3             | E8     |           | PMC_PWRBTN_N     |        |             |        |        |        |
| ISH_GPIO[3]/I2S3_DATAIN | Y1             | E15    |           | ISH_GPIO[3]      |        | I2S3_DATAIN |        |        |        |
| LPE_I2S1_DATAIN         | Y13            | SW37   |           | LPE_I2S1_DATAIN  |        |             |        |        |        |
| LPE_I2S1_DATAOUT        | Y14            | SW34   |           | LPE_I2S1_DATAOUT |        |             |        |        |        |
| LPE_I2S0_FRM            | Y16            | SW35   |           | LPE_I2S0_FRM     |        |             |        |        |        |





Table 37. Multiplexed Functions - T3 SoC (Sheet 9 of 9)

| GPIO Pin Name           | Package Ball # | GPIO # | Mode 0 | Mode 1        | Mode 2 | Mode 3  | Mode 4 | Mode 5 | Mode 6 |
|-------------------------|----------------|--------|--------|---------------|--------|---------|--------|--------|--------|
| I2C0_CLK                | Y17            | SW65   |        | I2C0_CLK      |        |         |        |        |        |
| I2C0_DATA               | Y18            | SW61   |        | I2C0_DATA     |        |         |        |        |        |
| ISH_GPIO[1]/<br>I2S3_FS | Y2             | E18    |        | ISH_GPIO[1]   |        | I2S3_FS |        |        |        |
| PMC_WAKE_N              | Y3             | E10    |        | PMC_WAKE_N    |        |         |        |        |        |
| PMC_SUSCLK[0]           | Y4             | E6     |        | PMC_SUSCLK[0] |        |         |        |        |        |
| PMC_PLTRST_N            | Y5             | E5     |        | PMC_PLTRST_N  |        |         |        |        |        |
| MMC1_D[1]               | Y8             | SE24   |        | MMC1_D[1]     |        |         |        |        |        |
| USB_OC[0]_N             | Y9             | SE80   |        | USB_OC[1]_N   |        |         |        |        |        |

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## 3 Processor Core

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Up to four out-of-order execution processor cores are supported, each dual core module supports up to 1 MB of L2 cache.

### 3.1 Features

- 14nm Process technology.
- Quad Out-of-Order Execution (OOE) processor cores.
- Primary 32 KB, 8-way L1 instruction cache and 24 KiB, 6-way L1 write-back data cache.
- Cores are grouped into dual-core modules: modules share a 1 MB, 16-way L2 cache (2 MB total for Quad Core) Intel® Streaming SIMD Extensions 4.1 and 4.2 (SSE4.1 and SSE4.2), which include new instructions for media and for fast XML parsing.
- Intel® 64 Bit architecture.
- Supports IA 32-bit.
- Supports Intel® VT-x2.
- Supports Intel® Advanced Encryption Standard (AES) New instructions (AES-NI).
- Supports Intel® Carry-Less Multiplication Instruction (PCLMULQDQ).
- Supports Digital Random Number Generator (DRNG).
- Supports C0, C1, C1E, C6C, C6 and C7 states.
- Thermal management support via Intel® Thermal Monitor (TM1 & TM2).
- Uses Power Aware Interrupt Routing (PAIR).

**Note:** Intel® Hyper-Threading Technology is not supported.

#### 3.1.1 Intel® Virtualization Technology (Intel® VT)

Intel® Virtualization Technology (Intel® VT) makes a single system appear as multiple independent systems to software. 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 for IA-32, Intel® 64 and Intel® Architecture (Intel® VT-x2) added hardware support in the processor to improve the virtualization performance and robustness.

Intel® VT-x2 specifications and functional descriptions are included in the *Intel® 64 and IA-32 Architectures Software Developer's Manual, Volume 3B* and is available at: <http://www.intel.com/products/processor/manuals/index.htm>.



Other Intel® VT-x2 documents can be referenced at: <http://www.intel.com/technology/virtualization/index.htm>

### 3.1.1.1 Intel® VT-x2 Objectives

- **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. Intel® VT-x2 provides hardware acceleration for virtualization of IA platforms. Virtual Machine Monitor (VMM) can use Intel® VT-x2 features to provide improved reliable virtualized platform.

#### 3.1.1.1.1 Intel® VT-x2 Features

- **Extended Page Tables (EPT)**
  - EPT is hardware assisted page table physical memory virtualization.
  - Support guest VM execution in unpagged protected mode or in real-address mode.
  - It eliminates VM exits from guest OS to the VMM for shadow page-table maintenance.
- **Virtual Processor IDs (VPID)**
  - A VM Virtual Processor ID is used to tag processor core hardware structures (such as TLBs) to allow a logic processor to cache information (such as TLBs) for multiple linear address spaces.
  - 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 VM 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 flexibility in guest VM scheduling and building Quality of Service (QoS) schemes.
- **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.
- VM Functions
  - VM function is an operation provided by the processor that can be invoked using the VMFUNC instruction from guest VM without a VM exit.
  - VM function to perform EPTP switching is supported and allows guest VM to load a new value for the EPT pointer, thereby establishing a different EPT paging structure hierarchy.

## 3.1.2 Security and Cryptography Technologies

### 3.1.2.1 Advanced Encryption Standard New Instructions (AES-NI)

The processor supports Advanced Encryption Standard New Instructions (AES-NI) that 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). 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.

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, 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.

### 3.1.2.2 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.

### 3.1.2.3 Digital Random Number Generator

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



Some possible uses 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.

### 3.1.3 Power Aware Interrupt Routing

PAIR is an improvement in H/W routing of “redirectable” interrupts. Each core power-state is considered in the routing selection to reduce the power or performance impact of interrupts. System BIOS configures the routing algorithm, e.g. fixed-priority, rotating, hash, or PAIR, during setup via non-architectural register. The PAIR algorithm can be biased to optimize for power or performance and the largest gains will be seen in systems with high interrupt rates.

## 3.2 Platform Identification and CPUID

In addition to verifying the processor signature, the intended processor platform type must be determined to properly target the microcode update. The intended processor platform type is determined by reading bits [52:50] of the IA32\_PLATFORM\_ID register, (MSR 17h) within the processor. This is a 64-bit register that must be read using the RDMSR instruction. The 3 Platform Id bits, when read as a binary coded decimal (BCD) number, indicate the bit position in the microcode update header’s Processor Flags field that is associated with the installed processor.

Executing the CPUID instruction with EAX=1 will provide the following information.

| EAX     | Field Description     |
|---------|-----------------------|
| [31:28] | Reserved              |
| [27:20] | Extended Family value |
| [19:16] | Extended Model value  |
| [15:13] | Reserved              |
| [12]    | Processor Type Bit    |
| [11:8]  | Family value          |
| [7:4]   | Model value           |
| [3:0]   | Stepping ID Value     |

## 3.3 References

For further details on Intel® 64 and IA-32 architectures refer Intel® 64 and IA-32 Architectures Software Developer’s Manual Combined Volumes:1, 2A, 2B, 2C, 3A, 3B, and 3C:

- <http://www.intel.com/content/www/us/en/processors/architectures-software-developer-manuals.html>



For more details on AES-NI refer:

- Intel<sup>®</sup> Performance Primitives (IPP) web page - <http://software.intel.com/en-us/intel-ipp/>
- White Paper on AES-NI - <http://software.intel.com/en-us/articles/intel-advanced-encryption-standard-aes-instructions-set/>

For more details on using the RDRAND instruction refer Intel<sup>®</sup> Advanced Vector Extensions Programming Reference.

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## 4 Integrated Clock

Clocks are integrated, consisting of multiple variable frequency clock domains, across different voltage domains. This architecture achieves a low power clocking solution that supports the various clocking requirements of the SoC's many interfaces. Platform clocking is provided internally by the iClock block and does not require external devices for clocking. All the required platform clocks are provided by only two inputs: a 19.2 MHz primary reference for the integrated clock block and a 32.768 kHz reference for the Real Time Clock (RTC) block. Both of these would likely be implemented as crystal references.

The different inputs and outputs are listed below.

**Table 38. SoC Clock Inputs**

| Clock Domain | Signal Name               | Frequency  | Usage/Description  |
|--------------|---------------------------|------------|--|
| Main         | ICLK_OSCIN<br>ICLK_OSCOUT | 19.2 MHz   | Reference crystal for the iCLK PLL   |
| RTC          | RTC_X1<br>RTC_X2          | 32.768 kHz | RTC crystal I/O for RTC block  |
| LPC          | LPC_CLKOUT                | 19.2 MHz   | Can be configured as an input to compensate for board routing delays through Soft Strap. |

**Table 39. SoC Clock Outputs (Sheet 1 of 2)**

| Clock Domain | Signal Name  | Frequency                    | Usage/Description   |
|--------------|--|------------------------------|---|
| DDR          | LPDDR3_M0_CK_P_A/B<br>LPDDR3_M0_CK_N_A/B<br>LPDDR3_M1_CK_P_A/B<br>LPDDR3_M1_CK_N_A/B | 800 MHz                      | Drives the Memory ranks 0-1. Data rate (MT/s) is 2x the clock rate. |
| SDXC         | MMC1_CLK<br>SD2_CLK<br>SD3_CLK   | 200 MHz                      | Clock for Storage Devices   |
| SPI          | SPI1_CLK<br>FST_SPI_CLK  | 20 MHz,<br>33 MHz,<br>50 MHz | Clock for SPI flash   |
| PMIC/COMMS   | PMC_SUSCLK[0]  | 32.768 kHz                   | Pass through clock from RTC oscillator                              |
| LPC          | LPC_CLKOUT[0:1]  | 19.2 MHz                     | Provided to devices requiring LPC clock                             |
| Display Port | DDI[0]_TXP[3]<br>DDI[0]_TXN[3]   | 162 or 270 MHz               | Differential clock for DP devices                                   |
| HDMI         | DDI[2]_TXP[3]<br>DDI[2]_TXN[3]   | 25-297 MHz                   | Differential clock for HDMI devices                                 |



**Table 39. SoC Clock Outputs (Sheet 2 of 2)**

| Clock Domain     | Signal Name  | Frequency   | Usage/Description                                       |
|------------------|--|-------------|---|
| HDMI DDC         | DDI[2:0]_DDCCLK  | 100 kHz     | Clock for HDMI DDC devices                              |
| MIPI DSI         | MDSI_A_CLKP<br>MDSI_A_CLKN<br>MDSI_C_CLKP<br>MDSI_C_CLKN                         | 1000 MHz    | Differential clock for MIPI DSI Devices                 |
| MIPI CSI         | MCSI1_CLKP<br>MCSI1_CLKN<br>MCSI2_CLKP<br>MCSI2_CLKN<br>MCSI3_CLKP<br>MCSI3_CLKN | 200-400 MHz | Clocks for front and rear cameras                       |
| SVID             | SVID_CLK   | 20 MHz      | Clock used by voltage regulator                         |
| I <sup>2</sup> S | LPE_I2S[2:0]_CLK   | 9.6 MHz     | Continuous serial clock for I <sup>2</sup> S interfaces |
| Platform Clocks  | PLT_CLK [5:0]  | 19.2MHz     | Platform clocks.  |
| SIO SPI          | SPI_CLK  | 15 MHz      | SPI clock output  |
| I <sup>2</sup> C | I2C[6:0]_CLK   | 1.7MHz      | I <sup>2</sup> C clocks                                 |
| NFC              | NFC_I2C_CLK  | 100 kHz     | Clock for NFC device                                    |

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# 5 Power Up and Reset Sequence

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This chapter provides information on the following topics:

- “Power Up Sequences”
- “Power Down Sequences”
- “Reset Behavior”

## 5.1 SoC System States

### 5.1.1 System Sleeping States Control (S-states)

The SoC supports the S0, S0i1, S0i2, S0i3, S4, and S5 sleep states. S4 and S5 states are identical from a hardware and power perspective. The differentiation is software determined (S4 = Suspend to Disk).

The SoC platform architecture assumes the usage of an external power management controller e.g., CPLD or PMIC. Some flows in this section refer the power management controller for support of the S-states transitions.

The SoC sleep states are described in [Chapter 7, “Power Management”](#).

## 5.2 Power Up Sequences

### 5.2.1 RTC Power Well Transition (G5 to G3 States Transition)

When RTC\_VCC (Real Time Clock power) is applied via RTC battery, the following occurs (refer [Figure 2](#) for timing):

1. RTC\_VCC ramps. RTC\_RST\_N should be low.
2. The system starts the real time clock oscillator.
3. A minimum of t1 units after RTC\_VCC ramps, the external RTC RC circuit de-asserts RTC\_RST\_N. The system is now in the G3 state. RTC oscillator is unlikely to be stable at this point.

Figure 2. RTC Power Well Timing Diagrams

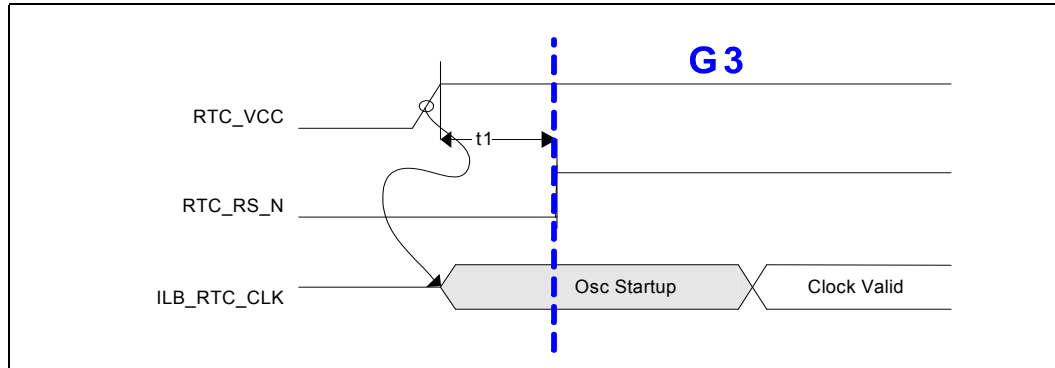


Table 40. RTC Power Well Timing Parameters

| Parameter | Description                       | Min | Max | Units |
|-----------|-----------------------------------|-----|-----|-------|
| t1        | RTC_VCC to RTC_RST_N de-assertion | 9   | -   | ms    |

**NOTES:**

1. This delay is typically created from an RC circuit.
2. The oscillator startup times are component and design specific. A crystal oscillator can take several second to reach a large enough voltage swing. A silicon oscillator can have startups times <10 ms.
3. All VCC measurements points are at 90% nominal VCC voltage.

### 5.2.2 G3 to S4/S5

The timings shown in Figure 3 occurs when a board event such as AC power or power button is pressed. The following occurs:

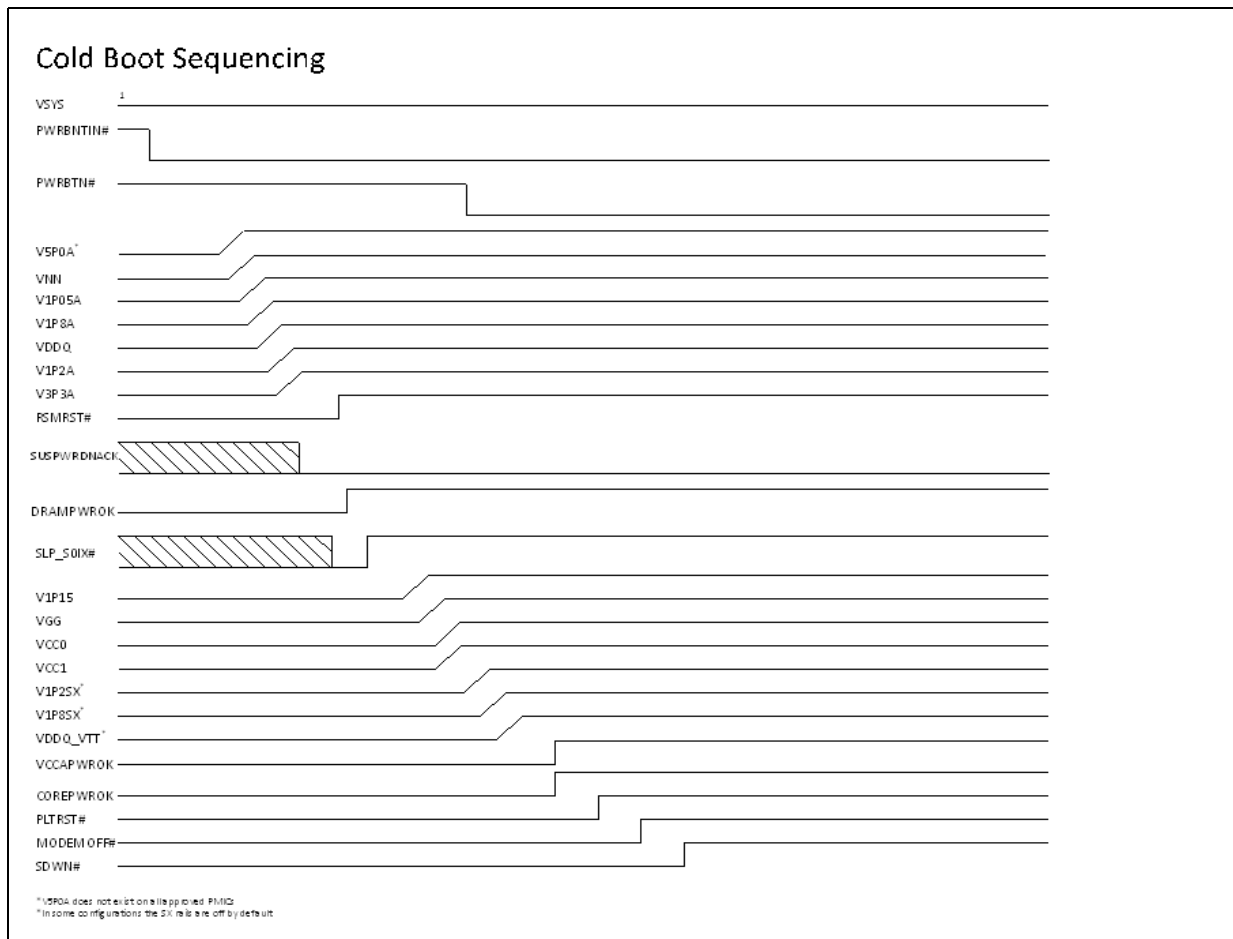
1. Suspend well ramp in the order given.
2. The external power management controller de-asserts PMC\_RSMRST\_N after the suspend rails become stable.
3. PMC\_SUSCLK will begin toggling after the de-assertion of PMC\_RSMRST\_N.
4. The system is now in S4/S5 state. Depending on policy bits, the system either waits for a wake event, or continues to S0 states.



### 5.2.3 S4/S5 to S0

1. The external power management controller detects an event (i.e., power button) to initiate transition from S4/S5 to S0.
2. VCC, VNN and other S0 core voltage power rails may be enabled after the initiation of the S4/S5 to S0 event. The VCC and VNN voltage rails must be driven to the default values.
3. After the DRAM power rail ramp, the external power management controller drives DRAM\_PWROK high.
4. After all of the S0 core voltage power rails are stable, external power management controller drives PMC\_CORE\_PWROK and VCCA\_PWROK to HIGH.
5. The processor de-asserts PMC\_PLTRST\_N after PMC\_CORE\_PWROK is stable. The PMC\_PLTRST\_N is the main platform reset to other components.
6. The processor will begin fetching code from either the PCU-located SPI interface or the LPC interface.

**Figure 3. S4/S5 to S0 (Power Up) Sequence**





**NOTES:**

1. RTC and SUS power rails may come up at the same time if no RTC battery is used.
2. RTC clock should be oscillating, but may not be at 32.768 KHz yet.
3. Wake events show in figure are optional and depending on platform configuration.

## 5.3 Power Down Sequences

### 5.3.1 S0 to S4/S5 Sequence

Entry to Sleep states (S4, S5) is initiated by any of the following methods:

- Setting the desired sleep type in PM1\_CNT.SLP\_TYP and setting PM1\_CNT.SLP\_EN.
- Detection of an external catastrophic temperature event may cause a transition to G3, if the system is designed to do so.

The following sequence applies to S0-S4/S5 transitions.

1. The Operating System Power Management (OSPM) will handle the enabling or disabling of interrupt generation after S4 resume. The Operating System Power Management (OSPM) will need to read and clear Wake status information and the processing of the clearing wake status which will include enabling interrupts (both at the core level and platform level).
2. All interrupts in the processor need to be disabled before the S4 sequence is started (and re-enabled on exit). The CPU APIC must be disabled.
3. When the desired sleep state is set in the PM1\_CNT.TYP and PM1\_CNT.SLP\_EN registers, a sleep state request is sent to the PMC.
4. The PMC flushes all the internal buffers to main memory.

The Power Down Sequence is shown in [Figure 4](#) below.

Other Assumptions:

- Entry to a Cx state is mutually exclusive with software-initiated entry to a Sleep state. This is because the processor(s) can only perform one register access at a time. This requirement is enforced by the CPU as well as the OS. The system may hang if it attempts to do a C-state and S-state at the same time.
- The G3 system state cannot be entered via any software mechanism. The G3 state indicates a complete loss of power. In this state, the RTC well may or may not be powered by an external coin cell battery.
- An external Power Management Controller (PMIC/EC) can be used to put the processor in G3 when the S4/S5 state is requested by the SoC. This is done to save power in S4/S5 state. This G3 like state is enabled by removing SUS rails via the SUSPWRDNACK pin. Doing so prevents the use of any of SUS wake events including USB, RTC, and GPIOs including the power button. The external Power Management Controller (or re-application of power) is required to return to S0.

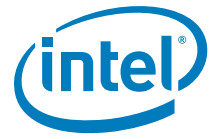
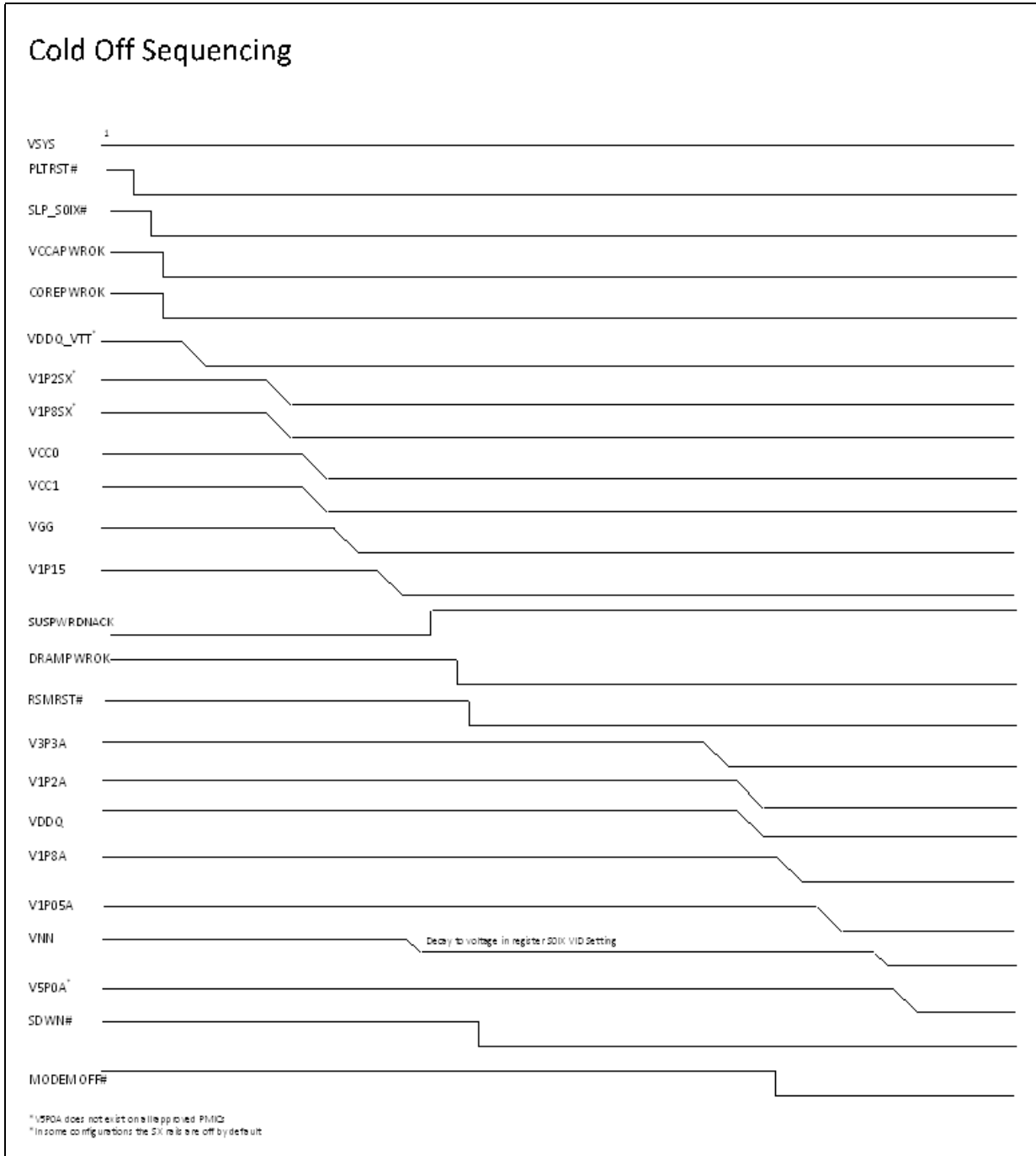


Figure 4. S0 to S4/S5 (Power Down) Sequence



### 5.3.2 S4/S5 to S0 (Exit Sleep States)

Sleep states (S5) are exited based on Wake events. The Wake events will force the system to a full on state (S0), although some non-critical subsystems might still be powered down and have to be brought back manually. For example, the hard disk may be powered down during a sleep state, and have to be enabled via an I/O pin before it can be used. Upon exit from software-entered Sleep states (i.e., those initiated via the PM1\_CNT.SLP\_EN bit), the PM1\_STS\_EN.WAK\_STS bit will be set.

To enable Wake Events, the possible causes of wake events (and their restrictions) are shown in Table 41.

**Table 41. S4/S5 to S0 Cause of Wake Events**

| Cause                            | Type     | How Enabled   |
|----------------------------------|----------|---|
| RTC Alarm                        | Internal | Set PM1_STS_EN.RTC_EN register bit  |
| PMC_PWRBTN_N<br>(Power Button)   | External | Default enabled as Wake event   |
| GPIO_NORTH<br>And GPIO_SOUTHWEST | External | GPE0a_EN register (after having gone to S5 via PM1_CNT.SLP_EN, but not after a power failure.)<br>Note: GPIOs that are in the core well are not capable of waking the system from sleep states where the core well is not powered.                            |
| GPIO_SOUTHEAST                   | External | Southeast GPIO can (optionally) be used as Wake sources based on GPIO register programming.   |
| Primary PME_N                    | Internal | GPE0a_EN.PME_B0_EN register bit. This wake status bit includes multiple internal agents:<br>EHCI (USB2)   |
| PMC - Initiated                  | Internal | No enable bits. The PMC can wake the host independent of other wake events listed, if desired. A bit is provided in PRSTS for reporting this wake event to BIOS. Note that this wake event may be used as a wake trigger on behalf of some other wake source. |

### 5.3.3 Enter S0ix

The S0IX state is entered when the SoC is in a shallow sleep state. This state is entered when the SoC asserts the PMC\_SLP\_S0IX\_N (LOW) pin to the PMIC. VDDQ\_VTT and SX rails are turned off. The VCC rail is turned off by SVID commands (not by PMC\_SLP\_S0IX\_N signal). The VNN rail is set to a voltage set in SVID address 39h. The rest of the VRs remain on but enters into PFM/power save mode.

### 5.3.4 Exit S0ix

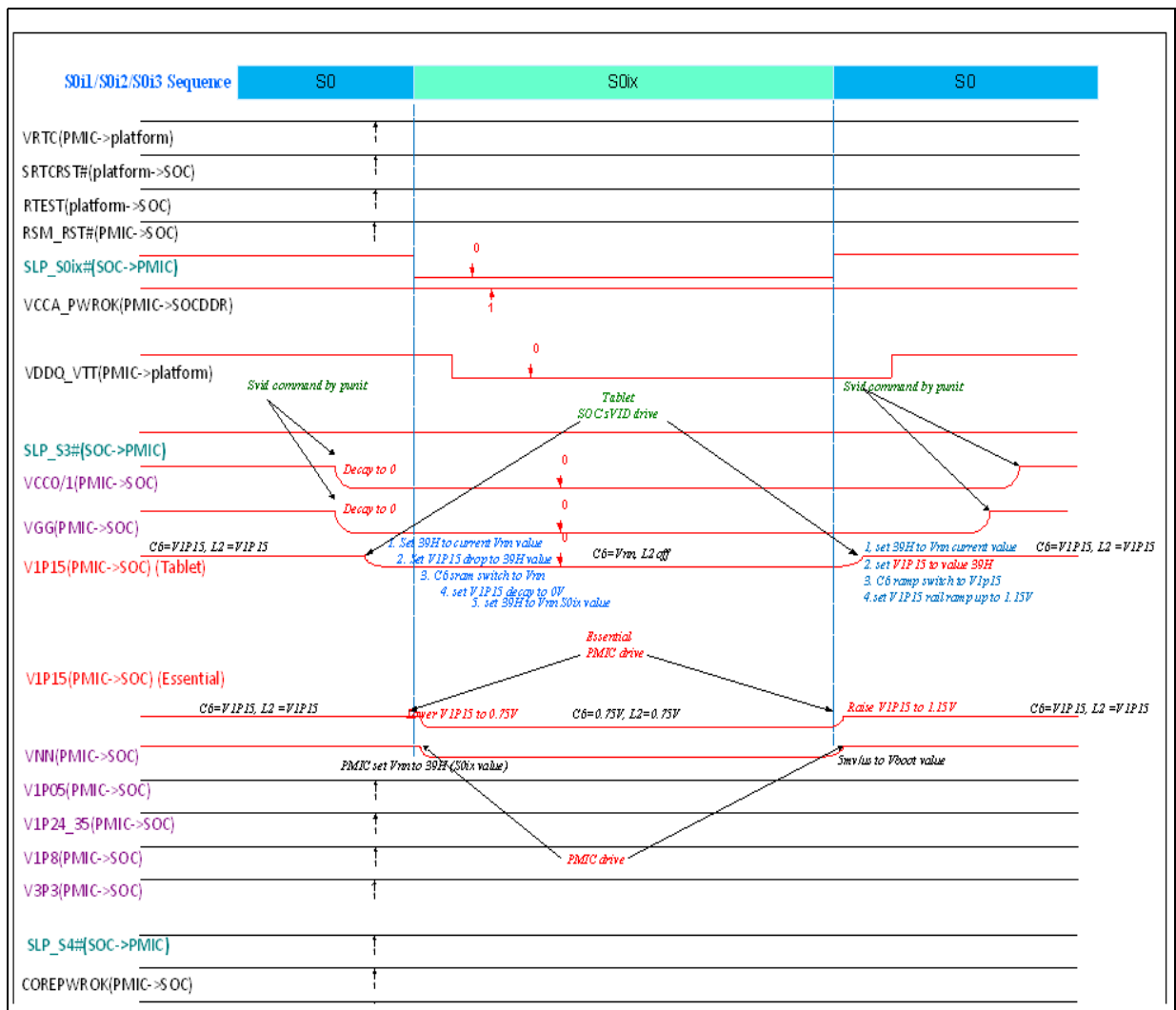
The S0IX state is exited when the SoC de-asserts the PMC\_SLP\_S0IX\_Npin (HIGH). VDDQ\_VTT and SX rails are turned on. The VCC rail will be turned on by SVID commands (not by PMC\_SLP\_S0IX\_N). The rest of the rails will come out of PFM/power save mode. All SMI/SCI events wake SoC from the S0ix states. The following table lists the addition events that wake the SoC from S0ix states.



**Table 42. S0ix Cause of Wake Events**

| Cause      | Type     | How Enabled   |
|------------|----------|---|
| Any GPIO   | External | IO-APIC forwards the interrupt, resulting in S0 (as configured by BIOS). Alternatively use S0ix Wake Register (S0IX_WAKE_EN and S0IX_WAKE_STS) in PMC |
| LPC CLKRUN | External | Wake from S0i2/3 only when the signal is asserted, moves the SoC to S0i1.   |
| ISH        | External | From External Sensors   |
| USB        | External | USB Port connected device / host  |

**Figure 5. S0 to S0ix Entry and Exit Sequence**





### 5.3.5 Handling Power Failures

The power failures can occur if the AC power or battery is removed. In this case, when the system was originally in a S0 state, power failure bit (GEN\_PMCON1.PWR\_FLR) is set after a power failure. Software can clear the bit.

## 5.4 Reset Behavior

There are several ways to reset the processor.

**Table 43. Types of Resets (Sheet 1 of 2)**

| Trigger                      | Description  | Note   |
|------------------------------|--|--|
| Write of 0Eh to CF9 Register | Write of 0Eh to the CF9 register   | TYPE 2: Host Reset with Power Cycle: Cold reset.<br>PMC will lose all the information. All the functionality in SoC gets reset.<br><br>The host system automatically is powered back up and brought out of reset to S0 state.<br>SoC must not drop this type of reset request if received while the system is in a software-entered S4/5 state. However, SoC is allowed to perform the reset without executing the RESET_WARN protocol in these states.<br>If the system is in S5 due to a reset type #8 event, SoC is allowed to drop this type of reset request. |
| PMC_RSTBTN_N & CF9h bit 3= 1 | User presses the reset button, causing the PMC_RSTBTN_N signal to go active (after the debounce logic) |  |
| PMC_RSTBTN_N & CF9h bit 3= 0 | User presses the reset button, causing the PMC_RSTBTN_N signal to go active (after the debounce logic) | TYPE 1: Host Reset with Power Cycle: Warm Reset<br>1. Host-Only functionality in SoC gets reset<br>2. Any functionality that needs to remain operational during a host reset must not get reset.<br>3. PMC does not get reset.<br>4. RTC remain information.<br>5. Suspend well remain information<br>6. S4/S5 drop the warm reset request.  |
| Write of 06h to CF9 Register | Write of 06h to the CF9 register   |  |
| TCO watchdog timer           | TCO timer reaches zero two times   |  |
| S4/S5                        | The processor is reset when going to S4 or S5 state  | TYPE 4: Sx Entry (host stays there)<br>1. All the Vnn reset by external power Good.<br>Except:<br>1. PMC remain information.<br>2. RTC remain information.<br>3. Suspend well remain information   |





**Table 43. Types of Resets (Sheet 2 of 2)**

| Trigger   | Description  | Note   |
|---|--|--|
| Power Failure                                   | PMC_CORE_PWROK signal goes inactive in S0/S1   | TYPE 7: Global, Power Cycle Reset: S0->S4/S5->S0   |
| Write of 06h or 0Eh to CF9 Register             | CF9h global Reset bit = 1b   | 1. All the Vnn reset by external power Good.<br>2. All power wells that are controlled by the PMC_SLP_S0iX_N pins are turned off.<br>3. PMC get reset.<br>4. External Dram-unchanged<br>Except:<br>1. RTC retain information.<br>2. Suspend well retain information. |
| Host Partition Reset Entry Timeout              | Host partition reset entry sequence took longer than the allowed timeout value (presumably due to a failure to receive one of the internal or external handshakes) |  |
| Processor Thermal Trip                          | The internal thermal sensor signals a catastrophic temperature condition – transition to S5 and reset asserts  | SOC_G3: Straight-to-S5 (thermal trip->SOC_G3)<br>SOC power cycle: S0->SOC_G3<br><br>SOC lost all the info<br>Except: RTC retain info   |
| PMC_PWRBTN_N                                    | 10-second press causes transition to S5 (and reset asserts)  | TYPE 8: Straight-to-S5 (Host stays there)<br>SOC power cycle: S0->S4->S5   |
| PMC_PWRBTN_N Power Button Override              |  | 1. All the Vnn reset by external power Good.   |
| S4/S5 Entry Timeout                             | S4, or S5 entry sequence took longer than the allowed timeout value (presumably due to a failure to receive one of the internal or external handshakes)            | 2. All power wells that are controlled by the PMC_SLP_S0iX_N pins are turned off.<br>3. External Dram-unchanged<br>Except:<br>1. PMC retain information.<br>2. RTC retain information.<br>3. Suspend well retain information   |
| PMC Watchdog Timer                              | Firmware hang and Watchdog Timeout detected in the PMC platform  | 1. PMC retain information.<br>2. RTC retain information.<br>3. Suspend well retain information   |
| CPU Shutdown with Policy to assert PMC_PLTRST_N | Shutdown special cycle from CPU can cause either INIT or Reset Control-style PMC_PLTRST_N  | Type 7:Global, Power Cycle Reset (if CF9h Global Reset bit = 1b)<br>Type 2:Host Reset with Power Cycle (if CF9h Register bit 3 = 1b)<br>Type 1:Host Reset without Power Cycle (others setting)   |

## 6 Thermal Management

The SoC’s thermal management system helps in managing the overall thermal profile of the system to prevent overheating and system breakdown. The architecture implements various proven methods of maintaining maximum performance while remaining within the thermal spec. Throttling mechanisms are used to reduce power consumption when thermal limits of the device are exceeded and the system is notified of critical conditions via interrupts or thermal signalling pins. SoC thermal management differs from legacy implementations primarily by replacing dedicated thermal management hardware with firmware.

The thermal management features are:

- Eight digital thermal sensors (DTS).
- Supports hardware trip point and four programmable trip points based on the temperature indicated by thermal sensors.
- Supports different thermal throttling mechanisms.

### 6.1 Thermal Sensors

SoC Sensors are based on DTS (Digital Thermal Sensor) to provide more accurate measure of system thermals.

The SoC has 8 DTS’s. DTS provides as wires the current temperature around the real estate it occupies on SoC. These are driven to PM unit, which in turn monitor the temperature from DTS on the SoC.

DTS output are adjusted for silicon variations. For a given temperature the output from DTS is always the same irrespective of silicon.

**Table 44. Temperature Reading Based on DTS (Sheet 1 of 2)**

| DTS Counter Value [8:0] | Temperature Reading (If T <sub>J-MAX</sub> =90°C) | Temperature Reading (If T <sub>J-MAX</sub> =100°C) | Temperature Reading (If T <sub>J-MAX</sub> =110°C) | Temperature Reading (If T <sub>J-MAX</sub> =100°C) Thermal Read Register [7:0] |
|-------------------------|---|--|--|--|
| 127                     | 90°C  | 100°C  | 110°C  | 100°C  |
| 137                     | 80°C  | 90°C   | 100°C  | 90°C   |
| 147                     | 70°C  | 80°C   | 90°C   | 80°C   |
| 157                     | 60°C  | 70°C   | 80°C   | 70°C   |
| 167                     | 50°C  | 60°C   | 70°C   | 60°C   |
| 177                     | 40°C  | 50°C   | 60°C   | 50°C   |
| 187                     | 30°C  | 40°C   | 50°C   | 40°C   |



**Table 44. Temperature Reading Based on DTS (Sheet 2 of 2)**

| DTS Counter Value [8:0] | Temperature Reading (If T <sub>J-MAX</sub> = 90°C) | Temperature Reading (If T <sub>J-MAX</sub> = 100°C) | Temperature Reading (If T <sub>J-MAX</sub> = 110°C) | Temperature Reading (If T <sub>J-MAX</sub> = 100°C) Thermal Read Register [7:0] |
|-------------------------|--|---|---|---|
| 197                     | 20°C   | 30°C  | 40°C  | 30°C  |
| 207                     | 10°C   | 20°C  | 30°C  | 20°C  |
| 217                     | 0°C  | 10°C  | 20°C  | 10°C  |
| 227                     | -10°C  | 0°C   | 10°C  | 0°C   |
| 237                     | -20°C  | -10°C   | 0°C   | -10°C   |
| 247                     | -30°C  | -20°C   | -10°C   | -20°C   |
| 257                     | -40°C  | -30°C   | -20°C   | -28°C [255]   |
| 247                     | -50°C  | -40°C   | -30°C   | -28°C [255]   |

**Note:** DTS encoding of 127 always represents Tjmax. If Tjmax is at 100°C instead of 90°C then the encoding 127 from DTS indicates 100°C, 137 indicates 90°C and so forth.

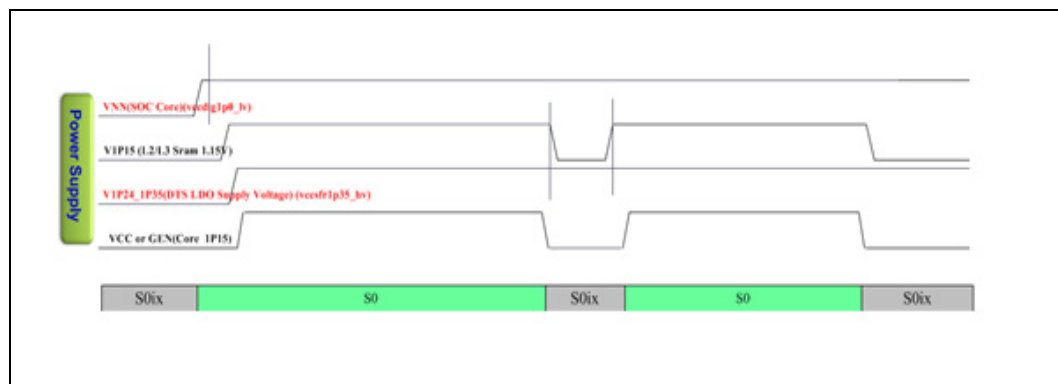
Thermal trip points are of two types:

- **Hard Trip:** The Catastrophic trip points generated by DTS’s based on predefined temperature setting defined in fuses.
- **Programmable Trips:** SoC provides four programmable trip settings (Hot, Aux2, Aux1, Aux0) that can be set by firmware/software. Default value for Hot Trip is from Fuses.

### 6.1.1 DTS Timing

DTS should be enabled only after setting up SoC and system to prevent spurious counts from DTS to trigger thermal events. P-Unit determines when DTS is enabled. The figure below shows the various control signals needed for DTS operations.

**Figure 6. DTS Operation Mode**





## 6.2 Hardware Trips

### 6.2.1 Catastrophic Trip (THERMTRIP)

Catastrophic trip is generated by DTS whenever the ambient temperature around it reaches (or extends) beyond the max value (indicated by a fuse). Catastrophic trip will not trip unless enabled (DTS are enabled only after HFPLL is locked). Within each DTS Catastrophic trips are flopped to prevent any glitches on Catastrophic signals from affecting the SoC behavior. Catastrophic trips are reset, once set, during power cycles.

Catastrophic trip signals from all DTS in the SoC are combined to generate THERMTRIP function which will in turn shut off all the PLL's and power rails to prevent SoC breakdown. To prevent glitches from triggering shutdown events, Catastrophic trip's from DTS's are registered before being sent out.

## 6.3 SoC Programmable Trips

Programmable trips can be programmed to cause different actions when triggered to reduce temperature of the die.

### 6.3.1 Aux3 Trip

By default, the Aux 3 (Hot Trip) point is set by software/firmware has an option to set these to a different value.

This trip point is enabled by firmware to monitor and control the system temperature while the rest of the system is being set up.

### 6.3.2 Aux2, Aux1, Aux0 Trip

These are fully programmable trip points for general hardware protection mechanisms. The programmable trips are only active after software/firmware enables the trip.

**Note:** Unlike Aux3, the Aux[2:0] trip registers are defaulted to zero. To prevent spurious results, software/firmware should program the trip values prior to enabling the trip point.

## 6.4 Platform Trips

### 6.4.1 PROCHOT#

The platform components use the signal PROCHOT# to indicate thermal events to SoC. Assertion of the PROCHOT# input will trigger Thermal Monitor 1 or Thermal Monitor 2 throttling mechanisms if they are enabled.



### 6.4.2 EXTTS

SoC does not support external thermal sensors and the corresponding bits in the P-Unit registers will be reserved for future use if needed.

For SoC, PROCHOT is the only mechanism for a platform component to indicate Thermal events to P-Unit.

### 6.4.3 sVID

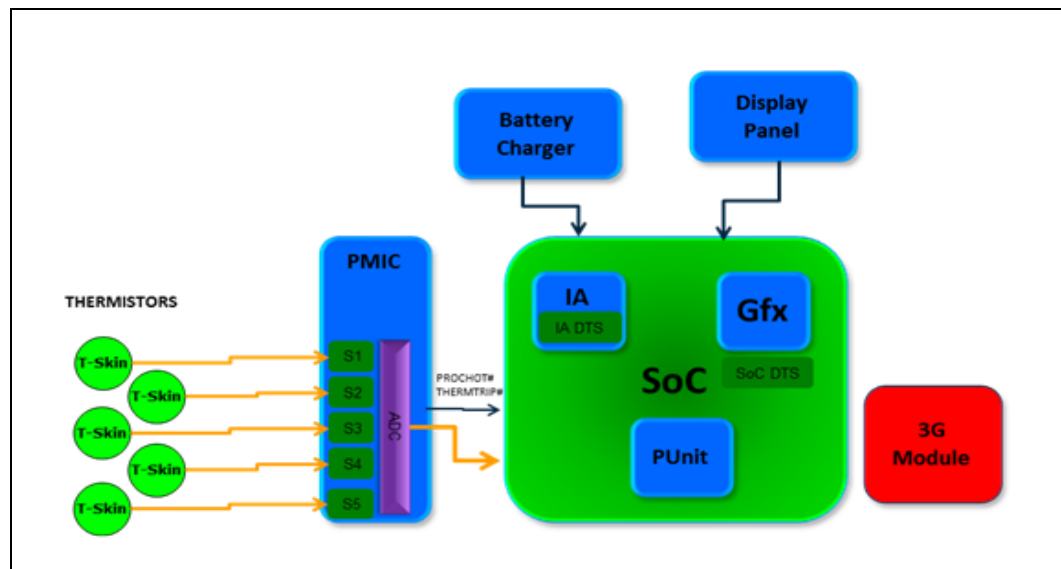
When the Voltage Regulator (VR) reaches it's threshold (VR\_Icc\_Max, VR\_Hot), status bits in sVID are set. sVID sends SVID\_Status message to PUnit.

## 6.5 Dynamic Platform Thermal Framework (DPTF)

SoC is required to support interface for OS level thermal drivers and Intel's DPTF (Dynamic Platform and Thermal Framework) drivers to control thermal management. This interface provides high-level system drivers a mechanism to manage thermal events within the SoC with respect to events outside SoC. These events could potentially be triggered before PM Unit firmware performs active management as DPTF/OS level drivers respond to events on platform outside of SoC. In addition, these interfaces also respond to interrupts from within the SoC.

Platform level thermal management layout is shown in the figure below.

**Figure 7. Platform Level Thermal Management HW Layout**





The thermal events happen outside of SoC on platform level are reported as interrupts from PMIC. PMIC monitors a number of catastrophic and critical thermal events, such as PMIC over-temperature, system over-temperature (reported by skin sensors), and battery over-temperature.

## **6.6 Thermal Status**

The firmware captures Thermal Trip events (other than THERMTRIP) in status registers to trigger thermal actions. Associated with each event is a set of programmable actions.

§



# 7 Power Management

This chapter provides information on the following power management topics:

- ACPI States
- Processor Core
- Integrated Graphics Controller

## 7.1 Features

- ACPI System States support (S0, S0i1, S0i2, S0i3, S4, S5).
- Processor Core/Package States support (C0 – C7).
- SoC Graphics Adapter States support D0 – D3.
- Supports CPU and GFX Burst.
- Dynamic I/O power reductions (disabling sense amps on input buffers, tri-stating output buffers).
- Active power down of display links.

## 7.2 States Supported

The Power Management states supported by the processor are described in this section.

### 7.2.1 System States

**Table 45. General Power States for System (Sheet 1 of 2)**

| States/Sub-states | Legacy Name / Description  |
|-------------------|--|
| G0/S0/C0          | <b>FULL ON:</b> CPU operating. Individual devices may be shut down to save power. The different CPU operating levels are defined by Cx states.                             |
| G0/S0/Cx          | <b>Cx State:</b> CPU manages C-state itself.   |
| G0/S0i1           | <b>S0i1 State:</b> Low power platform active state. All DRAM and IOSF traffic are halted. PLL are configured to be off. This state allows MP3 playing using ISH/LPE engine |
| G0/S0i2           | <b>S0i2 State:</b> The SoC clocks and oscillators are parked   |
| G0/S0i3           | <b>S0i3 State:</b> All SoC clocks and oscillators are turned off   |



**Table 45. General Power States for System (Sheet 2 of 2)**

| States/Sub-states | Legacy Name / Description  |
|-------------------|--|
| G1/S4             | <b>Suspend-To-Disk (STD):</b> The context of the system is maintained on the disk. All of the power is shut down except power for the logic to resume. The S4 and S5 states are treated the same.  |
| G2/S5             | <b>Soft-Off:</b> System context is not maintained. All of the power is shut down except power for the logic to restart. A full boot is required to restart. A full boot is required when waking. The S4 and S5 states are treated the same.  |
| G3                | <b>Mechanical OFF.</b> System content is not maintained. All power shutdown except for the RTC. No "Wake" events are possible, because the system does not have any power. This state occurs if the user removes the batteries, turns off a mechanical switch, or if the system power supply is at a level that is insufficient to power the "waking" logic. When system power returns, transition will depend on the state just prior to the entry to G3. |

Table 48 shows the transitions rules among the various states.

**Note:** Transitions among the various states may appear to temporarily transition through intermediate states. These intermediate transitions and states are not listed in the table.

**Table 46. Cause of Sx Wake Events**

| Cause          | How Enabled                          |
|----------------|--------------------------------------|
| RTC Alarm      | Set RTC_EN bit in PM1_EN Register    |
| Power Button   | Always enabled as Wake event from Sx |
| PMC_SLP_S4_N   | None                                 |
| PMC_BATLOW_N   | None                                 |
| PMC_SUS_STAT_N | None                                 |
| PMC_SLP_S0IX_N | None                                 |
| PMC_ACPRESENT  | None                                 |
| PMC_PLTRST_N   | None                                 |
| PMC_SUSCLK[0]  | None                                 |

The following shows the differences in the sleep states with regards to the processor's output signals.

**Table 47. SoC Sx-States to SLP\_S\*# (Sheet 1 of 2)**

| State         | S0    | S4  | S5  | Reset w/o Power Cycle | Reset w/ Power Cycle |
|---------------|-------|-----|-----|-----------------------|----------------------|
| CPU Executing | In C0 | OFF | OFF | No                    | OFF                  |
| PMC_SLP_S4_N  | HIGH  | LOW | LOW | HIGH                  | LOW                  |





**Table 47. SoC Sx-States to SLP\_S\*# (Sheet 2 of 2)**

| State          | S0   | S4  | S5  | Reset w/o Power Cycle | Reset w/ Power Cycle |
|----------------|------|-----|-----|-----------------------|----------------------|
| S0 Power Rails | ON   | OFF | OFF | ON                    | OFF                  |
| PMC_PLTRST_N   | 0    | 1   | 1   | 1                     | 1                    |
| PMC_SUS_STAT_N | HIGH | LOW | LOW | HIGH                  | LOW                  |

**NOTE:** The processor treats S4 and S5 requests the same. The processor does not have PMC\_SLP\_S4\_N. PMC\_SUS\_STAT\_N is required to drive low (asserted) even if core well is left on because PMC\_SUS\_STAT\_N also warns of upcoming reset.

**Table 48. ACPI PM State Transition Rules**

| Present State | Transition Trigger  | Next State  |
|---------------|---|---|
| G0/S0/C0      | IA Code MWAIT or LVL Rd   | C0/S0/Cx  |
|               | PM1_CNT.SLP_EN bit set  | G1/Sx or G2/S5 state (specified by PM1_CNT.SLP_TYP)   |
|               | Power Button Override   | G2/S5   |
|               | Mechanical Off/Power Failure  | G3  |
| G0/S0/Cx      | Cx break events which include: CPU snoop, MSI, Legacy Interrupt, AONT timer | G0/S0/C0  |
|               | Power Button Override   | G2/S5   |
|               | Resume Well Power Failure   | G3  |
| G1/S4         | Any Enabled Wake Event  | G0/S0/C0  |
|               | Power button Override   | G2/S5   |
|               | Resume Well Power Failure   | G3  |
| G2/S5         | Any Enabled Wake Event  | G0/S0/C0  |
|               | Resume Well Power Failure   | G3  |
| G3            | Power Returns   | Option to go to S0/C0 (reboot) or G2/S5 (stay off until power button pressed or other enabled wake event) or G1/S4 (if system state was S4 prior to the power failure). Some wake events are preserved through a power failure. |

## 7.2.2 Interface State Combinations

**Table 49. G, S and C State Combinations (Sheet 1 of 2)**

| Global (G) State | Sleep (S) State | Processor Core (C) State | Processor State | System Clocks | Description |
|------------------|-----------------|--------------------------|-----------------|---------------|-------------|
| G0               | S0              | C0                       | Full On         | On            | Full On     |



**Table 49. G, S and C State Combinations (Sheet 2 of 2)**

| Global (G) State | Sleep (S) State | Processor Core (C) State | Processor State | System Clocks                      | Description     |
|------------------|-----------------|--------------------------|-----------------|------------------------------------|-----------------|
| G0               | S0              | C1/C1E                   | Auto-Halt       | On                                 | Auto-Halt       |
| G0               | S0              | C6                       | Deep Power Down | On                                 | Deep Power Down |
| G0               | S0ix            | C7                       | Deep Power Down | On                                 | Deep Power Down |
| G1               | S4              | Power off                |                 | Off except RTC & internal ring OSC | Suspend to Disk |
| G2               | S5              | Power off                |                 | Off except RTC & internal ring OSC | Soft Off        |
| G3               | NA              | Power Off                |                 | Power off                          | Hard Off        |

### 7.2.3 Integrated Graphics Display States

**Table 50. SoC Graphics Adapter State Control**

| State | Description             |
|-------|-------------------------|
| D0    | Full on, Display active |
| D3    | Power off display       |

### 7.2.4 Integrated Memory Controller States

**Table 51. Main Memory States**

| States              | Description   |
|---------------------|---|
| Powerup             | CKE asserted. Active mode.  |
| Precharge Powerdown | CKE de-asserted (not self-refresh) with all banks closed.         |
| Active Powerdown    | CKE de-asserted (not self-refresh) with at least one bank active. |
| Self-Refresh        | CKE de-asserted using device self-refresh                         |

**Table 52. D, S and C State Combinations (Sheet 1 of 2)**

| Graphics Adapter (D) State | Sleep (S) State | (C) State | Description             |
|----------------------------|-----------------|-----------|-------------------------|
| D0                         | S0              | C0        | Full On, Displaying     |
| D0                         | S0              | C1        | Auto-Halt, Displaying   |
| D0                         | S0              | C6        | Deep Sleep, Display Off |



Table 52. D, S and C State Combinations (Sheet 2 of 2)

| Graphics Adapter (D) State | Sleep (S) State | (C) State | Description   |
|----------------------------|-----------------|-----------|---|
| D0                         | S0ix            | C7        | Deep Sleep, Display Off                             |
| D3                         | S0/S0ix         | Any       | Not Displaying                                      |
| D3                         | S4              |           | Not Displaying<br>Suspend to disk<br>Core power off |

## 7.3 Processor Core Power Management

While executing code, Enhanced Intel SpeedStep<sup>®</sup> 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.

### 7.3.1 Enhanced Intel SpeedStep<sup>®</sup> Technology

The following are the key features of Enhanced Intel SpeedStep<sup>®</sup> Technology:

- Applicable to Processor Core Voltage and Graphic Core Voltage
- 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:
  - If the target frequency is higher than the current frequency, Core\_VCC is ramped up slowly to an optimized voltage. This voltage is signaled by the SVID signals 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 signals.
- The processor controls voltage ramp rates by requesting appropriate ramp rates from an external SVID controller.
- Because there is low transition latency between P-states, a significant number of transitions per second are possible.
- Thermal Monitor mode.
  - Refer [Chapter 6, "Thermal Management"](#)



### 7.3.2 Dynamic Cache Sizing\*

Dynamic Cache Sizing allows the processor to flush and disable a programmable number of L2 cache ways upon each Deeper Sleep entry under the following condition:

- The C0 timer that tracks continuous residency in the Normal state, has not expired. This timer is cleared during the first entry into Deeper Sleep to allow consecutive Deeper Sleep entries to shrink the L2 cache as needed.
- The predefined L2 shrink threshold is triggered.

### 7.3.3 Low-Power Idle States

When the processor core is idle, low-power idle states (C-states) are used to save power. More power savings actions are taken for numerically higher C-state. However, higher C-states have longer exit and entry latencies. Resolution of C-state occur at the thread, processor core, and processor core level.

#### 7.3.3.1 Clock Control and Low-Power States\*

The processor core supports low power states at core level. The central power management logic ensures the entire processor core enters the new common processor core power state. For processor core power states higher than C1, this would be done by initiating a P\_LVLx (P\_LVL4 & P\_LVL6) I/O read to all of the cores. States that require external intervention and typically map back to processor core power states. States for processor core include Normal (C0, C1), and Stop Grant.

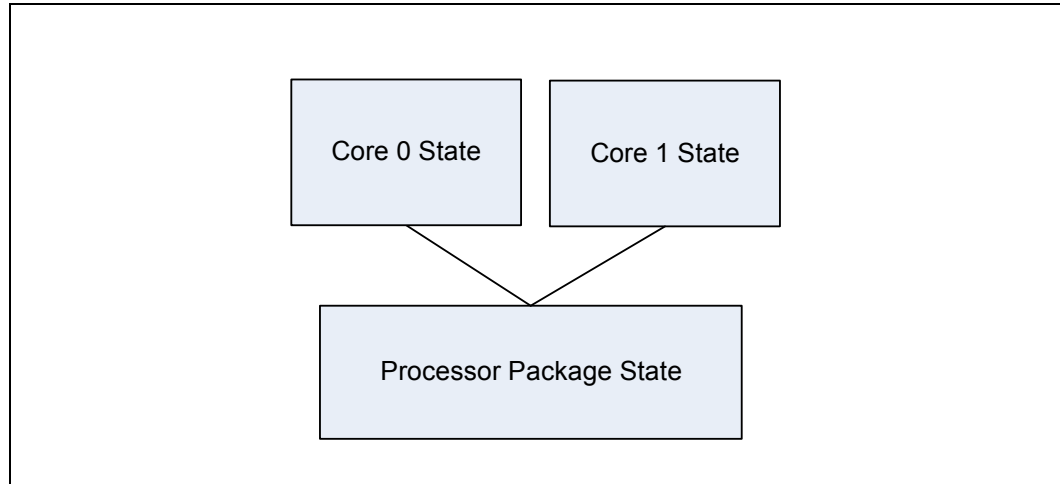
The processor core implements two software interfaces for requesting low power states: MWAIT instruction extensions with sub-state specifies and P\_LVLx reads to the ACPI P\_BLK register block mapped in the processor core's I/O address space. The P\_LVLx I/O reads are converted to equivalent MWAIT C-state requests inside the processor core and do not directly result in I/O reads on the processor core bus. The monitor address does not need to be setup before using the P\_LVLx I/O read interface. The sub-state specifications used for each P\_LVLx read can be configured in a software programmable MSR by BIOS.

The Cx state ends due to a break event. Based on the break event, the processor returns the system to C0. The following are examples of such break events:

- Any unmasked interrupt goes active
- Any internal event that will cause an NMI or SMI\_B
- CPU Pending Break Event (PBE\_B)
- MSI



**Figure 8. Idle Power Management Breakdown of Processor Cores**



### 7.3.4 Processor Core C-States Description

**Table 53. Processor Core/ States Support**

| State | Description  |
|-------|--|
| C0    | Active mode, processor executing code  |
| C1    | AutoHALT state   |
| C1E   | AutoHALT State with lowest frequency and voltage operating point.  |
| C6    | Deep Power Down. Prior to entering the Deep Power Down Technology (code named C6) State, The core process will flush its cache and save its core context to a special on die SRAM on a different power plane. Once Deep Power Down Technology (code named C6) sequence has completed. The core processor’s voltage is completely shut off. |
| C7    | Execution cores in this state behave similarly to the C6 state. Voltage is removed from the system agent domain  |

The following state descriptions assume that both threads are in common low power state.

#### 7.3.4.1 Core C0 State

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

#### 7.3.4.2 Core C1/C1E State

C1/C1E is a low power state entered when 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. Refer *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, refer [Section 7.3.8.2, "Package C1/C1E"](#).

#### 7.3.4.3 Core C6 State

Individual 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. During exit, the core is powered on and its architectural state is restored.

#### 7.3.4.4 Core C7 State

Individual core can enter the C7 state by initiating a P\_LVL7 I/O read or an MWAIT(C7) instruction. The core C7 state exhibits the same behavior as core C6 state, but in addition gives permission to the internal Power Management logic to enter a package S0ix state if possible.

#### 7.3.4.5 C-State Auto-Demotion

In general, deeper C-states, such as C6 or C7, have long latencies and 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 has a negative impact on battery life. In order to increase residency and improve battery life in deeper C-states, the processor supports C-state auto-demotion.

This is the C-State auto-demotion option:

- C7/C6 to C1

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

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.



## 7.3.5 Module C-states

Table 54. Module C-states

| C-states | Core Status   | Cache status  |
|----------|---|---|
| C0       | At least one core in C0   | Normal Operation  |
| C1       | Both cores HALTed. Most clocks OFF  | No Cache flushed; Snoops wake up cores  |
| C6       | Both cores in C6 (powered off)<br>CPLL bypassed (powered off)<br>CPU Refclk OFF<br>BIU domain powered off | Core DL1s flushed<br>L2 flushed<br>L2 domain powered off<br>C2 popup NOT required |

## 7.3.6 Module C6

There are two module C-states the Punit can put a CPU module into depending on the type of C-state entry sub-state hint and remaining size of L2. In this module C-state, both cores are power gated and all ways of L2 cache can be flushed. In this state, the Punit can power gate the BIU/L2 Vcc domain as well as the VCCSRAM\_GT domain.

## 7.3.7 S0i1

Once the core has entered package C6 or C7, the SoC can transition to S0i1. S0i1 transitions from a PC6 means that L2 state will be preserved through S0i1. Transitions from C7 no longer have state retention. These two paths are quite different due to the requirements on the L2 power rails and the need to snoop the core.

## 7.3.8 Package C-States\*

The processor supports C0, C1/C1E, 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:

- 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.



### 7.3.8.1 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 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.

### 7.3.8.2 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 than 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.

### 7.3.8.3 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 request to a package C7 state but has allowed a package C6 state.

In package C6 state, all cores have saved their architectural state and have had their core voltages reduced to zero volts.

### 7.3.8.4 Package C7 State

A processor enters the package C7 low power state when all cores are in the C7 state. In package C7, the processor will take action to remove power from portions of the system agent.

Core break events are handled the same way as in package C6.





## 7.3.9 Graphics, Video and Display Power Management

### 7.3.9.1 Graphics and video decoder C-State

GFX C-State (GC6) are designed to optimize the average power to the graphics and video decoder engines during times of idleness. GFX C-state is entered when the graphics engine, has no workload being currently worked on and no outstanding graphics memory transactions. When the idleness condition is met, the processor will power gate the Graphics and video decoder engines.

### 7.3.9.2 Intel® Display Power Saving Technology (Intel® DPST)

The Intel DPST technique achieves backlight power savings while maintaining visual experience. This is accomplished by adaptively enhancing the displayed image while decreasing the backlight brightness simultaneously. The goal of this technique is to provide equivalent end-user image quality at a decreased backlight power level.

1. The original (input) image produced by the operating system or application is analyzed by the Intel DPST subsystem. An interrupt to Intel® DPST software is generated whenever a meaningful change in the image attributes is detected. (A meaningful change is when the Intel DPST software algorithm determines that enough brightness, contrast, or color change has occurred to the displaying images that the image enhancement and backlight control needs to be altered.)
2. Intel DPST subsystem applies an image-specific enhancement to increase image contrast, brightness, and other attributes.
3. A corresponding decrease to the backlight brightness is applied simultaneously to produce an image with similar user-perceived quality (such as brightness) as the original image. Intel DPST 6.0 has improved the software algorithms and has minor hardware changes to better handle backlight phase-in and ensures the documented and validated method to interrupt hardware phase-in.

### 7.3.9.3 Intel® Automatic Display Brightness

The Intel Automatic Display Brightness feature dynamically adjusts the backlight brightness based upon the current ambient light environment. This feature requires an additional sensor to be on the panel front. The sensor receives the changing ambient light conditions and sends the interrupts to the Intel Graphics driver. As per the change in Lux, (current ambient light illuminance), the new backlight setting can be adjusted through BLC. The converse applies for a brightly lit environment. Intel Automatic Display Brightness increases the back light setting.

### 7.3.9.4 Intel® Seamless Display Refresh Rate Switching Technology (Intel® SDRRS Technology)

When a Local Flat Panel (LFP) supports multiple refresh rates, the Intel® Display Refresh Rate Switching power conservation feature can be enabled. The higher refresh rate will be used when on plugged in power or when the end user has not selected/



enabled this feature. The graphics software will automatically switch to a lower refresh rate for maximum battery life when the design application is on battery power and when the user has selected/enabled this feature.

There are two distinct implementations of Intel SDRRS—static and seamless. The static Intel SDRRS method uses a mode change to assign the new refresh rate. The seamless Intel SDRRS method is able to accomplish the refresh rate assignment without a mode change and therefore does not experience some of the visual artifacts associated with the mode change (SetMode) method.

## 7.4 Memory Power Management

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

### 7.4.1 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 unpopulated, or 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.

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

### 7.4.2 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.

#### 7.4.2.1 Initialization Role of CKE\*

During power-up, CKE is the only input to the SDRAM that 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.



#### 7.4.2.2 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 internal graphics is being used), as well as memory traffic patterns generated by other connected I/O devices.

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

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

#### 7.4.2.3 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.

#### 7.4.2.4 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.

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).

§

# 8 System Memory Controller

The system memory controller supports DDR3L-RS/LPDDR3 protocol with up to two 64-bit wide dual rank channels at data rates up to 1600 MT/s with ECC is also available on a single DDR3L-RS channel.

## 8.1 Signal Descriptions

Refer Chapter 2, “Physical Interfaces” for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in Chapter 19, “Electrical Specifications”.
- **Description:** A brief explanation of the signal’s function.

### 8.1.1 DDR3L-RS Interface Signals

Table 55. Memory Channel 0 DDR3L-RS Signals (Sheet 1 of 2)

| Signal Name                            | Direction Type | Description  |
|--|----------------|--|
| DDR3_M0_CK[1,0]_P<br>DDR3_M0_CK[1,0]_N | O<br>DDR3      | <b>Clock PAD:</b> (1 pair per Rank) Driven by PHY to DRAM.   |
| DDR3_M0_CS[1,0]_N                      | O<br>DDR3      | <b>Chip Select:</b> (1 per Rank). Driven by PHY to DRAM.   |
| DDR3_M0_CKE[3,0]                       | O<br>DDR3      | <b>Clock Enable:</b> (power management) Driven by PHY to DRAM.   |
| DDR3_M0_MA[15:0]                       | O<br>DDR3      | <b>Memory Address:</b> Driven by PHY to DRAM.  |
| DDR3_M0_BS[2:0]                        | O<br>DDR3      | <b>Bank Select:</b> Driven by PHY to DRAM.   |
| DDR3_M0_RAS_N                          | O<br>DDR3      | <b>Row Address Select:</b> Used with DDR3_M0_CAS# and DDR3_M0_WE# (along with DDR3_M0_CS#) to define the DRAM Commands                           |
| DDR3_M0_CAS_N                          | O<br>DDR3      | <b>Column Address Select:</b> Used with DDR3_M0_RAS# and DDR3_M0_WE# (along with DDR3_M0_CS#) to define the SRAM Commands                        |
| DDR3_M0_WE_N                           | O<br>DDR3      | <b>Write Enable Control Signal:</b> Used with DDR3_M0_WE# and DDR3_M0_CAS# (along with control signal, DDR3_M0_CS#) to define the DRAM Commands. |



Table 55. Memory Channel 0 DDR3L-RS Signals (Sheet 2 of 2)

| Signal Name                              | Direction Type | Description  |
|--|----------------|--|
| DDR3_M0_DQ[63:0]                         | I/O<br>DDR3    | <b>Data Lines:</b> Bidirectional signals between DRAM/PHY  |
| DDR3_M0_DM[7:0]                          | O<br>DDR3      | <b>Data Mask:</b> DM is an output mask signal for write data. Output data is masked when DM is sampled HIGH coincident with that output data during a Write access. DM is sampled on both edges of DQS.  |
| DDR3_M0_DQS[7:0]_P<br>DDR3_M0_DQS[7:0]_N | I/O<br>DDR3    | <b>Data Strobes:</b> The data is captured at the crossing point of each 'P' and its compliment 'N' during read and write transactions. For reads, the strobe crossover and data are edge aligned, whereas in the Write command, the strobe crossing is in the centre of the data window. |
| DDR3_M0_ODT[1,0]                         | O<br>DDR3      | <b>On Die Termination:</b> ODT signal going to DRAM in order to turn ON the DRAM ODT during Write.   |
| DDR3_M0_RCOMP                            | I<br>DDR       | <b>Resistor Compensation:</b> This signal needs to be terminated to VSS on board. This signal is driven from external clock source.  |
| DDR3_M0_OCAVREF                          | O<br>DDR       | <b>Reference Voltage:</b> DDR3 CA interface Reference Voltage  |
| DDR3_M0_ODQVREF                          | O<br>DDR       | <b>Reference Voltage:</b> DDR3 DQ interface Reference Voltage  |
| DDR3_CORE_PWROK                          | I<br>DDR       | <b>Core Power OK:</b> This signal indicates the status of the DRAM Core power supply (power on in S0). Active high signal indicates that DDR PHY voltage(1.5v) is good.  |
| DDR3_VDD_S4_PWROK                        | I<br>DDR       | <b>VDD Power OK:</b> Asserted once the VRM is settled.   |
| DDR3_M0_DRAMRST_N                        | O              | <b>DRAM Reset:</b> This signal is used to reset DRAM devices.  |

Table 56. Memory Channel 1 DDR3L-RS Signals (Sheet 1 of 2)

| Signal Name                            | Direction Type | Description  |
|--|----------------|--|
| DDR3_M1_CK[1,0]_P<br>DDR3_M1_CK[1,0]_N | O<br>DDR3      | <b>Clock PAD:</b> (1 pair per Rank) Driven by PHY to DRAM.     |
| DDR3_M1_CS[1,0]_N                      | O<br>DDR3      | <b>Chip Select:</b> (1 per Rank). Driven by PHY to DRAM.       |
| DDR3_M1_CKE[3,0]                       | O<br>DDR3      | <b>Clock Enable:</b> (power management) Driven by PHY to DRAM. |
| DDR3_M1_MA[15:0]                       | O<br>DDR3      | <b>Memory Address:</b> Driven by PHY to DRAM.                  |
| DDR3_M1_BS[2:0]                        | O<br>DDR3      | <b>Bank Select:</b> Driven by PHY to DRAM.                     |

**Table 56. Memory Channel 1 DDR3L-RS Signals (Sheet 2 of 2)**

| Signal Name                              | Direction Type | Description  |
|--|----------------|--|
| DDR3_M1_RAS_N                            | O<br>DDR3      | <b>Row Address Select:</b> Used with DDR3_M0_CAS# and DDR3_M0_WE# (along with DDR3_M0_CS#) to define the DRAM Commands   |
| DDR3_M1_CAS_N                            | O<br>DDR3      | <b>Column Address Select:</b> Used with DDR3_M0_RAS# and DDR3_M0_WE# (along with DDR3_M0_CS#) to define the SRAM Commands  |
| DDR3_M1_WE_N                             | O<br>DDR3      | <b>Write Enable Control Signal:</b> Used with DDR3_M0_WE# and DDR3_M0_CAS# (along with control signal, DDR3_M0_CS#) to define the DRAM Commands.   |
| DDR3_M1_DQ[63:0]                         | I/O<br>DDR3    | <b>Data Lines:</b> Bidirectional signals between DRAM/PHY  |
| DDR3_M1_DM[7:0]                          | O<br>DDR3      | <b>Data Mask:</b> DM is an output mask signal for write data. Output data is masked when DM is sampled HIGH coincident with that output data during a Write access. DM is sampled on both edges of DQS.  |
| DDR3_M1_DQS[7:0]_P<br>DDR3_M1_DQS[7:0]_N | I/O<br>DDR3    | <b>Data Strobes:</b> The data is captured at the crossing point of DDR3_M1_DQS[7:0] and its compliment 'N' during read and write transactions. For reads, the strobe crossover and data are edge aligned, whereas in the Write command, the strobe crossing is in the centre of the data window. |
| DDR3_M1_ODT[1,0]                         | O<br>DDR3      | <b>On Die Termination:</b> ODT signal going to DRAM in order to turn ON the DRAM ODT during Write.   |
| DDR3_M1_DRAMRST_N                        | O              | <b>Reset DRAM:</b> This signal can be used to reset DRAM devices.  |

### 8.1.2 DDR3L-RS Interface Signals

**Table 57. Memory Channel 0 DDR3L-RS Signals (Sheet 1 of 2)**

| Signal Name                            | Direction Type | Description  |
|--|----------------|--|
| DDR3_M0_CK[1,0]_P<br>DDR3_M0_CK[1,0]_N | O<br>DDR3      | <b>Clock PAD:</b> (1 pair per Rank) Driven by PHY to DRAM.   |
| DDR3_M0_CS[1,0]_N                      | O<br>DDR3      | <b>Chip Select:</b> (1 per Rank). Driven by PHY to DRAM.   |
| DDR3_M0_CKE[3,0]                       | O<br>DDR3      | <b>Clock Enable:</b> (power management) Driven by PHY to DRAM.   |
| DDR3_M0_MA[15:0]                       | O<br>DDR3      | <b>Memory Address:</b> Driven by PHY to DRAM.  |
| DDR3_M0_BS[2:0]                        | O<br>DDR3      | <b>Bank Select:</b> Driven by PHY to DRAM.   |
| DDR3_M0_RAS_N                          | O<br>DDR3      | <b>Row Address Select:</b> Used with DDR3_M0_CAS# and DDR3_M0_WE# (along with DDR3_M0_CS#) to define the DRAM Commands |



Table 57. Memory Channel 0 DDR3L-RS Signals (Sheet 2 of 2)

| Signal Name                              | Direction Type | Description  |
|--|----------------|--|
| DDR3_M0_CAS_N                            | O<br>DDR3      | <b>Column Address Select:</b> Used with DDR3_M0_RAS# and DDR3_M0_WE# (along with DDR3_M0_CS#) to define the SRAM Commands  |
| DDR3_M0_WE_N                             | O<br>DDR3      | <b>Write Enable Control Signal:</b> Used with DDR3_M0_WE# and DDR3_M0_CAS# (along with control signal, DDR3_M0_CS#) to define the DRAM Commands.   |
| DDR3_M0_DQ[63:0]                         | I/O<br>DDR3    | <b>Data Lines:</b> Bidirectional signals between DRAM/PHY  |
| DDR3_M0_DM[7:0]                          | O<br>DDR3      | <b>Data Mask:</b> DM is an output mask signal for write data. Output data is masked when DM is sampled HIGH coincident with that output data during a Write access. DM is sampled on both edges of DQS.  |
| DDR3_M0_DQS[7:0]_P<br>DDR3_M0_DQS[7:0]_N | I/O<br>DDR3    | <b>Data Strobes:</b> The data is captured at the crossing point of each 'P' and its complement 'N' during read and write transactions. For reads, the strobe crossover and data are edge aligned, whereas in the Write command, the strobe crossing is in the centre of the data window. |
| DDR3_M0_ODT[1,0]                         | O<br>DDR3      | <b>On Die Termination:</b> ODT signal going to DRAM in order to turn ON the DRAM ODT during Write.   |
| DDR3_M0_RCOMP                            | I<br>DDR       | <b>Resistor Compensation:</b> This signal needs to be terminated to VSS on board. This signal is driven from external clock source.  |
| DDR3_M0_OCAVREF                          | O<br>DDR       | <b>Reference Voltage:</b> DDR3 CA interface Reference Voltage  |
| DDR3_M0_ODQVREF                          | O<br>DDR       | <b>Reference Voltage:</b> DDR3 DQ interface Reference Voltage  |
| DDR3_CORE_PWROK                          | I<br>DDR       | <b>Core Power OK:</b> This signal indicates the status of the DRAM Core power supply (power on in S0). Active high signal indicates that DDR PHY voltage(1.5v) is good.  |
| DDR3_VDD_S4_PWROK                        | I<br>DDR       | <b>VDD Power OK:</b> Asserted once the VRM is settled.   |
| DDR3_M0_DRAMRST_N                        | O              | <b>DRAM Reset:</b> This signal is used to reset DRAM devices.  |



Table 58. Memory Channel 1 DDR3L-RS Signals

| Signal Name  | Direction Type | Description   |
|--|----------------|---|
| <b>DDR3_M1_CK[1,0]_P</b><br><b>DDR3_M1_CK[1,0]_N</b>   | O<br>DDR3      | <b>Clock PAD:</b> (1 pair per Rank) Driven by PHY to DRAM.  |
| <b>DDR3_M1_CS[1,0]_N</b>                               | O<br>DDR3      | <b>Chip Select:</b> (1 per Rank). Driven by PHY to DRAM.  |
| <b>DDR3_M1_CKE[3,0]</b>                                | O<br>DDR3      | <b>Clock Enable:</b> (power management) Driven by PHY to DRAM.  |
| <b>DDR3_M1_MA[15:0]</b>                                | O<br>DDR3      | <b>Memory Address:</b> Driven by PHY to DRAM.   |
| <b>DDR3_M1_BS[2:0]</b>                                 | O<br>DDR3      | <b>Bank Select:</b> Driven by PHY to DRAM.  |
| <b>DDR3_M1_RAS_N</b>                                   | O<br>DDR3      | <b>Row Address Select:</b> Used with DDR3_M0_CAS# and DDR3_M0_WE# (along with DDR3_M0_CS#) to define the DRAM Commands  |
| <b>DDR3_M1_CAS_N</b>                                   | O<br>DDR3      | <b>Column Address Select:</b> Used with DDR3_M0_RAS# and DDR3_M0_WE# (along with DDR3_M0_CS#) to define the SRAM Commands   |
| <b>DDR3_M1_WE_N</b>                                    | O<br>DDR3      | <b>Write Enable Control Signal:</b> Used with DDR3_M0_WE# and DDR3_M0_CAS# (along with control signal, DDR3_M0_CS#) to define the DRAM Commands.  |
| <b>DDR3_M1_DQ[63:0]</b>                                | I/O<br>DDR3    | <b>Data Lines:</b> Bidirectional signals between DRAM/PHY   |
| <b>DDR3_M1_DM[7:0]</b>                                 | O<br>DDR3      | <b>Data Mask:</b> DM is an output mask signal for write data. Output data is masked when DM is sampled HIGH coincident with that output data during a Write access. DM is sampled on both edges of DQS.   |
| <b>DDR3_M1_DQS[7:0]_P</b><br><b>DDR3_M1_DQS[7:0]_N</b> | I/O<br>DDR3    | <b>Data Strobes:</b> The data is captured at the crossing point of DDR3_M1_DQSP[7:0] and its compliment 'N' during read and write transactions. For reads, the strobe crossover and data are edge aligned, whereas in the Write command, the strobe crossing is in the centre of the data window. |
| <b>DDR3_M1_ODT[1,0]</b>                                | O<br>DDR3      | <b>On Die Termination:</b> ODT signal going to DRAM in order to turn ON the DRAM ODT during Write.  |
| <b>DDR3_M1_DRAMRST_N</b>                               | O              | <b>Reset DRAM:</b> This signal can be used to reset DRAM devices.   |





### 8.1.3 LPDDR3 Interface Signals

Table 59. Memory Channel 0 LPDDR3 Signals

| Signal Name  | Direction Type | Description  |
|--|----------------|--|
| LPDDR3_M0_CK_P_A/B<br>LPDDR3_M0_CK_N_A/B             | O<br>DDR3      | <b>SDRAM and inverted Differential Clock:</b> (1 pair per Rank)<br>The differential clock pair is used to latch the command into DRAM. Each pair corresponds to one rank on DRAM side.   |
| LPDDR3_M0_CS[1,0]_N                                  | O<br>DDR3      | <b>Chip Select:</b> (1 per Rank). Used to qualify the command on the command bus for a particular rank.  |
| LPDDR3_M0_CKE[1,0]_A/B                               | O<br>DDR3      | <b>Clock Enable:</b> (power management)<br>It is used during DRAM power up/power down and Self refresh.<br><b>NOTE:</b> LPDDR3 uses only LPDDR3_M0_CKE[2,0]. LPDDR3_M0_CKE[1,3] are not being used for LPDDR3.   |
| LPDDR3_M0_CA[9:0]                                    | O<br>DDR3      | <b>Memory Address:</b> Memory address bus for writing data to memory and reading data from memory. These signals follow common clock protocol w.r.t. LPDDR3_M0_CKN, LPDDR3_M0_CKP pairs  |
| LPDDR3_M0_DQ[31:0]_A/B                               | I/O<br>DDR3    | <b>Data Lines:</b> Data signal interface to the DRAM data bus  |
| LPDDR3_M0_DM[3:0]_A/B                                | O<br>DDR3      | <b>Data Mask:</b> DM is an output mask signal for write data. Output data is masked when DM is sampled HIGH coincident with that output data during a Write access. DM is sampled on both edges of DQS.  |
| LPDDR3_M0_DQS[3:0]_P_A/B<br>LPDDR3_M0_DQS[3:0]_N_A/B | I/O<br>DDR3    | <b>Data Strobes:</b> The data is captured at the crossing point of each 'P' and its complement 'N' during read and write transactions. For reads, the strobe crossover and data are edge aligned, whereas in the Write command, the strobe crossing is in the centre of the data window. |
| LPDDR3_M0_ODT_A/B                                    | O<br>DDR3      | <b>On Die Termination:</b> ODT signal going to DRAM in order to turn ON the DRAM ODT during Write.   |
| LPDDR3_M0_RCOMP                                      | I<br>DDR       | <b>Resistor Compensation:</b> This signal needs to be terminated to VSS on board. This signal is driven from external clock source.  |
| LPDDR3_M0_OCAVREF                                    | O<br>DDR       | <b>Reference Voltage:</b> LPLDDR3 CA interface Reference Voltage   |
| LPDDR3_M0_ODQVREF                                    | O<br>DDR       | <b>Reference Voltage:</b> LPLDDR3 DQ interface Reference Voltage   |

**Table 60. Memory Channel 1 LPDDR3 Signals**

| Signal Name  | Direction Type | Description   |
|--|----------------|---|
| LPDDR3_M1_CK_P_A/B<br>LPDDR3_M1_CK_N_A/B             | O<br>DDR3      | <b>SDRAM and inverted Differential Clock:</b> (1 pair per Rank)<br>The differential clock pair is used to latch the command into DRAM. Each pair corresponds to one rank on DRAM side.  |
| LPDDR3_M1_CS[1,0]_N                                  | O<br>DDR3      | <b>Chip Select:</b> (1 per Rank). Used to qualify the command on the command bus for a particular rank.   |
| LPDDR3_M1_CKE[1,0]_A/B                               | O<br>DDR3      | <b>Clock Enable:</b> (power management)<br>It is used during DRAM power up/power down and Self refresh.<br><b>NOTE:</b> LPDDR3 uses only LPDDR3_M1_CKE[0,2]. LPDDR3_M1_CKE[1,3] are not being used for LPDDR3.  |
| LPDDR3_M1_CA[9:0]                                    | O<br>DDR3      | <b>Memory Address:</b> Memory address bus for writing data to memory and reading data from memory. These signals follow common clock protocol relative to LPDDR3_M1_CKN, LPDDR3_M1_CKP pairs  |
| LPDDR3_M1_DQ[31:0]_A/B                               | I/O<br>DDR3    | <b>Data Lines:</b> Data signal interface to the DRAM data bus.  |
| LPDDR3_M1_DM[3:0]_A/B                                | O<br>DDR3      | <b>Data Mask:</b> DM is an output mask signal for write data. Output data is masked when DM is sampled HIGH coincident with that output data during a Write access. DM is sampled on both edges of DQS.   |
| LPDDR3_M1_DQS[3:0]_P_A/B<br>LPDDR3_M1_DQS[3:0]_N_A/B | I/O<br>DDR3    | <b>Data Strobes:</b> The data is captured at the crossing point of LPDDR3_M1_DQSP[7:0] and its compliment 'N' during read and write transactions. For reads, the strobe crossover and data are edge aligned, whereas in the Write command, the strobe crossing is in the centre of the data window. |
| LPDDR3_M1_ODT_A/B                                    | O<br>DDR3      | <b>On Die Termination:</b> ODT signal going to DRAM in order to turn ON the DRAM ODT during Write.  |
| LPDDR3_M1_OCAVREF                                    | O<br>DDR       | <b>Reference Voltage:</b> LPDDR3 CA interface Reference Voltage   |
| LPDDR3_M1_ODQVREF                                    | O<br>DDR       | <b>Reference Voltage:</b> LPDDR3 DQ interface Reference Voltage   |

### 8.1.4 ECC Support

The system memory controller supports ECC. When ECC is enabled, only Memory Channel 0 will be active. Memory Channel 1 will be disabled and used for the ECC data pins. The table below shows the details on the muxing relationship between the ECC Signals and the Memory Channel 1 signals.

**Note:** ECC SO-DIMMs are not backwards compatible with non-ECC SO-DIMMs.



Table 62. ECC Signals

| Signal Name  | Direction Type | Description   |
|--|----------------|---|
| <b>DDR3_M0_ECC_DQ[7:0]</b>                         | I/O<br>DDR3    | ECC Check Data Bits<br>These are muxed with channel 1.  |
| <b>DDR3_M0_ECC_DM</b>                              | O<br>DDR3      | <b>ECC Data Mask:</b> DM is an optional output mask signal for write data. Output data is masked when DM is sampled HIGH coincident with that output data during a Write access. DM is sampled on both edges of ECC_DQS.<br>This signal is muxed with channel 1 and may not be needed.                                      |
| <b>DDR3_M0_ECC_DQSP</b><br><b>DDR3_M0_ECC_DQSN</b> | I/O<br>DDR3    | <b>ECC Data Strobes:</b> The data is captured at the crossing point the 'P' and its compliment 'N' during read and write transactions. For reads, the strobe crossover and data are edge aligned, whereas in the Write command, the strobe crossing is in the centre of the data window.<br>These are muxed with channel 1. |

## 8.2 Features

### 8.2.1 System Memory Technology Supported

The system memory controller supports the following DDR3L-RS/LPDDR3 Data Transfer Rates, DRAM Device Technologies:

- DDR3L-RS/LPDDR3 Data Transfer Rates: 1600MT/s (12.8 GB/s per channel).
- LPDDR3 (1.2V DRAM VDDQ)
- DDR3L-RS (1.35V DRAM interface I/Os)
- DDR3L-RS DRAM Device Technology
  - Standard 2 Gb technologies and addressing
  - Read latency 5, 6, 7, 8, 9, 10, 11, 12, 13
  - Write latency 3, 4, 5, 6, 7, 8
- LPDDR3 DRAM Device Technology
  - x64, 253 ball LPDDR3 DRAM package
  - 8 GB (2 rank per channel) package density
  - Standard 2 Gb, 4 Gb and 8 Gb DRAM technologies and addressing
  - Read latency 5, 6, 7, 8, 9, 10, 11, 12, 13
  - Write latency 3, 4, 5, 6, 7, 8
- Supports Trunk Clock Gating
- ECC supports 64-bit data bus on DDR3L-RS single channel
- Supports early SR exit
- Supports slow power down
- Supports CA tri-state when not driving a valid command



**Table 63. Supported LPDDR3 DRAM Devices**

| DRAM Density | Data Width | Banks | Bank Address | Row Address | Column Address | Page Size |
|--------------|------------|-------|--------------|-------------|----------------|-----------|
| 2Gb          | x32        | 8     | BA[2:0]      | A[13:0]     | A[8:0]         | 2KB       |
| 4Gb          | x32        | 8     | BA[2:0]      | A[13:0]     | A[9:0]         | 4KB       |
| 8Gb          | x32        | 8     | BA[2:0]      | A[14:0]     | A[9:0]         | 4KB       |

**Table 64. Supported DDR3L-RS DRAM Devices**

| DRAM Density | Data Width | Banks | Bank Address | Row Address | Column Address | Page Size |
|--------------|------------|-------|--------------|-------------|----------------|-----------|
| 2Gb          | x16        | 8     | BA[2:0]      | A[13:0]     | A[9:0]         | 2KB       |

**Table 65. Supported DDR3L-RS DRAM Devices**

| DRAM Density | Data Width | Banks | Bank Address | Row Address | Column Address | Page Size |
|--------------|------------|-------|--------------|-------------|----------------|-----------|
| 2Gb          | x16        | 8     | BA[2:0]      | A[13:0]     | A[9:0]         | 2KB       |

**Table 66. Supported LPDDR3 Memory Size Per Rank**

| Memory Size/ Rank | DRAM Chips/ Rank | DRAM Chip Density | DRAM Chip Data Width | Page Size @ 64-bit Data Bus |
|-------------------|------------------|-------------------|----------------------|-----------------------------|
| 512MB             | 2                | 2Gb               | x32                  | 4KB = 2KB * 2 chips         |
| 1GB               | 2                | 4Gb               | x32                  | 8KB = 4KB * 2 chips         |
| 2GB               | 2                | 8Gb               | x32                  | 8KB = 4KB * 2 chips         |

**Table 67. Supported DDR3L-RS Memory Size Per Rank**

| Memory Size/ Rank | DRAM Chips/ Rank | DRAM Chip Density | DRAM Chip Data Width | Page Size @ 64-bit Data Bus |
|-------------------|------------------|-------------------|----------------------|-----------------------------|
| 1GB               | 4                | 2Gb               | x16                  | 8KB = 2KB * 4 chips         |

### 8.3 Register Map

For more information on System Memory Controller registers, refer Intel® Atom™ Z8000 Processor Series Datasheet (Volume 2 of 2), Doc ID:332066.

## 9 Graphics, Video and Display

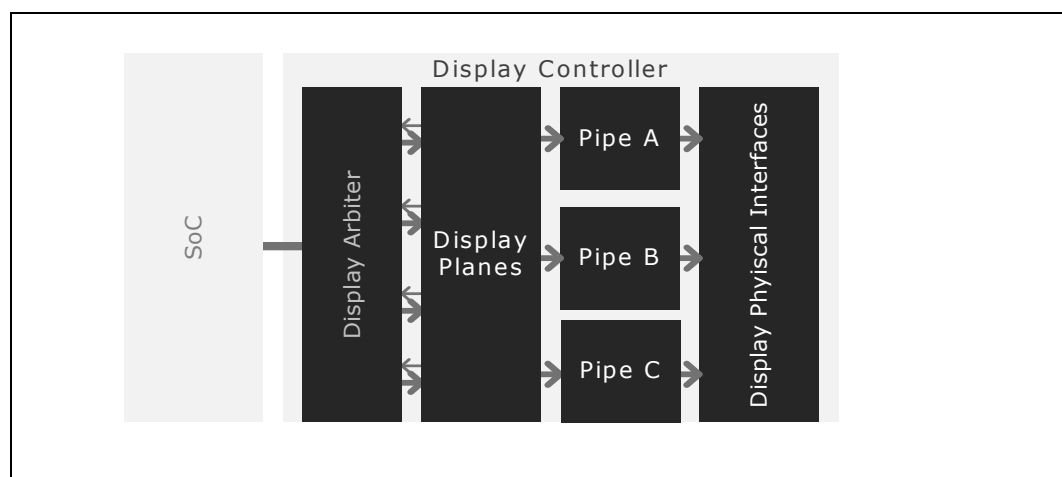
This chapter provides an overview of Graphics, Video and Display features of the SoC.

### 9.1 Features

The key features of the individual blocks are as follows:

- Refreshed eight generation Intel graphics core with sixteen Execution Units (EUs)
  - 3D graphics hardware acceleration including support for DirectX\*11.1, OpenGL 4.3, OGL ES 3.0, OpenCL 1.2.
  - Video decode hardware acceleration including support for H.263, MPEG4, H.264, H.265 (HEVC), VP8, VP9, MVC, MPEG2, VC1, JPEG.
  - Video encode hardware acceleration including support for H.264, H.263, VP8, MVC, JPEG.
  - Display controller, incorporating the display planes, pipes and physical interfaces.
  - Four planes available per pipe - 1x Primary, 2x Video Sprite & 1x Cursor.
  - Three multi-purpose Digital Display Interface (DDI) PHYs implementing HDMI, DVI, DisplayPort (DP) or Embedded DisplayPort (eDP) support.
  - Two dedicated digital Display Serial Interface PHYs implementing MIPI-DSI support.

### 9.2 SoC Graphics Display





The Processor Graphics controller display pipe can be broken down into three components:

- Display Planes
- Display Pipes
- Display Physical Interfaces

A display plane is a single displayed surface in memory and contains one image (desktop, cursor, overlay). It is the portion of the display hardware logic that defines the format and location of a rectangular region of memory that can be displayed on a display output device and delivers that data to a display pipe. This is clocked by the Core Display Clock.

### 9.2.1 Primary Planes A, B and C

Planes A, B and C are the main display planes and are associated with Pipes A, B and C respectively. Each plane supports per-pixel alpha blending.

### 9.2.2 Video Sprite Planes A, B, C, D, E and F

Video Sprite Planes A, B, C, D, E and F are planes optimized for video decode.

- Pipe A – Primary planeA, VSpriteA, VSpriteB, CursorA
- Pipe B – Primary planeB, VSpriteC, VSpriteD, CursorB
- Pipe C – Primary planeC, VSpriteE, VSpriteF, CursorC

### 9.2.3 Cursors A, B and C

Cursors A, B and C are small, fixed-sized planes dedicated for mouse cursor acceleration, and are associated with Planes A, B and C respectively.

## 9.3 Display Pipes

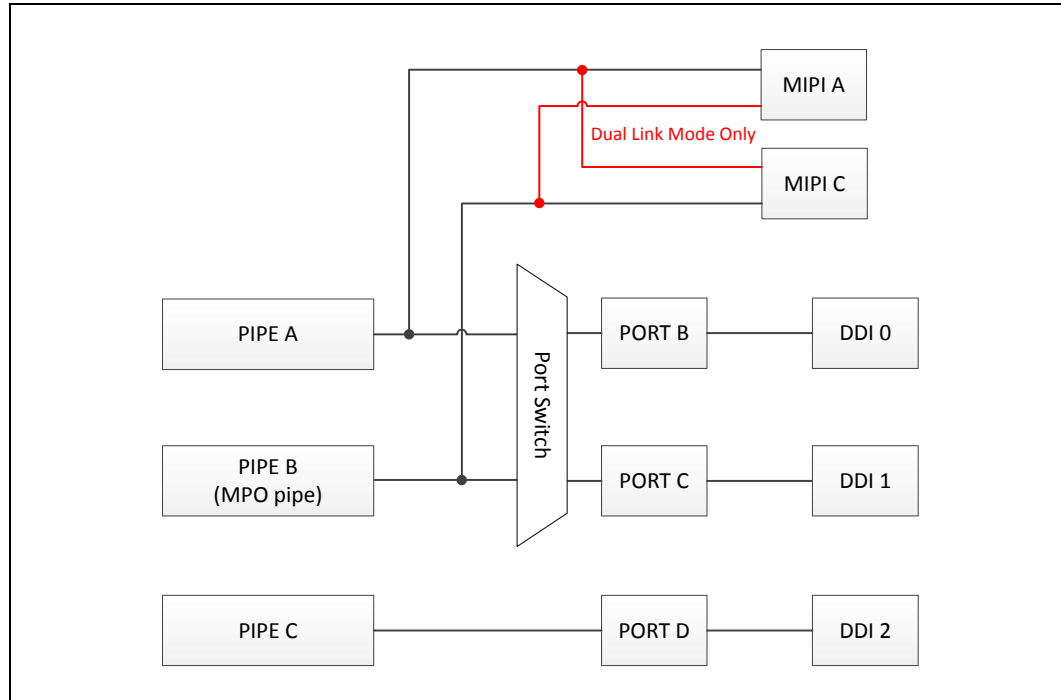
The display pipe blends and synchronizes pixel data received from one or more display planes and adds the timing of the display output device upon which the image is displayed.

The display pipes A, B and C operate independently of each other at the rate of one pixel per clock. They can attach to any of the display interfaces.

## 9.4 Display Physical Interfaces

The display physical interfaces consist of output logic and pins that transmit the display data to the associated encoding logic and send the data to the display device. These interfaces are digital (MIPI-DSI, DisplayPort\*, Embedded DisplayPort\*, DVI and HDMI\*) interfaces.

**Figure 9. Display Pipe to Port Mapping**



**Figure 10. Display Pipe to Port Mapping [T3]**

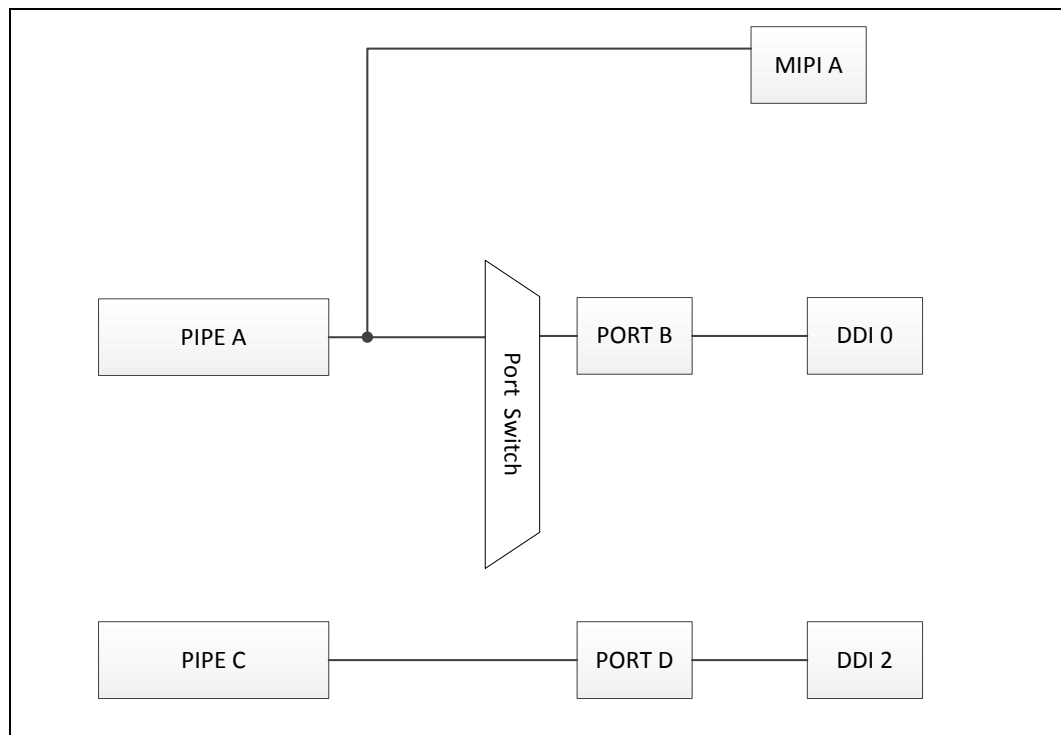
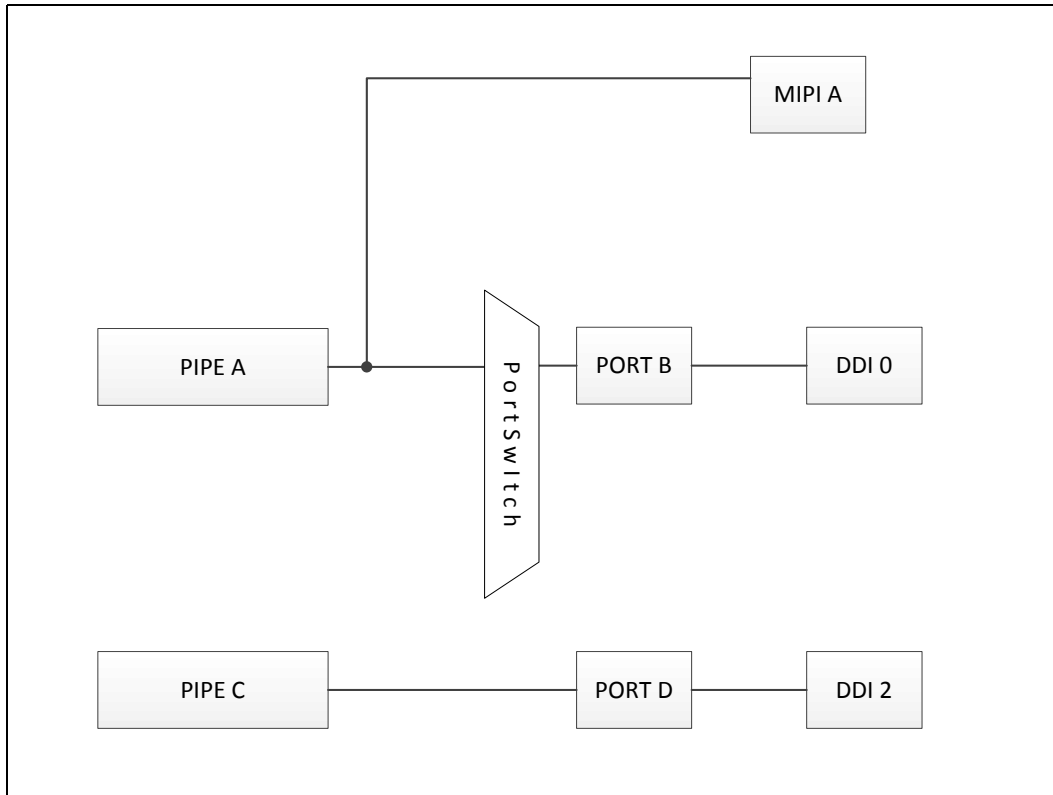


Figure 11. Display Pipe to Port Mapping [T3]



### 9.4.1 Digital Display Interfaces

Table 68. SoC Display Configuration (Sheet 1 of 2)

| Feature                                 | MIPI DSI                 | eDP                      | DP                       | HDMI/DVI  |
|---|--------------------------|--------------------------|--------------------------|---|
| Number of Ports                         | 2<br>(x4 @ 1Gbps)        | 2<br>(x4 @2.7Gbps)       | 2<br>(x4 @2.7GHz)        | 2<br>(x4 @2.97GHz)                                      |
| Max Resolution                          | 2560x1600<br>24bpp @60Hz | 2560x1600<br>24bpp @60Hz | 2560x1600<br>24bpp @60Hz | 1920x1080<br>24bpp @120Hz/<br>3840x2160<br>24bpp @ 30Hz |
| Standard                                | DSI1.01/<br>DPHY1.00     | eDP1.3                   | DP1.1a                   | HDMI1.4b  |
| Power gated during S0ix w/display off   | Yes                      | Yes                      | Yes                      | Yes   |
| DRRS (Refresh reduction)                | Yes (M/N pair)           | Yes (Panel command)      | N/A                      | N/A   |
| Self-Refresh with Frame buffer in Panel | Yes (Command Mode)       | Yes (PSR)                | No                       | No  |





**Table 68. SoC Display Configuration (Sheet 2 of 2)**

| Feature                         | MIPI DSI  | eDP               | DP  | HDMI/DVI |
|---------------------------------|---|-------------------|-----|----------|
| Content-Based backlight control | DPST6.0/CABC                                      | DPST6/CABC        | N/A | N/A      |
| HDCP wired display              | N/A   | N/A(ASSR support) | 1.4 | 1.4      |
| HDCP wireless display           | N/A   | N/A(ASSR support) | 2.2 | 2.2      |
| PAVP                            | AES-encrypted buffer, plane control, panic attack |                   |     |          |
| SEC                             | All display registers can be accessed by CEC      |                   |     |          |
| LPE Audio                       | N/A   | N/A               | Yes | Yes      |
| Compressed Audio                | N/A   | N/A               | Yes | Yes      |

**Table 69. SoC Display supported Resolutions**

|                    | 1 Display  |  | 2 Displays   |  | 3 Displays   |
|--------------------|--|--|--|--|--|
|                    | 1 Internal   | 1 External   | 1 Internal + 1 External  | 2 External   | 1 Internal + 2 External  |
| <b>Internal #1</b> | eDP*<br>2560x1600<br>@ 60Hz<br>or<br>MIPI DSI*<br>2560x1600<br>@60Hz | N/A  | eDP*<br>2560x1600<br>@ 60Hz<br>or<br>MIPI DSI*<br>2560x1600<br>@60Hz | N/A  | eDP*<br>2560x1600<br>@ 60Hz<br>or<br>MIPI DSI*<br>2560x1600<br>@60Hz |
| <b>External #1</b> | N/A  | HDMI/DP*<br>3840x2160<br>@ 30Hz<br>2560x1600<br>@ 60Hz | HDMI/DP*<br>3840x2160<br>@ 30Hz<br>2560x1600<br>@ 60Hz               | N/A  | HDMI/DP*<br>3840x2160<br>@ 30Hz<br>2560x1600<br>@ 60Hz               |
| <b>External #2</b> | N/A  | N/A  | N/A  | HDMI/DP*<br>3840x2160<br>@ 30Hz<br>2560x1600<br>@ 60Hz | HDMI/DP*<br>3840x2160<br>@ 30Hz<br>2560x1600<br>@ 60Hz               |

**NOTES:**

1. SoC is supported maximum of 3 simultaneous displays. External display in both clone and extended modes.
2. Experience may differ based on configuration, resolution, and work loads.

### 9.4.1.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 71. Display Physical Interfaces Signal Names (2 of 2)**

| Signal names   | Direction Type | Description   |
|----------------|----------------|---|
| MDSI_A_CLKP    | O              | MIPI Clock output for port A  |
| MDSI_A_CLKN    | O              | MIPI Clock complement output for port A   |
| MDSI_A_DP[3:0] | I/O            | MIPI Data Lane 3:0 for port A   |
| MDSI_A_DN[3:0] | I/O            | MIPI Data Lane 3:0 complement for port A  |
| MDSI_C_CLKP    | O              | MIPI Clock output for port C  |
| MDSI_C_CLKN    | O              | MIPI Clock complement output for port C   |
| MDSI_C_DP[3:0] | I/O            | MIPI Data Lane 3:0 for port C   |
| MDSI_C_DN[3:0] | I/O            | MIPI Data Lane 3:0 complement for port C  |
| MDSI_A_TE      | I/O            | Tearing Effect Signal from x4 port A display  |
| MDSI_C_TE      | I              | Tearing Effect Signal from x4 port C display  |
| MDSI_DDC_DATA  | I/O            | DDC Data  |
| MDSI_DDC_CLK   | I/O            | DDC Clock   |
| MDSI_RCOMP     | I/O            | MDSI_RCOMP: This is for pre-driver slew rate compensation for the MIPI DSI Interface.<br>An external precision resistor of 150 Ω ±1% should be connected from this pin to ground. |

### 9.4.1.2 Features

#### 9.4.1.2.1 MIPI-DSI

**Dual Link interface supports** display resolution up to 2560 x 1600p @ 60 Hz with 24b per pixel.

Interface supports maximum of 1Gbps per lane.

### Full Frame Buffer Panel

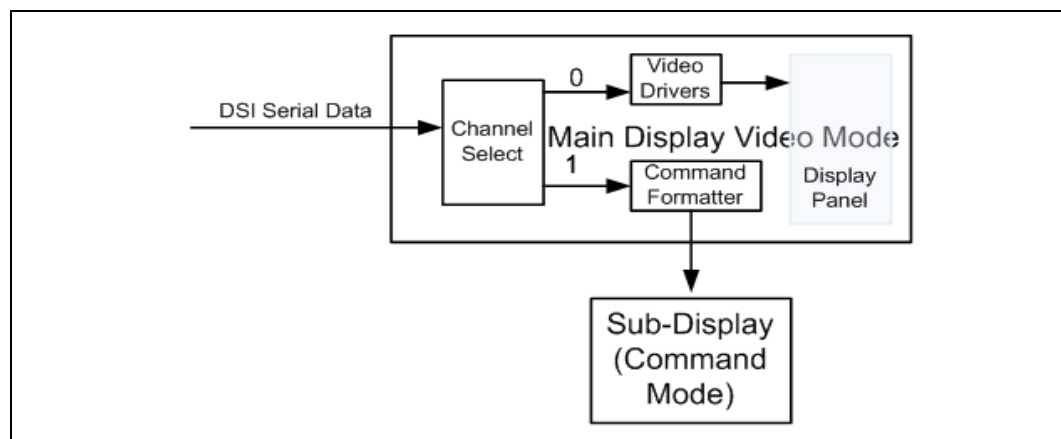
The display controller supports full frame buffer display (also called command-mode display) with optimizations for both SoC power consumption and system power consumption. Full frame buffer panel does not need to be refreshed regularly by a frame buffer in system memory so the path between panel and system memory can be power-managed as much as possible until a new request occurs to update one or more planes that are active in the display pipe.

### Sub-Display Support

The display controller supports a sub-display panel that uses a different virtual channel and shares the same interface with the main panel. The pixel data for this sub-display can come from a direct system memory read or it can come from the output at the pipe as described. Sub-display allows, for example, the pixel stream to be updated more frequently or presented in a format and/or resolution that would require software to convert or scale the panel resolution.

One example usage of sub-display is as a view finder for camera. The camera interface unit may output images in a format and resolution that are not read by the sub-display itself or must be blended with camera application graphics.

**Figure 12. Sub-Display Connection**



### Partial Display Mode Support

The display controller supports a partial display mode that utilizes the MIPI command set to transition the panel from normal mode to partial display mode, so a small part of the display panel can be kept active for pixel data. The same panel can switch from full screen mode to a sub-display mode with a handful of scan lines to show time, date, signal strength indicator, etc., to save power for the host processor and display panel.

There are two scenarios:

- Type 1 display panel—both full display and partial display operates in command mode.

- Type 2 display panel—full display (normal mode) operate in video mode; partial display operates in command mode. This requires the host processor and display panel to be in sync in transition from normal mode to partial mode after 2 frames from the `enter_partial_mode` command.

The software driver must implement most of the protocols of transition and send the correct commands to the display panel to start the transition. The software driver must program the display controller to select the buffer for partial display (display pipe output or system memory) and follow the protocol to be in sync with the display panel.

When the display transitions from partial mode to normal mode, it is recommended to turn the display off to avoid tearing effect as in a flow chart in DCS specification.

### MIPI DSI Dual-link Mode

The SoC supports MIPI DSI dual-link mode, so that a single display can transmit a single stream of video data across two independent MIPI DSI interfaces. The packetization and timing of each link follows MIPI DSI 1.00 and DPHY 1.00 precisely, but the receiving device, which is a panel or a bridge, can combine the streaming data from two interfaces and display it in a single panel.

There are two types of dual-link panels that the SoC can support:

- Front-back type of panel, the first half of columns of pixels is always transmitted by port A and the second half of columns of pixels is always transmitted by port B.
- Pixel alternative type of panel, odd columns of pixels are always transmitted by port A and even columns of pixels are always transmitted by port B. So the 1<sup>st</sup>, 3<sup>rd</sup>, 5<sup>th</sup>, 7<sup>th</sup>, etc., pixels are separated at the source and sent in the first interface; the 2<sup>nd</sup>, 4<sup>th</sup>, 6<sup>th</sup>, 8<sup>th</sup>, etc., pixels are sent in the second interface. When the platform requires a dual-link interface for a large MIPI DSI panel or bridge (usually with resolution larger than 1920x1080 in which a 4-lane interface does not have enough bandwidth), the driver treats dual-link a special port configuration, with special handling of DSI controller but the operation of dual-link mode is consistent with single-link mode for planes and pipe operations. The system interface with upper level of SW does not need to change, like flip mechanism, interrupt, and so on.

### LVDS Panel Support

An external MIPI DSI-to-LVDS bridge device is required to connect the display controller to a LVDS panel. A bridge device is used for larger panels.

#### 9.4.1.3 High Definition Multimedia Interface

The High-Definition Multimedia Interface (HDMI) is provided for transmitting digital audio and video signals from DVD players, set-top boxes and other audiovisual sources to television sets, projectors and other video displays. It can carry high quality multi-channel audio data and all standard and high-definition consumer electronics video formats. HDMI display interface connecting the SoC and display devices utilizes transition minimized differential signaling (TMDS) to carry audiovisual information through the same HDMI cable.



HDMI includes three separate communications channels: TMDS, DDC, and the optional CEC (consumer electronics control) (not supported by the SoC). As shown in Figure 13, the HDMI cable carries four differential pairs that make up the TMDS data and clock channels. These channels are used to carry video, audio, and auxiliary data. In addition, HDMI carries a VESA DDC. The DDC is used by an HDMI Source to determine the capabilities and characteristics of the sink.

Audio, video and auxiliary (control/status) data is transmitted across the three TMDS data channels. The video pixel clock is transmitted on the TMDS clock channel and is used by the receiver for data recovery on the three data channels. The digital display data signals driven natively through the SoC are AC coupled and needs level shifting to convert the AC coupled signals to the HDMI compliant digital signals.

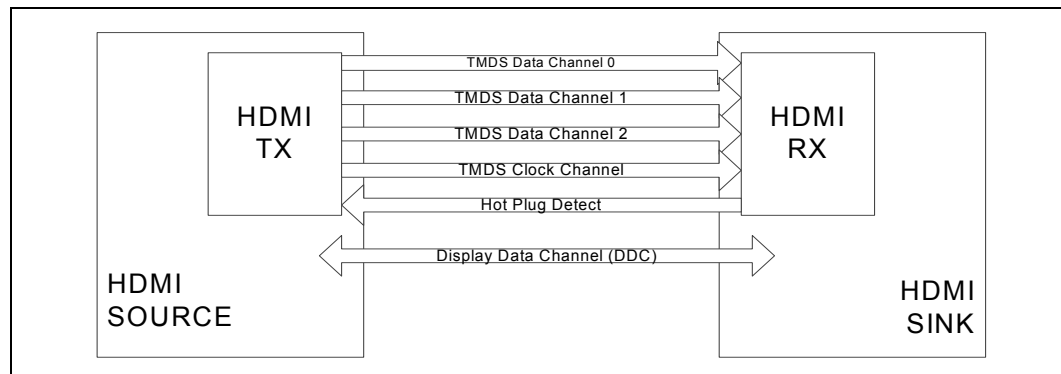
The SoC HDMI interface is designed as per the High-Definition Multimedia Interface Specification 1.4. The SoC supports High-Definition Multimedia Interface Compliance Test Specification 1.4.

**9.4.1.3.1 Stereoscopic Support on HDMI**

SoC display supports HDMI 1.4 3D video formats. If the HDMI panel is detected to support 3D video format then the SW driver will program Pipe2dB for the correct pipe timing parameters.

The left and right frames can be loaded from independent frame buffers in the main memory. Depending on the input S3D format, the display controller can be enabled to perform frame repositioning, image scaling, line interleaving.

**Figure 13. HDMI Overview**



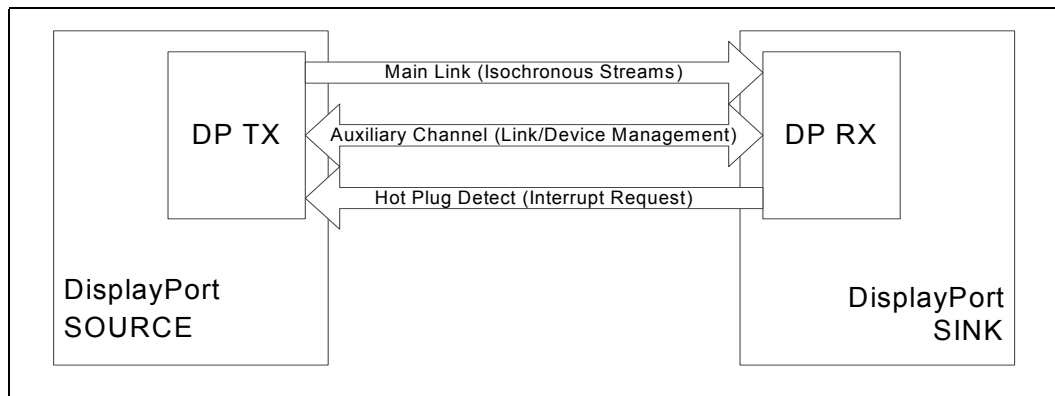
**9.4.1.4 Display Port**

Display Port is a digital communication interface that utilizes differential signalling to achieve a high bandwidth bus interface designed to support connections between PCs and monitors, projectors, and TV displays. Display Port is also suitable for display connections between consumer electronics devices such as high definition optical disc players, set top boxes, and TV displays.

A Display Port consists of a Main Link, Auxiliary channel, and a Hot Plug Detect signal. The Main Link is a uni-directional, high-bandwidth, and low latency channel used for transport of isochronous data streams such as uncompressed video and audio. The Auxiliary Channel (AUX CH) is a half-duplex bidirectional channel used for link management and device control. The Hot Plug Detect (HPD) signal serves as an interrupt request for the sink device.

The SoC supports DisplayPort Standard Version 1.2.

**Figure 14. DisplayPort\* Overview**



#### 9.4.1.5 Embedded DisplayPort (eDP)

Embedded DisplayPort (eDP) is an embedded version of the DisplayPort standard oriented towards applications such as notebook and All-In-One PCs. eDP is supported only on Digital Display Interfaces 0 and/or 1. Like DisplayPort, Embedded DisplayPort also consists of a Main Link, Auxiliary channel, and an optional Hot Plug Detect signal.

Each eDP port can be configured for up-to 4 lanes.

The SoC supports Embedded DisplayPort Standard Version 1.3.

##### 9.4.1.5.1 DisplayPort Auxiliary Channel

A bidirectional AC coupled AUX channel interface replaces the I<sup>2</sup>C for EDID read, link management and device control. I<sup>2</sup>C-to-Aux bridges are required to connect legacy display devices.

##### 9.4.1.5.2 Hot-Plug Detect (HPD)

SoC supports HPD for Hot-Plug sink events on the HDMI and DisplayPort interfaces.

##### 9.4.1.5.3 Integrated Audio over HDMI and DisplayPort

SoC can support two audio streams on DP/HDMI ports. Each stream can be programmable to either DDI port. HDMI/DP audio streams can be sent with video streams as follows.



LPE mode: In this mode the uncompressed or compressed audio sample buffers are generated either by OS the audio stack or by audio Lower Power Engine (LPE) and stored in system memory. The display controller fetches audio samples from these buffers, forms an SPDIF frame with VUCP and preamble (if needed), then sends out with video packets.

**9.4.1.5.4 High-Bandwidth Digital Content Protection (HDCP)**

HDCP is the technology for protecting high definition content against unauthorized copy or unreceptive between a source (computer, digital set top boxes, etc.) and the sink (panels, monitor, and TV). The SoC supports HDCP 1.4(wired)/2.2(wireless) for content protection over wired displays (HDMI, DisplayPort and Embedded DisplayPort).

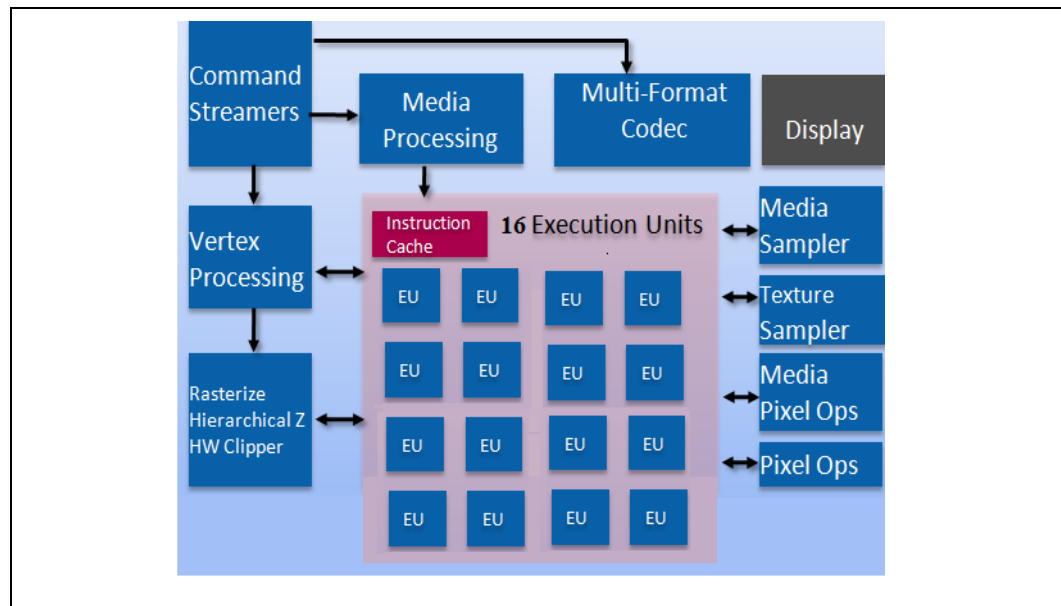
**9.5 References**

- High-Definition Multimedia Interface Specification, Version 1.4b
- High-bandwidth Digital Content Protection System, Revision 1.4
- VESA DisplayPort Standard, Version 1.2
- VESA Embedded DisplayPort Standard, Version 1.3

**9.6 3D Graphics and Video**

The SoC implements a derivative of the Generation 8 LP graphics engine which consists of rendering engine and bit stream encoder/decoder engine. The rendering engine is used for 3D rendering, media compositing and video encoding. The Graphics engine is built around sixteen execution units (EUs).

**Figure 15. 3D Graphics Block Diagram**





## 9.7 Features

The 3D graphics pipeline architecture simultaneously operates on different primitives or on different portions of the same primitive. All the cores are fully programmable, increasing the versatility of the 3D Engine. The Gen 8.0 LP 3D engine provides the following performance and power-management enhancements:

- Hierarchical-Z
- Video quality enhancements

### 9.7.1 3D Engine Execution Units

- The EUs perform 128-bit wide execution per clock
- Support SIMD8 instructions for vertex processing and SIMD16 instructions for pixel processing

### 9.7.2 3D Pipeline

#### 9.7.2.1 Vertex Fetch (VF) Stage

The VF stage executes 3DPRIMITIVE commands. Some enhancements have been included to better support legacy D3D APIs as well as SGI OpenGL\*.

#### 9.7.2.2 Vertex Shader (VS) Stage

The VS stage performs shading of vertices output by the VF function. The VS unit produces an output vertex reference for every input vertex reference received from the VF unit, in the order received.

#### 9.7.2.3 Geometry Shader (GS) Stage

The GS stage receives inputs from the VS stage. Compiled application-provided GS programs, specifying an algorithm to convert the vertices of an input object into some output primitives. For example, a GS shader may convert lines of a line strip into polygons representing a corresponding segment of a blade of grass centered on the line. Or it could use adjacency information to detect silhouette edges of triangles and output polygons extruding out from the edges.

#### 9.7.2.4 Clip Stage

The Clip stage performs general processing on incoming 3D objects. However, it also includes specialized logic to perform a Clip Test function on incoming objects. The Clip Test optimizes generalized 3D Clipping. The Clip unit examines the position of incoming vertices, and accepts/rejects 3D objects based on its Clip algorithm.





### 9.7.2.5 Strips and Fans (SF) Stage

The SF stage performs setup operations required to rasterize 3D objects. The outputs from the SF stage to the Windower stage contain implementation-specific information required for the rasterization of objects and also supports clipping of primitives to some extent.

### 9.7.2.6 Windower/IZ (WIZ) Stage

The WIZ unit performs an early depth test, which removes failing pixels and eliminates unnecessary processing overhead.

The Windower uses the parameters provided by the SF unit in the object-specific rasterization algorithms. The WIZ unit rasterizes objects into the corresponding set of pixels. The Windower is also capable of performing dithering, whereby the illusion of a higher resolution when using low-bpp channels in color buffers is possible. Color dithering diffuses the sharp color bands seen on smooth-shaded objects.

## 9.7.3 Video Engine

The video engine is part of the Intel Processor Graphics for image processing, playback and transcode of Video applications. Processor Graphics video engine has a dedicated fixed hardware pipe-line for high quality decode and encode of media content. This engine supports Full HW acceleration for decode of AVC/H.264, VC-1 and MPEG -2 contents along with encode of MPEG-2 and AVC/H.264 apart from various video processing features. The new Processor Graphics Video engine adds support for processing features such as frame rate conversion, image stabilization and gamut conversion.

## 9.8 VED (Video Encode/Decode)

The video engine is part of the Intel Processor Graphics for image processing, playback and transcode of Video applications. Processor Graphics video engine has a dedicated fixed hardware pipe-line for high quality decode and encode of media content.

### 9.8.1 Features

The features for the Video decode hardware accelerator in SoC are:

- VED core can be configured on a time division multiplex basis to handle single, dual and multi-stream HD decoding/encoding.
- VED provides full hardware acceleration Decode/Encode support below Media formats.



**Table 72. Hardware Accelerated Video Decode/Encode Codec Support**

| Encode Format | Profile                               | Level | Resolution     | Bitrate (Mbps) | Frame Rate |
|---------------|---------------------------------------|-------|----------------|----------------|------------|
| H.263         |                                       |       | 480p           |                | 30         |
| H.264         | HP/BP/CBP                             | L5.1  | 4kx2k<br>1080p | 100-130        | 30<br>120  |
| VP8           |                                       |       | 4kx2k          |                | 30         |
| MVC           | HP/BP/CBP                             | L4.2  | 1080p          |                | 60         |
| JPEG          | 1067Mpps (420), 800Mpps (422) @400Mhz |       |                |                |            |

| Decode Format | Profile                               | Level | Resolution     | Bitrate (Mbps) | Frame Rate |
|---------------|---------------------------------------|-------|----------------|----------------|------------|
| H.263         |                                       |       | 480p           |                | 30         |
| MPEG4         | SP                                    |       | 480p           |                | 30         |
| H.264         | HP,MP,CBP                             | L5.2  | 4Kx2K<br>1080P | 200-250        | 60<br>240  |
| H.265(HEVC)   | MP                                    | L5    | 4Kx2K          |                | 30         |
| VP8           |                                       |       | 4kx2k          |                | 30         |
| VP9           |                                       |       | 1080p          |                | 30         |
| MVC           |                                       |       | 4Kx2K          |                | 30         |
| MPEG2         | MP                                    | HL    | 1080p          |                | 60         |
| VC1           | AP                                    | L4    | 1080P          |                | 60         |
| JPEG          | 1067Mpps (420), 800Mpps (422) @400Mhz |       |                |                |            |

## 9.9 Register Map

For more information on Graphics, Video and Display registers refer Intel® Atom™ Z8000 Processor Series Datasheet (Volume 2 of 2), Doc ID:332066.

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# 10 PCI Express 2.0

There are up to two PCI Express root ports, each supporting the *PCI Express\* Base Specification*, Rev. 2.0 at a maximum 5 GT/s signaling rate. The root ports can be configured to support a diverse set of lane assignments.

## 10.1 Signal Descriptions

Refer [Chapter 2, "Physical Interfaces"](#) for additional details.

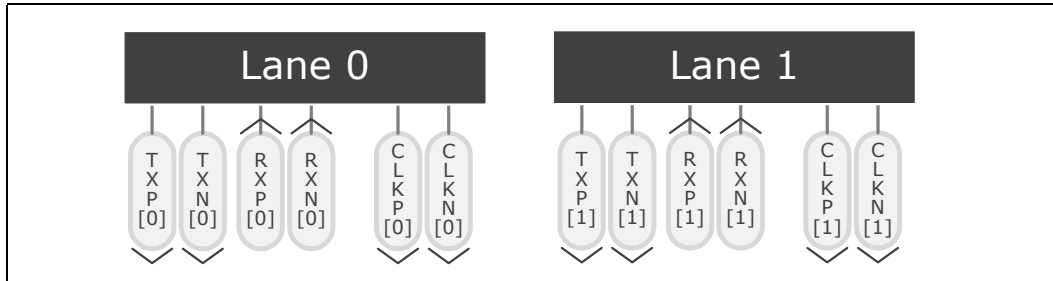
The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, "Electrical Specifications"](#).
- **Description:** A brief explanation of the signal's function.

**Table 73. Signals**

| Signal Name                    | Direction /Type | Description   |
|--------------------------------|-----------------|---|
| PCIE_TXP[1:0]<br>PCIE_TXN[1:0] | O<br>PCIe       | <b>PCI Express* Transmit</b><br>PCI Express* Ports 1:0 transmit pair (P and N) signals. Each pair makes up the transmit half of a lane.   |
| PCIE_RXP[1:0]<br>PCIE_RXN[1:0] | I<br>PCIe       | <b>PCI Express* Receive:</b><br>PCI Express* Ports 1:0 receive pair (P and N) signals. Each pair makes up the receive half of lane.   |
| PCIE_CLKREQ[1:0]_N             | IO              | <b>PCI Express* Clock Request</b><br>Used for devices that need to request one of the output clocks. Each clock request maps to the matching PCIe Root Port (e.g. PCIE_CLKREQ#[0] maps to PCIe Root Port [0] and so on)<br><b>NOTE:</b> These signals are muxed and may be used by other functions. |
| P_RCOMP_P<br>P_RCOMP_N         | I/O             | These pins connected with 402 Ohm 1% between RCOMP pads.  |

Figure 16. PCIe\* 2.0 Lane 0 Signal Example



## 10.2 Features

- Conforms to *PCI Express\* Base Specification, Rev. 2.0*.
- 5.0 or 2.5 GT/s operation per root port.
- Virtual Channel support for VC0 only.
- x1, x2 link widths (auto negotiated).
- Spread Spectrum Clocking (SSC) is supported for PCIe Gen1 components.
- Flexible Root Port configuration options
  - (1) x2's
  - (2) x1
- Interrupts and Events
  - Legacy (INTx) and MSI Interrupts
  - General Purpose Events
  - Express Card Hot Plug Events
  - System Error Events
- Power Management
  - Link State support for ASPM(L0s, L1), L1 sub states (L1.SNOOZ,L1.OFF), L23\_RDY,L2 and L3.
  - Powered down in ACPI S3 state - L3.

**Note:** Intel recommends disabling Spread Spectrum Clocking (SSC), if PCIe Gen2 based component is used.

### 10.2.1 Root Port Configurations

Depending on SKU, there are up to two possible lane assignments for root ports 1-2.

Root port configurations are set by SoftStraps stored in SPI flash, and the default option is "(2) x1". Links for each root port will train automatically to the maximum possible for each port.



**Note:** x2 link widths are not common. Most devices will only train to x1.

**Note:** PCI functions in PCI configuration space are disabled for root ports not available.

### 10.2.2 Interrupts and Events

A root port is capable of handling interrupts and events from an end point device. A root port can also generate its own interrupts for some events, including power management and hot plug events, but also including error events.

There are two interrupt types a root port will receive from an end point device: INTx (legacy), and MSI. MSI's are automatically passed upstream by the root port, just as other memory writes would be. INTx messages are delivered to the Legacy block's interrupt router/controller by the root port.

Events and interrupts that are handled by the root port are shown with the possible interrupts they can deliver to the interrupt decoder/router.

**Table 74. Possible Interrupts Generated From Events/Packets**

| Packet/Event          | Type   | INTx | MSI | SERR | SCI | SMI | GPE |
|-----------------------|--------|------|-----|------|-----|-----|-----|
| INTx                  | Packet | X    | X   |      |     |     |     |
| PM_PME                | Packet | X    | X   |      |     |     |     |
| Power Management (PM) | Event  | X    | X   |      | X   | X   |     |
| Hot Plug (HP)         | Event  | X    | X   |      | X   | X   |     |
| ERR_CORR              | Packet |      |     | X    |     |     |     |
| ERR_NONFATAL          | Packet |      |     | X    |     |     |     |
| ERR_FATAL             | Packet |      |     | X    |     |     |     |
| Internal Error        | Event  |      |     | X    |     |     |     |
| VDM                   | Packet |      |     |      |     |     | X   |

**NOTE:** Above table lists the possible interrupts and events generated based on Packets received, or events generated in the root port. Configuration needed by software to enable the different interrupts as applicable.

When INTx interrupts are received by an end point, they are mapped to the following interrupts and sent to the interrupt decoder/router in the iLB.

**Table 75. Interrupt Generated for INT[A-D] Interrupts**

|             | INTA  | INTB  | INTC  | INTD  |
|-------------|-------|-------|-------|-------|
| Root Port 1 | INTA# | INTB# | INTC# | INTD# |
| Root Port 2 | INTD# | INTA# | INTB# | INTC# |

**NOTE:** Interrupts generated from events within the root port are not swizzled.



### 10.2.2.1 Express Card Hot Plug Events

Express Card Hot Plug is available based on Presence Detection for each root port.

**Note:** A full Hot Plug Controller is not implemented.

Presence detection occurs when a PCI Express\* device is plugged in and power is supplied. The physical layer will detect the presence of the device, and the root port will set the SLSTS.PDS and SLSTS.PDC bits.

When a device is removed and detected by the physical layer, the root port will clear the SLSTS.PDS bit, and set the SLSTS.PDC bit.

Interrupts can be generated by the root port when a hot plug event occurs. A hot plug event is defined as the transition of the SLSTS.PDC bit from 0 to 1. Software can set the SLCTL.PDE and SLTCTL.HPE bits to allow hot plug events to generate an interrupt.

If SLCTL.PDE and SLTCTL.HPE are both set, and SLSTS.PDC transitions from 0 to 1, an interrupt will be generated.

### 10.2.2.2 System Error (SERR)

System Error events are support by both internal and external sources. Refer the PCI Express\* Base Specification, Rev. 2.0 for details.

## 10.2.3 Power Management

Each root port's link supports L0s, L1, and L2/3 link states per PCI Express\* Base Specification, Rev. 2.0. L2/3 is entered on entry to S3.

## 10.3 References

*PCI Express\* Base Specification, Rev. 2.0*

## 10.4 Register Map

For more information on PCI Express\* 2.0 registers refer Intel® Atom™ Z8000 Processor Series Datasheet (Volume 2 of 2), Doc ID:332066.

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# 11 MIPI-Camera Serial Interface (CSI) and ISP

MIPI CSI and controller front end interfaces with three sensors and is capable of simultaneously acquiring three streams, one from each sensor. These three streams are presented to the ISP.

## 11.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 76. CSI Signals**

| Signal Name            | Direction | Description   |
|------------------------|-----------|---|
| <b>MCSI1_CLKP/N</b>    | I         | <b>Clock Lane:</b> MIPI CSI input clock lane 0 for port 1.  |
| <b>MCSI1_DP/N[3:0]</b> | I         | <b>Data Lanes:</b> Four MIPI CSI Data Lanes (0-3) for port 1. Lanes 2 and 3 can optionally used as data lanes for port 3. |
| <b>MCSI2_CLKP/N</b>    | I         | <b>Clock Lane:</b> MIPI CSI input clock lane 0 for port 2.  |
| <b>MCSI2_DP/N[1:0]</b> | I         | <b>Data Lane:</b> Two MIPI CSI Data Lanes for port 2.   |
| <b>MCSI3_CLKP/N</b>    | I         | <b>Clock Lane:</b> MIPI CSI input clock lane 0 for port 3.  |
| <b>MCSI_RCOMP</b>      | I/O       | <b>Resistor Compensation:</b> This is for pre-driver slew rate compensation for the MIPI CSI Interface.                   |

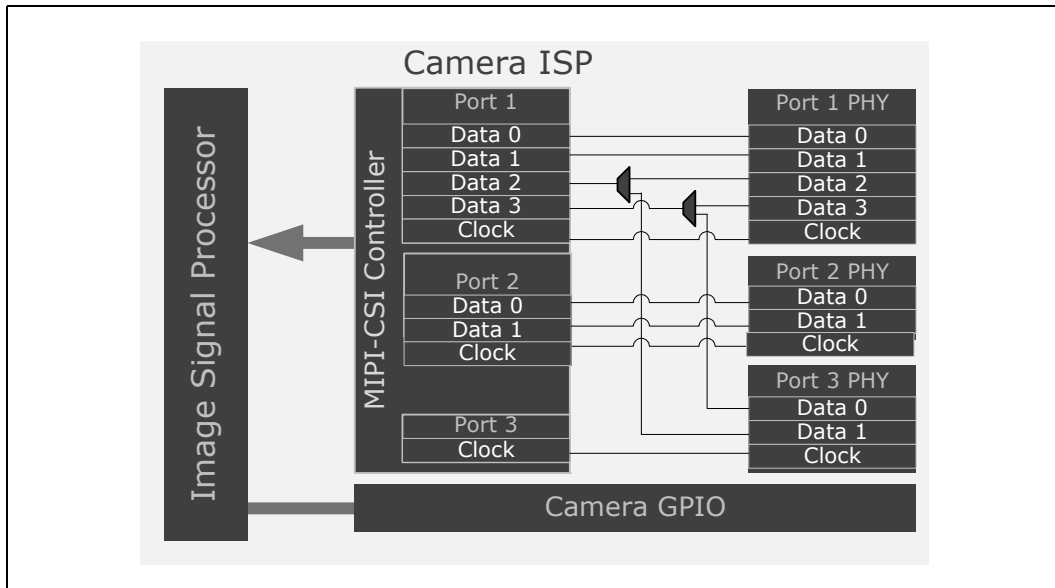
**Table 77. GPIO Signals (Sheet 1 of 2)**

| Signal Name          | Direction /Type | Description  |
|----------------------|-----------------|--|
| <b>MCSI_GPIO[00]</b> | I/O             | Output from shutter switch when its pressed halfway. This switch state is used to trigger the Auto focus LED for Xenon Flash or Torch mode for LED Flash |
| <b>MCSI_GPIO[01]</b> | I/O             | Output from shutter switch when its pressed full way. This switch state is used to trigger Xenon flash or LED Flash                                      |
| <b>MCSI_GPIO[02]</b> | I/O             | Active high control signal to Xenon Flash to start charging the Capacitor  |
| <b>MCSI_GPIO[03]</b> | I/O             | Active low output from Xenon Flash to indicate that the capacitor is fully charged and is ready to be triggered  |

Table 77. GPIO Signals (Sheet 2 of 2)

| Signal Name   | Direction /Type | Description  |
|---------------|-----------------|--|
| MCSI_GPIO[04] | I/O             | Active high Xenon Flash trigger / Enables Torch Mode on LED Flash IC   |
| MCSI_GPIO[05] | I/O             | Enables Red Eye Reduction LED for Xenon / Triggers STROBE on LED Flash IC /  |
| MCSI_GPIO[06] | I/O             | Camera Sensor 0 Strobe Output to SoC to indicate beginning of capture / Active high signal to still camera to power down the device. |
| MCSI_GPIO[07] | I/O             | Camera Sensor 1 Strobe Output to SoC to indicate beginning of capture / Active high signal to still camera to power down the device. |
| MCSI_GPIO[08] | I/O             | Active high signal to video camera to power down the device.   |
| MCSI_GPIO[09] | I/O             | Active low output signal to reset digital still camera #0.   |
| MCSI_GPIO[10] | I/O             | Active low output signal to reset digital still camera #1  |
| MCSI_GPIO[11] | I/O             | Active low output signal to reset digital video camera   |

Figure 17. Camera Connectivity







## 11.2 Features

- Integrated MIPI-CSI 2.0 interface.
- Image Signal Processor (ISP) with DMA and local SRAM.
- Imaging data is received by the MIPI-CSI interface and is relayed to the ISP for processing.
- Up to six MIPI-CSI 2.0 data lanes.
  - Each lane can operate at up to 1.5Gbp/s. resulting in roughly 1.2 Gbp/s of actual pixels.
- The MIPI-CSI interface supports lossless compressed image streams to increase the effective bandwidth without losing data.
- Up to 13MP sensors supported, and full HD 1080p30.
  - Can also support Stereo HD 1080p30.

### 11.2.1 Imaging Capabilities

The following table summarizes imaging capabilities.

**Table 78. Imaging Capabilities**

| Feature              | Capabilities  |
|----------------------|---|
| Sensor interface     | Configurable MIPI-CSI2 interfaces.<br>3 sensors: x2, x2, x2 or x1 x2, x3<br>2 sensors: x4, x2   |
| Simultaneous sensors | Up to 3 simultaneous sensors  |
| 2D Image capture     | 13MP ZSL @ 18fps  |
| 2D video capture     | Up to 1080p30   |
| Input formats        | RAW 8, 10, 12, 14, RGB444, 565, 888, YUV420, 422, JPEG.   |
| Output formats)      | YUV422, YUV420, RAW   |
| Special Features     | Image and video stabilization<br>Low light noise reduction<br>Burst mode capture<br>Memory to memory processing<br>3A (Auto Exposure (AE), Auto White Balance (AWB) and Auto Focus (AF))<br>High Dynamic Range (HDR)<br>Multi-focus<br>Zero shutter lag |

### 11.2.2 Simultaneous Acquisition

SoC will support on-the-fly processing for only one image at a time. While this image is being processed on-the-fly, images from the other two cameras are saved to DRAM for later processing.



### **11.2.3 Primary Camera Still Image Resolution**

Maximum still image resolution for the primary camera in post-processing mode is limited by the resolution of the sensors. Currently 13Mpixel sensors are supported.

Higher resolution, or higher frame rates are supported as long as the product of resolution and frame rate does not exceed 235 Mpixels/s (= 13 Mpixels \* 18 fps).

Maximum primary camera on-the-fly stereoscopic still image resolution for primary camera is 8 Mpixel for each of the left and right images at 18 fps. The number of Mpixels can be increased by decreasing the frame rate.

### **11.2.4 Burst Mode Support**

The SoC supports capturing multiple images back to back at maximum sensor resolution. At least 5 images must be captured in burst mode. The maximum number of images that can be so captured is limited only by available system memory. These images need not be processed on-the-fly.

### **11.2.5 Continuous Mode Capture**

SoC supports capturing images and saving them to DRAM in a ring of frame buffers continuously at maximum sensor resolution. This adds a round trip to memory for every frame and increases the bandwidth requirements.

### **11.2.6 Secondary Camera Still Image Resolution**

Maximum secondary camera still image resolution is 4 Mpixel at 15 fps.

### **11.2.7 Primary Camera Video Resolution**

Maximum primary camera video resolution is 1080p60.

Maximum primary camera dual video resolution is 1080p30.

### **11.2.8 Secondary Camera Video Resolution**

Maximum secondary camera video resolution is 1080p30.

### **11.2.9 Bit Depth**

Capable of processing 14-bit images at the stated performance levels.

Capable of processing 18-bit images at half the performance levels, i.e. process on-the-fly 13 Mpixel 18-bit images at 7 fps instead of 15 fps.

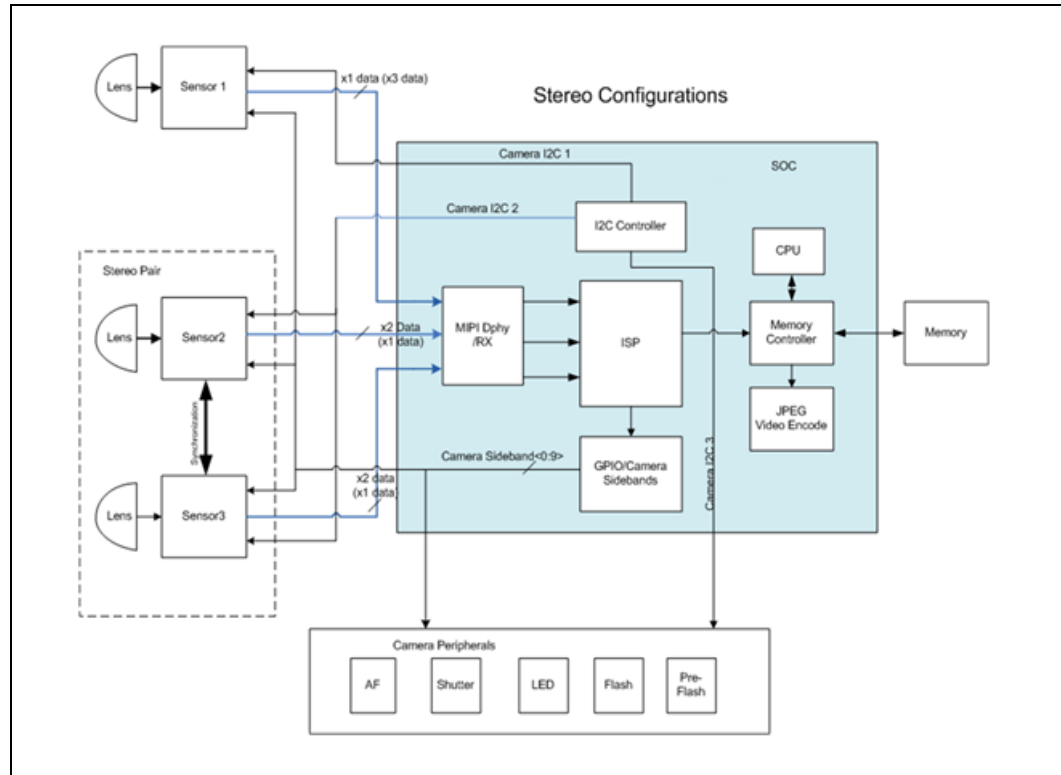
Capable of processing up to 18-bit precision.

The higher precision processing will be employed mainly for high dynamic range imaging (HDR).



## 11.3 Imaging Subsystem Integration

Figure 18. Image Processing Components



### 11.3.1 CPU Core

The CPU core augments the signal processing capabilities of the hardware to perform post-processing on images such as auto focus, auto white balance, and auto exposure. The CPU also runs the drivers that control the GPIOs and I<sup>2</sup>C for sensor control.

### 11.3.2 Imaging Signal Processor (ISP)

The ISP (Imaging Signal Processor) includes a 64-way vector processor enabling high quality camera functionality. Key features include support of three camera sensors.

#### 11.3.2.1 MIPI-CSI-2 Ports

The SoC has three MIPI clock lanes and six MIPI data lanes. The Analog Front End (AFE) and Digital Physical Layer (DPHY) take these lanes and connects them to three virtual ports. Two data lanes are dedicated to each of the rear facing cameras and the remaining data lane is connected to the front facing camera. The MIPI interfaces follow the MIPI-CSI-2 specifications as defined by the MIPI Alliance. They support YUV420, YUV422, RGB444, RGB555, RGB565, and RAW 8b/10b/12b. Both MIPI ports support



compression settings specified in MIPI-CSI-2 draft specification 1.01.00 Annex E. The compression is implemented in Hardware with support for Predictor 1 and Predictor 2. Supported compression schemes:

- 12-8-12
- 12-7-12
- 12-6-12
- 10-8-10
- 10-7-10
- 10-6-10

The data compression schemes above use an X-Y-Z naming convention where X is the number of bits per pixel in the original image, Y is the encoded (compressed) bits per pixel and Z is the decoded (uncompressed) bits per pixel.

### **11.3.2.2 I<sup>2</sup>C for Camera Interface**

The platform supports three (3) I<sup>2</sup>C ports for the camera interface. These ports are used to control the camera sensors and the camera peripherals such as flash LED and lens motor.

### **11.3.2.3 Camera Sideband for Camera Interface**

Twelve (12) GPIO signals are allocated for camera functions, refer [Table 77](#) for signal names. These GPIOs are multiplexed and are available for other usages without powering on the ISP. The ISP provides a timing control block through which the GPIOs can be controlled to support assertion, de-assertion, pulse widths and delay. The configuration below of camera GPIOs is just an example of how the GPIOs can be used. Several of these functions could be implemented using I<sup>2</sup>C, depending on the sensor implementation for the platform.

- Sensor Reset signals
  - Force hardware reset on one or more of the sensors.
- Sensor Single Shot Trigger signal
  - Indicate that the target sensor needs to send a full frame in a single shot mode, or to capture the full frame for flash synchronization.
- PreLight Trigger signal
  - Light up a pilot lamp prior to firing the flash for preventing red-eye.
- Flash Trigger signal
  - Indicate that a full frame is about to be captured. The Flash fires when it detects an assertion of the signal.
- Sensor Strobe Trigger signal
  - Asserted by the target sensor to indicate the start of a full frame, when it is configured in the single shot mode, or to indicate a flash exposed frame for flash synchronization.



## 11.4 Functional Description

At a high level, the Camera Subsystem supports the following modes:

- Preview
- Image capture
- Video capture

### 11.4.1 Preview

Once the ISP and the camera subsystem is enabled, the ISP goes into the preview mode where very low resolution frames, such as VGA/480p (programmable), are being processed.

### 11.4.2 Image Capture

During the image capture mode, the camera subsystem can acquire at a peak throughput of 13 Mpixels @ 18fps. While doing this, it continues to output preview frames simultaneously.

- The ISP can output RAW, RGB or YUV formats. The ISP can capture one full frame at a time or perform burst mode capture, where up to five full back-to-back frames are recorded.
- The ISP will not limit the number of back-to-back full frames captured, but the number is programmable and determined on how much memory can be allocated dynamically.
- The ISP can process all the frames on the fly and writes to memory only after fully processing the frames, without requiring download of any part of the frame for further processing.
  - The exceptions to this approach are image stabilization and some other advanced functions requiring temporal information over multiple frames.

The ISP can support image stabilization in image capture model.

- The ISP initially outputs preview frames.
- When the user decides to capture the picture, image stabilization is enabled. The ISP checks the previous frame for motion and compensates for it appropriately.

Auto Exposure (AE), Auto Focus (AF), and Auto White Balance (AWB), together known as 3A, are implemented in the CPU to provide flexibility.

### 11.4.3 Video Capture

During video recording, the ISP can capture video up to 1080p @ 60 fps and output preview frames concurrently. The ISP output video frames to memory in YUV420 or YUV422 format.

### 11.4.4 ISP

The Camera subsystem consists of 2 parts, the hardware subsystem and a software stack that implements the ISP functionality on top of this hardware.



The core of the ISP is a vector processor. The vector processor is supported by the following components:

- Interfaces for data and control
- A small input formatter that parallelizes the data
- A scalar (RISC) processor, for system control and low-rate processing
- An accelerator for scaling, digital zoom, and lens distortion correction
- A DMA engine transfers large amounts of data such as input and output image data or large parameter sets between LPDDR2 and the ISP block.

## **11.4.5 Memory Management Unit (MMU)**

The camera subsystem has capabilities to deal with a virtual address space, since a contiguous memory range in the order of 16–32MB cannot be guaranteed by the OS.

### **11.4.5.1 Interface**

The MMU performs the lookup required for address translation from a 32-bit virtual address to 36-bit physical address. The lookup tables are stored external to the system. The MMU performs the lookup through a master interface without burst support that is connected to the Open Core Protocol (OCP) master of the subsystem. The MMU configuration registers can be accessed through a 32-bit Core I/O (CIO) slave interface. Additionally there is a 32-bit CIO slave interface connected to the address translator.

## **11.5 MIPI-CSI-2 Receiver**

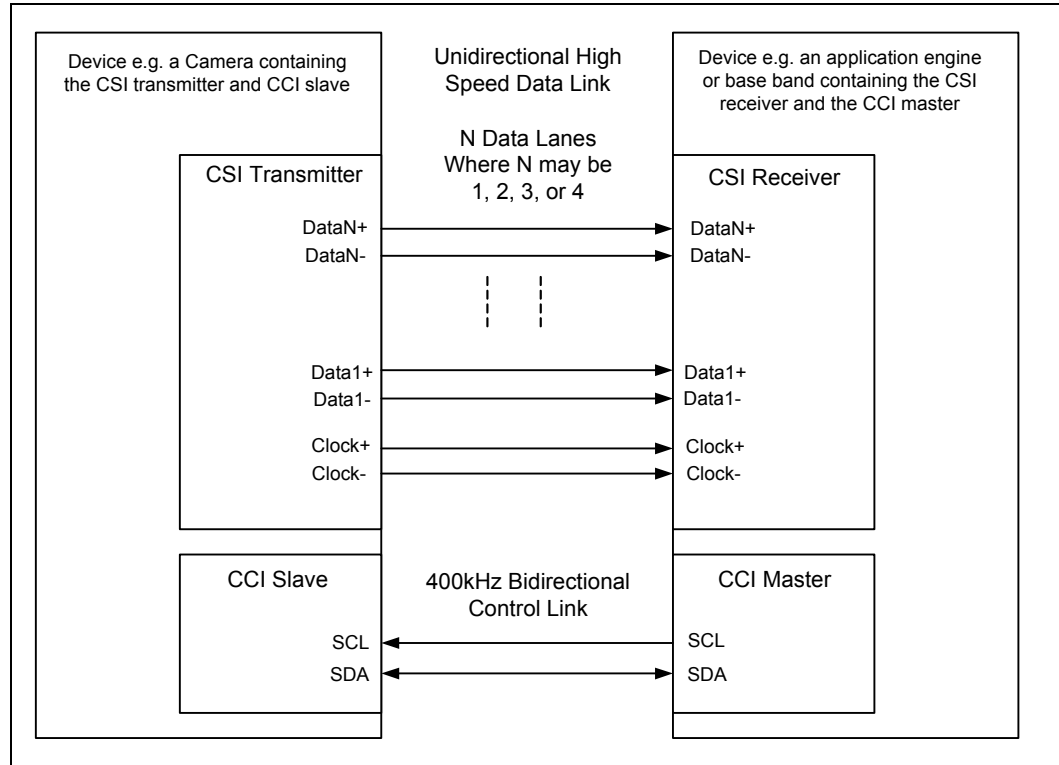
MIPI-CSI-2 devices are camera serial interface devices. They are categorized into two types, a CSI transmitter device with Camera Control Interface (CCI) slave and CSI receiver device with CCI master.

Data transfer by means of MIPI-CSI is unidirectional that is, from transmitter to receiver. CCI data transfer is bidirectional between the CCI slave and master.

Camera Serial Interface Bus (CSI) is a type of serial bus that enables transfer of data between a Transmitter device and a receiver device. The CSI device has a point-to-point connections with another CSI device by means of D-PHYs and as shown in [Figure 19](#).

Similarly, CCI (Camera Control Interface bus) is a type of serial bus that enables transfer back and forth between the master CCI and a Slave CCI Unit.

Figure 19. MIPI-CSI Bus Block Diagram



D-PHY data lane signals are transferred point-to-point differentially using two signal lines and a clock lane. There are two signaling modes, a high speed mode that operates up-to 1500Mbps and a low power mode that works at 10Mbps. The mode is set to low power mode and a stop state at start up/power up. Depending on the desired data transfer type, the lanes switch between high and low power modes.

The CCI interface consists of an I<sup>2</sup>C bus which has a clock line and a bidirectional data line.

The MIPI-CSI-2 devices operate in a layered fashion. There are 5 layers identified at the receiver and transmitter ends.

MIPI-CSI-2 Functional Layers:

- **PHY Layer**

- An embedded electrical layer sends and detects start of packet signalling and end of packet signalling on the data lanes. It contains a serializer and deserializer unit to interface with the PPI / lane management unit. There is also a clock divider unit to source and receive the clock during different modes of operation.

- **PPI/Lane Management Unit**

- This layer does the lane buffering and distributes the data in the lanes as programmed in a round robin manner and also merges them for the PLI/Low Level Protocol unit.



- **PLI/Low Level Protocol Unit**
  - This layer packetizes as well as de-packetizes the data with respect to channels, frames, colors and line formats. There is also a CRC checker or CRC generator unit to pack the payload data with CRC checksum bits for payload data protection.
- **Pixel/Byte to Byte/Pixel Packing Formats**
  - Conversion of pixel formats to data bytes in the payload data is done depending on the type of image data supported by the application. It also re-converts the raw data bytes to pixel format understandable to the application layer.
- **Application**
  - Depending on the type of formats, camera types, capability of the camera used by the transmitter, the application layer recovers the image formats and reproduces the image in the display unit. It also works on de-framing the data into pixel-to-packing formats. High level encoding and decoding of image data is handled in the application unit.

### 11.5.1 MIPI-CSI-2 Receiver Features

CSI Features:

- Compliant to CSI-2 MIPI specification for Camera Serial Interface (Version 1.00).
- Supports standard D-PHY receiver compliant to the MIPI Specification.
- Supports PHY data programmability up to four lanes.
- Supports PHY data time-out programming.
- Has controls to start and re-start the CSI-2 data transmission for synchronization failures and to support recovery.
- The ISP may not support all the data formats that the CSI-2 receiver can handle.
- Refer [Table 78](#) for formats supported by the ISP
- Supports all generic short packet data types
- Single Image Signal Processor interface for pixel transfers to support multiple image streams for all virtual channel numbers

D-PHY Features:

- Supports synchronous transfer in high speed mode with a bit rate of 80-1500Mb/s.
- Supports asynchronous transfer in low power mode with a bit rate of 10Mb/s.
- Differential signalling for HS data.
- Spaced one-hot encoding for Low Power [LP] data.
- Data lanes support transfer of data in high speed as well as low power modes.
- Supports ultra low power mode, escape mode, and high speed mode.
- Has a clock divider unit to generate clock for parallel data reception and transmission from and to the PPI unit.
- Activates and disconnects high speed terminators for reception and control mode.
- Activates and disconnects low power terminators for reception and transmission.

## 11.6 Register Map

For more information on MIPI- Camera Serial Interface (CSI) and ISP registers refer Intel® Atom™ Z8000 Processor Series Datasheet (Volume 2 of 2), Doc ID:332066.

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## 12 SoC Storage

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### 12.1 SoC Storage Overview

#### 12.1.1 Storage Control Cluster (eMMC, SDIO, SD)

The SCC consists of SDIO, SD and eMMC controllers to support mass storage and IO devices.

- One eMMC 4.51 interface
- One SD 3.0 interface
- One SDIO 3.0 interface

### 12.2 Signal Descriptions

Refer [Chapter 2, "Physical Interfaces"](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, "Electrical Specifications"](#).
- **Description:** A brief explanation of the signal's function.

**Table 79. eMMC Signals**

| Signal Name        | Direction /Type | Description   |
|--------------------|-----------------|---|
| <b>MMC1_CLK</b>    | I/O/GPIO        | <b>eMMC Clock</b><br>The frequency may vary between 25 and 200MHz.  |
| <b>MMC1_D[7:0]</b> | I/O/GPIO        | <b>eMMC Port Data bits 0 to 7</b><br>Bidirectional port used to transfer data to and from eMMC device.<br>By default, after power up or reset, only D[0] is used for data transfer. A wider data bus can be configured for data transfer, using either D[0]-D[3] or D[0]-D[7], by the MultiMedia Card controller.<br>The MultiMedia Card includes internal pull-ups for data lines D[1]-D[7]. Immediately after entering the 4-bit mode, the card disconnects the internal pull ups of lines D[1], D[2], and D[3]. Correspondingly, immediately after entering to the 8-bit mode the card disconnects the internal pull-ups of lines D[1]-D[7]. |
| <b>MMC1_CMD</b>    | I/O/GPIO        | <b>eMMC Port Command</b><br>This signal is used for card initialization and transfer of commands. It has two modes—open-drain for initialization, and push-pull for fast command transfer.  |
| <b>MMC1_RCOMP</b>  | I/O/GPIO        | <b>eMMC RCOMP</b><br>This signal is used for pre-driver slew rate compensation.   |
| <b>MMC1_RST_N</b>  | I/O/GPIO        | <b>eMMC Reset Signals</b><br>Active low to reset.   |
| <b>MMC1_RCLK</b>   | I/GPIO          | <b>eMMC Return Clock Signals</b>  |



Table 80. SDIO Signals

| Signal Name          | Direction /Type | Description  |
|----------------------|-----------------|--|
| <b>SD2_CLK</b>       | I/O/GPIO        | <b>SDIO Clock</b><br>The frequency may vary between 25 and 200MHz.   |
| <b>SD2_D[2:0]</b>    | I/O/GPIO        | <b>SDIO Port Data bits 0 to 2</b><br>Bidirectional port used to transfer data to and from SDIO device.<br>By default, after power up or reset, only D[0] is used for data transfer. A wider data bus can be configured for data transfer, using D[0]-D[3]. |
| <b>SD2_D[3]_CD_N</b> | I/O/GPIO        | <b>SDIO Port Data bit 3</b><br>Bidirectional port used to transfer data to and from the SDIO device.<br>Also, <b>Card Detect</b> .<br>Active low when device is present.   |
| <b>SD2_CMD</b>       | I/O/GPIO        | <b>SDIO Port Command</b><br>This signal is used for card initialization and transfer of commands. It has two modes—open-drain for initialization, and push-pull for fast command transfer.   |

Table 81. SD Signals (Sheet 1 of 2)

| Signal Name       | Direction /Type | Description  |
|-------------------|-----------------|--|
| <b>SD3_CLK</b>    | I/O/GPIO        | <b>SD Card Clock</b><br>The frequency may vary between 25 and 200 MHz.   |
| <b>SD3_D[3:0]</b> | I/O/GPIO        | <b>SD Card Data bits 0 to 3</b><br>Bidirectional port used to transfer data to and from SD/MMC card.<br>By default, after power up or reset, only D[0] is used for data transfer. A wider data bus can be configured for data transfer, using D[0]-D[3]. |
| <b>SD3_CD_N</b>   | I/O/GPIO        | <b>SD Card Detect</b><br>Active low when a card is present. Floating (pulled high with internal PU) when a card is not present.  |
| <b>SD3_CMD</b>    | I/O/GPIO        | <b>SD Card Command</b><br>This signal is used for card initialization and transfer of commands. It has two modes—open-drain for initialization, and push-pull for fast command transfer.   |
| <b>SD3_1P8EN</b>  | I/O/GPIO        | <b>SD Card 1.8V Enable</b><br>Controls the voltage of the SD Card, the default is low (3.3V). The voltage is 1.8V when this signal is high.  |

**Table 81. SD Signals (Sheet 2 of 2)**

| Signal Name        | Direction /Type | Description  |
|--------------------|-----------------|--|
| <b>SD3_RCOMP</b>   | I/O/GPIO        | <b>SD Card RCOMP</b><br>This signal is used for pre-driver slew rate compensation. |
| <b>SD3_PWREN_N</b> | I/O/GPIO        | <b>SD Card Power Enable</b><br>This signal is used to enable power on a SD device. |
| <b>SD3_WP</b>      | I/O/GPIO        | <b>SD Card Write Protect</b><br>Active high to protect from write.                 |

## 12.3 Features

### 12.3.1 Memory Capacity

- Standard Capacity SD Memory Card (SDSC): Up to and including 2 GB.
- High Capacity SD Memory Card (SDHC): More than 2GB and up to and including 32GB.
- Extended Capacity SD Memory Card (SDXC): More than 32GB and up to and including 2TB.

### 12.3.2 SDIO/SD Interface Features

- Host clock rate variable between 0 and 200 MHz.
- Up to 800 Mbits per second data rate using 4 parallel data lines (SDR104 mode).
- Transfers the data in 1 bit and 4 bit SD modes.
- Transfers the data in following UHS-I modes (SDR12/25/50/104 and DDR50).
- Cyclic Redundancy Check CRC7 for command and CRC16 for data integrity.
- Designed to work with I/O cards, Read-only cards and Read/Write cards.
- Supports Read wait Control, Suspend/Resume operation.

### 12.3.3 eMMC Interface Features

- Supports eMMC v4.51.
- Host clock rate variable between 0 and 200 MHz.
- Supports HS400 mode.
- Up to 1600 Mbits per second data rate using 8 bit parallel data lines (High Speed DDR mode).
- Up to 3200 Mbits per second data rate using 8 bit parallel data lines (HS400 mode).
- Transfers the data in 1 bit, 4 bit and 8 bit modes.
- Cyclic Redundancy Check CRC7 for command and CRC16 for data integrity.
- Supports MMC Plus and MMC mobile.

## 12.3.4 Storage Interfaces

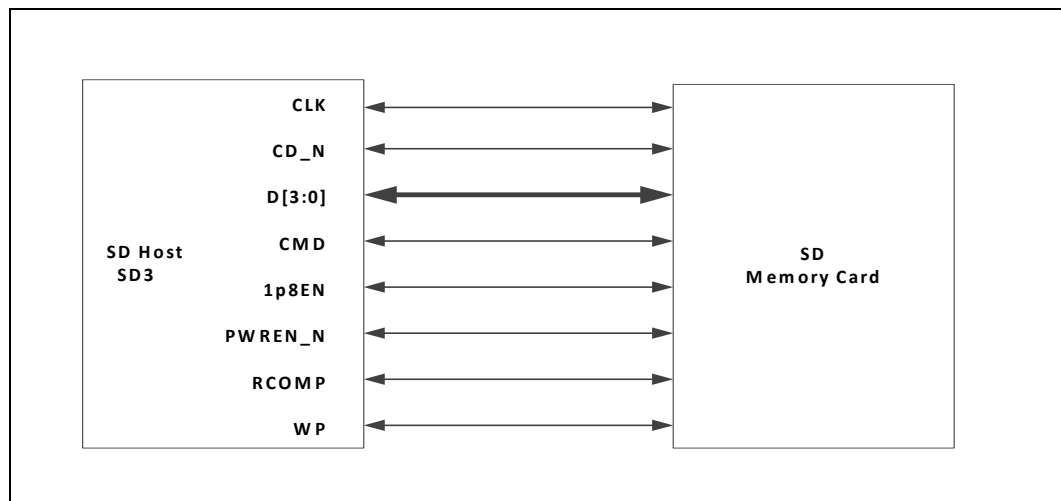
This section provides a very high level overview of the SD, SDIO, eMMC 4.51 specification.

### 12.3.4.1 SD 3.0 Bus Interface

The SD Card bus has a single master, single slaves (card), synchronous topology (refer [Figure 20](#)). During initialization process commands are sent to the card, allowing the application to detect the card and assign logical addresses to the physical slot. All data communication in the Card Identification Mode uses the command line (CMD) only.

SD bus allows dynamic configuration of the number of data lines. After power up, by default, the SD Card will use only SD3\_D[0] for data transfer. After initialization the host can change the bus width (number of active data lines). This feature allows easy trade off between hardware cost and system performance. Note that while DAT1-SD3\_D[3:1] are not in use, the SoC will tri-state those signals.

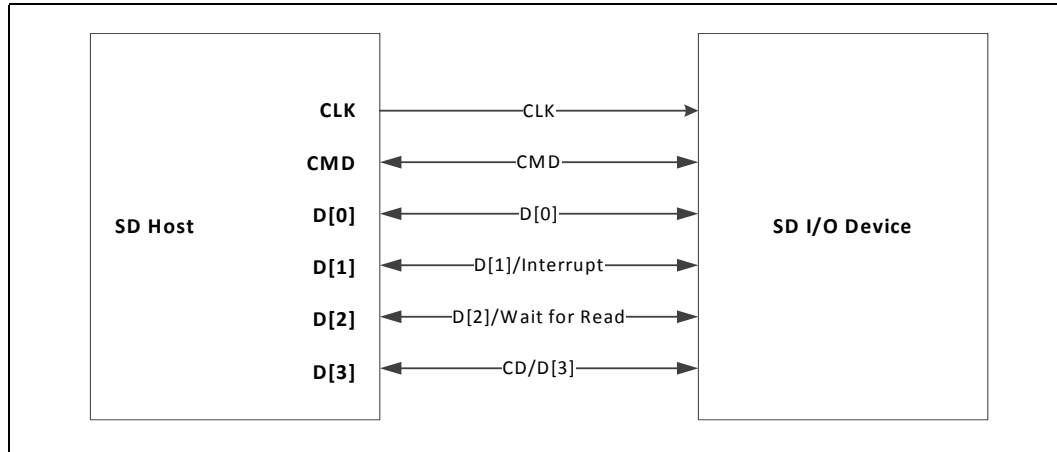
**Figure 20. SD Memory Card Bus Topology**



### 12.3.4.2 SDIO 3.0 Interface

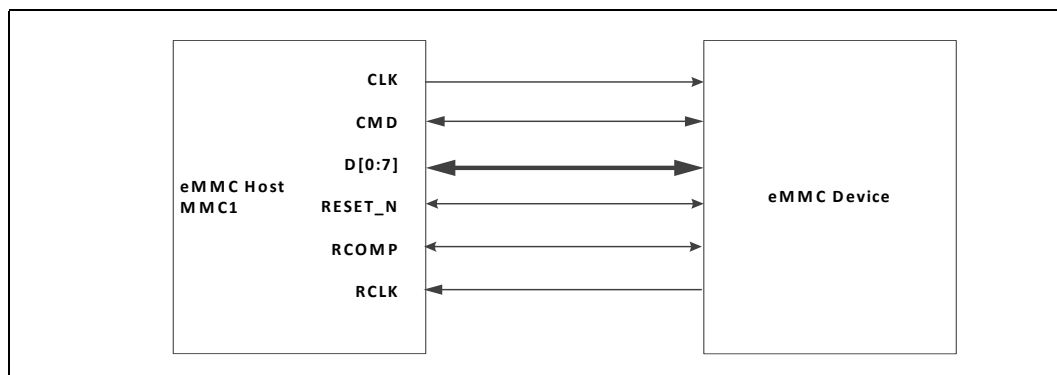
The SDIO interface is the very much like the SD card interface. The SoC supports one SDIO device.

Figure 21. SDIO Device Bus Topology



### 12.3.4.3 eMMC 4.51 Interface

Figure 22. eMMC Interface



The standard offers performance enhancement features, including HS400 support and has an interface bandwidth of 400 MByte/sec.

The command protocol is significantly improved with Packed Commands (the ability to group a series of commands in a single data transaction), Context ID (grouping different memory transactions under a single ID so the device can understand that they are related), and Data Tag (tagging specific write transactions so they can be prioritized and targeted to a memory region with higher performance and better reliability).

The v4.51 standard also adds provision for volatile data cache, which can greatly reduce the latency between data transactions to improve performance.



## 12.4 References

The controller is configured to comply with:

- SD Specification Part 01 Physical Layer Specification version 3.00, April 16, 2009.
- SD Specification Part E1 SDIO Specification version 3.00, December 16, 2010.
- SD Specification Part A2 SD Host Controller Standard Specification version 3.00, February 18, 2010.
- SD Specification Part 03 security Specification version 1.01, April 15, 2001.
- Embedded MultiMedia Card (eMMC) Product Standard v4.51, JESD84-A5.

## 12.5 Register Map

For more information on SoC Storage registers refer Intel® Atom™ Z8000 Processor Series Datasheet (Volume 2 of 2), Doc ID:332066.

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# 13 USB Controller Interfaces

USB Controller contains xHCI host controller that supports xHCI framework and USB1/2/3 specifications. And it has xDCI controller block for device only mode functionality. These 2 controllers will use an integrated mux to select between the 2 modes. All of this functionality is located in xDCI Controller.

## 13.1 SoC Supports

- Two (2) Super Speed Inter-Chip (SSIC) ports
- Three (3) Super Speed (SS) ports [Backward Compatible of USB 2.0 HS/FS/LS]
- One (1) Super Speed (SS) OTG port
- Two (2) High Speed Inter-Chip (HSIC) ports

**Note:** SoC can support the 4th SS port when OTG port is in Host mode.

## 13.2 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 82. USB SSIC Signals**

| Signal Name          | Direction /Type | Description  |
|----------------------|-----------------|--|
| USB_SSIC_RX_P/N[0,1] | I/O/ SSIC PHY   | <b>Receiver serial data inputs:</b> High-speed serialized data inputs.   |
| USB_SSIC_TX_P/N[0,1] | I/O/ SSIC PHY   | <b>Transmitter serial data outputs:</b> High-Speed Serialized data outputs.                                      |
| USB_SSIC_RCOMP_P/N   | I / SSIC PHY    | <b>Resistor Compensation:</b> An external resistor of 90 Ohm $\pm 1\%$ must be connected between the RCOMP pads. |



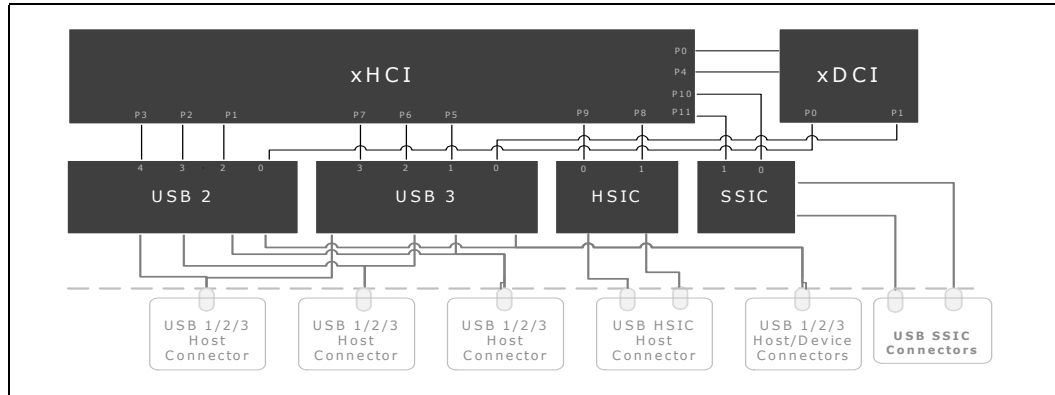


**Table 83. USB Signals**

| Signal Name            | Direction /Type | Description   |
|------------------------|-----------------|---|
| <b>USB3_TXP/N[0:3]</b> | O<br>USB3 PHY   | <b>Transmitter serial data outputs:</b> High-Speed Serialized data outputs.                                       |
| <b>USB3_RXP/N[0:3]</b> | I<br>USB3 PHY   | <b>Receiver serial data inputs:</b> High-speed serialized data inputs.  |
| <b>USB3_RCOMP_P/N</b>  | I<br>USB3 PHY   | <b>Resistor Compensation:</b> An external resistor of 402 Ohm $\pm 1\%$ must be connected between the RCOMP pads. |
| <b>USB_DP/N[0:3]</b>   | I/O<br>USB2 PHY | <b>USB2 Data:</b> High speed serialized data I/O.   |
| <b>USB_RCOMP</b>       | O<br>USB2 PHY   | <b>Resistor Compensation:</b> An external resistor of 113 Ohm $\pm 1\%$ must be connected between pin and GND.    |
| <b>USB_OTG_ID</b>      | I/O<br>USB2 PHY | <b>OTG ID:</b> Pin out to detect the OTG ID.  |
| <b>USB_PLL_MON</b>     | O<br>USB2 PHY   | USB High Speed Observation  |
| <b>USB_VBUSSNS</b>     | I/O<br>USB2 PHY | OTG Interface: VBUS_Sense   |

**Table 84. HSIC Signals**

| Signal Name                 | Direction /Type    | Description  |
|-----------------------------|--------------------|--|
| <b>USB_HSIC[0:1]_DATA</b>   | I/O<br>HSIC Buffer | <b>HSIC Data.</b>  |
| <b>USB_HSIC[0:1]_STROBE</b> | I/O<br>HSIC Buffer | <b>HSIC Strobe</b>   |
| <b>USB_HSIC_RCOMP</b>       | I/O<br>HSIC Buffer | <b>Resistor Compensation:</b> RCOMP for HSIC buffer. Resistor: 450ohm $\pm 1\%$ connected between USB_HSIC_RCOMP and ground. |

**Figure 23. xHCI Port Mapping**


## 13.3 USB 3.0 xHCI (Extensible Host Controller Interface)

The xHCI compliant host controller can control up to 2 SSIC, 3 USB3.0 ports. USB3.0 being backward compatible to support USB2.0. It supports devices conforming to USB 1.x to 3.0 at bit rates up to 5 Gbps.

### 13.3.1 USB 3.0 Host Features

The USB 3.0 Super Speed data interface is a four wire differential (TX and RX pairs) interface that supports simultaneous bi-directional data transmission. The interface supports a bit rate of 5 Gbps with a maximum theoretical data throughput over 3.2 Gbps due to 8b/10b symbol encoding scheme and protocol overhead (link flow control, packet framing and protocol overhead).

Low Frequency Periodic signaling (LFPS) is used to communicate initialization, training and power management information across a link that is in low power link state without using Super Speed signaling. This reduces power consumption.

#### 13.3.1.1 USB SSIC

- Supports the SuperSpeed protocol only as defined in [USB 3.0].
- Optimized for Power, Area, Cost and EMI robustness.
- Supports 2 ports of 1 lane each.

#### 13.3.1.2 USB 3.0

- Supported by xHCI software host controller interface.
- USB3 port disable.
- Supports local dynamic clock gating and trunk clock gating.
- Supports USB 3.0 LPM (U0, U1, U2, and U3) and also a SS Disabled low power state.



- Supports USB3 Debug Device.
- Supports IVCAM(USB PC Camera).

### 13.3.2 USB HSIC Features

HSIC is a 2-signal (strobe and data) source synchronous serial interface for on board inter-chip USB communication. The interface uses 240 MHz DDR signaling to provide High-Speed 480 Mb/s USB transfers which are 100% host driver compatible with traditional USB cable connected topologies. Full Speed (FS) and Low Speed (LS) USB transfers are not directly supported by the HSIC interface.

Major feature and performance highlights are as follows:

- Supported by xHCI software host controller interface
- High-Speed 480 Mb/s data rate only.
- Source-synchronous serial interface.
- Power is only consumed when a transfer is in progress.
- No Plug and Play support.
- No hot plug removal/attach.
- Signals driven at 1.2V standard LVCMOS levels.
- Designed for low power applications.
- Support for two host ports compliant to High Speed Inter-Chip Supplement (HSIC) to the USB 2.0 Specification. (USB 2.0).
- Clock request/ack mechanism.

## 13.4 USB 3.0 xDCI (Extensible Device Controller Interface)

The xDCI compliant Device controller can control up to 1 USB3.0 OTG port. USB3 being backward compatible to support USB2.0. It supports devices conforming to USB 1.x to 3.0 at bit rates up to 5 Gbps.

## 13.5 References

USB 3.0 Specification

USB 2.0 Specification (Includes High-Speed Inter-Chip USB Electrical Specification)

### 13.5.1 Host Controller Specifications

Extensible Host Controller Interface (xHCI) Specification for USB 3.0 version 1.0.



## **13.6 Register Map**

For more information on USB Controller Interfaces registers refer Intel® Atom™ Z8000 Processor Series Datasheet (Volume 2 of 2), Doc ID:332066.

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# 14 Low Power Engine (LPE) for Audio (I<sup>2</sup>S)

Low Power Engine for Audio provides acceleration for common audio and voice functions. The voice and audio engine provides a mechanism for rendering audio and voice streams and tones from the operating system, applications to an audio or voice codec, and ultimately to the speaker, headphones, or Bluetooth\* headsets.

Audio streams in the SoC can be encoded and decoded by the Low Power Engine (LPE) in the Audio subsystem.

LPE Audio provides three external I<sup>2</sup>S audio interfaces.

## 14.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 85. LPE Signals**

| Signal Name          | Direction /Type | Description                              |
|----------------------|-----------------|--|
| LPE_I2S[2:0]_CLK     | I/O             | Clock signal for I <sup>2</sup> S        |
| LPE_I2S[2:0]_FRM     | I/O             | Frame select signal for I <sup>2</sup> S |
| LPE_I2S[2:0]_DATAIN  | I/O             | RX data for I <sup>2</sup> S             |
| LPE_I2S[2:0]_DATAOUT | I/O             | TX data for I <sup>2</sup> S             |

**NOTE:** All LPE signals are muxed and may be used by other functions.

## 14.2 Features

The LPE Audio Subsystem consists of the following:

- Integrated, power-efficient 32-bit architecture core with 24-bit audio processing instructions.
- Core processing speeds up to 343 MHz.
- Closely Coupled Memories (CCMs)
  - 80 KB Instruction RAM



- 160 KB Data RAM
- 48 KB Instruction Cache
- 96 KB Data Cache
- Very low-power consumption coupled with high-fidelity 24-bit audio.
- Dual-issue, static, super-scalar VLIW processing engine.
- Mode-less switching between 16-, 24-, and 64-bit dual-issue instructions.
- Dual MACs which can operate with 32 x 16-bit and/or 24 x 24-bit operands.
- Inter-Process Communication (IPC) mechanism to communicate with the SoC Processor Core including 4 KB mailbox memory.
- Flexible audio interfaces include three SSPs with I<sup>2</sup>S port functionality for BI-directional audio transfers.
  - I<sup>2</sup>S mode supports PCM payloads
  - Frame counters for all I<sup>2</sup>S ports
- High Performance DMA
  - DMA IP to support multiple outstanding transactions
  - Interleaved scatter-gather support for Audio DMA transfers
- Clock switching logic including new frequency increments.
- External timer function with an always running clock.

The LPE core runs at a peak clock frequency of 343 MHz and has dedicated on-chip program and data memories and caches. The LPE core can access shared SRAM blocks, and external DRAM through OCP fabric. It communicates with audio peripherals using the audio sub-fabric, and employs Inter-Processor Communication (IPC) mechanism to communicate with the SoC Processor Core.

The Audio subsystem includes two OCP-based DMA engines. These DMA engines support single and multi-block transfers. They can be configured to transfer data between DRAM and audio CCMs or transfer data between CCMs and the audio peripheral interfaces.

All these interfaces are peripherals in the Audio subsystem. LPE, LPE DMA, or the SoC processor core may access the peripherals during normal operation. The PMC may access all peripherals during specific tasks such as at boot time or during power state changes. A complete audio solution based on an internal audio processing engine which includes several I<sup>2</sup>S-based output ports.

The audio core used is a dedicated audio DSP core designed specifically for audio processing (decoding, post-processing, mixing, etc.)

**Note:** LPE requires systems with more than 512 MB memory. This is required since the LPE firmware must reside at a stolen memory location on 512 MB boundaries below 3 GiB. The LPE firmware itself is ~1 MB, and is reserved by BIOS for LPE use.



## 14.2.1 Audio Capabilities

### 14.2.1.1 Audio Decode

Audio core supports decoding of the following formats:

- MP3
- AAC-LC
- HE-AAC v1/2
- WMA9,10, PRO, Lossless, Voice
- MPEG layer 2
- RealAudio
- OggVorbis
- FLAC
- DD/DD+

### 14.2.1.2 Audio Encode

Audio core supports encoding of the following formats:

- MP3
- AAC-LC
- WMA
- DD-2channel

## 14.3 Clocks

### 14.3.1 Clock Frequencies

Table 86 shows the clock frequency options for the Audio functional blocks.

**Table 86. Clock Frequencies**

| Clock              | Frequency   | Notes  |
|--------------------|---|--|
| Audio core         | 343/250/200 MHz/100/50 MHz/2x Osc/Osc<br>50(RO)/100(RO) | Audio input clock trunk. CCU drives one of several frequencies as noted. |
| DMA 0              | 50/OSC  | DMA clock  |
| DMA1               | 50/OSC  | DMA clock  |
| Audio fabric clock | 50/OSC  | Fabric clock derived from audio core clock                               |



**Table 86. Clock Frequencies**

| Clock      | Frequency  | Notes              |
|------------|--|--------------------|
| SSP0 Clock | Fabric side: 50/OSC<br>Link side: Up to 19.2 MHz | SSP0 clock domains |
| SSP1 Clock | Fabric side: 50/OSC<br>Link side: Up to 19.2 MHz | SSP1 clock domains |
| SSP2 Clock | Fabric side: 50/OSC<br>Link side: Up to 19.2 MHz | SSP2 clock domains |

### 14.3.2 38.4 MHz Clock for LPE

38.4 MHz, the 2X OSC clock, is added to increase MIPS for low power MP3 mode. This frequency will be supplied by the clock doubler internal to the SoC's Clock Control Unit.

### 14.3.3 Calibrated Ring Osc (50/100 MHz) Clock for LPE

A calibrated Ring Oscillator in the CCU\_SUS provides a 50Mhz or an 100Mhz clock as another option for higher MIPS for low power MP3 mode. It is expected that this will be required to support decode of HE-AAC streams in the low power mode.

### 14.3.4 Cache and CCM Clocking

Data CCM, Data cache, Instruction CCM, and Instruction Cache run off of the LPE clock. These memories are in a single clock domain.

**Note:** All Data CCM and Instruction CCM run in the same clock domain.

## 14.4 SSP (I<sup>2</sup>S)

The SoC audio subsystem consists of the LPE Audio Engine and three Synchronous Serial Protocol (SSP) ports. These ports are used in PCM mode and enable simultaneous support of voice and audio streams over I<sup>2</sup>S. The SoC audio subsystem also includes two DMA controllers dedicated to the LPE. The LPE DMA controllers are used for transferring data between external memory and CCMs, between CCMs and the SSP ports, and between CCMs. All peripheral ports can operate simultaneously.

The Enhanced SSP Serial Ports are full-duplex synchronous serial interfaces. They can connect to a variety of external analog-to-digital (A/D) converters, audio, and telecommunication codecs, and many other devices which use serial protocols for transferring data. Formats supported include National\* Microwire, Texas Instruments\* Synchronous Serial Protocol (SSP), Motorola\* Serial Peripheral Interface (SPI) protocol and a flexible Programmable Serial Port protocol (PSP).





The Enhanced SSPs operate in master mode (the attached peripheral functions as a slave) or slave mode (the attached peripheral functions as a master), and support serial bit rates from 0 to 6.5 Mbps, dependent on the input clock. Serial data formats range from 4 to 32-bits in length. Two on-chip register blocks function as independent FIFOs for transmit and receive data.

FIFOs may be loaded or emptied by the system processor using single transfers or DMA burst transfers of up to the FIFO depth. Each 32-bit word from the bus fills one entry in a FIFO using the lower significant bits of a 32-bit word.

### 14.4.1 Features

The SSP port features are:

- Inter-IC Sound (I<sup>2</sup>S) protocols, are supported by programming the Programmable Serial Protocol (PSP).
- One FIFO for transmit data (TXFIFO) and a second, independent, FIFO for receive data (RXFIFO), where each FIFO is 16 samples deep x 32 bits wide.
- Data sample sizes from 8, 16, 18, or 32 bits.
- 6.5 Mbps maximum serial bit-rate in both modes: master and slave.
- Clock master or slave mode operations.
- Receive-without-transmit operation.
- Network mode with up to eight time slots for PSP formats, and independent transmit/receive in any/all/none of the time slots.
- After updating SSP configuration, for example active slot count, the SSP will need to be disabled and enabled again. In other words, a SSP will not function correctly if a user changes the configuration setting on the fly.

## 14.5 Register Map

For more information on Low Power Engine (LPE) for Audio (I<sup>2</sup>S) registers refer Intel<sup>®</sup> Atom™ Z8000 Processor Series Datasheet (Volume 2 of 2), Doc ID:332066.



# 15 Intel® Trusted Execution Engine (Intel® TXE)

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This chapter describes the security components and capabilities. The security system contains an Intel® TXE and additional hardware security feature that enable a secure and robust platform.

## 15.1 Features

### 15.1.1 Security Features

Intel® TXE in the SoC is responsible for supporting and handling security related features.

- 32-bit RISC processor.
- 256KB Data/Code RAM accessible only to the Intel® TXE.
- 128KB On Chip Mask ROM for storage of Intel® TXE code.
- Inter-Processor Communication for message passing between the Host CPU and Intel® TXE.
- 64 byte input and output command buffers.
- 256 byte shared payload (enables 2048-bit keys to be exchanged as part of the command).
- Multiple context DMA engine to transfer data between Host CPU address domain (System memory) and the Intel® TXE; programmable by the Intel® TXE CPU only.
- Secure I<sup>2</sup>C interface to NFC using master I<sup>2</sup>C block integrated into the Intel TXE - IP. Secure GPIOs to support input alert and two GP Outputs.

#### 15.1.1.1 HW Accelerators

- DES/3DES (ECB, CBC) – 128b ABA key for 3DES Key Ladder Operations.
- Three AES engines - Two fast -128 and one slow- 128/256.
- Exponentiation Acceleration Unit (EAU) for modular exponentiation, modular reduction, large number addition, subtraction, and multiplication.
- SHA1, SHA256/384/512, MD5.

#### 15.1.1.2 FW Utilities and Ciphers

- RSA (with EAU acceleration).
- Flash Write Enable/Disable.
- Comprehensive IPC Command Set.
- Chip Unique Key encryption key wrapping of other platform keys (Flash).



### 15.1.1.3 Downloadable FW Utilities and Ciphers

- Integrated Theft Deterrence Technology - Intel® Anti-Theft Technology (Intel® AT).
- One Time Programmable (OTP).
- Firmware TPM (fTPM) measured boot.

### 15.1.2 TXE Interaction with NFC

- The NFC device requests attention from the TXE from GPIO\_ALERT pin to a SoC input interrupt pin (GPIO\_SUS[8] pin).
- The GPIO block sends the pin value to TXE over a dedicated wire.
- The wire is connected to the TXE clock request mechanism in order to get a clock for sampling the wire. The TXE bridge includes a configuration register which includes an enable bit to qualify the clock request (which allows masking the clock request, in case the GPIO\_SUS[8] is not used by NFC), and a polarity bit (which allows selecting whether the a clock request would be set on a high or low value in the wire).)
- The same qualified & polarity configured clock request input is also sent to PMU. In S0ix PMU uses it as a wake request.
- When a clock is available, the wire value is updated to an ICR (SICR31) in TXE bridge.
- TXE Bridge configuration register also includes two bits that allow detection of falling and/or rising edge on the alert pin. They cause an ISR (SISR[31]) to be set. When both ISR and IER bits for the alert are set an interrupt is generated.
- When the TXE is interrupted it parses the interrupt status registers in the TXE Bridge and figures the cause is the NFC device.
- TXE clears the Bridge ISR and sets configuration to detect the next edge on the alert pin.
- In order to use the I2C master, the TXE sets an I2C clock request register in the Bridge.
- The firmware then uses the I2C master to communicate with the NFC device. The firmware configures the I2C master to read up to 33Bytes of data (up to 36 bytes are supported by HW for read/write).
- When the I2C read is completed, the firmware is interrupted. The TXE may then read the data/status and clear the interrupt.
- The firmware repeats read/write sequence's as many times as it needs.
- When firmware is done with the I2C master, it must poll the controller to check that the I2C bus is idle before writing to the register to remove the I2C clock request, and before any reset of the I2C controller or power gating sequence. Shutting off clock or I2C master before the completion all activity on the bus will hang the I2C device.

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# 16 Intel® Sensor Hub

This chapter describes Intel® Sensor Hub.

## 16.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 87. ISH Signals**

| Signal Name         | Direction | Description                        |
|---------------------|-----------|------------------------------------|
| <b>ISH_I2C1_CLK</b> | I/O       | <b>Clock Lane:</b> ISH input clock |
| <b>ISH_I2C1_SDA</b> | I/O       | <b>Data Lane:</b> ISH Data Lane    |
| <b>ISH_GPIO</b>     | I/O       | ISH GPIO                           |

## 16.2 Features

- Acquisition / sampling of sensor data.
- The ability to combine data from individual sensors to create a more complex Virtual sensor that can be directly used by the firmware/OS.
- Low power operation through clock gating of the ISH together with the ability to turn sensors off under control of host SW.
- The ability to operate independently when the host platform is in a low power state(S0-S0i3).
- Power saving features.
- Clock gating and power gating of functional blocks depending on current workloads.

### 16.2.1 Hardware

- Minute IA microprocessor.
- 384KB on chip Data/Code SRAM accessible only to the ISH.
- 8KB on chip ROM for ISH boot code.



- Inter-Processor Communication for message passing between the Host CPU and Intel® ISH.
  - Single Command/Doorbell DWORD register and 32 DWORD data registers each direction.
- Inter-Processor Communication for message passing between the Intel® ISH and Intel® TXE for ISH FW load.
  - Single Command/Doorbell DWORD register and 32 DWORD data registers each direction.
- Inter-Processor Communication for message passing between the Intel® ISH and PMC for ISH power management and ISH TXE communication assistance by PMC.
  - Single Command/Doorbell DWORD register each direction.
- DMA engine to transfer data between Host CPU address domain (System memory) and the Intel® ISH; programmable by the Intel® ISH CPU only.
- Two I2C interfaces and up to 15 GPIO lines for connecting sensors to ISH.

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## ***17 Serial IO (SIO) Overview***

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The Serial I/O (SIO) is a collection of hardware blocks that implement simple but key serial I/O interfaces for platform usage. These hardware blocks include:

- "SIO - I2C Interface"
- "SIO - High Speed UART"
- "SIO - Serial Peripheral Interface (SPI)"
- "SIO - Pulse Width Modulation (PWM)"



## 17.1 SIO - Serial Peripheral Interface (SPI)

The Serial I/O implements three SPI controllers that supports master mode.

### 17.1.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 88. SPI Interface Signals**

| Signal Name        | Direction /Type | Description  |
|--------------------|-----------------|--|
| SPI[1,2,3]_CLK     | O<br>GPIO       | <b>SPI Clock:</b> When the bus is idle, the owner will drive the clock signal low.   |
| SPI[1,2,3]_CS[0]_N | O<br>GPIO       | <b>SPI Chip Select 0:</b> Used as the SPI Chip select 0.   |
| SPI[1,2,3]_CS[1]_N | O<br>GPIO       | <b>SPI Chip Select 1:</b> Used as the SPI Chip select 1.   |
| SPI[1,2,3]_MISO    | I<br>GPIO       | <b>SPI Master IN Slave OUT:</b> Data input pin for the SoC.  |
| SPI[1,2,3]_MOSI    | O<br>GPIO       | <b>SPI Master OUT Slave IN:</b> Data output pin for the SoC. Operates as a second data input pin for the SoC when in Single Input, Dual Output Fast Read mode. |

### 17.1.2 Features

The following is list of SPI features:

- Single interrupt line.
  - Could be assigned to interrupt PCI INT [A] or ACPISIO INT[1].
- Configurable frame format, clock polarity and clock phase.
- Supports three SPI peripherals only.
- Two Chip selects are supported for each of the 3 SPI controllers.
- Supports master mode only.
- Receive and transit buffers are both 256x32 Bits.
  - The receive buffer has only 1 water mark.
  - The transmit buffer has 2 water marks.

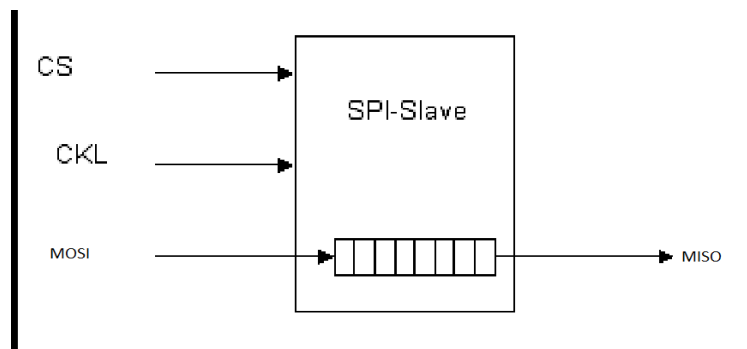
- Supports up to 20 Mbps.

### 17.1.2.1 General

The Serial Peripheral Interface is used primarily for a synchronous serial communication of host processor and peripherals.

In the standard configuration for a slave device, two control and two data lines are used. The data output MISO serves on the one hand the reading back of data, offers however also the possibility to cascade several devices. The data output of the preceding device then forms the data input for the next IC.

Figure 24. SPI Slave



There is a MASTER and a SLAVE mode. The MASTER device provides the clock signal and determines the state of the chip select lines, i.e. it activates the SLAVE it wants to communicate with. CS and CKL are therefore outputs. The SLAVE device receives the clock and chip select from the MASTER, CS and CKL are therefore inputs. This means there is one master, while the number of slaves is only limited by the number of chip selects.

A SPI device can be a simple shift register up to an independent subsystem. The basic principle of a shift register is always present. Command codes as well as data values are serially transferred, pumped into a shift register and are then internally available for parallel processing.

The SPI requires two control lines (CS and CLK) and two data lines MOSI (Master-Out-Slave-In) and MISO (Master-In-Slave-Out).

### 17.1.2.2 Data and Control lines for SPI

With CS (Chip-Select) the corresponding peripheral device is selected. This pin is mostly active-low. In the un-selected state the MISO lines are hi-Z and therefore inactive. The master decides with which peripheral device it wants to communicate. The clock line CLK is brought to the device whether it is selected or not. The clock serves as synchronization of the data communication. The majority of SPI devices provide these four lines. Sometimes it happens that MOSI and MISO are multiplexed.





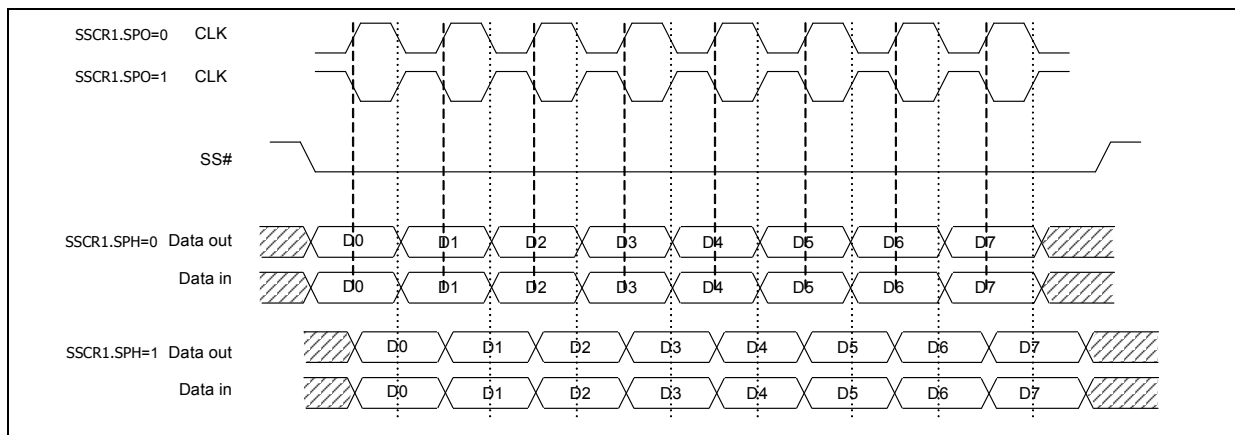
### 17.1.2.3 SPI Configuration: Clock Phase and Polarity

SPI clock phase and clock polarity overview.

- The SSCR1.SPO polarity setting bit determines whether the serial transfer occurs on the rising edge of the clock or the falling edge of the clock.
  - When SSCR1.SPO = 0, the inactive or idle state of SPI1\_CLK is low.
  - When SSCR1.SPO = 1, the inactive or idle state of SPI1\_CLK is high.
- The SSCR1.SPH phase setting bit selects the relationship of the serial clock with the slave select signal.
  - When SSCR1.SPH = 0, SPI1\_CLK is inactive until one cycle after the start of a frame and active until 1/2 cycle after the end of a frame.
  - When SSCR1.SPH = 1, SPI1\_CLK is inactive until 1/2 cycle after the start of a frame and active until one cycle after the end of a frame.

Below figure shows an 8-bit data transfer with different phase and polarity settings.

**Figure 25. Clock Phase and Polarity**



In a single frame transfer, the SPI controller supports all four possible combinations for the serial clock phase and polarity.

The combinations of polarity and phases are referred to as modes which are commonly numbered according to the following convention, with SSCR1.SPO as the high order bit and SSCR1.SPH as the low order bit.

**Table 89. SPI Modes**

| Mode | SSCR1.SPO | SSCR1.SPH |
|------|-----------|-----------|
| 0    | 0         | 0         |
| 1    | 0         | 1         |
| 2    | 1         | 0         |
| 3    | 1         | 1         |



## 17.2 SIO - I<sup>2</sup>C Interface

The SoC supports 7 instances of I<sup>2</sup>C controller. Both 7-bit and 10-bit addressing modes are supported. These controllers operate in master mode only.

### 17.2.1 Signal Descriptions

I<sup>2</sup>C is a two-wire bus for inter-IC communication. Data and clock signals carry information between the connected devices. The following is the I<sup>2</sup>C Interface. The SoC supports 7 I<sup>2</sup>C interfaces for general purpose to control external devices. The I<sup>2</sup>C signals are muxed over GPIOs.

Refer [Chapter 2, "Physical Interfaces"](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, "Electrical Specifications"](#).
- **Description:** A brief explanation of the signal's function.

**Table 90. I<sup>2</sup>C[6:0] Signals**

| Signal Name   | Direction /Type            | Description  |
|---------------|----------------------------|--|
| I2C[6:0]_DATA | I/O/<br>GPIOMV,<br>MS, I2C | <b>I<sup>2</sup>C Serial Data</b><br><i>These signals are muxed and may be used by other functions.</i>  |
| I2C[6:0]_CLK  | I/O/<br>GPIOMV,<br>MS, I2C | <b>I<sup>2</sup>C Serial Clock</b><br><i>These signals are muxed and may be used by other functions.</i> |

### 17.2.2 NFC I<sup>2</sup>C Interface Signals

**Table 91. NFC I<sup>2</sup>C Interface Signals**

| Signal Name  | Direction/Type             | Description  |
|--------------|----------------------------|--|
| NFC_I2C_DATA | I/O/<br>GPIOMV,<br>MS, I2C | <b>NFC I<sup>2</sup>C Serial Data</b><br><i>These signals are muxed and may be used by other functions.</i>  |
| NFC_I2C_CLK  | I/O/<br>GPIOMV,<br>MS, I2C | <b>NFC I<sup>2</sup>C Serial Clock</b><br><i>These signals are muxed and may be used by other functions.</i> |
| GPIO_ALERT   | I/O/<br>GPIOMV, MS         | <b>ALERT pin for NFC</b><br><i>These signals are muxed and may be used by other functions.</i>               |



## 17.2.3 Features

### 17.2.3.1 I<sup>2</sup>C Protocol

The I<sup>2</sup>C bus is a two-wire serial interface, consisting of a serial data line and a serial clock. These wires carry information between the devices connected to the bus. Each device is recognized by a unique address and can operate as either a “transmitter” or “receiver,” depending on the function of the device. Devices are considered slaves when performing data transfers, as the SoC will always be a Master. A master is a device which initiates a data transfer on the bus and generates the clock signals to permit that transfer. At that time, any device addressed is considered a slave.

- The SoC is always the I<sup>2</sup>C master; and it supports multi-master mode.
- The SoC can support clock stretching by slave devices.
- The I2Cx\_DATA line is a bidirectional signal and changes only while the I2Cx\_CLK line is low, except for STOP, START, and RESTART conditions.
- The output drivers are open-drain or open-collector to perform wire-AND functions on the bus.
- The maximum number of devices on the bus is limited by the maximum capacitance specification of 400 pF. Refer [Chapter 19, “Electrical Specifications”](#) for more details.
- Data is transmitted in byte packages.

### 17.2.3.2 I<sup>2</sup>C Modes of Operation

The I<sup>2</sup>C module can operate in the following modes:

- Standard mode (with a bit rate up to 100 Kb/s).
- Fast mode (with a bit rate up to 400 Kb/s).
- Fast Mode plus mode (with a bit rate up to 1 Mb/s).
- High-speed mode (with a bit rate up to 1.7 Mb/s).

The I<sup>2</sup>C can communicate with devices only using these modes as long as they are attached to the bus. Additionally, high speed mode, fast mode plus and fast mode devices are downward compatible.

- High-speed mode devices can communicate with fast mode and standard mode devices in a mixed speed bus system.
- Fast mode devices can communicate with standard mode devices in a 0–100 Kb/s I<sup>2</sup>C bus system.

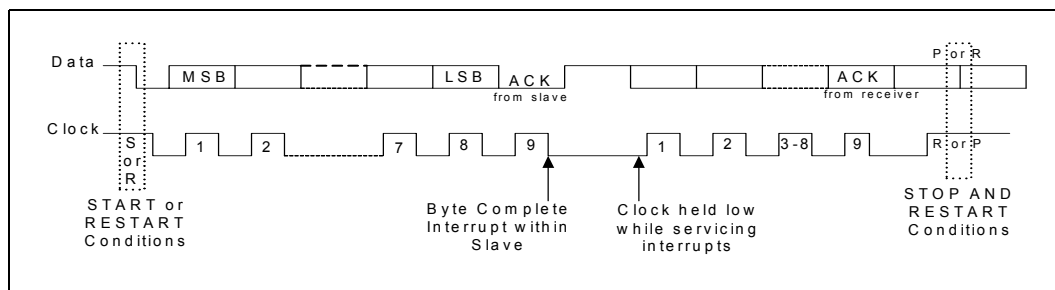
However, according to the I<sup>2</sup>C specification, standard mode devices are not upward compatible and should not be incorporated in a fast-mode I<sup>2</sup>C bus system since they cannot follow the higher transfer rate and unpredictable states would occur.

Refer [Table 1](#) for more information on the I2C interface speed for different Sku's.

### 17.2.3.3 Functional Description

- The I<sup>2</sup>C master is responsible for generating the clock and controlling the transfer of data.
- The slave is responsible for either transmitting or receiving data to/from the master.
- The acknowledgement of data is sent by the device that is receiving data, which can be either a master or a slave.
- Each slave has a unique address that is determined by the system designer:
  - When a master wants to communicate with a slave, the master transmits a START/RESTART condition that is then followed by the slave's address and a control bit (R/W), to determine if the master wants to transmit data or receive data from the slave.
  - The slave then sends an acknowledge (ACK) pulse after the address.
- If the master (master-transmitter) is writing to the slave (slave-receiver)
  - The receiver gets one byte of data.
  - This transaction continues until the master terminates the transmission with a STOP condition.
- If the master is reading from a slave (master-receiver)
  - The slave transmits (slave-transmitter) a byte of data to the master, and the master then acknowledges the transaction with the ACK pulse.
  - This transaction continues until the master terminates the transmission by not acknowledging (NACK) the transaction after the last byte is received, and then the master issues a STOP condition or addresses another slave after issuing a RESTART condition. This behavior is illustrated in below figure.

Figure 26. Data Transfer on the I<sup>2</sup>C Bus



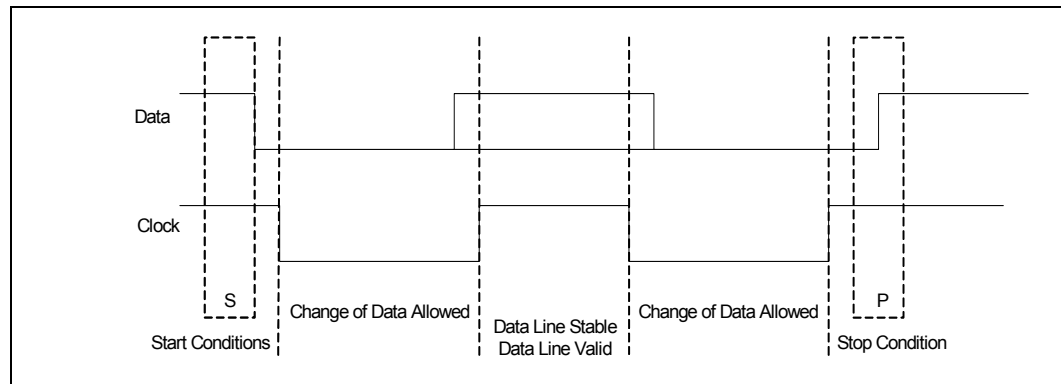
#### 17.2.3.3.1 START and STOP Conditions

When the bus is idle, both the clock and data signals are pulled high through external pull-up resistors on the bus.

When the master wants to start a transmission on the bus, the master issues a START condition.

- This is defined to be a high-to-low transition of the data signal while the clock is high.
- When the master wants to terminate the transmission, the master issues a STOP condition. This is defined to be a low-to-high transition of the data line while the clock is high. Figure 27 shows the timing of the START and STOP conditions.
- When data is being transmitted on the bus, the data line must be stable when the clock is high.

**Figure 27. START and STOP Conditions**



The signal transitions for the START/STOP conditions, as depicted above, reflect those observed at the output of the master driving the I<sup>2</sup>C bus. Care should be taken when observing the data/clock signals at the input of the slave(s), because unequal line delays may result in an incorrect data/clock timing relationship.

## 17.3 NFC I<sup>2</sup>C

NFC device requires 1.8V I/Os.

For more information refer "[TXE Interaction with NFC](#)"

### 17.3.1 References

I<sup>2</sup>C-Bus Specification and User Manual, Revision 03: <http://ics.nxp.com/support/documents/interface/pdf/i2c.bus.specification.pdf>



## 17.4 SIO - High Speed UART

The SoC implements two instances of high speed UART controller that support baud rates between 300 and 3686400. Hardware flow control is also supported.

### 17.4.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 92. UART 1 Interface Signals**

| Signal Name          | Direction/<br>Type | Description   |
|----------------------|--------------------|---|
| <b>UART1_DATAIN</b>  | I/O/<br>GPIOMV, MS | <b>High-speed UART receive data input:</b><br><i>This signal is muxed and may be used by other functions.</i> |
| <b>UART1_DATAOUT</b> | I/O/<br>GPIOMV, MS | <b>High-speed UART transmit data:</b><br><i>This signal is muxed and may be used by other functions.</i>      |
| <b>UART1_RTS_N</b>   | I/O/<br>GPIOMV, MS | <b>High-speed UART request to send:</b><br><i>This signal is muxed and may be used by other functions.</i>    |
| <b>UART1_CTS_N</b>   | I/O/<br>GPIOMV, MS | <b>High-speed UART clear to send:</b><br><i>This signal is muxed and may be used by other functions.</i>      |

**Table 93. UART 2 Interface Signals**

| Signal Name          | Direction/<br>Type | Description   |
|----------------------|--------------------|---|
| <b>UART2_DATAIN</b>  | I/O/<br>GPIOMV, MS | <b>High-speed UART receive data input:</b><br><i>This signal is muxed and may be used by other functions.</i> |
| <b>UART2_DATAOUT</b> | I/O/<br>GPIOMV, MS | <b>High-speed UART transmit data:</b><br><i>This signal is muxed and may be used by other functions.</i>      |
| <b>UART2_RTS_N</b>   | I/O/<br>GPIOMV, MS | <b>High-speed UART request to send:</b><br><i>This signal is muxed and may be used by other functions.</i>    |
| <b>UART2_CTS_N</b>   | I/O/<br>GPIOMV, MS | <b>High-speed UART clear to send:</b><br><i>This signal is muxed and may be used by other functions.</i>      |



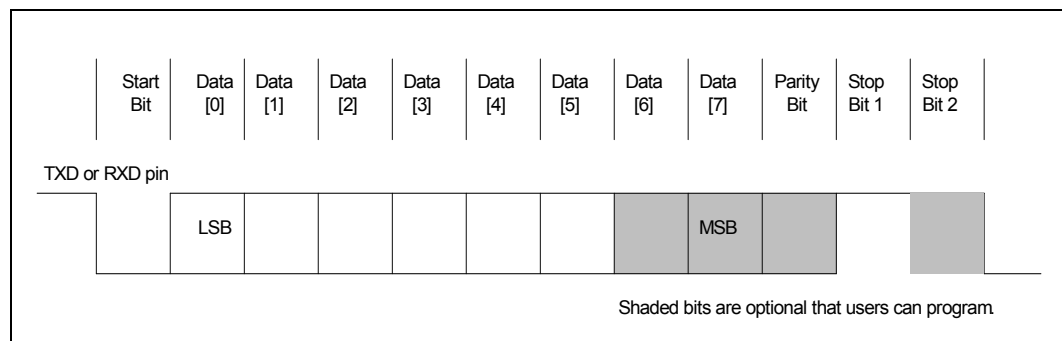
## 17.4.2 Features

### 17.4.2.1 UART Function

The UART transmits and receives data in bit frames as shown in [Figure 29](#).

- Each data frame is between 7 and 12 bits long, depending on the size of data programmed and if parity and stop bits are enabled.
- The frame begins with a start bit that is represented by a high-to-low transition.
- Next, 5 to 8 bits of data are transmitted, beginning with the least significant bit. An optional parity bit follows, which is set if even parity is enabled and an odd number of ones exist within the data byte; or, if odd parity is enabled and the data byte contains an even number of ones.
- The data frame ends with one, one-and-one-half, or two stop bits (as programmed by users), which is represented by one or two successive bit periods of a logic one.

**Figure 29. UART Data Transfer Flow**



Each UART has a Transmit FIFO and a Receive FIFO and each holds 64 characters of data. There are two separate methods for moving data into/out of the FIFOs—Interrupts and Polling.

### 17.4.2.2 Clock and Reset

The BAUD rate generates from base frequency of 50 MHz.

### 17.4.2.3 Baud Rate Generator

The baud rates for the UARTs are generated with from the base frequency ( $F_{base}$ ) indicated in [Table 94](#) by programming the DLH and DLL registers as divisor. The hexadecimal value of the divisor is  $(IER\_DLH[7:0] \ll 8) | RBR\_THR\_DLL[7:0]$ .

$F_{base}$  44236800 Hz can be achieved by programming the DDS Multiplier as 44,236,800 (in decimal), and DDS Divisor as the system clock frequency in Hz. (50,000,000 in decimal when the system clock frequency is 50 MHz.)



The output baud rate 3686400 is equal to the base frequency divided by thirteen times the value of the divisor, as follows:  $\text{baud rate} = (\text{Fbase}) / (13 * \text{divisor})$ . The output baud rate for all other baud rates is equal to the base frequency divided by sixteen times the value of the divisor, as follows:  $\text{baud rate} = (\text{Fbase}) / (16 * \text{divisor})$ .

**Table 94. Baud Rates Achievable with Different DLAB Settings**

| DLH,DLL Divisor      | DLH,DLL Divisor Hexadecimal | Baud Rate |
|----------------------|-----------------------------|-----------|
| Fbase 1: 47923200 Hz |                             |           |
| 1                    | 0001                        | 3686400   |
| Fbase 2: 44236800 Hz |                             |           |
| 1                    | 0001                        | 2764800   |
| 3                    | 0003                        | 921600    |
| 6                    | 0006                        | 460800    |
| 9                    | 0009                        | 307200    |
| 12                   | 000C                        | 230400    |
| 15                   | 000F                        | 184320    |
| 18                   | 0012                        | 153600    |
| 24                   | 0018                        | 115200    |
| 48                   | 0030                        | 57600     |
| 72                   | 0048                        | 38400     |
| 144                  | 0090                        | 19200     |
| 288                  | 0120                        | 9600      |
| 384                  | 0180                        | 7200      |
| 576                  | 0240                        | 4800      |
| 768                  | 0300                        | 3600      |
| 1152                 | 0480                        | 2400      |
| 1536                 | 0600                        | 1800      |
| 2304                 | 0900                        | 1200      |
| 4608                 | 1200                        | 600       |
| 9216                 | 2400                        | 300       |

### 17.4.3 Use

Each UART has a transmit FIFO and a receive FIFO, each FIFO holding 64 characters of data. Three separate methods move data into and out of the FIFOs: interrupts, DMA, and polled.

#### 17.4.3.1 DMA Mode Operation

##### 17.4.3.1.1 Receiver DMA

The data transfer from the HSUART to host memory is controlled by the DMA write channel. To configure the channel in write mode, channel direction in the channel control register needs to be programmed to "1". The software need to program the





descriptor start address register, descriptor transfer size register, and descriptor control register before starting the channel using the channel active bit in the channel control register.

#### **17.4.3.1.2 Transmit DMA**

The data transfer from host memory to HSUART is controlled by DMA read channel. To configure the channel in read mode, channel direction in the channel control register needs to be programmed to "0". The software need to program the descriptor start address register, descriptor transfer size register, and descriptor control register before starting the channel using the channel active bit in the channel control register.

#### **17.4.3.1.3 Removing Trailing Bytes in DMA Mode**

When the number of entries in the Receive FIFO is less than its trigger level, and no additional data is received, the remaining bytes are called Trailing bytes. These are DMAed out by the DMA as it has visibility into the FIFO Occupancy register.

#### **17.4.3.2 FIFO Polled-Mode Operation**

With the FIFOs enabled (IIR\_FCR.IID0\_FIFOE bit set to 1), clearing IER\_DLH[7] and IER\_DLH[4:0] puts the serial port in the FIFO Polled Operation mode. Because the receiver and the transmitter are controlled separately, either one or both can be in Polled Operation mode. In this mode, software checks Receiver and Transmitter status using the Line Status Register (LSR). The processor polls the following bits for Receive and Transmit Data Service.

##### **17.4.3.2.1 Receive Data Service**

The processor checks data ready (LSR.DR) bit which is set when 1 or more bytes remains in the Receive FIFO or Receive Buffer Register (RBR\_THR\_DLL).

##### **17.4.3.2.2 Transmit Data Service**

The processor checks transmit data request LSR.THRE bit, which is set when the transmitter needs data.

The processor can also check transmitter empty LSR.TEMT, which is set when the Transmit FIFO or Holding register is empty.

##### **17.4.3.2.3 Autoflow Control**

Autoflow Control uses Clear-to-Send (nCTS) and Request-to-Send (nRTS) signals to automatically control the flow of data between the UART and external modem. When autoflow is enabled, the remote device is not allowed to send data unless the UART asserts nRTS low. If the UART de-asserts nRTS while the remote device is sending data, the remote device is allowed to send one additional byte after nRTS is deasserted. An overflow could occur if the remote device violates this rule. Likewise, the UART is not



allowed to transmit data unless the remote device asserts nCTS low. This feature increases system efficiency and eliminates the possibility of a Receive FIFO Overflow error due to long interrupt latency.

Autoflow mode can be used in two ways: Full autoflow, automating both nCTS and nRTS, and half autoflow, automating only nCTS. Full Autoflow is enabled by writing a 1 to bits 1 and 5 of the Modem Control Register (MCR). Auto-nCTS-Only mode is enabled by writing a 1 to bit 5 and a 0 to bit 1 of the MCR register.

#### **17.4.3.2.4 RTS (UART Output)**

When in full autoflow mode, nRTS is asserted when the UART FIFO is ready to receive data from the remote transmitter. This occurs when the amount of data in the Receive FIFO is below the programmable threshold value. When the amount of data in the Receive FIFO reaches the programmable threshold, nRTS is de-asserted. It will be asserted once again when enough bytes are removed from the FIFO to lower the data level below the threshold.

#### **17.4.3.2.5 CTS (UART Input)**

When in Full or Half-Autoflow mode, nCTS is asserted by the remote receiver when the receiver is ready to receive data from the UART. The UART checks nCTS before sending the next byte of data and will not transmit the byte until nCTS is low. If nCTS goes high while the transfer of a byte is in progress, the transmitter will complete this byte.



## 17.5 SIO - Pulse Width Modulation (PWM)

The Pulse Width Modulation block allows control the frequency and duty cycle of an output signal. The SoC has 2 instances of the PWM interface.

### 17.5.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

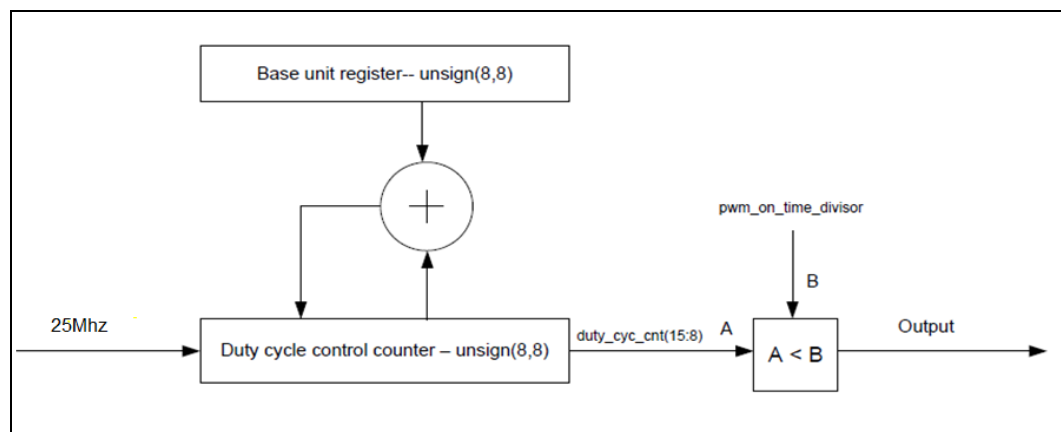
Figure 30. PWM Signals

| Signal Name | Direction/Type     | Description                      |
|-------------|--------------------|----------------------------------|
| PWM[0]      | I/O/<br>GPIOMV, MS | Pulse Width Modulation output 0. |
| PWM[1]      | I/O/<br>GPIOMV, MS | Pulse Width Modulation output 1. |

### 17.5.2 Features

The software controls the PWM block by updating the PWMCTRL register and setting the PWMCTRL.PWM\_SW\_UPDATE bit whenever a change in frequency or duty cycle of the PWM output signal is required. The PWM block applies the new settings at the start of the next output cycle and resets the PWMCTRL.PWM\_SW\_UPDATE bit. The SoC uses 25 MHz for the counter. Refer [Figure 31](#) for PWM block diagram.

Figure 31. PWM Block Diagram





There are two controls of the PWM output:

- Frequency is controlled by the PWMCTRL.PWM\_BASE\_UNIT bits. The PWMCTRL.PWM\_BASE\_UNIT value is added to a 16 bit counter every clock cycle and the counter roll-over marks the start of a new cycle.
- **Duty cycle** is controlled by the PWMCTRL.PWM\_ON\_TIME\_DIVISOR setting (0 to 255). When the counter rolls-over it is reset and a new cycle starts with the output signal being 0, once the counter reaches the PWMCTRL.PWM\_ON\_TIME\_DIVISOR value the output toggles to 1 and stays high until the counter rolls over.

The PWM block is clocked by the 25 MHz oscillator clock. The output frequency can be estimated with the equation:

- Target frequency = 25MHz \* base\_unit value/256.

**NOTE:** The larger the value of base\_unit, the larger the error that the PWM output frequency will have with respect to the equation above. For example any Base\_unit\_value > 128 will result in 12.5 MHz max frequency. Any value between 86 and 128 will result in 8.33 MHz output frequency. And accordingly the larger the base\_unit value the smaller duty cycle resolution. Maximum duty cycle resolution is 8 bits.

Table 95 illustrates the output frequency and duty-cycle resolution for different settings of the base\_unit\_value (when using 25 MHz oscillator clock).

**Table 95. Example PWM Output Frequency and Resolution**

| Target Frequency | Base Unit Value | CLK Cycle Count   | Duty Cycle Resolution |
|------------------|-----------------|---|-----------------------|
| 12.5 MHz         | >=128           | 1   | no resolution         |
| 1.07 MHz         | 11              | 23  | <8 bit resolution     |
| 488 kHz          | 5               | 51  | <8 bit resolution     |
| 97.6 kHz         | 1               | 256   | 8 resolution          |
| 48.8 kHz         | 0.5             | Theoretically 512 but only 255 available since On Time Divisor is only 8b | >8bit                 |
| 0                | 0               | 0   | Flat 0 output         |

## 17.6 Register Map

For more information on Serial IO registers refer Intel® Atom™ Z8000 Processor Series Datasheet (Volume 2 of 2), Doc ID:332066.

§



# 18 Platform Controller Unit (PCU) Overview

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Platform Controller Unit (PCU) is a collection of HW blocks that are critical for implementing a Windows\* compatible platform. These HW blocks include:

- “PCU - Power Management Controller (PMC)”
- “PCU - Fast Serial Peripheral Interface (SPI)”
  - For boot FW and system configuration data Flash storage
- “PCU - Universal Asynchronous Receiver/Transmitter (UART)”
- “PCU - Intel Legacy Block (iLB) Overview”

The PCU also implements some high level configuration features for BIOS/EFI boot.

## 18.1 Features

The key features of the individual blocks are as follows:

- Universal Asynchronous Receiver/Transmitter (UART)
  - 16550 controller compliant.
  - Reduced Signal Count: TX and RX only.
  - COM1 interface.
- Fast Serial Peripheral Interface (FST\_SPI)
  - For SPI Flash, of up to 16MB size per chip select is supported. No other SPI peripherals are supported.
  - Stores boot FW and system configuration data.
  - Supports frequencies of 20 MHz, 33 MHz and 50 MHz.
- Power Management Controller (PMC)
  - Controls many of the power management features present in the SoC.
- Intel Legacy Block (iLB)
  - Supports legacy PC platform features.
  - Sub-blocks include LPC, GPIO, 8259 PIC, IO-APIC, 8254 timers, HPET timers and the RTC.



## 18.2 PCU - Power Management Controller (PMC)

Power Management Controller (PMC) controls many of the power management features present in the SoC.

### 18.2.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 96. PMC Signals (Sheet 1 of 2)**

| Signal Name           | Direction /Type       | Description   |
|-----------------------|-----------------------|---|
| <b>PMC_ACPRESENT</b>  | I/O/<br>GPIOMV,<br>MS | <b>AC Present:</b> This input pin indicates when the platform is plugged into AC power.   |
| <b>PMC_BATLOW_N</b>   | I/O/<br>GPIOMV,<br>MS | <b>Battery Low:</b> An input from the battery to indicate that there is insufficient power to boot the system. Assertion will prevent wake from the S4/S5 state. This signal can also be enabled to cause an SMI_N when asserted.<br><br>In desktop configurations without a battery, this signal should be tied high to V1P8_S5.   |
| <b>PMC_CORE_PWROK</b> | I/GPIOMV,<br>MS       | <b>Core Power OK:</b> When asserted, this signal is an indication to the SoC that all of its core power rails have been stable for 10 ms. It can be driven asynchronously. When it is negated, the SoC asserts PMC_PLTRST_N.<br><b>NOTE:</b> It is required that the power rails associated with PCI Express (typically the 3.3V, 5V, and 12V core well rails) have been valid for 99 ms prior to PMC_CORE_PWROK assertion in order to comply with the 100 ms T <sub>PVPERL</sub> PCI Express 2.0 specification on PMC_PLTRST_N deassertion.<br><b>NOTE:</b> PMC_CORE_PWROK must not glitch, even if PMC_RSMRST_N is low. |
| <b>PMC_PLTRST_N</b>   | I/O/<br>GPIOMV,<br>MS | <b>Platform Reset:</b> The SoC asserts this signal to reset devices on the platform. The SoC asserts the signal during power-up and when software initiates a hard reset sequence through the Reset Control (RST_CNT) register.   |



Table 96. PMC Signals (Sheet 2 of 2)

| Signal Name     | Direction /Type       | Description  |
|-----------------|-----------------------|--|
| PMC_PWRBTN_N    | I/O/<br>GPIOMV,<br>MS | <b>Power Button:</b> The signal will cause SMI_N or SCI to indicate a system request to go to a sleep state. If the system is already in a sleep state, this signal will cause a wake event. If the signal is pressed for more than 4 seconds, this will cause an unconditional transition (power button override) to the S5 state. Override will occur even if the system is in the S4 states. This signal has an internal pull-up resistor and has an internal 16 ms de-bounce on the input. |
| PMC_RSMRST_N    | I/GPIOMV,<br>MS       | <b>Resume Well Reset:</b> Used for resetting the resume well. An external RC circuit is required to guarantee that the resume well power is valid prior to this signal going high.   |
| PMC_RSTBTN_N    | I/O/<br>GPIOMV,<br>MS | <b>System Reset:</b> This signal forces an internal reset after being debounced.<br><i>This signal is muxed and may be used by other functions.</i>  |
| PMC_SLP_S0IX_N  | I/O/<br>GPIOMV,<br>MS | <b>S0ix Sleep Control:</b> This signal is for power plane control. It can be used to control system power when it is in a S0ix state.  |
| PMC_SLP_S4_N    | I/O/<br>GPIOMV,<br>MS | <b>S4 Sleep Control:</b> This signal is for power plane control. It can be used to control system power when it is in a S4 (Suspend to Disk) or S5 (Soft Off) state.   |
| PMC_SUS_STAT_N  | I/O/<br>GPIOMV,<br>MS | <b>Suspend Status:</b> This signal is asserted by the SoC to indicate that the system will be entering a low power state soon. This can be monitored by devices with memory that need to switch from normal refresh to suspend refresh mode. It can also be used by other peripherals as an indication that they should isolate their outputs that may be going to powered-off planes.<br><i>This signal is muxed and may be used by other functions.</i>                                      |
| PMC_SUSCLK      | I/O/<br>GPIOMV,<br>MS | <b>Suspend Clock:</b> This 32 kHz clock is an output of the RTC generator circuit for use by other chips for refresh clock.<br><i>This signal is muxed and may be used by other functions.</i>   |
| PMC_SUSPWRDNACK | I/O/<br>GPIOMV,<br>MS | <b>Suspend Power Down Acknowledge:</b> Asserted by the SoC when it does not require its Suspend well to be powered. This pin requires a pull-up to UNCORE_V1P8_G3.<br><i>This signal is muxed and may be used by other functions.</i>  |



## 18.2.2 Features

### 18.2.2.1 Sx-G3-Sx, Handling Power Failures

Depending on when the power failure occurs and how the system is designed, different transitions could occur due to a power failure.

The GEN\_PMCON1.AG3E bit provides the ability to program whether or not the system should boot once power returns after a power loss event. If the policy is to not boot, the system remains in an S5 state (unless previously in S4). There are only two possible events that will wake the system after a power failure.

- **PMC\_PWRBTN\_N:** PMC\_PWRBTN\_N is always enabled as a wake event. When RSMRST\_N is low (G3 state), the PM1\_STS\_EN.PWRBTN\_STS bit is reset. When the SoC exits G3 after power returns (PMC\_RSMRST\_N goes high), the PMC\_PWRBTN\_N signal is already high (because the suspend plane goes high before PMC\_RSMRST\_N goes high) and the PM1\_STS\_EN.PWRBTN\_STS bit is 0b.
- **RTC Alarm:** The PM1\_STS\_EN.RTC\_EN bit is in the RTC well and is preserved after a power loss. Like PM1\_STS\_EN.PWRBTN\_STS the PM1\_STS\_EN.RTC\_STS bit is cleared when PMC\_RSMRST\_N goes low.

The SoC monitors both PMC\_CORE\_PWROK and PMC\_RSMRST\_N to detect for power failures. If PMC\_CORE\_PWROK goes low, the GEN\_PMCON1.PWR\_FLR bit is set. If PMC\_RSMRST\_N goes low, GEN\_PMCON1.SUS\_PWR\_FLR is set.

Table 97. Transitions Due to Power Failure

| State at Power Failure | GEN_PMCON1.AG3E bit | Transition When Power Returns |
|------------------------|---------------------|-------------------------------|
| S0                     | 1<br>0              | S5<br>S0                      |
| S4                     | 1<br>0              | S4<br>S0                      |
| S5                     | 1<br>0              | S5<br>S0                      |

### 18.2.2.2 Event Input Signals and Usage

The SoC has various input signals that trigger specific events. This section describes those signals and how they should be used.

#### 18.2.2.2.1 PMC\_PWRBTN\_N (Power Button)

The PMC\_PWRBTN\_N signal operates as a “Fixed Power Button” as described in the Advanced Configuration and Power Interface specification. The signal has a 16 ms debounce on the input. The state transition descriptions are included in Table 98.

**Note:** The transitions start as soon as the PMC\_PWRBTN\_N is pressed (but after the debounce logic), and does not depend on when the power button is released.





**Note:** During the time that the PMC\_SLP\_S4\_N signal is stretched for the minimum assertion width (if enabled), the power button is not a wake event. Refer note below for more details.

**Table 98. Transitions Due to Power Button**

| Present State | Event  | Transition/Action  | Comment   |
|---------------|--|--|---|
| S0/Cx         | PMC_PWRBTN_N goes low                                    | SMI_N or SCI generated (depending on PM1_CNT.SCI_EN, PM1_STS_EN.PWRBTN_EN and SMI_EN.GBL_SMI_EN) | Software typically initiates a Sleep state                            |
| S4/S5         | PMC_PWRBTN_N goes low                                    | Wake Event. Transitions to S0 state  | Standard wakeup   |
| G3            | PMC_PWRBTN_N pressed                                     | None   | No effect since no power Not latched nor detected                     |
| S0, S4        | PMC_PWRBTN_N held low for at least 4 consecutive seconds | Unconditional transition to S5 state   | No dependence on processor or any other subsystem                     |
| S0ix          | PMC_PWRBTN_N goes low                                    | Wake Event. Transitions to S0 state  | PM1_STS_EN.PWRBTN_EN should be set since a SMI/SCI event is required. |

#### Power Button Override Function

If PMC\_PWRBTN\_N is observed active for at least four consecutive seconds, the state machine should unconditionally transition to the S5 state, regardless of present state (S0–S4), even if the PMC\_CORE\_PWROK is not active. In this case, the transition to the G2/S5 state should not depend on any particular response from the processor nor any similar dependency from any other subsystem.

The PMC\_PWRBTN\_N status is readable to check if the button is currently being pressed or has been released. The status is taken after the de-bounce, and is readable using the GEN\_PMCON2.PWRBTN\_LVL bit.

**Note:** The 4 seconds PMC\_PWRBTN\_N assertion should only be used if a system lock-up has occurred. The 4-second timer starts counting when the SoC is in a S0 state. If the PMC\_PWRBTN\_N signal is asserted and held active when the system is in a suspend state (S4), the assertion causes a wake event. Once the system has resumed to the S0 state, the 4-second timer starts.

**Note:** During the time that the SLP\_S4\_N signal is stretched for the minimum assertion width (if enabled by GEN\_PMCON1.S4ASE), the power button is not a wake event. As a result, it is conceivable that the user will press and continue to hold the power button waiting for the system to awake. Since a 4 seconds press of the power button is already defined as an unconditional power down, the power button timer will be forced to inactive while the power-cycle timer is in progress. Once the power-cycle timer has



expired, the power button awakes the system. Once the minimum PMC\_SLP\_S4\_N power cycle expires, the power button must be pressed for another 4 to 5 seconds to create the override condition to S5.

#### 18.2.2.2.2 Sleep Button

The Advanced Configuration and Power Interface specification defines an optional sleep button. It differs from the power button in that it only is a request to go from S0 to S4 (not S5). Also, in an S5 state, the power button can wake the system, but the sleep button cannot.

Although the SoC does not include a specific signal designated as a sleep button, one of the GPIO signals can be used to create a "Control Method" sleep button. Refer Advanced Configuration and Power Interface specification for implementation details.

#### 18.2.2.2.3 PME\_B0 (PCI Power Management Event Bus 0)

The GPE0a\_STS.PME\_B0\_STS bit exists to implement PME\_N-like functionality for any internal device on Bus 0 with PCI power management capabilities.

#### 18.2.2.2.4 PMC\_RSTBTN\_N Signal

When the PMC\_RSTBTN\_N pin is detected as active after the 16 ms debounce logic, the SoC attempts to perform a "graceful" reset, by waiting for the relevant internal devices to signal their idleness. If all devices are idle when the pin is detected active, the reset occurs immediately; otherwise, a counter starts. If at any point during the count all devices go idle the reset occurs. If the counter expires and any device is still active, a reset is forced upon the system even though activity is still occurring.

Once the reset is asserted, it remains asserted for 5 to 6 ms regardless of whether the PMC\_RSTBTN\_N input remains asserted or not. It cannot occur again until PMC\_RSTBTN\_N has been detected inactive after the debounce logic, and the system is back to a full S0 state with PMC\_PLTRST\_N inactive. Note that if RST\_CNT.FULL\_RST is set then PMC\_RSTBTN\_N will result in a full power cycle reset.

### 18.2.2.3 System Power Planes

The system has several independent power planes, as described in [Table 99](#).

**Note:** When a particular power plane is shut off, it should go to a 0 V level.



Table 99. System Power Planes

| Plane              | Controlled By           | Description   |
|--------------------|-------------------------|---|
| Devices and Memory | PMC_SLP_S4_N            | When PMC_SLP_S4_N goes active, power can be shut off to any circuit not required to wake the system from the S4/S5. Since the memory context does not need to be preserved in the S4/S5 state, the power to the memory can also be shut down.<br>S4 and S5 requests are treated the same so no PMC_SLP_S5_N signal is implemented.  |
| Devices            | Implementation Specific | Individual subsystems may have their own power plane. For example, GPIO signals may be used to control the power to disk drives, audio amplifiers, or the display screen.   |
| Suspend            | PMC_SUSPWRDNACK         | The suspend power planes are generally left on whenever the system has a charged main battery or is plugged in to AC power.<br>In some cases, it may be preferable to disable the suspend power planes in S4/S5 states to save additional power. This requires some external logic (such as an embedded controller) to ensure that a wake event is still possible (such as the power button).<br>When the SeC is enabled it is advised that the suspend power planes not be removed. Doing so may result in extremely long Sx exit times since the SeC if forced to consider it a cold boot which may, in turn, cause exit latency violations for software using the TXE. |

#### 18.2.2.3.1 Power Plane Control with PMC\_SLP\_S0IX\_N and PMC\_SLP\_S4\_N

The PMC\_SLP\_S0IX\_N output signal can be used to cut power to any systems supplies that are not required during a S0ix system state.

Cutting power to the core may be done using the power supply, or by external FETs on the motherboard.

The PMC\_SLP\_S4\_N output signal can be used to cut power to the system core supply, as well as power to the system memory, since the context of the system is saved on the disk. Cutting power to the memory may be done using the power supply, or by external FETs on the motherboard.

#### 18.2.2.3.2 PMC\_SLP\_S4\_N and Suspend-To-RAM Sequencing

The system memory suspend voltage regulator is controlled by the Glue logic. The PMC\_SLP\_S4\_N signal should be used to remove power to system memory. The PMC\_SLP\_S4\_N logic in the SoC provides a mechanism to fully cycle the power to the DRAM and/or detect if the power is not cycled for a minimum time.

**Note:** To use the minimum DRAM power-down feature that is enabled by the GEN\_PMCON1.S4ASE bit, the DRAM power must be controlled by the PMC\_SLP\_S4\_N signal.



### 18.2.2.3.3 PMC\_CORE\_PWROK Signal

When asserted, PMC\_CORE\_PWROK is an indication to the SoC that its core well power rails are powered and stable. PMC\_CORE\_PWROK can be driven asynchronously. When PMC\_CORE\_PWROK is low, the SoC asynchronously asserts PMC\_PLTRST\_N. PMC\_CORE\_PWROK must not glitch, even if PMC\_RSMRST\_N is low.

It is required that the power rails associated with PCI Express have been valid for 99 ms prior to PWROK assertion in order to comply with the 100 ms  $T_{PVPERL}$  PCI Express 2.0 specification on PMC\_PLTRST\_N deassertion.

**Note:** PMC\_RSTBTN\_N is recommended for implementing the system reset button. This saves external logic that is needed if the PMC\_CORE\_PWROK input is used. Additionally, it allows for better handling of the processor resets and avoids improperly reporting power failures.

### 18.2.2.3.4 PMC\_BATLOW\_N (Battery Low)

The PMC\_BATLOW\_N input can inhibit waking from S4, and S5 states if there is not sufficient power. It also causes an SMI if the system is already in an S0 state.

### 18.2.2.4 SMI\_N/SCI Generation

Upon any enabled SMI event taking place while the SMI\_EN.EOS bit is set, the SoC will clear the EOS bit and assert SMI to the CPU core, which will cause it to enter SMM space. SMI assertion is performed using a Virtual Legacy Wire (VLW) message. Prior system generations (those based upon legacy processors) used an actual SMI\_N pin.

Once the SMI message has been delivered, the SoC takes no action on behalf of active SMI events until Host software sets the End of SMI (EOS) bit. At that point, if any SMI events are still active, the SoC will send another SMI message.

The SCI is a level-mode interrupt that is typically handled by an ACPI-aware operating system. In non-APIC systems (which is the default), the SCI IRQ is routed to one of the 8259 interrupts (IRQ 9, 10, or 11). The 8259 interrupt controller must be programmed to level mode for that interrupt.

In systems using the APIC, the SCI can be routed to interrupts IRQs[11:9] or IRQs[23:20]. The interrupt polarity changes depending on whether it is on an interrupt shareable with a PIRQ or not. The interrupt remains asserted until all SCI sources are removed.

Table 100 shows which events can cause an SMI and SCI. Note that some events can be programmed to cause either an SMI or SCI. The usage of the event for SCI (instead of SMI) is typically associated with an ACPI-based system. Each SMI or SCI source has a corresponding enable and status bit.



Table 100. Causes of SMI and SCI (Sheet 1 of 2)

| Event  | Status Indication <sup>1</sup>  | Enable Condition  | Interrupt Result           |                            |                           |                           |
|--|---|---|----------------------------|----------------------------|---------------------------|---------------------------|
|  |   |   | SMI_EN.<br>GBL_SMI_EN=1b   |                            | SMI_EN.<br>GBL_SMI_EN=0b  |                           |
|  |   |   | PM1_CNT.<br>.SCI_EN=<br>1b | PM1_CNT.<br>.SCI_EN=<br>0b | PM1_CNT.<br>SCI_EN=<br>1b | PM1_CNT.<br>SCI_EN=0<br>b |
| Power Button Override <sup>3</sup>             | PM1_STS_EN.<br>PWRBTNOR_STS   | None  | SCI                        | None                       | SCI                       | None                      |
| RTC Alarm                                      | PM1_STS_EN.<br>RTC_STS  | PM1_STS_EN_EN.<br>RTC_EN=1b   | SCI                        | SMI                        | SCI                       | None                      |
| Power Button Press                             | PM1_STS_EN.<br>PWRBTN_STS   | PM1_STS_EN_EN.<br>PWRBTN_EN=1b  | SCI                        | SMI                        | SCI                       | None                      |
| SMI_EN.BIOS_RLS bit written to 1b <sup>4</sup> | PM1_STS_EN.<br>GBL_STS  | PM1_STS_EN_EN.<br>GBL_EN=1b   | SCI                        |                            |                           |                           |
| ACPI Timer overflow (2.34 seconds)             | PM1_STS_EN.<br>TMROF_STS  | PM1_STS_EN_EN.<br>TMROF_EN =1b  | SCI                        | SMI                        | SCI                       | None                      |
| GPI[n] <sup>9</sup>                            | GPE0a_STS.<br>CORE_GPIO_STS[n] <sup>2</sup><br>or<br>GPE0a_STS.<br>SUS_GPIO_STS[n] <sup>2</sup> | GPIO_ROUT[n] = 10b &<br>GPE0a_EN.<br>CORE_GPIO_EN[n] <sup>2</sup> =<br>1b<br>or<br>GPE0a_EN.<br>SUS_GPIO_EN[n] <sup>2</sup> =1<br>b | SCI                        | None                       | SCI                       | None                      |
| Internal, Bus 0, PME-Capable Agents (PME_B0)   | GPE0a_STS.<br>PME_B0_STS  | GPE0_EN.<br>PME_B0_EN=1b  | SCI                        | SMI                        | SCI                       | None                      |
| BATLOW_N pin goes low                          | GPE0a_STS.<br>BATLOW_STS_N  | GPE0_EN.<br>BATLOW_EN=1b  | SCI                        | SMI                        | SCI                       | None                      |
| Software Generated GPE                         | GPE0a_STS.<br>SWGPE_STS   | GPE0_EN.<br>SWGPE_EN=1b   | SCI                        | SMI                        | SCI                       | None                      |
| DOSCI message from GUNIT <sup>5</sup>          | GPE0a_STS.<br>GUNIT_STS   | None (enabled by G-Unit <sup>8</sup> )  | SCI                        | None                       | SCI                       | None                      |
| ASSERT_SMI message from SPI <sup>5</sup>       | SMI_STS.<br>SPI_SMI_STS   | None (enabled by SPI controller)  | SMI                        |                            | None                      |                           |
| ASSERT_IS_SMI message from USB                 | SMI_STS.<br>USB_IS_STS  | SMI_EN.<br>USB_IS_SMI_EN=1b   | SMI                        |                            | None                      |                           |
| ASSERT_SMI message from USB                    | SMI_STS.USB_STS   | SMI_EN.<br>USB_SMI_EN=1b  | SMI                        |                            | None                      |                           |
| ASSERT_SMI message from iLB <sup>5</sup>       | SMI_STS.<br>ILB_SMI_STS   | None (enabled by iLB)   | SMI                        |                            | None                      |                           |
| Periodic timer expires                         | SMI_STS.<br>PERIODIC_STS  | SMI_EN.<br>PERIODIC_EN=1b   | SMI                        |                            | None                      |                           |



Table 100. Causes of SMI and SCI (Sheet 2 of 2)

| Event  | Status Indication <sup>1</sup>  | Enable Condition   | Interrupt Result           |                            |                           |                           |
|--|---|--|----------------------------|----------------------------|---------------------------|---------------------------|
|  |   |  | SMI_EN.<br>GBL_SMI_EN=1b   |                            | SMI_EN.<br>GBL_SMI_EN=0b  |                           |
|  |   |  | PM1_CNT.<br>.SCI_EN=<br>1b | PM1_CNT.<br>.SCI_EN=<br>0b | PM1_CNT.<br>SCI_EN=<br>1b | PM1_CNT.<br>SCI_EN=0<br>b |
| WDT first expiration   | SMI_STS.TCO_STS   | SMI_EN.TCO_EN=1b   | SMI                        |                            | None                      |                           |
| 64 ms timer expires  | SMI_STS.<br>SWSMI_TMR_STS   | SMI_EN.<br>SWSMI_TMR_EN=1b   | SMI                        |                            | None                      |                           |
| PM1_CNT.SLP_EN bit written to 1b                                 | SMI_STS.<br>SMI_ON_SLP_EN_S<br>TS   | SMI_EN.<br>SMI_ON_SLP_EN<br>=1b  | Sync SMI <sup>6</sup>      |                            | None                      |                           |
| PM1_CNT.GBL_RLS written to 1b                                    | SMI_STS.BIOS_STS  | SMI_EN.<br>BIOS_EN=1b  | Sync SMI <sup>6</sup>      |                            | None                      |                           |
| DOSMI message from GUNIT <sup>5</sup>                            | SMI_STS.<br>GUNIT_SMI_STS   | None (enabled by G-Unit <sup>8</sup> )   | SMI                        |                            | None                      |                           |
| ASSERT_IS_SMI message from iLB <sup>5</sup>                      | SMI_STS.<br>ILB_SMI_STS   | None (enabled by iLB)  | Sync SMI <sup>7</sup>      |                            | None                      |                           |
| GPI[n] <sup>10</sup>   | ALT_GPIO_SMI.<br>CORE_GPIO_SMI_S<br>TS[n] <sup>2</sup><br>or<br>ALT_GPIO_SMI.<br>SUS_GPIO_SMI_ST<br>S[n] <sup>2</sup> | GPIO_ROUT[n]=01b &<br>ALT_GPIO_SMI.<br>CORE_GPIO_SMI_EN<br>[n] <sup>2</sup> =1b<br>or<br>ALT_GPIO_SMI.<br>SUS_GPIO_SMI_EN[n]<br>] <sup>2</sup> =1b | SMI                        |                            | None                      |                           |
| USB Per-Port Registers Write Enable bit is changed from 0b to 1b | UPRWC.WE_STS &<br>SMI_STS.<br>USB_IS_STS  | UPRWC.<br>WE_SMI_E=1b &<br>SMI_EN.<br>USB_IS_SMI_EN=1b   | Sync SMI <sup>6</sup>      |                            | None                      |                           |

**NOTES:**

1. Most of the status bits (except otherwise is noted) are set according to event occurrence regardless to the enable bit.
2. GPIO status bits are set only if enable criteria is true. GPIO\_ROUT[n]=10b & GPE0a\_EN.x\_GPIO\_EN[n] for GPE0a\_STS.x\_GPIO\_STS[n] (SCI). GPIO\_ROUT[n]=01b & ALT\_GPIO\_SMI.x\_GPIO\_SMI\_EN[n]=1b for ALT\_GPIO\_SMI.x\_GPIO\_SMI\_STS[n] (SMI).
3. When power button override occurs, the system will transition immediately to S5. The SCI will only occur after the next wake to S0 if the residual status bit (PM1\_STS\_EN.PWRBTNOR\_STS) is not cleared prior to setting PM1\_CNT.SCI\_EN.
4. PM1\_STS\_EN.GBL\_STS being set will cause an SCI, even if the PM1\_CNT.SCI\_EN bit is not set. Software must take great care not to set the SMI\_ENBIOS\_RLS bit (which causes PM1\_STS\_EN.GBL\_STS to be set) if the SCI handler is not in place.
5. No enable bits for these SCI/SMI messages in the PMC. Enable capability should be implemented in the source unit.
6. Sync SMI has the same message opcode toward T-Unit. Special treatment regarding this Sync SMI is holding completion to host till SYNC\_SMI\_ACK message is received from T-Unit.



7. Sync SMI has the same message opcode toward T-Unit. Special treatment regarding this Sync SMI is holding the SSMI\_ACK message to iLB till SYNC\_SMI\_ACK message is received from T-Unit.
8. The G-Unit is an internal functional sub-block which forms part of the graphics functional block.
9. The GPE0a\_STS.CORE\_GPIO\_STS[31:24] & GPE0a\_EN.CORE\_GPIO\_EN[31:24] register bits correspond to GPIO\_S0\_SC[7:0]. GPE0a\_STS.SUS\_GPIO\_STS[23:16] & GPE0a\_EN.SUS\_GPIO\_EN[23:16] correspond to GPIO\_S5[7:0].
10. The ALT\_GPIO\_SMI.CORE\_GPIO\_SMI\_STS[31:24] & ALT\_GPIO\_SMI.CORE\_GPIO\_SMI\_EN[15:8] register bits correspond to GPIO\_S0\_SC[7:0]. ALT\_GPIO\_SMI.SUS\_GPIO\_SMI\_STS[23:16] & ALT\_GPIO\_SMI.SUS\_GPIO\_SMI\_EN[7:0] correspond to GPIO\_S5[7:0].

### 18.2.2.5 Platform Clock Support

The SoC supports up to 6 clocks (PMC\_PLT\_CLK[5:0]) with a frequency of 19.2 MHz. These clocks are available for general system use, where appropriate and each have Control and Frequency register fields associated with them.

### 18.2.2.6 INIT\_N (Initialization) Generation

The INIT\_N functionality is implemented as a 'virtual wire' internal to the SoC rather than a discrete signal. This virtual wire is asserted based on any one of the events described in below table. When any of these events occur, INIT\_N is asserted for 16 PCI clocks and then driven high.

INIT\_N, when asserted, resets integer registers inside the CPU cores without affecting its internal caches or floating-point registers. The cores then begin execution at the power on Reset vector configured during power on configuration.

**Table 101. INIT\_N Assertion Causes**

| Cause  |
|--|
| PORT92.INIT_NOW transitions from 0b to 1b.                         |
| RST_CNT.SYS_RST = 0b and RST_CNT.RST_CPU transitions from 0b to 1b |

### 18.2.3 References

Advanced Configuration and Power Interface Specification, Revision 3.0: <http://www.acpi.info/>



## 18.3 PCU - Fast Serial Peripheral Interface (SPI)

The SoC implements a SPI controller as the interface for BIOS Flash storage. This SPI Flash device is also required to support configuration storage for the firmware for the Trusted Execution Engine. The controller supports a maximum of two SPI Flash devices, using two chip select signals, with speeds of 14.28 MHz, 20 MHz, 25 MHz, 40 MHz or 50 MHz and both have to be Fast SPI. SoC Supports FAST SPI mode.

**Note:** The default interface speed is 20 MHz.

SPI 'Fast mode' is quad mode.

### 18.3.1 Signal Descriptions

Refer [Chapter 2, "Physical Interfaces"](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, "Electrical Specifications"](#).
- **Description:** A brief explanation of the signal's function.

**Table 102. SPI Signals**

| Signal Name     | Direction /Type | Description   |
|-----------------|-----------------|---|
| FST_SPI_CLK     | I/O<br>GPIO     | <b>Fast SPI Clock:</b> When the bus is idle, the owner will drive the clock signal low.             |
| FST_SPI_CS[0]_N | I/O<br>GPIO     | <b>Fast SPI Chip Select 0:</b> Used as the SPI bus request signal for the first SPI Flash device.   |
| FST_SPI_CS[1]_N | I/O<br>GPIO     | <b>Fast SPI Chip Select 1:</b> Used as the SPI bus request signal for the second SPI Flash devices. |
| FST_SPI_CS[2]_N | I/O<br>GPIO     | <b>Fast SPI Chip Select 2:</b> Used as the SPI bus request signal for the second SPI Flash devices. |
| FST_SPI_D[3:0]  | I/O<br>GPIO     | <b>Fast SPI Data Pad:</b> Data Input/output pin for the SoC.  |

**Note:** All SPI signals are tri-stated when PMC\_RSMRST\_N and PMC\_CORE\_PWROK are asserted. FST\_SPI\_CS[0:2] and FST\_SPI\_CLK are not tri-stated.

### 18.3.2 Features

- 1)Descriptor Mode Capabilities
  - a)Two modes of operation
    - i)Descriptor mode with security access restrictions





- ii) Non-Descriptor mode, no access security restrictions (ICH7 style)
    - (1) BIOS Only
    - (2) If the SPI Flash Signature is invalid, the SPI flash operates in non-descriptor mode
  - a. Supports Flash that is divided into 5 regions and accessible by 3 masters
    - i) Regions (5)
      - (1) Flash Descriptor and Chipset Soft Straps
      - (2) BIOS
      - (3) TXE
      - (4) Platform Data
    - ii) Masters (3)
      - (1) Host CPU (for BIOS)
      - (2) TXE
    - iii) Regions are allowed to extend across multiple Flash components
    - iv) Regions are aligned to 4K blocks/sectors
  - b. Chipset Soft Strap region provides the ability to use Flash NVM as an alternative to hardware pullup/pulldown resistors for both SoC and the processor Complex
    - i) Each Unit that pulls Soft straps from SPI should have a default value that is used if the Flash Signature is invalid.
  - c. The top of the Flash Descriptor contains the Flash Upper Map
    - ii) This is used by software to define Flash vendor specific capabilities
  - d. The top 256B of the flash descriptor is reserved for use by the OEM
- 2) Security Capabilities
- a. Descriptor based Region Restriction: Hardware enforced security restricting master accesses to different regions
    - i) Flash Descriptor region settings define separate read/write access to each region per master.
    - ii) Uses SAI for master accesses security checking
      - (1) Soft Strap+fuse to disable sourceID and SAI checks
    - iii) Flash Security Override Pin Strap
      - (1) Removes all descriptor based security
      - (2) Disables the write protection to the BIOS Protected Range 4 (PR4).
    - iv) Each master can grant other masters read/write access to its region
  - b. Protected Range Registers.
    - i) 3 sets (one for each master) of Lockable Protected Range registers that can restrict program register accesses from the same master.
    - ii) Can span multiple regions



- iii) Separate read and write protection
  - iv) Special case: BIOS PR4 write protect values are received from Soft Strap and affect all masters.
  - c. SMI Write Protection for BIOS
    - i) If enabled, will cause an SMI if a program register access occurs. The primary purpose of this requirement is to support SMI based BIOS update utilities.
  - d. Illegal Instruction protection for instructions such as Chip Erase
  - e. Lockable software sequencing opcodes
- 3) SPI Flash Access
- a. Direct Read Access
  - b. Program Register Access
    - i) Hardware Sequencing
      - (1) Software Sequencing uses HW to provide the basic instructions of read, write, and erase.
    - ii) Software Sequencing
      - (1) Allows SW to use any legal Opcode
  - c. Support for Boot BIOS on SPI.
    - i) Non-boot BIOS that is accessible through program register only can be used on SPI when boot BIOS is located on some other interface.
  - d. Pre-fetching/Caching to improve performance
    - i) Separate 64B pre-fetch/cache each for HOST and SEC direct read accesses
- 4) SFDP Parameter Discoverability<sup>1</sup>
- 5) Flash Component Capabilities
- a. In Descriptor mode, supports two SPI Flash components using two separate chip select pins, CS0# and CS1#. Only one component supported in non-descriptor mode.
    - i) Components must have the same erasable block/sector size
    - ii) Each component can be up to 16MB (32MB total addressable) using 24-bit addressing.
  - b. 1.8V SPI I/O buffer VCC
  - c. Supports the SPI Fast Read/Write instruction and frequencies of 20MHz, 33MHz and 50 MHz. Supports the SPI Dual Output Fast Read/Write instruction with frequencies of 20 MHz, 33 MHz and 50 MHz
  - d. Supports the SPI Quad Output Fast Read/Write instruction with frequencies of 20 MHz, 33 MHz and 50 MHz
  - e. Uses standardized Flash Instruction Set.
  - f. Supports non-power of 2 flash sizes, with the following restrictions:



- i) Only supported in Descriptor Mode.
- ii) BIOS accesses in non-descriptor mode to a non-binary flash size will not function properly.
- iii) The Flash Regions must be programmed to the actual size of the Flash Component(s).
- iv) If using two flash components, the 1st flash component (the one with the Flash Descriptor) must be of binary size. The 2nd flash component can be a non-binary size. If using only one flash component, it can be of non-binary size.
- v) The value programmed in the Flash Descriptor Component Density must be set to the next power of 2 value larger than the non-binary size.

8) Reset Capabilities

a. RSMRST#

- i) When RSMRST# is asserted, SoC will tri-state with a weak pull-up all SPI pins
- i) The SPI Controller will implement a sideband handshake ((handshake is reset warn message)) with PMC when a host reset is requested to allow the SPI Flash controller to complete any outstanding atomic sequences and quiescence the SPI Bus

**Note:** There is no N\*parameter headers support on SoC, DTR and 32-bit addressing is not supported.



## 18.4 PCU - Universal Asynchronous Receiver/Transmitter (UART)

This section describes the Universal Asynchronous Receiver/Transmitter (UART) serial port integrated into the PCU. The UART may be controlled through programmed IO.

**Note:** Only a minimal ball-count, comprising receive & transmit signals, UART port is implemented. Further, a maximum baud rate of only 115,200 bps is supported. For this reason, it is recommended that the UART port be used for debug purposes only.

### 18.4.1 Signal Descriptions

Refer [Chapter 2, "Physical Interfaces"](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, "Electrical Specifications"](#).
- **Description:** A brief explanation of the signal's function.

**Table 103. UART Signals**

| Signal Name   | Direction /Type | Description   |
|---------------|-----------------|---|
| UART0_DATAIN  | I/GPIOHV, HS    | <b>COM1 Receive:</b> Serial data input from device pin to the receive port.<br><i>This signal is muxed and may be used by other functions.</i>    |
| UART0_DATAOUT | O/GPIOHV, HS    | <b>COM1 Transmit:</b> Serial data output from transmit port to the device pin.<br><i>This signal is muxed and may be used by other functions.</i> |

### 18.4.2 Features

The serial port consists of a UART which supports a subset of the functions of the 16550 industry standard.

The UART performs serial-to-parallel conversion on data characters received from a peripheral device and parallel-to-serial conversion on data characters received from the processor. The processor may read the complete status of the UART at any time during the functional operation. Available status information includes the type and condition of the transfer operations being performed by the UART and any error conditions.

The serial port may operate in either FIFO or non-FIFO mode. In FIFO mode, a 16-byte transmit FIFO holds data from the processor to be transmitted on the serial link and a 16-byte Receive FIFO buffers data from the serial link until read by the processor.



The UART includes a programmable baud rate generator which is capable of generating a baud rate of between 50 bps and 115,200 bps from a fixed baud clock input of 1.8432 MHz. The baud rate is calculated as follows:

**Baud Rate Calculation:**

$$\text{BaudRate} = \frac{1.8432 \times 10^6}{16 \times \text{Divisor}}$$

The divisor is defined by the Divisor Latch LSB and Divisor Latch MSB registers. Some common values are shown in [Table 104](#).

**Table 104. Baud Rate Examples**

| Desired Baud Rate | Divisor | Divisor Latch LSB Register | Divisor Latch MSB Register |
|-------------------|---------|----------------------------|----------------------------|
| 115,200           | 1       | 1h                         | 0h                         |
| 57,600            | 2       | 2h                         | 0h                         |
| 38,400            | 3       | 3h                         | 0h                         |
| 19,200            | 6       | 6h                         | 0h                         |
| 9,600             | 12      | Ch                         | 0h                         |
| 4,800             | 24      | 18h                        | 0h                         |
| 2,400             | 48      | 30h                        | 0h                         |
| 1,200             | 96      | 60h                        | 0h                         |
| 300               | 384     | 80h                        | 1h                         |
| 50                | 2,304   | 0h                         | 9h                         |

The UART has interrupt support and those interrupts may be programmed to the user's requirements, minimizing the computing required to handle the communications link. Each UART may operate in a polled or an interrupt driven environment as configured by software.

### 18.4.2.1 FIFO Operation

#### 18.4.2.1.1 FIFO Interrupt Mode Operation

##### Receiver Interrupt

When the Receive FIFO and receiver interrupts are enabled (FIFO Control Register, bit 0 = 1b and Interrupt Enable Register (IIR), bit 0 = 1b), receiver interrupts occur as follows:

- The receive data available interrupt is invoked when the FIFO has reached its programmed trigger level. The interrupt is cleared when the FIFO drops below the programmed trigger level.



- The IIR receive data available indication also occurs when the FIFO trigger level is reached, and like the interrupt, the bits are cleared when the FIFO drops below the trigger level.
- The receiver line status interrupt (IIR = C6h), as before, has the highest priority. The receiver data available interrupt (IIR = C4h) is lower. The line status interrupt occurs only when the character at the top of the FIFO has errors.
- The COM1\_LSR.DR bit is set to 1b as soon as a character is transferred from the shift register to the Receive FIFO. This bit is reset to 0b when the FIFO is empty.

### Character Time Out Interrupt

When the receiver FIFO and receiver time out interrupt are enabled, a character time out interrupt occurs when all of the following conditions exist:

- At least one character is in the FIFO.
- The last received character was longer than four continuous character times ago (if 2 stop bits are programmed the second one is included in this time delay).
- The most recent processor read of the FIFO was longer than four continuous character times ago.
- The receiver FIFO trigger level is greater than one.

The maximum time between a received character and a timeout interrupt is 160 ms at 300 baud with a 12-bit receive character (i.e., 1 start, 8 data, 1 parity, and 2 stop bits).

When a time out interrupt occurs, it is cleared and the timer is reset when the processor reads one character from the receiver FIFO. If a time out interrupt has not occurred, the time out timer is reset after a new character is received or after the processor reads the receiver FIFO.

### Transmit Interrupt

When the transmitter FIFO and transmitter interrupt are enabled (FIFO Control Register, bit 0 = 1b and Interrupt Enable Register, bit 0 = 1b), transmit interrupts occur as follows:

The Transmit Data Request interrupt occurs when the transmit FIFO is half empty or more than half empty. The interrupt is cleared as soon as the Transmit Holding Register is written (1 to 16 characters may be written to the transmit FIFO while servicing the interrupt) or the Interrupt Identification Register is read.

#### 18.4.2.1.2 FIFO Polled Mode Operation

With the FIFOs enabled (FIFO Control register, bit 0 = 1b), setting Interrupt Enable register (IER), bits 3:0 = 000b puts the serial port in the FIFO polled mode of operation. Since the receiver and the transmitter are controlled separately, either one or both may be in the polled mode of operation. In this mode, software checks receiver and transmitter status through the Line Status Register (LSR). As stated in the register description:



- LSR[0] is set as long as there is one byte in the receiver FIFO.
- LSR[1] through LSR[4] specify which error(s) has occurred for the character at the top of the FIFO. Character error status is handled the same way as interrupt mode. The Interrupt Identification Register is not affected since IER[2] = 0b.
- LSR[5] indicates when the transmitter FIFO needs data.
- LSR[6] indicates that both the transmitter FIFO and shift register are empty.
- LSR[7] indicates whether there are any errors in the receiver FIFO.

### 18.4.3 Use

#### 18.4.3.1 Base I/O Address

##### COM1

The base I/O address for the COM1 UART is fixed to 3F8h.

#### 18.4.3.2 Legacy Interrupt

##### COM1

The legacy interrupt assigned to the COM1 UART is fixed to IRQ4.

### 18.4.4 UART Enable/Disable

The COM1 UART may be enabled or disabled using the UART\_CONT.COM1EN register bit. By default, the UART is disabled.

**Note:**

It is recommended that the UART be disabled during normal platform operation. An enabled UART can interfere with platform power management.

### 18.4.5 IO Mapped Registers

There are 12 registers associated with the UART. These registers share eight address locations in the IO address space. [Table 105](#) shows the registers and their addresses as offsets of a base address. Note that the state of the COM1\_LCR.DLAB register bit, which is the most significant bit (MSB) of the Serial Line Control register, affects the selection of certain of the UART registers. The COM1\_LCR.DLAB register bit must be set high by the system software to access the Baud Rate Generator Divisor Latches.



## 18.5 Register Map

Table 105. Register Access List

| Register Address<br>(Offset to Base<br>IO Address) | COM1_LCR.DLA<br>B Value | Register<br>Access<br>Type | Register Accessed                                       |
|--|-------------------------|----------------------------|---|
| 0h   | 0b                      | RO                         | Receiver Buffer <sup>1</sup>                            |
| 0h   | 0b                      | WO                         | Transmitter Holding <sup>1</sup>                        |
| 0h   | 1b                      | RW                         | Divisor Latch LSB (Lowest Significant Bit) <sup>1</sup> |
| 1h   | 0b                      | RW                         | Interrupt Enable <sup>2</sup>                           |
| 1h   | 1b                      | RW                         | Divisor Latch MSB (Most Significant Bit) <sup>2</sup>   |
| 2h   | xb                      | RO                         | Interrupt Identification <sup>3</sup>                   |
| 2h   | xb                      | WO                         | FIFO Control <sup>3</sup>                               |
| 3h   | xb                      | RW                         | Line Control  |
| 4h   | xb                      | RW                         | Modem Control <sup>4</sup>                              |
| 5h   | xb                      | RO                         | Line Status   |
| 6h   | xb                      | RO                         | Modem Status <sup>4</sup>                               |
| 7h   | xb                      | RW                         | Scratchpad  |

**NOTES:**

1. These registers are consolidated in the Receiver Buffer / Transmitter Holding Register (COM1\_RX\_TX\_BUFFER).
2. These registers are consolidated in the Interrupt Enable Register (COM1\_IER)
3. These registers are consolidated in the Interrupt Identification / FIFO Control Register (COM1\_IIR).
4. These registers are implemented but unused since the UART signals related to modem interaction are not implemented.





## 18.6 PCU - Intel Legacy Block (iLB) Overview

The Intel Legacy Block (iLB) is a collection of disparate functional blocks that are critical for implementing the legacy PC platform features. These blocks include:

- “PCU - iLB - Low Pin Count (LPC) Bridge”
- “PCU - iLB - Real Time Clock (RTC)”
- “PCU - iLB - 8254 Timers”
- “PCU - iLB - High Precision Event Timer (HPET)”
- “PCU - iLB - GPIO”
- “PCU - iLB - IO APIC”
- “PCU - iLB - 8259 Programmable Interrupt Controllers (PIC)”

The iLB also implements a register range for configuration of some of those blocks along with support for Non-Maskable Interrupts (NMI).

### 18.6.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details as well as the subsequent sections.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 106. iLB Signals**

| Signal Name  | Direction /Type | Description  |
|--------------|-----------------|--|
| <b>NMI_N</b> | I/GPIOMV, MS    | Non-Maskable Interrupt: This is an NMI event indication into the SoC.<br><i>This signal is muxed and may be used by other functions.</i> |

### 18.6.2 Features

#### 18.6.2.1 Key Features

The key features of various blocks are as follows:

- LPC Interface
  - Supports Low Pin Count (LPC) 1.1 Specification
  - No support for DMA or bus mastering
  - Supports Trusted Platform Module (TPM) 1.2



- General Purpose Input Output
  - Legacy control interface for SoC GPIOs
  - I/O mapped registers
- 8259 Programmable Interrupt Controller
  - Supports Legacy interrupt
  - 15 total interrupts through two cascaded controllers
  - I/O mapped registers
- I/O Advanced Programmable Interrupt Controller
  - Supports Legacy-free interrupt
  - 115 total interrupts
  - Memory mapped registers
- 8254
  - Legacy timer support
  - Three timers with fixed uses: System Timer, Refresh Request Signal and Speaker Tone
  - I/O mapped registers
- HPET - High Performance Event Timers
  - Supports Legacy-free timer
  - Three timers and one counter
  - Memory mapped registers
- Real-Time Clock (RTC)
  - 242 byte RAM backed by battery (aka CMOS RAM)
  - Can generate wake/interrupt when time matches programmed value
  - I/O and indexed registers

### **18.6.2.2 Non-Maskable Interrupt**

NMI support is enabled by setting the NMI Enable (NMI\_EN) bit, at IO Port 70h, Bit 7, to 1b.

Non-Maskable Interrupts (NMIs) can be generated by several sources, as described in [Table 107](#).



Table 107. NMI Sources

| NMI Source  | NMI Source Enabler/ Disabler | NMI Source Status | Alternate Configuration   |
|---|------------------------------|-------------------|---|
| SERR# goes active<br><b>NOTE:</b> A SERR# is only generated internally in the SoC)  | NSC.SNE                      | NSC.SNS           | All NMI sources may, alternatively, generate a SMI by setting GNMI.NMI2SMIEN=1b |
| IOCHK# goes active<br><b>NOTE:</b> A IOCHK# is only generated as a SERIRQ# frame  | NSC.INE                      | NSC.INS           |   |
| NMI goes active<br><b>NOTE:</b> Active can be defined as being on the positive or negative edge of the signal using the GNMI.GNMIED register bit. | GNMI.GNMIED                  | GNMI.GNMIS        | The SoC uses GNMI.NMI2SMIST for observing SMI status                            |
| Software sets the GNMI.NMIN register bit  | GNMI.NMIN                    | GNMI.NMINS        |   |

### 18.6.2.3 S0ix Support

There is no requirement to set "HPET\_GCFG.EN" to 0b. Basically turn off HPET during S0i2/3. RTD3hot status is not a key requirement for OS anymore.

The S1 state described in the HPET spec is a "CPU Stop Grant" condition. This condition is met during the S0i2/3 states, (although entry into S0i2/3 is performed in a different way).

## 18.6.3 Use

### 18.6.3.1 S0ix Support

Prior to entry into S0i2 or S0i3 state, the driver/OS must set HPET\_GCFG.EN to 0b to indicate RTD3hot status.



## 18.7 PCU - iLB - Low Pin Count (LPC) Bridge

The SoC implements an LPC Interface as described in the LPC 1.1 Specification. The Low Pin Count (LPC) bridge function of the SoC resides in PCI Device 31, Function 0.

**Note:** In addition to the LPC bridge interface function, D31:F0 contains other functional units including interrupt controllers, timers, power management, system management, GPIO, and RTC.

### 18.7.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 108. LPC Signals**

| Signal Name   | Direction/Type     | Description  |
|---------------|--------------------|--|
| LPC_AD[3:0]   | I/O/<br>GPIOHV, HS | <b>LPC Multiplexed Command, Address, Data:</b> Internal pull-ups are provided for these signals.<br><i>These signals are muxed and may be used by other functions.</i>   |
| LPC_CLKOUT[0] | I/O/<br>GPIOHV, HS | <b>LPC Clock [0] Out:</b> 19MHz PCI-like clock driven to LPC peripherals.<br><i>These signals are muxed and may be used by other functions.</i>  |
| LPC_CLKOUT[1] | I/O/<br>GPIOHV, HS | <b>LPC Clock [1] Out:</b> 19MHz PCI-like clock driven to LPC peripherals. Can be configured as an input to compensate for board routing delays through Soft Strap.<br><i>These signals are muxed and may be used by other functions.</i>   |
| LPC_CLKRUN_N  | I/O/<br>GPIOHV, HS | <b>LPC Clock Run:</b> Input to determine the status of LPC_CLK and an open drain output used to request starting or speeding up LPC_CLK. This is a sustained tri-state signal used by the central resource to request permission to stop or slow LPC_CLK. The central resource is responsible for maintaining the signal in the asserted state when LPC_CLK is running and deasserts the signal to request permission to stop or slow LPC_CLK. An internal pull-up is provided for this signal.<br><i>This signal is muxed and may be used by other functions.</i> |
| LPC_FRAME_N   | I/O/<br>GPIOHV, HS | <b>LPC Frame:</b> This signal indicates the start of an LPC cycle, or an abort.<br><i>This signal is muxed and may be used by other functions.</i>   |
| LPC_SERIRQ    | I/O/<br>GPIOHV, HS | <b>Serial Interrupt Request:</b> This signal implements the serial interrupt protocol.<br><i>This signal is muxed and may be used by other functions.</i><br><b>NOTE:</b> A level shifter needs to be implemented on this signal.  |

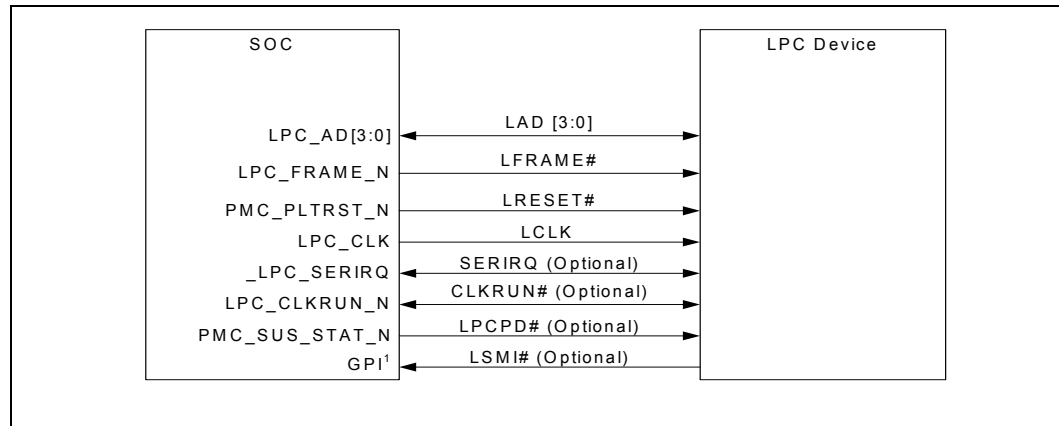


## 18.7.2 Features

The LPC interface to the SoC is shown in [Figure 32](#). Note that the SoC implements all of the signals that are shown as optional, but peripherals are not required to do so.

**Note:** The LPC controller does not implement bus mastering cycles or DMA.

**Figure 32. LPC Interface Diagram**



**NOTE:** The General Purpose Input (GPI) must use a SMI capable GPIO: GPIO\_S0\_SC[7:0].

### 18.7.2.1 Memory Cycle Notes

For cycles below 16M, the LPC Controller will perform standard LPC memory cycles. For cycles targeting firmware (BIOS/EFI code only), firmware memory cycles are used. Only 8-bit transfers are performed. If a larger transfer appears, the LPC controller will break it into multiple 8-bit transfers until the request is satisfied.

If the cycle is not claimed by any peripheral (and subsequently aborted), the LPC Controller will return a value of all 1's to the CPU.

### 18.7.2.2 Trusted Platform Module (TPM) 1.2 Support

The LPC interface supports accessing Trusted Platform Module (TPM) 1.2 devices via the LPC TPM START encoding. Memory addresses within the range FED00000h to FED40FFFh will be accepted by the LPC Bridge and sent on LPC as TPM special cycles. No additional checking of the memory cycle is performed.

**Note:** This is different to the FED00000h to FED4BFFFh range implemented on some other Intel components since no Intel<sup>®</sup> Trusted Execution Technology (Intel<sup>®</sup> TXT) transactions are supported.

### 18.7.2.3 FWH Cycle Notes

If the LPC controller receives any SYNC returned from the device other than short (0101), long wait (0110), or ready (0000) when running a FWH cycle, indeterminate results may occur. A FWH device is not allowed to assert an Error SYNC.



BIOS/EFI boot from LPC is not supported when Secure Boot is enabled.

#### 18.7.2.4 Subtractive Decode

All cycles that are not decoded internally, and are not targeted for LPC (i.e., configuration cycles, IO cycles above 64KB and memory cycles above 16MB), will be sent to LPC with LPC\_FRAME\_N not asserted.

#### 18.7.2.5 POST Code Redirection

Writes to addresses 80h - 8Fh in IO register space will also be passed to the LPC bus.

**Note:** Reads of these addresses do not result in any LPC transactions.

#### 18.7.2.6 Power Management

##### 18.7.2.6.1 LPCPD\_N Protocol

Same timings as for PMC\_SUS\_STAT\_N. After driving PMC\_SUS\_STAT\_N active, the SoC drives LPC\_FRAME\_N low, and tri-states (or drives low) LPC\_AD[3:0].

**Note:** The Low Pin Count Interface Specification, Revision 1.1 defines the LPCPD\_N protocol where there is at least 30  $\mu$ s from LPCPD\_N assertion to LRST\_N assertion. This specification explicitly states that this protocol only applies to entry/exit of low power states which does not include asynchronous reset events. The SoC asserts both PMC\_SUS\_STAT\_N (connects to LPCPD\_N) and PLTRST\_N (connects to LRST\_N) at the same time during a global reset. This is not inconsistent with the LPC LPCPD\_N protocol.

##### 18.7.2.6.2 Clock Run (CLKRUN)

When there are no pending LPC cycles, and SERIRQ is in quiet mode, the SoC can shut down the LPC clock. The SoC indicates that the LPC clock is going to shut down by de-asserting the LPC\_CLKRUN\_N signal. LPC devices that require the clock to stay running should drive LPC\_CLKRUN\_N\_N low within 4 clocks of its de-assertion. If no device drives the signal low within 4 clocks, the LPC clock will stop. If a device asserts LPC\_CLKRUN\_N, the SoC will start the LPC clock and assert LPC\_CLKRUN\_N.

**Note:** The CLKRUN protocol is disabled by default. Refer [Section 18.7.3.2.2, "Clock Run Enable"](#) for further details.

##### 18.7.2.7 Serialized IRQ (SERIRQ)

The interrupt controller supports a serial IRQ scheme. The signal used to transmit this information is shared between the interrupt controller and all peripherals that support serial interrupts. The signal line, LPC\_SERIRQ, is synchronous to LPC clock, and follows the sustained tri-state protocol that is used by LPC signals. The serial IRQ protocol defines this sustained tri-state signaling in the following fashion:

- **S - Sample Phase:** Signal driven low.



- **R - Recovery Phase:** Signal driven high.
- **T - Turn-around Phase:** Signal released.

The interrupt controller supports 21 serial interrupts. These represent the 15 ISA interrupts (IRQ0- 1, 3-15), the four PCI interrupts, and the control signals SMI\_N and IOCHK\_N. Serial interrupt information is transferred using three types of frames:

- **Start Frame:** LPC\_SERIRQ line driven low by the interrupt controller to indicate the start of IRQ transmission.
- **Data Frames:** IRQ information transmitted by peripherals. The interrupt controller supports 21 data frames.
- **Stop Frame:** LPC\_SERIRQ line driven low by the interrupt controller to indicate end of transmission and next mode of operation.

#### 18.7.2.7.1 Start Frame

The serial IRQ protocol has two modes of operation which affect the start frame:

- **Continuous Mode:** The interrupt controller is solely responsible for generating the start frame.
- **Quiet Mode:** Peripheral initiates the start frame, and the interrupt controller completes it.

These modes are entered via the length of the stop frame.

Continuous mode must be entered first, to start the first frame. This start frame width is 8 LPC clocks. This is a polling mode.

In Quiet mode, the LPC\_SERIRQ line remains inactive and pulled up between the Stop and Start Frame until a peripheral drives LPC\_SERIRQ low. The interrupt controller senses the line low and drives it low for the remainder of the Start Frame. Since the first LPC clock of the start frame was driven by the peripheral, the interrupt controller drives LPC\_SERIRQ low for 1 LPC clock less than in continuous mode. This mode of operation allows for lower power operation.

#### 18.7.2.7.2 Data Frames

Once the Start frame has been initiated, the LPC\_SERIRQ peripherals start counting frames based on the rising edge of LPC\_SERIRQ. Each of the IRQ/DATA frames has exactly 3 phases of 1 clock each:

- **Sample Phase:** During this phase, a device drives LPC\_SERIRQ low if its corresponding interrupt signal is low. If its corresponding interrupt is high, then the LPC\_SERIRQ devices tri-state LPC\_SERIRQ. LPC\_SERIRQ remains high due to pull-up resistors.
- **Recovery Phase:** During this phase, a device drives LPC\_SERIRQ high if it was driven low during the Sample Phase. If it was not driven during the sample phase, it remains tri-stated in this phase.
- **Turn-around Phase:** The device tri-states LPC\_SERIRQ.



### 18.7.2.7.3 Stop Frame

After the data frames, a Stop Frame will be driven by the interrupt controller. LPC\_SERIRQ will be driven low for two or three LPC clocks. The number of clocks is determined by the SCNT.MD register bit. The number of clocks determines the next mode, as indicated in Table 109.

**Table 109. SERIRQ, Stop Frame Width to Operation Mode Mapping**

| Stop Frame Width | Next Mode   |
|------------------|---|
| Two LPC clocks   | <b>Quiet Mode:</b> Any SERIRQ device initiates a Start Frame                  |
| Three LPC clocks | <b>Continuous Mode:</b> Only the interrupt controller initiates a Start Frame |

### 18.7.2.7.4 Serial Interrupts Not Supported

There are four interrupts on the serial stream which are not supported by the interrupt controller. These interrupts are:

- IRQ0: Heartbeat interrupt generated off of the internal 8254 counter 0.
- IRQ8: RTC interrupt can only be generated internally.
- IRQ13: This interrupt (floating point error) is not supported.

The interrupt controller will ignore the state of these interrupts in the stream.

### 18.7.2.7.5 Data Frame Format and Issues

Table below shows the format of the data frames. The decoded INT[A:D]\_N values are ANDed with the corresponding PCI-express input signals (PIRQ[A:D]\_N). This way, the interrupt can be shared.

The other interrupts decoded via SERIRQ are also ANDed with the corresponding internal interrupts. For example, if IRQ10 is set to be used as the SCI, then it is ANDed with the decoded value for IRQ10 from the SERIRQ stream.

**Table 110. SERIRQ Interrupt Mapping**

| Data Frame # | Interrupt | Clocks Past Start Frame | Comment   |
|--------------|-----------|-------------------------|---|
| 1            | IRQ0      | 2                       | Ignored. Can only be generated via the internal 8524        |
| 2            | IRQ1      | 5                       | Before port 60h latch                                       |
| 3            | SMI_N     | 8                       | Causes SMI_N if low. Sets SMI_STS.ILB_SMI_STS register bit. |
| 4            | IRQ3      | 11                      |   |
| 5            | IRQ4      | 14                      |   |
| 6            | IRQ5      | 17                      |   |





Table 110. SERIRQ Interrupt Mapping

| Data Frame # | Interrupt  | Clocks Past Start Frame | Comment  |
|--------------|------------|-------------------------|--|
| 7            | IRQ6       | 20                      |  |
| 8            | IRQ7       | 23                      |  |
| 9            | IRQ8       | 26                      | Ignored. IRQ8_N can only be generated internally |
| 10           | IRQ9       | 29                      |  |
| 11           | IRQ10      | 32                      |  |
| 12           | IRQ11      | 35                      |  |
| 13           | IRQ12      | 38                      | Before port 60h latch                            |
| 14           | IRQ13      | 41                      | Ignored.   |
| 15           | IRQ14      | 44                      | Ignored  |
| 16           | IRQ15      | 47                      |  |
| 17           | IOCHCK_N   | 50                      | Same as ISA IOCHCK_N going active.               |
| 18           | PCI INTA_N | 53                      |  |
| 19           | PCI INTB_N | 56                      |  |
| 20           | PCI INTC_N | 59                      |  |
| 21           | PCI INTD_N | 62                      |  |

#### 18.7.2.7.6 S0ix Support

During S0i2 and S0i3, the LPC and SERIRQ interfaces are disabled.

### 18.7.3 Usage

#### 18.7.3.1 LPC Clock Delay Compensation

In order to meet LPC interface AC timing requirements, a LPC clock loop back is required. The operation of this loop back can be configured in two ways:

1. On the SOC: In this configuration, LPC\_CLK[0] is looped back on itself on the SOC pad.
  - a. Benefit:  
LPC\_CLK[0] and LPC\_CLK[1] are both available for system clocking
  - b. Drawback:  
Clock delay compensation is less effective at compensating for mainboard delay
  - c. Soft Strap & Register Requirements:  
Soft Strap LPCCLK\_SLC = 0b



Configuration is reflected by register bit LPCC.LPCCLK\_SLC=0b

Soft Strap LPCCLK1\_ENB = 0b (LPC\_CLK[1] disabled) or 1b (LPC\_CLK[1] enabled)

2. Configuration is reflected by register bit LPCC.LPCCLK1EN=0b (LPC\_CLK[1] disabled) or 1b (LPC\_CLK[1] enabled)
3. On the main board: In this configuration, LPC\_CLK[0] is looped back to LPC\_CLK[1] on the main board.

a. Benefit:

Clock delay compensating is more effective at compensating for main board delay

b. Drawback:

Only LPC\_CLK[0] is available for system clocking. LPC\_CLK[1] must be disabled.

c. Soft Strap & Register Requirements:

Soft Strap LPCCLK\_SLC = 1b

Configuration is reflected by register bit LPCC.LPCCLK\_SLC=1b

Soft Strap LPCCLK1\_ENB = 0b (LPC\_CLK[1] disabled)

Configuration is reflected by register bit LPCC.LPCCLK1EN=0b

### 18.7.3.2 LPC Power Management

#### 18.7.3.2.1 Clock Enabling

The LPC clocks can be enabled or disabled by setting or clearing, respectively, the LPCC.LPCCLK[1:0]EN bits.

#### 18.7.3.2.2 Clock Run Enable

The Clock Run protocol is disabled by default and should only be enabled during operating system run-time, once all LPC devices have been initialized. The Clock Run protocol is enabled by setting the LPCC.CLKRUN\_EN register bit.

#### 18.7.3.3 SERIRQ Disable

Serialized IRQ support may be disabled by setting the OIC.SIRQEN bit to 0b.

### 18.7.4 References

- Low Pin Count Interface Specification, Revision 1.1 (LPC): <http://www.intel.com/design/chipsets/industry/lpc.htm>.
- Serialized IRQ Support for PCI Systems, Revision 6.0: [http://www.smsc.com/media/Downloads\\_Public/papers/serirq60.doc](http://www.smsc.com/media/Downloads_Public/papers/serirq60.doc).
- Implementing Industry Standard Architecture (ISA) with Intel® Express Chipsets (318244): <http://www.intel.com/assets/pdf/whitepaper/318244.pdf>.



## 18.8 PCU - iLB - Real Time Clock (RTC)

The SoC contains a real-time clock with 242 bytes of battery-backed RAM. The real-time clock performs two key functions—keeping track of the time of day and storing system data, even when the system is powered down. The RTC operates on a 32.768 kHz crystal and a 3.3 V battery.

The RTC supports two lockable memory ranges. By setting bits in the configuration space, two 8-byte ranges can be locked to read and write accesses. This prevents unauthorized reading of passwords or other system security information.

The RTC supports a date alarm that allows for scheduling a wake up event up to 30 days in advance.

### 18.8.1 Signal Descriptions

Refer [Chapter 2, “Physical Interfaces”](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, “Electrical Specifications”](#).
- **Description:** A brief explanation of the signal’s function.

**Table 111. RTC Signals**

| Signal Name | Direction /Type | Description   |
|-------------|-----------------|---|
| RTC_X1      | I<br>Analog     | <b>Crystal Input 1:</b> This signal is connected to the 32.768 kHz crystal. If no external crystal is used, the signal can be driven with the desired clock rate.   |
| RTC_X2      | I<br>Analog     | <b>Crystal Input 2:</b> This signal is connected to the 32.768 kHz crystal. If no external crystal is used, the signal should be left floating.   |
| RTC_RST_N   | I               | <b>RTC Reset:</b> When asserted, this signal resets register bits in the RTC well.<br><b>NOTE:</b> Unless CMOS is being cleared (only to be done in the G3 power state), the signal input must always be high when all other RTC power planes are on.<br><b>NOTE:</b> In the case where the RTC battery is dead or missing on the platform, the signal should be deasserted before the PMC_RSMRST_N signal is deasserted. |
| RTC_TEST_N  | I               | <b>RTC Battery Test:</b> An external RC circuit creates a time delay for the signal such that it will go high (to ILB_RTC_3P3_G3) sometime after the battery voltage is valid. The RC time delay should be in the 10-20 ms range. This signal will be asserted just after suspend power is up if the coin cell battery is weak.<br><b>NOTE:</b> This signal may also be used for debug purposes, as part of a XDP port.   |



## 18.8.2 Features

The Real Time Clock (RTC) module provides a battery backed-up date and time keeping device. Three interrupt features are available: time of day alarm with once a second to once a month range, periodic rates of 122 ms to 500 ms, and end of update cycle notification. Seconds, minutes, hours, days, day of week, month, and year are counted. The hour is represented in twelve or twenty-four hour format, and data can be represented in BCD or binary format. The design is meant to be functionally compatible with the Motorola\* MS146818B. The time keeping comes from a 32.768 kHz oscillating source, which is divided to achieve an update every second. The lower 14 bytes on the lower RAM block have very specific functions. The first ten are for time and date information. The next four (0Ah to 0Dh) are registers, which configure and report RTC functions. A host-initiated write takes precedence over a hardware update in the event of a collision.

### 18.8.2.1 Update Cycles

An update cycle occurs once a second, if the B.SET bit is not asserted and the divide chain is properly configured. During this procedure, the stored time and date are incremented, overflow checked, a matching alarm condition is checked, and the time and date are rewritten to the RAM locations. The update cycle starts at least 488 ms after A.UIP is asserted, and the entire cycle does not take more than 1984 ms to complete. The time and date RAM locations (00h to 09h) are disconnected from the external bus during this time.

## 18.8.3 Interrupts

The real-time clock interrupt is internally routed within the SoC both to the I/O APIC and the 8259. It is mapped to interrupt vector 8. This interrupt does not leave the SoC, nor is it shared with any other interrupt. IRQ8# from the ILB\_LPC\_SERIRQ stream is ignored. However, the High Performance Event Timers can also be mapped to IRQ8#; in this case, the RTC interrupt is blocked.

### 18.8.3.1 Lockable RAM Ranges

The RTC battery-backed RAM supports two 8-byte ranges that can be locked: the RC.UL and RC.LL register bits. When the locking bits are set, the corresponding range in the RAM is not readable or writable. A write cycle to those locations will have no effect. A read cycle to those locations will not return the location's actual value (resultant value is undefined).

Once a range is locked, the range can be unlocked only by a hard reset, which will invoke the BIOS and allow it to re-lock the RAM range.

### 18.8.3.2 Clearing Battery-Backed RTC RAM

Clearing CMOS RAM in an SoC-based platform can be done by using a jumper on RTC\_RST\_N or a GPI. Implementations should not attempt to clear CMOS by using a jumper to pull RTC\_VCC low.



### 18.8.3.2.1 Using RTC\_RST\_N to Clear CMOS

A jumper on RTC\_RST\_N can be used to clear CMOS values, as well as reset to default, the state of those configuration bits that reside in the RTC power well. When the RTC\_RST\_N is strapped to ground, the GEN\_PMC1.RPS register bit will be set and those configuration bits in the RTC power well will be set to their default state. BIOS can monitor the state of this bit, and manually clear the RTC CMOS array once the system is booted. The normal position would cause RTC\_RST\_N to be pulled up through a weak pull-up resistor. Table 112 shows which bits are set to their default state when RTC\_RST\_N is asserted. This RTC\_RST\_N jumper technique allows the jumper to be moved and then replaced—all while the system is powered off. Then, once booted, the GEN\_PMC1.RPS bit can be detected in the set state.

**Table 112. Register Bits Reset by RTC\_RST\_N Assertion**

| Register Bit                    | Bit(s) | Default State |
|---------------------------------|--------|---------------|
| RCRB_GENERAL_CONTROL.TS         | 1      | xb            |
| GEN_PMC1.PME_B0_S5_DIS          | 15     | 0b            |
| GEN_PMC1.WOL_EN_OVRD            | 13     | 0b            |
| GEN_PMC1.DIS_SLP_X_STRCH_SUS_UP | 12     | 0b            |
| GEN_PMC1.RTC Reserved           | 8      | 0b            |
| GEN_PMC1.SWSMI_RATESEL          | 7:6    | 00b           |
| GEN_PMC1.S4MAW                  | 5:4    | 00b           |
| GEN_PMC1.S4ASE                  | 3      | 0b            |
| GEN_PMC1.RPS                    | 2      | 1b            |
| GEN_PMC1.AG3E                   | 0      | 0b            |
| PM1_STS_EN.RTC_EN               | 26     | 0b            |
| PM1_STS_EN.PWRBTNOR_STS         | 11     | 0b            |
| PM1_CNT.SLP_TYP                 | 12:10  | 0b            |
| GPE0a_EN.PME_B0_EN              | 13     | 0b            |
| GPE0a_EN.BATLOW_EN              | 10     | 0b            |

### 18.8.3.3 Using GPI to Clear CMOS

A jumper on a GPI can also be used to clear CMOS values. BIOS should detect the setting of this GPI on system boot-up, and manually clear the CMOS array.

**Note:** The GPI strap technique to clear CMOS requires multiple steps to implement. The system is booted with the jumper in new position, then powered back down. The jumper is replaced back to the normal position, then the system is rebooted again.

**Warning:** Do not implement a jumper on RTC\_VCC to clear CMOS.

### 18.8.3.4 S0i3 Support

During S0i3, the RTC interface is active.



### 18.8.4 References

Accessing the Real Time Clock Registers and the NMI Enable Bit: <http://download.intel.com/design/intarch/PAPERS/321088.pdf>.

### 18.8.5 IO Mapped Registers

The RTC internal registers and RAM is organized as two banks of 128 bytes each, called the standard and extended banks.

**Note:** It is not possible to disable the extended bank.

The first 14 bytes of the standard bank contain the RTC time and date information along with four registers, A - D, that are used for configuration of the RTC. The extended bank contains a full 128 bytes of battery backed SRAM. All data movement between the host CPU and the RTC is done through registers mapped to the standard I/O space.

**Note:** Registers `reg_RTC_IR_type` and `reg_RTC_TR_type` are used for data movement to and from the standard bank. Registers `reg_RTC_RIR_type` and `reg_RTC_RTR_type` are used for data movement to and from the extended bank. All of these registers have alias I/O locations, as indicated in [Table 113](#).

**Table 113. I/O Registers Alias Locations**

| Register                      | Original I/O Location | Alias I/O Location |
|-------------------------------|-----------------------|--------------------|
| <code>reg_RTC_IR_type</code>  | 70h                   | 74h                |
| <code>reg_RTC_TR_type</code>  | 71h                   | 75h                |
| <code>reg_RTC_RIR_type</code> | 72h                   | 76h                |
| <code>reg_RTC_RTR_type</code> | 73h                   | 77h                |

### 18.8.6 Indexed Registers

The RTC contains indexed registers that are accessed via the `reg_RTC_IR_type` and `reg_RTC_TR_type` registers.

**Table 114. RTC Indexed Registers (Sheet 1 of 2)**

| Start | End | Name          |
|-------|-----|---------------|
| 00h   | 00h | Seconds       |
| 01h   | 01h | Seconds Alarm |
| 02h   | 02h | Minutes       |
| 03h   | 03h | Minutes Alarm |
| 04h   | 04h | Hours         |
| 05h   | 05h | Hours Alarm   |
| 06h   | 06h | Day of Week   |



**Table 114. RTC Indexed Registers (Sheet 2 of 2)**

| Start | End | Name                  |
|-------|-----|-----------------------|
| 07h   | 07h | Day of Month          |
| 08h   | 08h | Month                 |
| 09h   | 09h | Year                  |
| 0Ah   | 0Ah | Register A            |
| 0Bh   | 0Bh | Register B            |
| 0Ch   | 0Ch | Register C            |
| 0Dh   | 0Dh | Register D            |
| 0Eh   | 7Fh | 114 Bytes of User RAM |



## 18.9 PCU - iLB - 8254 Timers

The 8254 contains three counters which have fixed uses including system timer and speaker tone. All registers are clocked by a 14.31818 MHz clock.

### 18.9.1 Signal Descriptions

Refer [Chapter 2, "Physical Interfaces"](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, "Electrical Specifications"](#).
- **Description:** A brief explanation of the signal's function.

### 18.9.2 Features

#### 18.9.2.1 Counter 0, System Timer

This counter functions as the system timer by controlling the state of IRQ0 and is programmed for Mode 3 operation. The counter produces a square wave with a period equal to the product of the counter period (838 ns) and the initial count value. The counter loads the initial count value one counter period after software writes the count value to the counter I/O address. The counter initially asserts IRQ0 and decrements the count value by two each counter period. The counter negates IRQ0 when the count value reaches 0. It then reloads the initial count value and again decrements the initial count value by two each counter period. The counter then asserts IRQ0 when the count value reaches 0, reloads the initial count value, and repeats the cycle, alternately asserting and negating IRQ0.

#### 18.9.2.2 Counter 1, Refresh Request Signal

This counter is programmed for Mode 2 operation and impacts the period of the NSC.RTS register bit. Programming the counter to anything other than Mode 2 results in undefined behavior.

#### 18.9.2.3 Counter 2, Speaker Tone

This counter provides the speaker tone and is typically programmed for Mode 3 operation. The counter provides a speaker frequency equal to the counter clock frequency (1.193 MHz) divided by the initial count value. The speaker must be enabled by a write to the NSC.SDE register bit.

#### 18.9.2.4 S0ix Support

During S0i2 and S0i3, the 8254 timer is halted. A platform that requires the 8254 timer to be always active, should disable S0i2/3 using the S0ix\_Enable register.





## 18.9.3 Usage

### 18.9.3.1 Timer Programming

The counter/timers are programmed in the following fashion:

1. Write a control word to select a counter.
2. Write an initial count for that counter.
3. Load the least and/or most significant bytes (as required by Control Word Bits 5, 4) of the 16-bit counter.
4. Repeat with other counters.

Only two conventions need to be observed when programming the counters. First, for each counter, the control word must be written before the initial count is written. Second, the initial count must follow the count format specified in the control word (least significant byte only, most significant byte only, or least significant byte and then most significant byte).

A new initial count may be written to a counter at any time without affecting the counter's programmed mode. Counting is affected as described in the mode definitions. The new count must follow the programmed count format.

If a counter is programmed to read/write two-byte counts, the following precaution applies: A program must not transfer control between writing the first and second byte to another routine which also writes into that same counter. Otherwise, the counter will be loaded with an incorrect count.

The Control Word Register at port 43h controls the operation of all three counters. Several commands are available:

- **Control Word Command.** Specifies which counter to read or write, the operating mode, and the count format (binary or BCD).
- **Counter Latch Command.** Latches the current count so that it can be read by the system. The countdown process continues.
- **Read Back Command.** Reads the count value, programmed mode, the current state of the OUT pins, and the state of the Null Count Flag of the selected counter.

Table 115 lists the six operating modes for the interval counters.

**Table 115. Counter Operating Modes**

| Mode | Function                             | Description   |
|------|--------------------------------------|---|
| 0    | Out signal on end of count (=0)      | Output is 0. When count goes to 0, output goes to 1 and stays at 1 until counter is reprogrammed. |
| 1    | Hardware re-triggerable one-shot     | Output is 0. When count goes to 0, output goes to 1 for one clock time.                           |
| 2    | Rate generator (divide by n counter) | Output is 1. Output goes to 0 for one clock time, then back to 1 and counter is reloaded.         |



Table 115. Counter Operating Modes

| Mode | Function                  | Description   |
|------|---------------------------|---|
| 3    | Square wave output        | Output is 1. Output goes to 0 when counter rolls over, and counter is reloaded. Output goes to 1 when counter rolls over, and counter is reloaded, etc. |
| 4    | Software triggered strobe | Output is 1. Output goes to 0 when count expires for one clock time.  |
| 5    | Hardware triggered strobe | Output is 1. Output goes to 0 when count expires for one clock time.  |

### 18.9.3.2 Reading from Interval Timer

It is often desirable to read the value of a counter without disturbing the count in progress. There are three methods for reading the counters: a simple read operation, counter Latch command, and the Read-Back command. Each is explained below.

With the simple read and counter latch command methods, the count must be read according to the programmed format; specifically, if the counter is programmed for two byte counts, two bytes must be read. The two bytes do not have to be read one right after the other. Read, write, or programming operations for other counters may be inserted between them.

#### 18.9.3.2.1 Simple Read

The first method is to perform a simple read operation. The counter is selected through Port 40h (Counter 0), 41h (Counter 1), or 42h (Counter 2).

**Note:** Performing a direct read from the counter does not return a determinate value, because the counting process is asynchronous to read operations. However, in the case of Counter 2, the count can be stopped by writing 0b to the NSC.TC2E register bit.

#### 18.9.3.2.2 Counter Latch Command

The Counter Latch command, written to Port 43h, latches the count of a specific counter at the time the command is received. This command is used to ensure that the count read from the counter is accurate, particularly when reading a two-byte count. The count value is then read from each counter’s Count register as was programmed by the Control register.

The count is held in the latch until it is read or the counter is reprogrammed. The count is then unlatched. This allows reading the contents of the counters on the fly without affecting counting in progress. Multiple Counter Latch Commands may be used to latch more than one counter. Counter Latch commands do not affect the programmed mode of the counter in any way.

If a counter is latched and then, some time later, latched again before the count is read, the second Counter Latch command is ignored. The count read is the count at the time the first Counter Latch command was issued.



### 18.9.3.2.3 Read Back Command

The Read Back command, written to Port 43h, latches the count value, programmed mode, and current states of the OUT pin and Null Count flag of the selected counter or counters. The value of the counter and its status may then be read by I/O access to the counter address.

The Read Back command may be used to latch multiple counter outputs at one time. This single command is functionally equivalent to several counter latch commands, one for each counter latched. Each counter's latched count is held until it is read or reprogrammed. Once read, a counter is unlatched. The other counters remain latched until they are read. If multiple count Read Back commands are issued to the same counter without reading the count, all but the first are ignored.

The Read Back command may additionally be used to latch status information of selected counters. The status of a counter is accessed by a read from that counter's I/O port address. If multiple counter status latch operations are performed without reading the status, all but the first are ignored.

Both count and status of the selected counters may be latched simultaneously. This is functionally the same as issuing two consecutive, separate Read Back commands. If multiple count and/or status Read Back commands are issued to the same counters without any intervening reads, all but the first are ignored.

If both count and status of a counter are latched, the first read operation from that counter returns the latched status, regardless of which was latched first. The next one or two reads, depending on whether the counter is programmed for one or two type counts, returns the latched count. Subsequent reads return unlatched count.



## 18.10 PCU - iLB - High Precision Event Timer (HPET)

This function provides a set of timers that to be used by the operating system for timing events. One timer block is implemented, containing one counter and three timers.

### 18.10.1 Features

#### 18.10.1.1 Non-Periodic Mode - All Timers

This mode can be thought of as creating a one-shot. When a timer is set up for non-periodic mode, it generates an interrupt when the value in the main counter matches the value in the timer's comparator register. As timers 1 and 2 are 32-bit, they will generate another interrupt when the main counter wraps.

T0CV cannot be programmed reliably by a single 64-bit write in a 32-bit environment unless only the periodic rate is being changed. If T0CV needs to be re-initialized, the following algorithm is performed:

1. Set T0C.TVS
2. Set T0CV[31:0]
3. Set T0C.TVS
4. Set T0CV[63:32]

Every timer is required to support the non-periodic mode of operation.

#### 18.10.1.2 Periodic Mode - Timer 0 Only

When set up for periodic mode, when the main counter value matches the value in T0CV, an interrupt is generated (if enabled). Hardware then increases T0CV by the last value written to T0CV. During run-time, T0CV can be read to find out when the next periodic interrupt will be generated. Software is expected to remember the last value written to T0CV.

Example: if the value written to T0CV is 00000123h, then

- An interrupt will be generated when the main counter reaches 00000123h.
- T0CV will then be adjusted to 00000246h.
- Another interrupt will be generated when the main counter reaches 00000246h.
- T0CV will then be adjusted to 00000369h.

When the incremented value is greater than the maximum value possible for T0CV, the value will wrap around through 0. For example, if the current value in a 32-bit timer is FFFF0000h and the last value written to this register is 20000, then after the next interrupt the value will change to 00010000h.



If software wants to change the periodic rate, it writes a new value to T0CV. When the timer's comparator matches, the new value is added to derive the next matching point. If software resets the main counter, the value in the comparator's value register must also be reset by setting T0C.TVS. To avoid race conditions, this should be done with the main counter halted. The following usage model is expected:

1. Software clears GCFG.EN to prevent any interrupts.
2. Software clears the main counter by writing a value of 00h to it.
3. Software sets T0C.TVS.
4. Software writes the new value in T0CV.
5. Software sets GCFG.EN to enable interrupts.

#### 18.10.1.2.1 Interrupts

If each timer has a unique interrupt and the timer has been configured for edge-triggered mode, then there are no specific steps required. If configured to level-triggered mode, then its interrupt must be cleared by software by writing a '1' back to the bit position for the interrupt to be cleared.

Interrupts associated with the various timers have several interrupt mapping options. Software should mask GCFG.LRE when reprogramming HPET interrupt routing to avoid spurious interrupts.

#### 18.10.1.2.2 Mapping Option #1: Legacy Option (GCFG.LRE set)

This forces the following mapping:

**Table 116. 8254 Interrupt Mapping**

| Timer | 8259 Mapping | APIC Mapping | Comment                                      |
|-------|--------------|--------------|--|
| 0     | IRQ0         | IRQ2         | The 8254 timer will not cause any interrupts |
| 1     | IRQ8         | IRQ8         | RTC will not cause any interrupts.           |
| 2     | T2C.IR       | T2C.IRC      |  |

#### 18.10.1.2.3 Mapping Option #2: Standard Option (GCFG.LRE cleared)

Each timer has its own routing control. The interrupts can be routed to various interrupts in the I/O APIC. T[2:0]C.IRC indicates which interrupts are valid options for routing. If a timer is set for edge-triggered mode, the timers should not be shared with any other interrupts.

#### 18.10.1.3 S0ix Support

During S0i1, the HPET is kept running. During S0i2 & S0i3, the HPET is halted.



#### **18.10.1.4 S0ix Support**

Prior to entry into S0i2 or S0i3 state, the driver/OS must set HPET\_GCFG.EN to 0b to indicate RTD3<sub>hot</sub> status.

#### **18.10.2 References**

IA-PC HPET (High Precision Event Timers) Specification, Revision 1.0a: [http://www.intel.com/hardware design/hpetspec\\_1.pdf](http://www.intel.com/hardware design/hpetspec_1.pdf).

#### **18.10.3 Memory Mapped Registers**

The register space is memory mapped to a 1K block at address FED00000h. All registers are in the core well. Accesses that cross register boundaries result in undefined behavior.



## 18.11 PCU - iLB - GPIO

187 GPIOs are available for use. Most of these GPIOs can be used as legacy GPIOs. This chapter describes their use as legacy GPIOs.

### 18.11.1 Signal Descriptions

Refer [Chapter 2, "Physical Interfaces"](#) for additional details.

The signal description table has the following headings:

- **Signal Name:** The name of the signal/pin.
- **Direction:** The buffer direction can be either input, output, or I/O (bidirectional).
- **Type:** The buffer type found in [Chapter 19, "Electrical Specifications"](#).
- **Description:** A brief explanation of the signal's function.

### 18.11.2 Features

GPIOs can generate general purpose events (GPEs) on rising and/or falling edges.

#### 18.11.2.1 GPIO Controller

The GPIO controllers handle all GPIO interface to SoC,

- GPIO NORTH - used for Camera sensors, DFX, SVID, and Display Pins.
- GPIO SOUTHEAST - Defines the pads/Pins for MMC/SD host controller, LPC pins, FAST SPI pins and Platform Clock.
- GPIO SOUTHWEST - Defines the Pads/Pins for HS UART,I2S HS, LPE, PCIe and SPI pins.
- GPIO EAST - Defines the Pads/Pins for SoC power state related signals of PMU and ISH pins.

### 18.11.3 Usage

Each GPIO has six registers that control how it is used, or report its status:

- Use Select
- I/O Select
- GPIO Level
- Trigger Positive Edge
- Trigger Negative Edge
- Trigger Status

The Use Select register selects a GPIO pin as a GPIO, or leaves it as its programmed function. This register must be set for all other registers to affect the GPIO.



The I/O Select register determines the direction of the GPIO.

The Trigger Positive Edge and Trigger Negative Edge registers enable general purpose events on a rising and falling edge respectively. This only applies to GPIOs set as input.

The Trigger Status register is used by software to determine if the GPIO triggered a GPE. This only applies to GPIOs set as input and with one or both of the Trigger modes enabled.

Additionally, there is one additional register for each S5 GPIO:

- Wake Enable

This register allows S5 GPIOs to trigger a wake event based on the Trigger registers' settings.

## 18.11.4 GPIO Registers

### 18.11.4.1 SD Card and LPC Pins (3.3V versus 1.8V Modes)

The CFIO cells for both the SD Card Pins (SDMMC3\_\*) and LPC (LPC\_\*) are 3.3V capable.

To use as 1.8V IOs:

- Set power supply to 1.8V for the pads.
- Set v1p8mode in family configuration register.
- Trigger a RCOMP cycle using Family RCOMP register
- Copy RCOMP value to Family p and n strength values.

**Note:** All GPIO registers must be accessed as double words. Unpredictable results will occur otherwise.

**Note:** All MMIO GPIO \*\_PAD\_VAL's must set Ienenb = 0 in order to read the pad\_val of the GPIO. This applies to RO GPIO's as well.





## 18.12 PCU - iLB - Interrupt Decoding and Routing

The interrupt decoder is responsible for receiving interrupt messages from other devices in the SoC and decoding them for consumption by the interrupt router, the "PCU - iLB - 8259 Programmable Interrupt Controllers (PIC)" and/or the "PCU - iLB - IO APIC".

The interrupt router is responsible for mapping each incoming interrupt to the appropriate PIRQx, for consumption by the "PCU - iLB - 8259 Programmable Interrupt Controllers (PIC)" and/or the "PCU - iLB - IO APIC".

### 18.12.1 Features

#### 18.12.1.1 Interrupt Decoder

The interrupt decoder receives interrupt messages from devices in the SoC. These interrupts can be split into two primary groups:

- For consumption by the interrupt router
- For consumption by the 8259 PIC

##### **For Consumption by Interrupt Router**

When a PCI-mapped device in the SoC asserts or de-asserts an INT[A:D] interrupt, an interrupt message is sent to the decoder. This message is decoded to indicate to the interrupt router which specific interrupt is asserted or de-asserted and which device the INT[A:D] interrupt originated from.

##### **For Consumption by the 8259 PIC**

When a device in the SoC asserts or de-asserts a legacy interrupt (IRQ), an interrupt message is sent to the decoder. This message is decoded to indicate to the 8259 PIC, which specific interrupt (IRQ[3, 4, 14 or 15]) was asserted or de-asserted.

#### 18.12.1.2 Interrupt Router

The interrupt router aggregates the INT[A:D] interrupts for each PCI-mapped device in the SoC, received from the interrupt decoder, and the INT[A:D] interrupts direct from the Serialized IRQ controller. It then maps these aggregated interrupts to 8 PCI based interrupts: PIRQ[A:H]. This mapping is configured using the IR[31:0] registers.

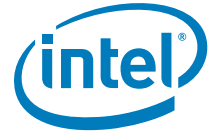
PCI based interrupts PIRQ[A:H] are then available for consumption by either the 8259 PICs or the IO-APIC, depending on the configuration of the 8 PIRQx Routing Control Registers: PIRQA, PIQRB, PIRQC, PIRQD, PIRQE, PIRQF, PIRQG, PIRQH.



### **Routing PCI Based Interrupts to 8259 PIC**

The interrupt router can be programmed to allow PIRQA-PIRQH to be routed internally to the 8259 as ISA compatible interrupts IRQ 3-7, 9-12 & 14-15. The assignment is programmable through the 8 PIRQx Routing Control Registers: PIRQA, PIQRB, PIRQC, PIRQD, PIRQE, PIRQF, PIRQG, PIRQH. One or more PIRQs can be routed to the same IRQ input. If ISA Compatible Interrupts are not required, the Route registers can be programmed to disable steering.

The PIRQx# lines are defined as active low, level sensitive. When a PIRQx# is routed to specified IRQ line, software must change the IRQ's corresponding ELCR bit to level sensitive mode. The SoC internally inverts the PIRQx# line to send an active high level to the PIC. When a PCI interrupt is routed onto the PIC, the selected IRQ can no longer be used by an active high device (through SERIRQ). However, active low interrupts can share their interrupt with PCI interrupts.



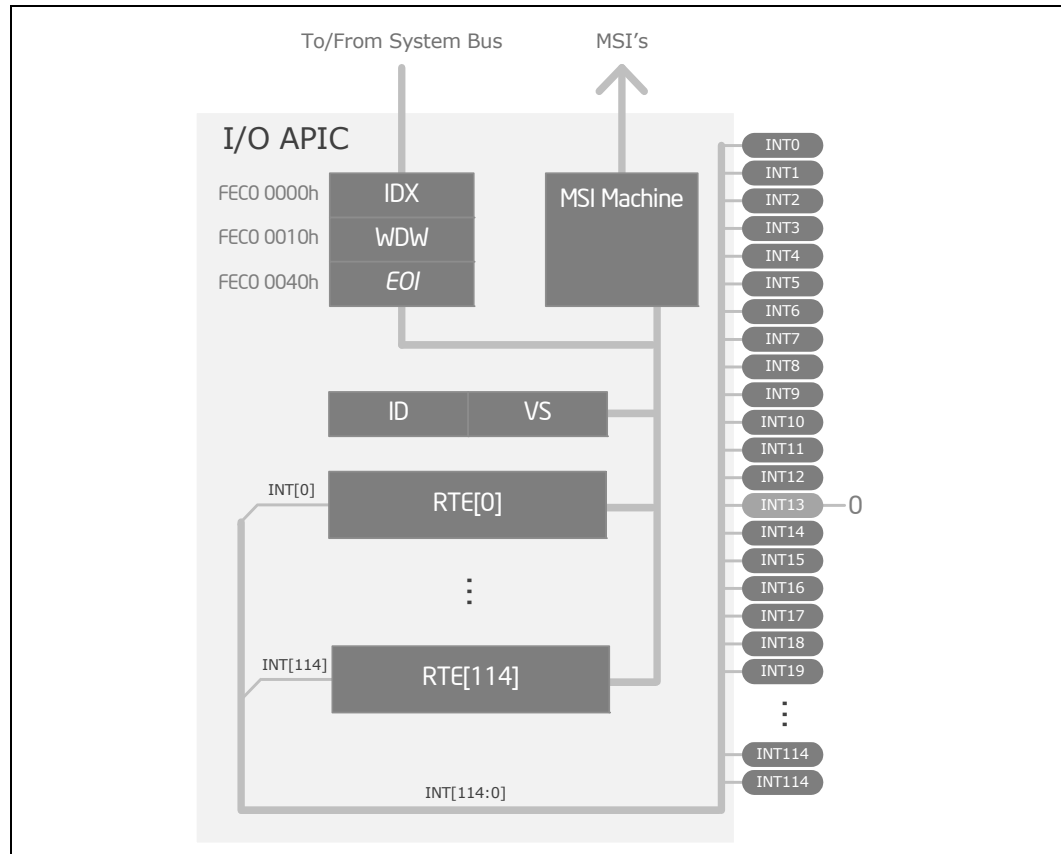
## 18.13 PCU - iLB - IO APIC

The IO Advanced Programmable Interrupt Controller (APIC) is used to support line interrupts more flexibly than the 8259 PIC. Line interrupts are routed to it from multiple sources, including legacy devices, via the interrupt decoder and serial IRQs, or they are routed to it from the interrupt router in the iLB. These line based interrupts are then used to generate interrupt messages targeting the local APIC in the processor.

### 18.13.1 Features

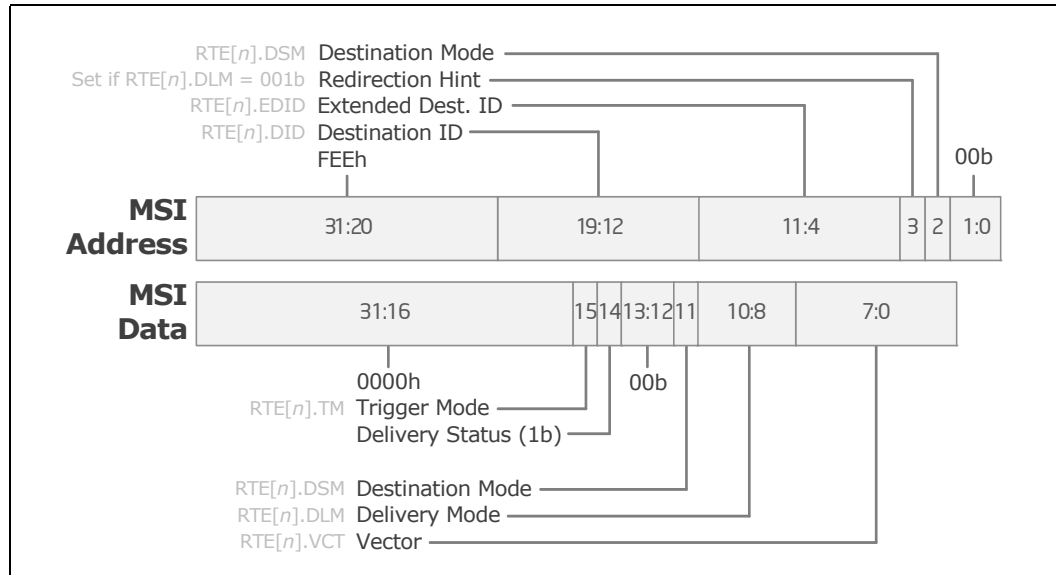
- 115 interrupt lines
  - IRQ0-114
- Edge or level trigger mode per interrupt
- Active low or high polarity per interrupt
- Works with local APIC in processor via MSIs
- MSIs can target specific processor core
- Established APIC programming model

Figure 33. Detailed Block Diagram



MSIs generated by the I/O APIC are sent as 32-bit memory writes to the Local APIC. The address and data of the write transaction are used as follows.

**Figure 34. MSI Address and Data**



Destination ID (DID) and Extended Destination ID (EDID) are used to target a specific processor core's local APIC.

### 18.13.2 Usage

The I/O APIC contains indirectly accessed I/O APIC registers and normal memory mapped registers. There are three memory mapped registers:

- Index Register (IDX)
- Window Register (WDW)
- End Of Interrupt Register (EOI)

The Index register selects an indirect I/O APIC register (ID/VS/RTE[n]) to appear in the Window register.

The Window register is used to read or write the indirect register selected by the Index register.

The EOI register is written to by the Local APIC in the processor. The I/O APIC compares the lower eight bits written to the EOI register to the Vector set for each interrupt (RTE.VCT). All interrupts that match this vector will have their RTE.RIRR register cleared. All other EOI register bits are ignored.



### 18.13.3 Indirect I/O APIC Registers

These registers are selected with the IDX register, and read/written through the WDW register. Accessing these registers must be done as DW requests, otherwise unspecified behavior will result. Software should not attempt to write to reserved registers. Reserved registers may return non-zero values when read.

**Note:** There is one pair of redirection (RTE) registers per interrupt line. Each pair forms a 64-bit RTE register.

**Note:** Specified offsets should be placed in IDX, not added to IDX.



## 18.14 PCU - iLB - 8259 Programmable Interrupt Controllers (PIC)

SoC provides an ISA-compatible programmable interrupt controller (PIC) that incorporates the functionality of two, cascaded 8259 interrupt controllers.

### 18.14.1 Features

In addition to providing support for ISA compatible interrupts, this interrupt controller can also support PCI based interrupts (PIRQs) by mapping the PCI interrupt onto a compatible ISA interrupt line. Each 8259 controller supports eight interrupts, numbered 0–7. Table 117 shows how the controllers are connected.

**Note:** SoC does not implement any external PIRQ# signals. The PIRQs referred to in this chapter originate from the interrupt routing unit.

Table 117. Interrupt Controller Connections

| 8259   | 8259 Input | Connected Pin / Function  |
|--------|------------|---|
| Master | 0          | Internal Timer / Counter 0 output or HPET #0; determined by GCFG.LRE register bit |
|        | 1          | IRQ1 using SERIRQ, Keyboard Emulation   |
|        | 2          | Slave controller INTR output  |
|        | 3          | IRQ3 via SERIRQ, PIRQx or PCU UART 1  |
|        | 4          | IRQ4 via SERIRQ or PIRQx  |
|        | 5          | IRQ5 via SERIRQ or PIRQx  |
|        | 6          | IRQ6 via SERIRQ or PIRQx  |
|        | 7          | IRQ7 via SERIRQ or PIRQx  |
| Slave  | 0          | Inverted IRQ8# from internal RTC or HPET  |
|        | 1          | IRQ9 via SERIRQ, SCI or PIRQx   |
|        | 2          | IRQ10 via SERIRQ, SCI or PIRQx  |
|        | 3          | IRQ11 via SERIRQ, SCI, HPET or PIRQx  |
|        | 4          | IRQ12 via SERIRQ, PIRQx or mouse emulation  |
|        | 5          | None  |
|        | 6          | PIRQx   |
|        | 7          | IRQ15 via SERIRQ or PIRQx o   |

The SoC cascades the slave controller onto the master controller through master controller interrupt input 2. This means there are only 15 possible interrupts for the SoC PIC.

Interrupts can be programmed individually to be edge or level, except for IRQ0, IRQ2 and IRQ8#.



**Note:** Active-low interrupt sources (such as a PIRQ#) are inverted inside the SoC. In the following descriptions of the 8259s, the interrupt levels are in reference to the signals at the internal interface of the 8259s, after the required inversions have occurred. Therefore, the term “high” indicates “active,” which means “low” on an originating PIRQ#.

### 18.14.1.1 Interrupt Handling

#### Generating Interrupts

The PIC interrupt sequence involves three bits, from the IRR, ISR, and IMR, for each interrupt level. These bits are used to determine the interrupt vector returned, and status of any other pending interrupts. [Table 118](#) defines the IRR, ISR, and IMR.

**Table 118. Interrupt Status Registers**

| Bit | Description  |
|-----|--|
| IRR | <b>Interrupt Request Register.</b> This bit is set on a low to high transition of the interrupt line in edge mode, and by an active high level in level mode.                          |
| ISR | <b>Interrupt Service Register.</b> This bit is set, and the corresponding IRR bit cleared, when an interrupt acknowledge cycle is seen, and the vector returned is for that interrupt. |
| IMR | <b>Interrupt Mask Register.</b> This bit determines whether an interrupt is masked. Masked interrupts will not generate INTR.  |

#### Acknowledging Interrupts

The processor generates an interrupt acknowledge cycle that is translated into a Interrupt Acknowledge Cycle to the SoC. The PIC translates this command into two internal INTA# pulses expected by the 8259 controllers. The PIC uses the first internal INTA# pulse to freeze the state of the interrupts for priority resolution. On the second INTA# pulse, the master or slave sends the interrupt vector to the processor with the acknowledged interrupt code. This code is based upon the ICW2.IVBA bits, combined with the ICW2.IRL bits representing the interrupt within that controller.

**Note:** References to ICWx and OCWx registers are relevant to both the master and slave 8259 controllers.

**Table 119. Content of Interrupt Vector Byte**

| Master, Slave Interrupt | Bits [7:3] | Bits [2:0] |
|-------------------------|------------|------------|
| IRQ7,15                 | ICW2.IVBA  | 111        |
| IRQ6,14                 |            | 110        |
| IRQ5,13                 |            | 101        |
| IRQ4,12                 |            | 100        |
| IRQ3,11                 |            | 011        |
| IRQ2,10                 |            | 010        |
| IRQ1,9                  |            | 001        |
| IRQ0,8                  |            | 000        |

**Hardware/Software Interrupt Sequence**

1. One or more of the Interrupt Request lines (IRQ) are raised high in edge mode, or seen high in level mode, setting the corresponding IRR bit.
2. The PIC sends INTR active to the processor if an asserted interrupt is not masked.
3. The processor acknowledges the INTR and responds with an interrupt acknowledge cycle.
4. Upon observing the special cycle, the SoC converts it into the two cycles that the internal 8259 pair can respond to. Each cycle appears as an interrupt acknowledge pulse on the internal INTA# pin of the cascaded interrupt controllers.
5. Upon receiving the first internally generated INTA# pulse, the highest priority ISR bit is set and the corresponding IRR bit is reset. On the trailing edge of the first pulse, a slave identification code is broadcast by the master to the slave on a private, internal three bit wide bus. The slave controller uses these bits to determine if it must respond with an interrupt vector during the second INTA# pulse.
6. Upon receiving the second internally generated INTA# pulse, the PIC returns the interrupt vector. If no interrupt request is present because the request was too short in duration, the PIC returns vector 7 from the master controller.
7. This completes the interrupt cycle. In AEOI mode the ISR bit is reset at the end of the second INTA# pulse. Otherwise, the ISR bit remains set until an appropriate EOI command is issued at the end of the interrupt subroutine.

**18.14.1.2 Initialization Command Words (ICWx)**

Before operation can begin, each 8259 must be initialized. In the SoC, this is a four byte sequence. The four initialization command words are referred to by their acronyms: ICW1, ICW2, ICW3, and ICW4.

The base address for each 8259 initialization command word is a fixed location in the I/O memory space: 20h for the master controller, and A0h for the slave controller.





### ICW1

A write to the master or slave controller base address with data bit 4 equal to 1 is interpreted as a write to ICW1. Upon sensing this write, the PIC expects three more byte writes to 21h for the master controller, or A1h for the slave controller, to complete the ICW sequence.

A write to ICW1 starts the initialization sequence during which the following automatically occur:

1. Following initialization, an interrupt request (IRQ) input must make a low-to-high transition to generate an interrupt.
2. The Interrupt Mask Register is cleared.
3. IRQ7 input is assigned priority 7.
4. The slave mode address is set to 7.
5. Special mask mode is cleared and Status Read is set to IRR.

### ICW2

The second write in the sequence (ICW2) is programmed to provide bits [7:3] of the interrupt vector that will be released during an interrupt acknowledge. A different base is selected for each interrupt controller.

### ICW3

The third write in the sequence (ICW3) has a different meaning for each controller.

- For the master controller, ICW3 is used to indicate which IRQ input line is used to cascade the slave controller. Within the SoC, IRQ2 is used. Therefore, MICW3.CCC is set to a 1, and the other bits are set to 0s.
- For the slave controller, ICW3 is the slave identification code used during an interrupt acknowledge cycle. On interrupt acknowledge cycles, the master controller broadcasts a code to the slave controller if the cascaded interrupt won arbitration on the master controller. The slave controller compares this identification code to the value stored in its ICW3, and if it matches, the slave controller assumes responsibility for broadcasting the interrupt vector.

### ICW4

The final write in the sequence (ICW4) must be programmed for both controllers. At the very least, ICW4.MM must be set to a 1 to indicate that the controllers are operating in an Intel Architecture-based system.

#### 18.14.1.3 Operation Command Words (OCW)

These command words reprogram the Interrupt controller to operate in various interrupt modes.

- OCW1 masks and unmask interrupt lines.



- OCW2 controls the rotation of interrupt priorities when in rotating priority mode, and controls the EOI function.
- OCW3 sets up ISR/IRR reads, enables/disables the special mask mode (SMM), and enables/disables polled interrupt mode.

#### 18.14.1.4 Modes of Operation

##### Fully Nested Mode

In this mode, interrupt requests are ordered in priority from 0 through 7, with 0 being the highest. When an interrupt is acknowledged, the highest priority request is determined and its vector placed on the bus. Additionally, the ISR for the interrupt is set. This ISR bit remains set until: the processor issues an EOI command immediately before returning from the service routine; or if in AEOI mode, on the trailing edge of the second INTA#. While the ISR bit is set, all further interrupts of the same or lower priority are inhibited, while higher levels generate another interrupt.

Interrupt priorities can be changed in the rotating priority mode.

##### Special Fully-Nested Mode

This mode is used in the case of a system where cascading is used, and the priority has to be conserved within each slave. In this case, the special fully-nested mode is programmed to the master controller. This mode is similar to the fully-nested mode with the following exceptions:

- When an interrupt request from a certain slave is in service, this slave is not locked out from the master's priority logic and further interrupt requests from higher priority interrupts within the slave are recognized by the master and initiate interrupts to the processor. In the normal-nested mode, a slave is masked out when its request is in service.
- When exiting the Interrupt Service routine, software has to check whether the interrupt serviced was the only one from that slave. This is done by sending a Non-Specific EOI command to the slave and then reading its ISR. If it is 0, a non-specific EOI can also be sent to the master.

##### Automatic Rotation Mode (Equal Priority Devices)

In some applications, there are a number of interrupting devices of equal priority. Automatic rotation mode provides for a sequential 8-way rotation. In this mode, a device receives the lowest priority after being serviced. In the worst case, a device requesting an interrupt has to wait until each of seven other devices are serviced at most once.

There are two ways to accomplish automatic rotation using OCW2.REOI; the Rotation on Non-Specific EOI Command (OCW2.REOI=101b) and the rotate in automatic EOI mode which is set by (OCW2.REOI=100b).



### **Specific Rotation Mode (Specific Priority)**

Software can change interrupt priorities by programming the bottom priority. For example, if IRQ5 is programmed as the bottom priority device, then IRQ6 is the highest priority device. The Set Priority Command is issued in OCW2 to accomplish this, where: OCW2.REOI=11xb, and OCW2.ILS is the binary priority level code of the bottom priority device.

In this mode, internal status is updated by software control during OCW2. However, it is independent of the EOI command. Priority changes can be executed during an EOI command by using the Rotate on Specific EOI Command in OCW2 (OCW2.REOI=111b) and OCW2.ILS=IRQ level to receive bottom priority.

### **Poll Mode**

Poll mode can be used to conserve space in the interrupt vector table. Multiple interrupts that can be serviced by one interrupt service routine do not need separate vectors if the service routine uses the poll command. Poll mode can also be used to expand the number of interrupts. The polling interrupt service routine can call the appropriate service routine, instead of providing the interrupt vectors in the vector table. In this mode, the INTR output is not used and the microprocessor internal Interrupt Enable flip-flop is reset, disabling its interrupt input. Service to devices is achieved by software using a Poll command.

The Poll command is issued by setting OCW3.PMC. The PIC treats its next I/O read as an interrupt acknowledge, sets the appropriate ISR bit if there is a request, and reads the priority level. Interrupts are frozen from the OCW3 write to the I/O read. The byte returned during the I/O read contains a 1 in Bit 7 if there is an interrupt, and the binary code of the highest priority level in Bits 2:0.

### **Edge and Level Triggered Mode**

In ISA systems this mode is programmed using ICW1.LTIM, which sets level or edge for the entire controller. In the SoC, this bit is disabled and a register for edge and level triggered mode selection, per interrupt input, is included. This is the Edge/Level control Registers ELCR1 and ELCR2.

If an ELCR bit is 0, an interrupt request will be recognized by a low-to-high transition on the corresponding IRQ input. The IRQ input can remain high without generating another interrupt. If an ELCR bit is 1, an interrupt request will be recognized by a high level on the corresponding IRQ input and there is no need for an edge detection. The interrupt request must be removed before the EOI command is issued to prevent a second interrupt from occurring.

In both the edge and level triggered modes, the IRQ inputs must remain active until after the falling edge of the first internal INTA#. If the IRQ input goes inactive before this time, a default IRQ7 vector is returned.



### 18.14.1.5 End of Interrupt (EOI) Operations

An EOI can occur in one of two fashions: by a command word write issued to the PIC before returning from a service routine, the EOI command; or automatically when the ICW4.AEOI bit is set to 1.

#### Normal End of Interrupt

In normal EOI, software writes an EOI command before leaving the interrupt service routine to mark the interrupt as completed. There are two forms of EOI commands: Specific and Non-Specific. When a Non-Specific EOI command is issued, the PIC clears the highest ISR bit of those that are set to 1. Non-Specific EOI is the normal mode of operation of the PIC within the SoC, as the interrupt being serviced currently is the interrupt entered with the interrupt acknowledge. When the PIC is operated in modes that preserve the fully nested structure, software can determine which ISR bit to clear by issuing a Specific EOI.

An ISR bit that is masked is not cleared by a Non-Specific EOI if the PIC is in the special mask mode. An EOI command must be issued for both the master and slave controller.

#### Automatic End of Interrupt Mode

In this mode, the PIC automatically performs a Non-Specific EOI operation at the trailing edge of the last interrupt acknowledge pulse. From a system standpoint, this mode should be used only when a nested multi-level interrupt structure is not required within a single PIC. The AEOI mode can only be used in the master controller and not the slave controller.

**Note:** Both the master and slave PICs have an AEOI bit: MICW4.AEOI and SICW4.AEOI respectively. Only the MICW4.AEOI bit should be set by software. The SICW4.AEOI bit should not be set by software.

### 18.14.1.6 Masking Interrupts

#### Masking on an Individual Interrupt Request

Each interrupt request can be masked individually by the Interrupt Mask Register (IMR). This register is programmed through OCW1. Each bit in the IMR masks one interrupt channel. Masking IRQ2 on the master controller masks all requests for service from the slave controller.

#### Special Mask Mode

Some applications may require an interrupt service routine to dynamically alter the system priority structure during its execution under software control. For example, the routine may wish to inhibit lower priority requests for a portion of its execution but enable some of them for another portion.



The special mask mode enables all interrupts not masked by a bit set in the Mask register. Normally, when an interrupt service routine acknowledges an interrupt without issuing an EOI to clear the ISR bit, the interrupt controller inhibits all lower priority requests. In the special mask mode, any interrupts may be selectively enabled by loading the Mask Register with the appropriate pattern.

The special mask mode is set by OCW3.ESMM=1b & OCW3.SMM=1b, and cleared where OCW3.ESMM=0b & OCW3.SMM=0b.

### 18.14.1.7 S0ix Support

During S0i2 & S0i3, the 8259 PICs are disabled. A platform that requires the 8259 PICs to be always active, should disable S0i2/3 using the S0ix\_Enable register.

## 18.14.2 IO Mapped Registers

The interrupt controller registers are located at 20h and 21h for the master controller (IRQ0 - 7), and at A0h and A1h for the slave controller (IRQ8 - 13). These registers have multiple functions, depending upon the data written to them. Table 120 is a description of the different register possibilities for each address.

**Note:** The register descriptions after Table 120 represent one register possibility.

**Table 120. I/O Registers Alias Locations**

| Registers                        | Original I/O Location | Alias I/O Locations |
|----------------------------------|-----------------------|---------------------|
| MICW1<br>MOCW2<br>MOCW3          | 20h                   | 24h                 |
|                                  |                       | 28h                 |
|                                  |                       | 2Ch                 |
|                                  |                       | 30h                 |
|                                  |                       | 34h                 |
|                                  |                       | 38h                 |
| MICW2<br>MICW3<br>MICW4<br>MOCW1 | 21h                   | 3Ch                 |
|                                  |                       | 25h                 |
|                                  |                       | 29h                 |
|                                  |                       | 2Dh                 |
|                                  |                       | 31h                 |
|                                  |                       | 35h                 |
|                                  |                       | 39h                 |
|                                  |                       | 3Dh                 |



**Table 120. I/O Registers Alias Locations**

| Registers                        | Original I/O Location | Alias I/O Locations |
|----------------------------------|-----------------------|---------------------|
| SICW1<br>SOCW2<br>SOCW3          | A0h                   | A4h                 |
|                                  |                       | A8h                 |
|                                  |                       | ACH                 |
|                                  |                       | B0h                 |
|                                  |                       | B4h                 |
|                                  |                       | B8h                 |
|                                  |                       | BCh                 |
| SICW2<br>SICW3<br>SICW4<br>SOCW1 | A1h                   | A5h                 |
|                                  |                       | A9h                 |
|                                  |                       | ADh                 |
|                                  |                       | B1h                 |
|                                  |                       | B5h                 |
|                                  |                       | B9h                 |
| BDh                              |                       |                     |
| ELCR1                            | 4D0h                  | N/A                 |
| ELCR2                            | 4D1h                  | N/A                 |

## 18.15 Register Map

For more information on Platform Controller Unit (PCU) registers refer Intel® Atom™ Z8000 Processor Series Datasheet (Volume 2 of 2), Doc ID:332066.

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# 19 Electrical Specifications

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This chapter is categorized into the following sections:

- "Absolute Maximum and Minimum Specifications"
- "Thermal Specifications"
- "Storage Conditions"
- "Voltage and Current Specifications"
- "Crystal Specifications"
- "DC Specifications"

## 19.1 Absolute Maximum and Minimum Specifications

The absolute maximum and minimum specifications are used to specify conditions allowable outside of the functional limits of the SoC, but with possible reduced life expectancy once returned to function limits.

At conditions exceeding absolute specifications, neither functionality nor long term reliability can be expected. Parts may not function at all once returned to functional limits.

Although the processor contains protective circuitry to resist damage from Electrostatic discharge (ESD), precautions should always be taken to avoid high static voltages or electric fields.

## 19.2 Thermal Specifications

These specifications define the operating thermal limits of the SoC. Thermal solutions not designed to provide the following level of thermal capability may affect the long-term reliability of the processor and system, but more likely result in performance throttling to ensure silicon junction temperatures within specification.

This section specifies the thermal specifications for all SKUs. Some definitions are needed, however. "Tj Max" defines the maximum operating silicon junction temperature. Unless otherwise specified, all specifications in this document assume Tj Max as the worst case junction temperature. This is the temperature needed to ensure TDP specifications when running at guaranteed CPU and graphics frequencies. "TDP" defines the thermal dissipated power for a worst case estimated real world thermal scenario. "SDP", or scenario dissipated power, defines the thermal dissipated power under a lighter workload specific to a user scenario and at a lower thermal junction temperature than Tj Max. Note that turbo frequencies are opportunistically selected when thermal headroom exists. Automatic throttling along with a proper thermal solution ensure Tj Max will not be exceeded.



Table 121. Thermal Specifications

|  | T4    | T3    |
|--|-------|-------|
| T <sub>j</sub> Max                             | 90 °C | 90 °C |
| T <sub>j</sub> Min                             | 0 °C  | 0 °C  |
| T <sub>j</sub> @ Max. Steady State Power (SDP) | 70 °C | 70 °C |
| SDP  | 2W    | 2.2 W |

## 19.3 Storage Conditions

This section specifies absolute maximum and minimum storage temperature and humidity limits for given time durations. Failure to adhere to the specified limits could result in physical damage to the component. If this is suspected, Intel recommends a visual inspection to determine possible physical damage to the silicon or surface components.

Table 122. Storage Conditions Prior to Board Attach

| Symbol              | Parameter   | Min    | Max         |
|---------------------|---|--------|-------------|
| Tabsolute storage   | Device storage temperature when exceeded for any length of time.  | -25 °C | 125 °C      |
| Tshort term storage | The ambient storage temperature and time for up to 72 hours.      | -25 °C | 85 °C       |
| Tsustained storage  | The ambient storage temperature and time for up to 30 months.     | 5 °C   | 40 °C       |
| RHsustained storage | The maximum device storage relative humidity for up to 30 months. |        | 60% @ 24 °C |

### NOTES:

- Specified temperatures are not to exceed values based on data collected. Exceptions for surface mount re-flow are specified by the applicable JEDEC standard. Non-adherence may affect processor reliability.
- Component product device storage temperature qualification methods may follow JESD22-A119 (low temperature) and JESD22-A103 (high temperature) standards when applicable for volatile memory.
- Component stress testing is conducted in conformance with JESD22-A104.
- The JEDEC J-JSTD-020 moisture level rating and associated handling practices apply to all moisture sensitive devices removed from the moisture barrier bag.





### 19.3.1 Post Board-Attach

The storage condition limits for the component once attached to the application board are not specified. Intel does not conduct component-level certification assessments post board-attach given the multitude of attach methods, socket types, and board types used by customers.

Provided as general guidance only, board-level Intel-branded products are specified and certified to meet the following temperature and humidity limits:

- Non-Operating Temperature Limit: -40 °C to 70 °C
- Humidity: 50% to 90%, non-condensing with a maximum wet-bulb of 28 °C

## 19.4 Voltage and Current Specifications

The I/O buffer supply voltages are specified at the SoC package balls. The tolerances shown in [Table 138](#) are inclusive of all noise from DC up to 20 MHz. The voltage rails should be measured with a bandwidth limited oscilloscope with a roll-off of 3 dB/decade above 20 MHz under all operating conditions. [Table 124](#) indicates which supplies are connected directly to a voltage regulator or to a filtered voltage rail. For voltage rails that are connected to a filter, they should be measured at the input of the filter. If the recommended platform decoupling guidelines cannot be met, the system designer will have to make trade-offs between the voltage regulator out DC tolerance and the decoupling performances of the capacitor network to stay within the voltage tolerances listed below.

**Note:** The SoC is a pre-launch product. Voltage and current specifications are subject to change.

**Table 123. SoC Power Rail DC Specs and Max Current**

| Platform Rail |                   | Voltage Tolerances           | Max Icc |
|---------------|-------------------|------------------------------|---------|
| V1P05A        | UNCORE1_V1P05A_G3 | 1.05 V<br>DC: ±2%<br>AC: ±2% | 1700 mA |
|               | UNCORE2_V1P05A_G3 |                              |         |
|               | DDR_V1P05A_G3     |                              |         |
|               | USB3_V1P05A_G3    |                              |         |
|               | USBSSIC_V1P05A_G3 |                              |         |
|               | F_V1P05A_G3       |                              |         |
|               | PCIECLK_V1P05A_G3 |                              |         |
| V1P15         | CORE_V1P15_S0iX   | 1.15 V<br>DC: ±2%<br>AC: ±3% | 2100 mA |
|               | DDI_V1P15_S0iX    |                              |         |
|               | UNCORE_V1P15_S0iX |                              |         |
|               | F_V1P15_S0iX      |                              |         |



Table 123. SoC Power Rail DC Specs and Max Current

| Platform Rail |                     | Voltage Tolerances        | Max Icc |
|---------------|---------------------|---------------------------|---------|
| V1P2A         | USBSSIC_V1P2A_G3    | 1.24 V                    | 67 mA   |
|               | MIPI_V1P2A_G3       | DC: ±2%                   |         |
|               | USBHSIC_V1P2A_G3    | AC: ±2%                   |         |
| V1P8A         | USB_V1P8A_G3        | 1.8 V                     | 971 mA  |
|               | UNCORE_V1P8A_G3     | DC: ±2%                   |         |
|               | GPIOSE_V1P8A_G3     | AC: ±2%                   |         |
|               | GPION_V1P8A_G3      |                           |         |
|               | F_V1P8A_G3          |                           |         |
| V3P3A         | USB_V3P3A_G3        | 3.3 V                     | 196 mA  |
|               | F_V3P3A_G3          | DC: ±2%                   |         |
|               | RTC_V3P3A_G5        | AC: ±2%                   |         |
| V3P3A_V1P8A   | SDIO_V3P3A_V1P8A_G3 | 1.8 V/3.3 V               | -       |
|               | LPC_V3P3A_V1P8A_S4  | DC: ±2%                   |         |
| VSFR          | ICLK_VSFR_G3        | 1.05 V/1.24 V/            | -       |
|               | CORE0_VSFR_G3       | 1.35 V                    |         |
|               | CORE1_VSFR_G3       | DC: ±2%                   |         |
|               | UNCORE_VSFR_G3      | AC: ±3%                   |         |
| VCC0          | CORE_VCC0_S0iX      | Refer                     | 3200 mA |
|               | CORE_VCC0_SENSE     | <a href="#">Table 124</a> |         |
| VCC1          | CORE_VCC1_S0iX      | Refer                     | 3200 mA |
|               | CORE_VCC1_SENSE     | <a href="#">Table 124</a> |         |
| VNN           | UNCORE_VNN_S4       | Refer                     | 2500 mA |
|               | UNCORE_VNN_SENSE    | <a href="#">Table 124</a> |         |
| VGG           | DDI_VGG_S0iX        | Refer                     | 8000 mA |
|               | DDI_VGG_SENSE       | <a href="#">Table 124</a> |         |



Table 123. SoC Power Rail DC Specs and Max Current

| Platform Rail |                    | Voltage Tolerances                                       | Max Icc       |
|---------------|--------------------|--|---------------|
| VDDQ          | DDI1_VDDQ_G3       | 1.24 V/1.35 V<br>DC: $\pm 2\%$<br>AC: $\pm 2\%$          | 1900 - 2500mA |
|               | DDI2_VDDQ_G3       |  |               |
|               | USB_VDDQ_G3        |  |               |
| VDDQG         | DDR_VDDQG_S4       | 1.24 V/1.35 V<br>DC: $\pm 2\%$<br>AC: $\pm 2\%$          |               |
|               | DDRCH0_VDDQG_S4    |  |               |
|               | DDRCH1_VDDQG_S4    |  |               |
|               | DDRSFRCH0_VDDQG_S4 |  |               |
|               | DDRSFRCH1_VDDQG_S4 |  |               |
| V3P3RTC       | RTC_V3P3RTC_G5     | G5: 2-3 V at battery<br>Otherwise V3P3A (pre diode drop) | -             |

**NOTE:**

1. RTC\_VCC average current draw (G5) is specified at 27°C under battery conditions
2. This value is applicable only for Z8350 and Z8300 SKUs.

### 19.4.1 VCC and VNN Voltage Specifications

Table 124 and Table 138 list the DC specifications for the SoC power rails. They are valid only while meeting specifications for junction temperature, clock frequency, and input voltages. Care should be taken to read all notes associated with each parameter.

Table 124. VCC and VNN DC Voltage Specifications

| Symbol                        | Parameter                       | Min           | Typ | Max  | Unit | Note |
|-------------------------------|---------------------------------|---------------|-----|------|------|------|
| CORE_VCC VID [Z8700, Z8750]   | Core VID Target Range           | 0.6           |     | 1.30 | V    |      |
| CORE_VCC VID [Z8500, Z8550]   | Core VID Target Range           | 0.6           |     | 1.28 | V    |      |
| CORE_VCC VID [Z8300, Z8350]   | Core VID Target Range           | 0.6           |     | 1.13 | V    |      |
| CORE_VCC0_S0iX                | V <sub>CC0</sub> for SoC Core 0 | Refer VCC VID |     |      | V    | 2    |
| CORE_VCC1_S0iX                | V <sub>CC1</sub> for SoC Core 1 | Refer VCC VID |     |      | V    | 2    |
| UNCORE_VNN VID [Z8700]        | Uncore VID Target Range         | 0.4           |     | 1.28 | V    |      |
| UNCORE_VNN VID [Z8500]        | Uncore VID Target Range         | 0.4           |     | 1.28 | V    |      |
| UNCORE_VNN VID [Z8300, Z8350] | Uncore VID Target Range         | 0.4           |     | 1.1  | V    |      |
| UNCORE_VNN_S4                 | V <sub>NN</sub> for SoC Uncore  | Refer VNN VID |     |      | V    | 2    |
| DDI_VGG_S0iX [Z8700]          | V <sub>GG</sub> for SoC Display | 0.4           |     | 0.9  | V    |      |
| DDI_VGG_S0iX [Z8500]          | V <sub>GG</sub> for SoC Display | 0.4           |     | 0.9  | V    |      |
| DDI_VGG_S0iX [Z8300, Z8350]   | V <sub>GG</sub> for SoC Display | 0.4           |     | 1.1  | V    |      |

**Table 124. VCC and VNN DC Voltage Specifications**

| Symbol                                   | Parameter   | Min             | Typ           | Max | Unit | Note |
|--|---|-----------------|---------------|-----|------|------|
| CORE_VCC/UNCORE_VNN<br>V <sub>BOOT</sub> | Default target V <sub>CC</sub> /V <sub>NN</sub> voltage for initial power up. |                 | 1.0 or<br>1.1 |     | V    | 3    |
| VCC0/1 Tolerance                         | Tolerance of VCC0/1 voltage at VID target.                                    | DC: ±2% AC: ±3% |               |     | %    | 1    |
| VNN Tolerance                            | Tolerance of VNN voltage at VID target.                                       | DC: ±2% AC: ±2% |               |     | %    | 1    |
| VGG Tolerance                            | Tolerance of VGG voltage at VID target.                                       | DC: ±2% AC: ±3% |               |     | %    | 1    |

**NOTES:**

- Contact local Intel representative for load line and tolerance details.
- Each SoC is programmed with voltage identification value (VID), which is set at manufacturing and cannot be altered. Individual VID values are calibrated during manufacturing such that two SoCs at the same frequency may have different settings within the VID range. Note this differs from the VID employed by the SoC during a power management event.
- Refer VR12/IMVP7 Pulse Width Modulation specification for additional details. Either value is ok.

## 19.4.2 CPU ESD LEVEL

**Table 125. CPU ESD level details**

| CPU Type | CDM   | HBM    |
|----------|-------|--------|
| T4/T3    | ±250v | ±1000v |

## 19.5 Crystal Specifications

There are two crystal oscillators. One for RTC which maintains time and provides initial timing reference for power sequencing. The other is for the Integrated Clock, which covers clocking for the entire SoC.

**Table 126. ILB RTC Crystal Specification**

| Symbol                         | Parameter                                 | Min | Typ    | Max   | Units | Notes |
|--------------------------------|---|-----|--------|-------|-------|-------|
| F <sub>RTC</sub>               | Frequency                                 | -   | 32.768 | -     | kHz   | 1     |
| T <sub>PPM</sub>               | Crystal frequency tolerance (refer notes) | -   | -      | +/-20 | ppm   | 1     |
| P <sub>DRIVE</sub>             | Crystal drive load                        | -   | 0.1    | 0.5   | uW    | 1     |
| C <sub>LOAD</sub>              | Crystal load capacitance                  |     | 12.5   |       | pF    |       |
| C <sub>SHUNT</sub>             | Crystal shunt capacitance                 | -   | 1.3    | -     | pF    | 1     |
| C <sub>1</sub> /C <sub>2</sub> | Load Capacitance tolerance                |     |        | +/-10 | %     |       |

**NOTES:**

- These are the specifications needed to select a crystal oscillator for the RTC circuit.



2. Crystal tolerance impacts RTC time. A 10 ppm crystal is recommended for 1.7 s tolerance per day, RTC circuit itself contributes addition 10 ppm for a total of 20 ppm in this example.

**Table 127. Integrated Clock Crystal Specification**

| Symbol                         | Parameter                               | Min | Typ  | Max   | Units | Notes |
|--------------------------------|---|-----|------|-------|-------|-------|
| F <sub>ICLK</sub>              | Frequency                               | -   | 19.2 | -     | MHz   | 1     |
| T <sub>PPM</sub>               | Crystal frequency tolerance & stability | -   | -    | +/-30 | ppm   | 1     |
| P <sub>DRIVE</sub>             | Crystal drive load                      | -   | -    | 100   | uW    | 1     |
| R <sub>ESR</sub>               | ESR                                     | -   | -    | 80    | Ohm   | 1     |
| C <sub>LOAD</sub>              | Crystal load capacitance                |     | 12   |       | pF    |       |
| C <sub>SHUNT</sub>             | Crystal shunt capacitance               | -   | 0.75 | -     | pF    | 1     |
| C <sub>1</sub> /C <sub>2</sub> | Load Capacitance tolerance              |     |      | +/-10 | %     |       |

**NOTE:**

1. These are the specifications required to select a crystal oscillator for the Integrated Clock circuit. Crystal must be AT cut, fundamental, parallel resonance.

## 19.6 DC Specifications

Platform reference voltages are specified at DC only. V<sub>REF</sub> measurements should be made with respect to the supply voltages specified in ["Voltage and Current Specifications"](#).

**Note:** V<sub>IH/OH</sub> Max and V<sub>IL/OL</sub> Min values are bounded by reference voltages.

The following DC Specifications are explained in this section:

- ["Display DC Specification"](#)
- ["MIPI-Camera Serial Interface \(CSI\) DC Specification"](#)
- ["SDIO DC Specification"](#)
- ["SD Card DC Specification"](#)
- ["eMMC 4.51 DC Specification"](#)
- ["JTAG DC Specification"](#)
- ["LPDDR3 Memory Controller DC Specification"](#)
- ["USB 2.0 Host DC Specification"](#)
- ["USB 3.0 DC Specification"](#)
- ["SSIC DC Specification"](#)
- ["SPI and FST\\_SPI DC Specification"](#)
- ["Power Management/Thermal \(PMC\) and RTC DC Specification"](#)
- ["SVID DC Specification"](#)
- ["GPIO DC Specification"](#)



- "SIO - I2C DC Specification"
- "SIO - UART DC Specification"
- "I2S (Audio) DC Specification"
- "PCI Express DC Specification"

**Note:** Care should be taken to read all notes associated with each parameter.

### 19.6.1 Display DC Specification

DC specifications for display interfaces:

- "Display Port DC Specification"
- "HDMI DC Specification"
- "Embedded Display Port DC Specification"
- "Display Port AUX Channel DC Specification"
- "Embedded Display Port AUX Channel DC Specification"
- "DDC Signal DC Specification"
- "MIPI DSI DC Specification"

#### 19.6.1.1 Display Port DC Specification

**Table 128. Display Port DC specification**

| Symbol                      | Parameter  | Min  | Typ | Max  | Units | Notes |
|-----------------------------|--|------|-----|------|-------|-------|
| $V_{TX-DIFFp-p-}$<br>Level0 | Differential Peak-to-peak Output Voltage Level 0 | 0.34 | 0.4 | 0.46 | V     |       |
| $V_{TX-DIFFp-p-}$<br>Level1 | Differential Peak-to-peak Output Voltage Level 1 | 0.51 | 0.6 | 0.68 | V     |       |
| $V_{TX-DIFFp-p-}$<br>Level2 | Differential Peak-to-peak Output Voltage Level 2 | 0.69 | 0.8 | 0.92 | V     |       |
| $V_{TX-DIFFp-p-}$<br>Level3 | Differential Peak-to-peak Output Voltage Level 3 | 0.85 | 1.2 | 1.38 | V     |       |
| $V_{TX-PREEMP-}$<br>RATIO   | No Pre-emphasis                                  | 0.0  | 0.0 | 0.0  | dB    |       |
|                             | 3.5 dB Pre-emphasis                              | 2.8  | 3.5 | 4.2  | dB    |       |
|                             | 6.0 dB Pre-emphasis                              | 4.8  | 6.0 | 7.2  | dB    |       |
|                             | 9.5 dB Pre-emphasis                              | 7.5  | 9.5 | 11.4 | dB    |       |
| $V_{TX-DC-CM}$              | Tx DC Common Mode Voltage                        | 0    |     | 2.0  | V     |       |



Table 128. Display Port DC specification

| Symbol                | Parameter   | Min | Typ | Max | Units | Notes |
|-----------------------|---|-----|-----|-----|-------|-------|
| RL <sub>TX-DIFF</sub> | Differential Return Loss at 0.675GHz at Tx Package pins | 12  |     |     | dB    |       |
|                       | Differential Return Loss at 1.35 GHz at Tx Package pins | 9   |     |     | dB    | 1     |
| C <sub>TX</sub>       | TX Output Capacitance                                   |     |     | 1.5 | pF    | 2     |

**NOTES:**

1. Straight loss line between 0.675 GHz and 1.35 GHz.
2. Represents only the effective lump capacitance seen at the SoC interface that shunts the TX termination.

## 19.6.1.2 HDMI DC Specification

Table 129. HDMI DC specification

| Symbol                      | Parameter                                  | Min  | Typ | Max  | Units | Notes    |
|-----------------------------|--|------|-----|------|-------|----------|
| V <sub>off</sub>            | Single Ended Standby (off), output voltage | -10  |     | 10   | mV    | 1 @ AVcc |
| V <sub>swing</sub>          | Single Ended output swing voltage          | 400  |     | 600  | mV    |          |
| V <sub>OH</sub> (<=165 MHz) | Single Ended high level, output voltage    | -10  |     | 10   | mv    | 1 @ AVcc |
| V <sub>OH</sub> (>165 MHz)  | Single Ended high level, output voltage    | -200 |     | 10   | mV    | 1 @ AVcc |
| V <sub>OL</sub> (<=165 MHz) | Single Ended low level, output voltage     | -600 |     | -400 | mV    | 1 @ AVcc |
| V <sub>OL</sub> (>165MHz z) | Single Ended low level, output voltage     | -700 |     | -400 | mV    | 1 @ AVcc |

**NOTE:** 1. The min/max values are with reference to AVcc (Analog Voltage level) = 3.3V ±5%

## 19.6.1.3 Embedded Display Port DC Specification

Table 130. Embedded Display Port DC Specification

| Symbol                         | Parameter  | Min  | Typ  | Max   | Units | Notes |
|--------------------------------|--|------|------|-------|-------|-------|
| V <sub>TX-DIFFp-p-Level0</sub> | Differential Peak-to-peak Output Voltage Level 0 | 0.18 | 0.2  | 0.22  | V     | 1,2   |
| V <sub>TX-DIFFp-p-Level1</sub> | Differential Peak-to-peak Output Voltage Level 1 | 0.2  | 0.25 | 0.275 | V     | 1,2   |
| V <sub>TX-DIFFp-p-Level2</sub> | Differential Peak-to-peak Output Voltage Level 2 | 0.27 | 0.3  | 0.33  | V     | 1,2   |

**Table 130. Embedded Display Port DC Specification**

| Symbol                         | Parameter  | Min   | Typ  | Max   | Units | Notes |
|--------------------------------|--|-------|------|-------|-------|-------|
| V <sub>TX-DIFFP-p-Level3</sub> | Differential Peak-to-peak Output Voltage Level 3         | 0.315 | 0.35 | 0.385 | V     | 1,2   |
| V <sub>TX-DIFFP-p-Level4</sub> | Differential Peak-to-peak Output Voltage Level 4         | 0.36  | 0.4  | 0.44  | V     | 1,2   |
| V <sub>TX-DIFFP-p-Level5</sub> | Differential Peak-to-peak Output Voltage Level 5         | 0.405 | 0.45 | 0.495 | V     | 1,2   |
| V <sub>TX-DIFFP-p-MAX</sub>    | Maximum Allowed Differential Peak-to-peak Output Voltage |       |      | 1.380 | V     | 3     |
| V <sub>TX-DC-CM</sub>          | Tx DC Common Mode Voltage                                | 0     |      | 2.0   | V     | 1,2,3 |
| V <sub>TX-PREEMP-RATIO</sub>   | No Pre-emphasis  | 0.0   | 0.0  | 0.0   | dB    | 1,2,3 |
|                                | 3.5 dB Pre-emphasis                                      | 2.8   | 3.5  | 4.2   | dB    | 1,2,3 |
|                                | 6.0 dB Pre-emphasis                                      | 4.8   | 6.0  | 7.2   | dB    | 1,2,3 |
|                                | 9.5 dB Pre-emphasis                                      | 7.5   | 9.5  | 11.4  | dB    | 1,2,3 |
| RL <sub>TX-DIFF</sub>          | Differential Return Loss at 0.675GHz at Tx Package pins  | 12    |      |       | dB    | 4     |
|                                | Differential Return Loss at 1.35 GHz at Tx Package pins  | 9     |      |       | dB    | 4     |
| C <sub>TX</sub>                | TX Output Capacitance                                    |       |      | 1.5   | pF    | 5     |

**NOTES:**

1. Steps between VTX-DIFFP-P voltages must be monotonic. The actual VTX-DIFFP-P-1 voltage must be equal to or greater than the actual VTX-DIFFP-P-0 voltage; the actual VTX-DIFFP-P-2 voltage must be greater than the actual VTX-DIFFP-P-1 voltage; etc.
2. The recommended minimum VTX-DIFFP-P delta between adjacent voltages is mV.
3. Allows eDP Source devices to support differential signal voltages compatible with eDP v1.3 (and lower) devices and designs.
4. Straight loss line between 0.675 GHz and 1.35 GHz.
5. Represents only the effective lump capacitance seen at the SoC interface that shunts the TX termination.





### 19.6.1.4 Display Port AUX Channel DC Specification

**Table 131. DDI AUX Channel DC Specification**

| Symbol            | Parameter   | Min  | Typ | Max  | Units    | Notes |
|-------------------|---|------|-----|------|----------|-------|
| $V_{AUX-DIFFp-p}$ | AUX Peak-to-peak Voltage at a transmitting Device | 0.29 |     | 1.38 | V        | 1     |
| $V_{AUX-TERM\_R}$ | AUX CH termination DC resistance                  |      | 100 |      | $\Omega$ |       |
| $V_{AUX-DC-CM}$   | AUX DC Common Mode Voltage                        | 0    |     | 2.0  | V        | 2     |
| $V_{AUX-TURN-CM}$ | AUX turn around common mode voltage               |      |     | 0.3  | V        | 3     |
| $I_{AUX\_SHORT}$  | AUX Short Circuit Current Limit                   |      |     | 90   | mA       | 4     |
| $C_{AUX}$         | AC Coupling Capacitor                             | 75   |     | 200  | nF       | 5     |

**NOTES:**

- $V_{AUX-DIFFp-p} = 2 * |V_{AUXP} - V_{AUXM}|$
- Common mode voltage is equal to  $V_{bias\_Tx}$  (or  $V_{bias\_Rx}$ ) voltage.
- Steady state common mode voltage shift between transmit and receive modes of operation.
- Total drive current of the transmitter when it is shorted to its ground.
- All DisplayPort Main Link lanes as well as AUX CH must be AC coupled. AC coupling capacitors must be placed on the transmitter side. Placement of AC coupling capacitors on the receiver side is optional.

### 19.6.1.5 Embedded Display Port AUX Channel DC Specification

**Table 132. Embedded Display Port AUX Channel DC Specification**

| Symbol            | Parameter   | Min  | Typ | Max  | Units    | Notes |
|-------------------|---|------|-----|------|----------|-------|
| $V_{AUX-DIFFp-p}$ | AUX Peak-to-peak Voltage at a transmitting Device | 0.29 |     | 1.38 | V        | 1     |
| $V_{AUX-TERM\_R}$ | AUX CH termination DC resistance                  |      | 100 |      | $\Omega$ |       |
| $V_{AUX-DC-CM}$   | AUX DC Common Mode Voltage                        | 0    |     | 1.2  | V        | 2     |
| $V_{AUX-TURN-CM}$ | AUX turn around common mode voltage               |      |     | 0.3  | V        | 3     |
| $I_{AUX\_SHORT}$  | AUX Short Circuit Current Limit                   |      |     | 90   | mA       | 4     |
| $C_{AUX}$         | AC Coupling Capacitor                             | 75   |     | 200  | nF       | 5     |

**NOTES:**

- $V_{AUX-DIFFp-p} = 2 * |V_{AUXP} - V_{AUXM}|$
- Common mode voltage is equal to  $V_{bias\_Tx}$  (or  $V_{bias\_Rx}$ ) voltage.
- Steady state common mode voltage shift between transmit and receive modes of operation.



4. Total drive current of the transmitter when it is shorted to its ground.
5. All DisplayPort Main Link lanes as well as AUX CH must be AC coupled. AC coupling capacitors must be placed on the transmitter side. Placement of AC coupling capacitors on the receiver side is optional.

### 19.6.1.6 DDC Signal DC Specification

**Table 133. DDC Signal DC Specification (DCC\_DATA, DDC\_CLK)**

| Symbol           | Parameter          | Min                   | Typ | Max                   | Units | Notes |
|------------------|--------------------|-----------------------|-----|-----------------------|-------|-------|
| V <sub>REF</sub> | I/O Voltage        | GPION_V1P8A_G3        |     |                       | V     |       |
| V <sub>IH</sub>  | Input High Voltage | 0.75*V <sub>REF</sub> |     |                       | V     | 1     |
| V <sub>IL</sub>  | Input Low Voltage  |                       |     | 0.35*V <sub>REF</sub> | V     | 2     |
| V <sub>OL</sub>  | Output Low Voltage |                       |     | 0.45                  | V     | 3     |
| I <sub>i</sub>   | Input Pin Leakage  | -10                   |     | 10                    | μA    | 4     |

**NOTES:**

1. V<sub>IH</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value
2. V<sub>IL</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value.
3. This buffer reaches VOH/VOL with 3mA load.
4. For VIN between 0V and CORE\_VCC\_S0iX. Measured when driver is tri-stated.

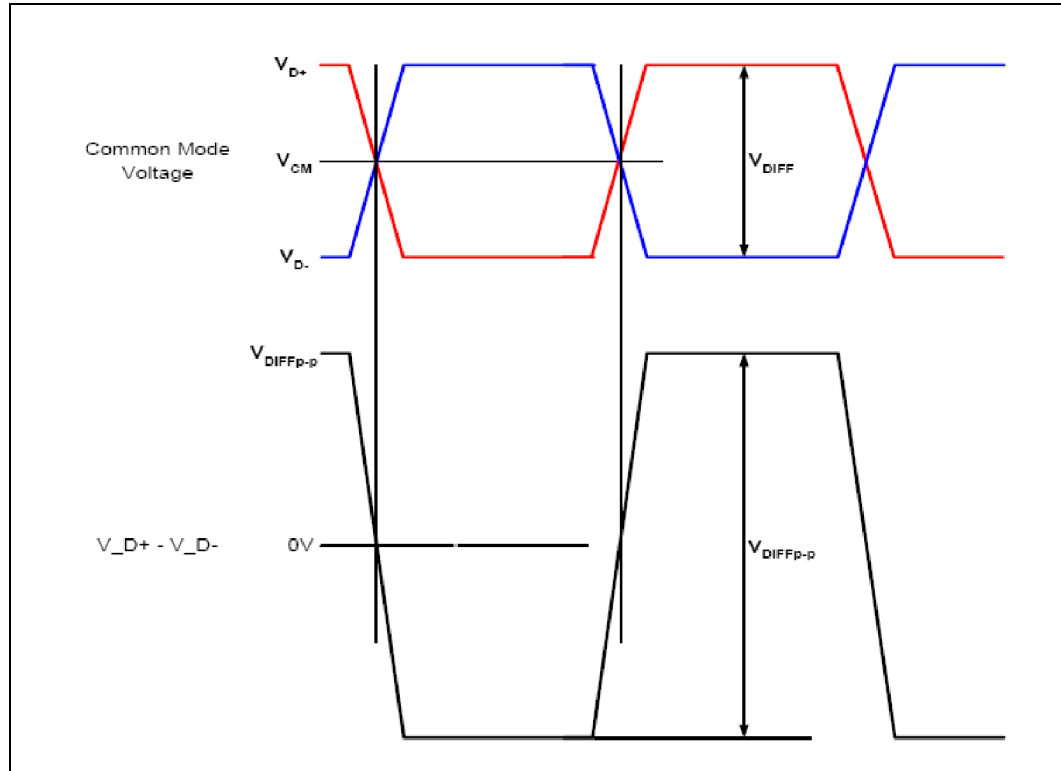
**Table 134. DDC Misc Signal DC Specification (HPD, BKLCTL, VDDEN, BKLTEN)**

| Symbol           | Parameter           | Min                   | Typ | Max                   | Units | Notes |
|------------------|---------------------|-----------------------|-----|-----------------------|-------|-------|
| V <sub>REF</sub> | I/O Voltage         | GPION_V1P8A_G3        |     |                       | V     |       |
| V <sub>IH</sub>  | Input High Voltage  | 0.75*V <sub>REF</sub> |     |                       | V     | 1     |
| V <sub>IL</sub>  | Input Low Voltage   |                       |     | 0.35*V <sub>REF</sub> | V     | 2     |
| Z <sub>pu</sub>  | Pull up Impedance   | 40                    | 50  | 60                    | Ω     | 3     |
| Z <sub>pd</sub>  | Pull down Impedance | 40                    | 50  | 60                    | Ω     | 3     |
| I <sub>i</sub>   | Input Pin Leakage   | -10                   |     | 10                    | μA    | 4     |

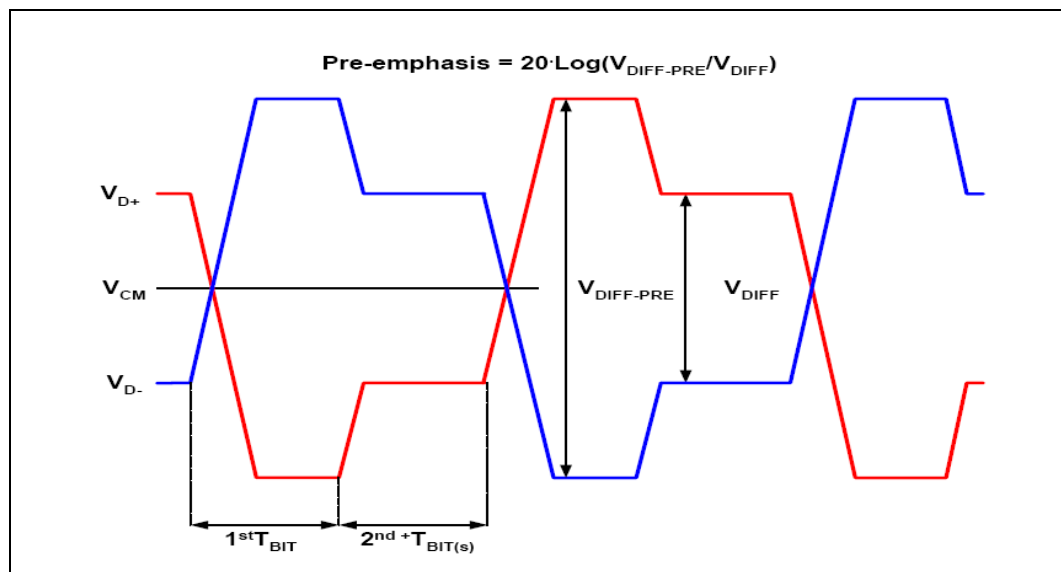
**NOTES:**

1. V<sub>IH</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value.
2. V<sub>IL</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value.
3. Measured at CORE\_VCC0\_S0iX and CORE\_VCC1\_S0iX.
4. For VIN between 0V and CORE\_VCC0\_S0iX and CORE\_VCC1\_S0iX. Measured when driver is tri-stated.
5. This buffer reaches VOH/VOL with 3mA load.

**Figure 35. Definition of Differential Voltage and Differential Voltage Peak-to-Peak**



**Figure 36. Definition of Pre-emphasis**





19.6.1.7 MIPI DSI DC Specification

Table 135. MIPI DSI DC Specification

| Symbol                     | Parameter   | Min. | Nom. | Max. | Unit | Notes |
|----------------------------|---|------|------|------|------|-------|
| ILEAK                      | Pin Leakage current   | -10  | -    | 10   | μA   |       |
| <b>MIPI DSI HS-TX Mode</b> |   |      |      |      |      |       |
| $V_{CMTX}$                 | HS transmit static common-mode voltage                              | 150  | 200  | 250  | mV   |       |
| $ V_{CMTX(1,0)} $          | $V_{CMTX}$ mismatch when output is differential-1 or differential-0 | -    | -    | 5    | mV   |       |
| $ V_{OD} $                 | HS transmit differential voltage                                    | 140  | 200  | 270  | mV   |       |
| $ \Delta V_{OD} $          | $V_{OD}$ mismatch when output is Differential-1 or Differential-0   | -    | -    | 14   | mV   |       |
| $V_{OHHS}$                 | HS output high voltage  | -    | -    | 360  | mV   |       |
| $Z_{OS}$                   | Single-ended output impedance                                       | 40   | 50   | 62.5 | Ω    |       |
| $\Delta Z_{OS}$            | Single-ended output impedance mismatch                              | -    | -    | 10   | %    |       |
| <b>MIPI DSI LP-TX Mode</b> |   |      |      |      |      |       |
| $V_{OH}$                   | Thevenin output high level  | 1.1  | 1.2  | 1.3  | V    |       |
| $V_{OL}$                   | Thevenin output low level   | -50  | -    | 50   | mV   |       |
| $Z_{OLP}$                  | Output impedance of LP transmitter                                  | 50   | -    | -    | Ω    | 1     |
| <b>MIPI DSI LP-RX Mode</b> |   |      |      |      |      |       |
| $V_{IH}$                   | Logic 1 input voltage   | 880  | -    | -    | mV   |       |
| $V_{IL}$                   | Logic 0 input voltage, not in ULP state                             | -    | -    | 550  | mV   |       |
| $V_{HYST}$                 | Input hysteresis  | 25   | -    | -    | mV   |       |
| $V_{IHCD}$                 | Logic 1 Contention threshold  | 450  | -    | -    | mV   |       |
| $V_{ILCD}$                 | Logic 0 Contention threshold  | -    | -    | 200  | mV   |       |

**NOTE:** Deviates from MIPI D-PHY specification Rev 1.0, which has minimum ZOLP of 110 Ω.



## 19.6.2 MIPI-Camera Serial Interface (CSI) DC Specification

**Table 136. MIPI HS-RX/MIPI LP-RX Minimum, Nominal, and Maximum Voltage Parameters**

| Symbol                     | Parameter  | Min. | Typ. | Max. | Unit     | Notes |
|----------------------------|--|------|------|------|----------|-------|
| $I_{LEAK}$                 | Pin Leakage current                              | -10  | -    | 10   | $\mu$ A  |       |
| <b>MIPI-CSI HS-RX Mode</b> |  |      |      |      |          |       |
| $V_{CMRX(DC)}$             | Common-mode voltage HS receive mode              | 70   | -    | 330  | mV       | 1     |
| $V_{IDTH}$                 | Differential input high threshold                | -    | -    | 70   | mV       |       |
| $V_{IDTL}$                 | Differential input low threshold                 | -70  | -    | -    | mV       |       |
| $V_{IHHS}$                 | Single-ended input high voltage                  | -    | -    | 460  | mV       |       |
| $V_{ILHS}$                 | Single-ended input low voltage                   | -40  | -    | -    | mV       |       |
| $V_{TERM-EN}$              | Single-ended threshold for HS termination enable | -    | -    | 450  | mV       |       |
| $Z_{ID}$                   | Differential input impedance                     | 80   | 100  | 125  | $\Omega$ |       |
| <b>MIPI-CSI LP-RX Mode</b> |  |      |      |      |          |       |
| $V_{IH}$                   | Logic 1 input voltage                            | 880  | -    | -    | mV       |       |
| $V_{IL}$                   | Logic 0 input voltage, not in ULP state          | -    | -    | 550  | mV       |       |
| $V_{IL-ULPS}$              | Logic 0 input voltage, ULP state                 | -    | -    | 300  | mV       |       |
| $V_{HYST}$                 | Input hysteresis                                 | 25   | -    | -    | mV       |       |

**NOTE:** 1. Setup/hold violation will be seen for a VCM higher than 250mv.

## 19.6.3 SDIO DC Specification

Table 137 provides the SDIO DC Specification, for all other DC Specifications not listed in this table, refer to Table 160.

**Table 137. SDIO DC Specification**

| Symbol          | Parameter           | Min. | Typ. | Max. | Unit | Notes                         |
|-----------------|---------------------|------|------|------|------|-------------------------------|
| $V_{OH}$        | Output High Voltage | 1.4  | -    | -    | V    | Measured at $I_{OH}$ maximum. |
| $I_{OH}/I_{OL}$ | Current at VoL/Voh  | -2   | -    | -    | mA   |                               |

## 19.6.4 SD Card DC Specification

Table 138 provides the SD Card DC Specification, for all other DC Specifications not listed in in this table, refer to Table 160.



**Table 138. SD Card DC Specification**

| Symbol          | Parameter                  | Min.                  | Max.                  | Unit |
|-----------------|----------------------------|-----------------------|-----------------------|------|
| $V_{REF}$       | I/O Voltage                | SDIO_V3P3A_V1P8A_G3   |                       |      |
| $V_{OH(3.3)}$   | Output High Voltage        | $0.75 \cdot V_{REF}$  | -                     | V    |
| $V_{OL(3.3)}$   | Output Low Voltage         | -                     | $0.125 \cdot V_{REF}$ | V    |
| $V_{IH(3.3)}$   | Input High Voltage (3.3 V) | $0.625 \cdot V_{REF}$ | $V_{REF} + 0.3$       | V    |
| $V_{IL(3.3)}$   | Input Low Voltage (3.3 V)  | VSS-0.3               | $0.25 \cdot V_{REF}$  | V    |
| $V_{OH(1.8)}$   | Output High Voltage        | 1.40                  | -                     | V    |
| $V_{OL(1.8)}$   | Output Low Voltage         | -                     | 0.45                  | V    |
| $V_{IH(1.8)}$   | Input High Voltage (1.8 V) | 1.27                  | 2.00                  | V    |
| $V_{IL(1.8)}$   | Input Low Voltage (1.8 V)  | VSS-0.3               | 0.58                  | V    |
| $I_{OH}/I_{OL}$ | Current at VoL/Voh         | -2                    | 2                     | mA   |
| $C_{LOAD}$      | total Load Capacitance     | -                     | 40                    | pF   |



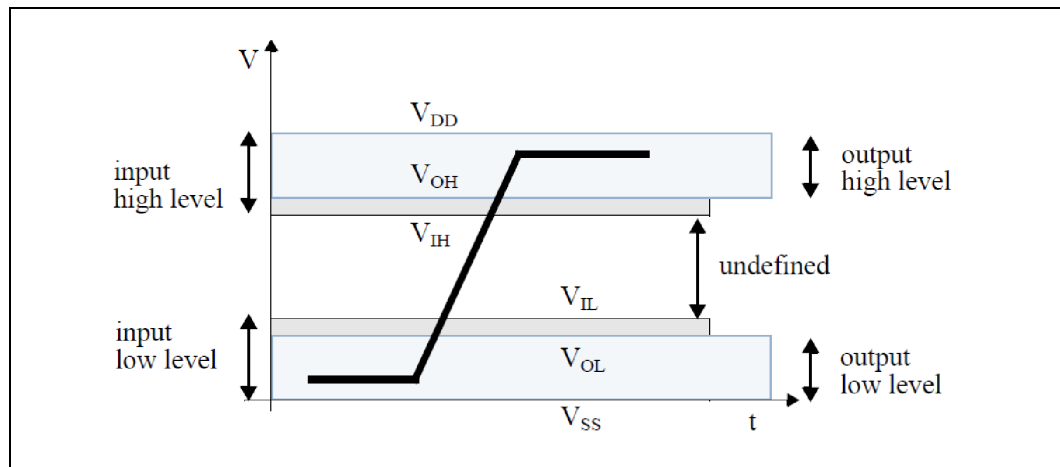
### 19.6.5 eMMC 4.51 DC Specification

**Table 139. eMMC 4.51 DC Electrical Specifications**

| Symbol    | Parameter                   | Min              | Max              | Units   |
|-----------|-----------------------------|------------------|------------------|---------|
| $V_{REF}$ | I/O Voltage                 | GPIOSE_V1P8A_G3  |                  |         |
| $V_{OH}$  | Output HIGH voltage         | $V_{REF} - 0.45$ | -                | V       |
| $V_{OL}$  | Output LOW voltage          | -                | 0.45             | V       |
| $V_{IH}$  | Input HIGH voltage          | $0.65 * V_{REF}$ | $V_{REF} + 0.3$  | V       |
| $V_{IL}$  | Input LOW voltage           | -0.3             | $0.35 * V_{REF}$ | V       |
| $C_L$     | Bus Signal Line capacitance | -                | 30               | pF      |
| $I_{IL}$  | Input Leakage Current       | -10              | 10               | $\mu$ A |
| $I_{OL}$  | Output Leakage Current      | -10              | 10               | $\mu$ A |

**NOTE:** This buffer reaches VOH/VOL with 3mA load.

**Figure 37. eMMC 4.51 DC Bus Signal Level**



### 19.6.6 JTAG DC Specification

**Table 140. JTAG Signal Group DC Specification (JTAG\_TCK, JTAG\_TMS, JTAG\_TDI, JTAG\_TRST\_N) (Sheet 1 of 2)**

| Symbol    | Parameter              | Min              | Typ | Max              | Units     | Notes |
|-----------|------------------------|------------------|-----|------------------|-----------|-------|
| $V_{REF}$ | I/O Voltage            | GPION_V1P8A_G3   |     |                  |           |       |
| $V_{IH}$  | Input High Voltage     | $0.75 * V_{REF}$ |     |                  | V         | 1     |
| $V_{IL}$  | Input Low Voltage      |                  |     | $0.35 * V_{REF}$ | V         | 2     |
| $R_{wpu}$ | Weak Pull Up Impedance | 2.5              | 5   | 7.5              | $k\Omega$ | 3     |



**Table 140. JTAG Signal Group DC Specification (JTAG\_TCK, JTAG\_TMS, JTAG\_TDI, JTAG\_TRST\_N) (Sheet 2 of 2)**

| Symbol               | Parameter                    | Min | Typ | Max | Units | Notes |
|----------------------|------------------------------|-----|-----|-----|-------|-------|
| R <sub>wpd</sub>     | Weak Pull Down Impedance     | 2.5 | 5   | 7.5 | kΩ    | 3     |
| R <sub>wpu-20K</sub> | Weak Pull Up Impedance 20K   | 12  |     | 28  | kΩ    | 4     |
| R <sub>wpd-40K</sub> | Weak Pull Down Impedance 40K | 20  |     | 70  | kΩ    | 4     |

**NOTES:**

1. V<sub>IH</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value.
2. V<sub>IL</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value.
3. Measured at GPIO\_V1P8A\_G3.
4. R<sub>wpu\_40k</sub> and R<sub>wpd\_40k</sub> are only used for JTAG\_TRST#.
5. This buffer reaches VOH/VOL with 3mA load.

**Table 141. JTAG Signal Group DC Specification (JTAG\_TDO)**

| Symbol           | Parameter                | Min                   | Typ | Max                   | Units | Notes |
|------------------|--------------------------|-----------------------|-----|-----------------------|-------|-------|
| V <sub>REF</sub> | I/O Voltage              | GPION_V1P8A_G3        |     |                       |       |       |
| V <sub>IH</sub>  | Input High Voltage       | 0.75*V <sub>REF</sub> |     |                       | V     | 1     |
| V <sub>IL</sub>  | Input Low Voltage        |                       |     | 0.45*V <sub>REF</sub> | V     | 2     |
| Z <sub>pd</sub>  | Pull down Impedance      | 17.5                  |     | 35                    | Ω     | 3     |
| R <sub>wpu</sub> | Weak Pull Up Impedance   | 12                    |     | 28                    | kΩ    | 3     |
| R <sub>wpd</sub> | Weak Pull Down Impedance | 20                    |     | 70                    | kΩ    | 3     |

**NOTES:**

1. V<sub>IH</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value.
2. V<sub>IL</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value.
3. Measured at GPIO\_V1P8A\_G3.
4. This buffer reaches VOH/VOL with 3mA load.

**Table 142. JTAG Signal Group DC Specification (JTAG\_PRDY#, JTAG\_PREQ#)**

| Symbol           | Parameter              | Min                   | Typ | Max                   | Units | Notes |
|------------------|------------------------|-----------------------|-----|-----------------------|-------|-------|
| V <sub>REF</sub> | I/O Voltage            | GPION_V1P8A_G3        |     |                       |       |       |
| V <sub>IH</sub>  | Input High Voltage     | 0.75*V <sub>REF</sub> |     |                       | V     | 1     |
| V <sub>IL</sub>  | Input Low Voltage      |                       |     | 0.45*V <sub>REF</sub> | V     | 2     |
| Z <sub>pd</sub>  | Pull down Impedance    | 17.5                  |     | 35                    | Ω     | 3     |
| R <sub>wpu</sub> | Weak Pull Up Impedance | 2.5                   | 5   | 7.5                   | kΩ    | 3     |



**NOTES:**

1.  $V_{IH}$  is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value.
2.  $V_{IL}$  is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value.
3. Measured at GPIO\_V1P8A\_G3.
4. This buffer reaches VOH/VOL with 3mA load.

## 19.6.7 DDR3L-RS Memory Controller DC Specification

**Table 143. DDR3L-RS Signal Group DC Specifications**

| Symbol   | Parameter                                  | Min              | Type   | Max              | Units    | Notes               |
|----------|--|------------------|--|------------------|----------|---------------------|
| $V_{IL}$ | Input Low Voltage                          |                  |  | DDR_VREF - 200mV | V        | 1                   |
| $V_{IH}$ | Input High Voltage                         | DDR_VREF + 200mV |  |                  | V        | 2, 3                |
| $V_{OL}$ | Output Low Voltage                         |                  | $(DDR\_VDDQG\_S4 / 2) * (RON / (RON + RVTT\_TERM))$                    |                  |          | 3,4                 |
| $V_{OH}$ | Output High Voltage                        |                  | $DDR\_VDDQG\_S4 - ((DDR\_VDDQG\_S4 / 2) * (RON / (RON + RVTT\_TERM)))$ |                  | V        | 3,4                 |
| $I_{IL}$ | Input Leakage Current                      |                  |  | 5                | $\mu$ A  | For all DDR Signals |
| $R_{ON}$ | DDR3L-RS Clock Buffer strength             | 26               |  | 40               | $\Omega$ | 5                   |
| $C_{IO}$ | DQ/DQS/DQS#<br>DDR3L-RS IO Pin Capacitance |                  | 3.0  |                  | pF       |                     |

**NOTES:**

1.  $V_{IL}$  is defined as the maximum voltage level at the receiving agent that will be received as a logical low value. DDR\_VREF is normally DDR\_VDDQG\_S4
2.  $V_{IH}$  is defined as the minimum voltage level at the receiving agent that will be received as a logical high value. DDR\_VREF is normally DDR\_VDDQG\_S4
3.  $V_{IH}$  and  $V_{OH}$  may experience excursions above DDR\_VDDQG\_S4. However, input signal drivers must comply with the signal quality specifications.
4. RON is DDR driver resistance whereas RTT\_TERM is DDR ODT resistance which is controlled by DDR.
5. DDR3L-1333 CLK buffer Ron is 26Ohm and SR target is 4V/ns; DQ-DQS buffer Ron is 30Ohms and SR target is 4V/ns; CMD/CTL buffer Ron is 20Ohms and SR target is 1.8V/ns.



### 19.6.8 LPDDR3 Memory Controller DC Specification

Table 144. LPDDR3 Signal Group DC Specifications

| Symbol          | Parameter             | Min               | Typ   | Max               | Units | Notes |
|-----------------|-----------------------|-------------------|-------|-------------------|-------|-------|
| DDR_VDDQG_S4    | I/O Supply Voltage    | 1.14              | 1.24  | 1.26              | V     |       |
| V <sub>IL</sub> | Input Low Voltage     |                   |       | DDR_VREF - 200 mV | V     |       |
| V <sub>IH</sub> | Input High Voltage    | DDR_VREF + 200 mV |       |                   | V     |       |
| V <sub>OL</sub> | Output Low Voltage    | -                 | 0.260 | -                 | V     | 1,2   |
| V <sub>OH</sub> | Output High Voltage   | -                 | 0.960 | -                 | V     | 1,2   |
| I <sub>IL</sub> | Input Leakage Current | -                 | 5     | -                 | μA    | 3,4   |
| R <sub>ON</sub> | Clock Buffer strength | 26                |       | 40                | Ω     |       |
| C <sub>IO</sub> | IO Pin Capacitance    |                   | 3.0   |                   | pF    |       |

**NOTES:**

1. V<sub>OL</sub> and V<sub>OH</sub> is determined with 400ohm buffer strength setting into a 600ohm to 0.5x V1p5\_ddr test load.
2. LPDDR3-1066 CLK buffer Ron is 350ohm and SR target is 2.5V/ns; DQ-DQS buffer Ron is 400ohms and SR target is 2V/ns; CMD/CTL buffer Ron is 300ohms and SR target is 1.5V/ns.
3. Applies to the pin to VCC or VSS leakage current.
4. Applies to the pin to pin leakage current.

### 19.6.9 USB 2.0 Host DC Specification

Table 145. USB 2.0 Host DC Specification (Sheet 1 of 3)

| Symbol                | Parameter                      | Min  | Type | Max  | Units | Notes |
|-----------------------|--------------------------------|------|------|------|-------|-------|
| <b>Supply Voltage</b> |                                |      |      |      |       |       |
| VBUS                  | High-power Port                | 4.75 |      | 5.25 | V     | 2     |
| VBUS                  | Low-power Port                 | 4.20 |      | 5.25 | V     |       |
| <b>Supply Current</b> |                                |      |      |      |       |       |
| ICCPRT                | High-power Hub Port (out)      | 500  |      |      | mA    |       |
| ICCUPT                | Low-power Hub Port (out)       | 100  |      |      | mA    |       |
| ICCHPF                | High-power Function (in)       |      |      | 500  | mA    |       |
| ICCLPF                | Low-power Function (in)        |      |      | 100  | mA    |       |
| ICCINIT               | Unconfigured Function/Hub (in) |      |      | 100  | mA    |       |
| ICCSH                 | Suspended High-power Device    |      |      | 2.5  | mA    | 15    |
| ICCSL                 | Suspended Low-power Device     |      |      | 500  | μA    |       |



Table 145. USB 2.0 Host DC Specification (Sheet 2 of 3)

| Symbol                                   | Parameter  | Min | Type | Max  | Units | Notes                              |
|--|--|-----|------|------|-------|------------------------------------|
| <b>Input Levels for Low-/full-speed</b>  |  |     |      |      |       |                                    |
| VIH                                      | High (driven)  | 2.0 |      |      | V     | 4                                  |
| VIHZ                                     | High (floating)  | 2.7 |      | 3.6  | V     | 4                                  |
| VIL                                      | Low  |     |      | 0.8  | V     | 4                                  |
| VDI                                      | Differential Input Sensitivity   | 0.2 |      |      | V     | $(D+) - (D-)$  ; Figure ; Note 4   |
| VCM                                      | Differential Common Mode Range   | 0.8 |      | 2.5  | V     | Includes VDI range; Figure; Note 4 |
| <b>Input Levels for High-speed</b>       |  |     |      |      |       |                                    |
| VHSSQ                                    | High-speed squelch detection threshold (differential signal amplitude)       | 100 |      | 150  | mV    |                                    |
| VHSDSC                                   | High speed disconnect detection threshold (differential signal amplitude)    | 525 |      | 625  | mV    |                                    |
|  | High-speed differential input signaling levels                               |     |      |      |       | 16                                 |
| VHSCM                                    | High-speed data signaling common mode voltage range (guideline for receiver) | -50 |      | 500  | mV    |                                    |
| <b>Output Levels for Low-/full-speed</b> |  |     |      |      |       |                                    |
| VOL                                      | Low  | 0.0 |      | 0.8  | V     | 4,5                                |
| VOH                                      | High (Driven)  | 2.8 |      | 3.6  | V     | 4,6                                |
| VOSE1                                    | SE1  | 0.8 |      |      | V     |                                    |
| VCRS                                     | Output Signal Crossover Voltage  | 1.3 |      | 2.0  | V     | 10                                 |
| <b>Output Levels for High-speed:</b>     |  |     |      |      |       |                                    |
| VHSOI                                    | High-speed idle level  | -10 |      | 10   | mV    |                                    |
| VHSOH                                    | High-speed data signaling high   | 360 |      | 440  | mV    |                                    |
| VHSOL                                    | High-speed data signaling low  | -10 |      | 10   | mV    |                                    |
| VCHIRPJ                                  | Chirp J level (differential voltage)   | 700 |      | 1100 | mV    |                                    |



Table 145. USB 2.0 Host DC Specification (Sheet 3 of 3)

| Symbol  | Parameter  | Min   | Type | Max   | Units | Notes      |
|---|--|-------|------|-------|-------|------------|
| VCHIRPK                                       | Chirp K level (differential voltage)                                 | -900  |      | -500  | mV    |            |
| <b>Decoupling Capacitance:</b>                |  |       |      |       |       |            |
| CHPB  | Downstream Facing Port Bypass Capacitance (per hub)                  | 120   |      |       | μF    |            |
| CRPB  | Upstream Facing Port Bypass Capacitance                              | 1.0   |      | 10.0  | μF    | 9          |
| <b>Input Capacitance for Low-/full-speed:</b> |  |       |      |       |       |            |
| CIND  | Downstream Facing Port   |       |      | 150   | pF    | 2          |
| CINUB   | Upstream Facing Port (w/o cable)                                     |       |      | 100   | pF    | 3          |
| CEDGE   | Transceiver edge rate control capacitance                            |       |      | 75    | pF    |            |
| <b>Input Impedance for High-speed:</b>        |  |       |      |       |       |            |
|   | TDR spec for high-speed termination                                  |       |      |       |       |            |
| <b>Terminations:</b>                          |  |       |      |       |       |            |
| RPU   | Bus Pull-up Resistor on Upstream Facing Port                         | 1.425 |      | 1.575 | kΩ    | 1.5 kΩ ±5% |
| RPD   | Bus Pull-down Resistor on Downstream Facing Port                     | 14.25 |      | 15.75 | kΩ    | 1.5 kΩ ±5% |
| ZINP  | Input impedance exclusive of pull-up/pull-down (for low-/full speed) | 300   |      |       | kΩ    |            |
| VTERM   | Termination voltage for upstream facing port pull-up (RPU)           | 3.0   |      | 3.6   | V     |            |
| <b>Terminations in High-speed:</b>            |  |       |      |       |       |            |
| VHSTERM                                       | Termination voltage in high speed                                    | -10   |      | 10    | mV    |            |
| RTERM   | High Speed Termination   | 40    | 45   | 50    | Ω     |            |
| VBUSD   | VBUS Voltage drop for detachable cables                              | -     | -    | 1     | mV    |            |

**NOTES:**

1. Measured at A plug.
2. Measured at A receptacle.
3. Measured at B receptacle.
4. Measured at A or B connector.
5. Measured with RL of 1.425 kΩ to 3.6 V.



6. Measured with RL of 14.25 kΩ to GND.
7. Timing difference between the differential data signals.
8. Measured at crossover point of differential data signals.
9. The maximum load specification is the maximum effective capacitive load allowed that meets the target VBUS drop of 330 mV.
10. Excluding the first transition from the Idle state.
11. The two transitions should be a (nominal) bit time apart.
12. For both transitions of differential signaling.
13. Must accept as valid EOP.
14. Single-ended capacitance of D+ or D- is the capacitance of D+/D- to all other conductors and, if present, shield in the cable. That is, to measure the single-ended capacitance of D+, short D-, VBUS, GND, and the shield line together and measure the capacitance of D+ to the other conductors .
15. For high power devices (non-hubs) when enabled for remote wakeup.
16. Specified by eye pattern templates.

### 19.6.10 USB HSIC DC Specification

**Table 146. USB HSIC DC Electrical Specifications**

| Symbol           | Parameter                      | Min                     | Max                     | Units |
|------------------|--------------------------------|-------------------------|-------------------------|-------|
| V <sub>REF</sub> | I/O Voltage                    | USBHSIC_V1P2A_G3        |                         |       |
| V <sub>OH</sub>  | Output HIGH voltage            | 0.75 * V <sub>REF</sub> | -                       | V     |
| V <sub>OI</sub>  | Output LOW voltage             | -                       | 0.25 * V <sub>REF</sub> | V     |
| V <sub>IH</sub>  | Input HIGH voltage             | 0.65 * V <sub>REF</sub> | V <sub>REF</sub> + 0.3  | V     |
| V <sub>IL</sub>  | Input LOW voltage              | -0.3                    | 0.35 * V <sub>REF</sub> | V     |
| O <sub>D</sub>   | I/O Pad Drive Strength         | 40                      | 60                      | Ω     |
| C <sub>L</sub>   | Load capacitance               | 1                       | 5                       | pF    |
| Z <sub>I</sub>   | I/O input impedance            | 240                     | -                       | kΩ    |
| T <sub>I</sub>   | Characteristic Trace Impedance | 45                      | 55                      | Ω     |

### 19.6.11 USB 3.0 DC Specification

**Table 147. USB 3.0 DC transmitter specifications**

| Symbol                      | Parameter  | Min    | Max    | Units | Notes |
|-----------------------------|--|--------|--------|-------|-------|
| UI                          | Unit Interval  | 199.94 | 200.06 | ps    | 4     |
| V <sub>TX-DIFF-PP</sub>     | Differential peak-peak Tx voltage swing                        | 0.8    | 1.2    | V     |       |
| V <sub>TX-DIFF-PP-LOW</sub> | Low-Power Differential peak-peak Tx voltage swing              | 0.4    | 1.2    | V     | 1     |
| R <sub>TX-DIFF-DC</sub>     | DC differential impedance                                      | 72     | 92     | Ω     |       |
| V <sub>TX-RCV-DETECT</sub>  | The amount of voltage change allowed during Receiver Detection |        | 0.6    | V     | 2     |



| Symbol                    | Parameter                            | Min | Max  | Units | Notes    |
|---------------------------|--------------------------------------|-----|------|-------|----------|
| C <sub>AC-COUPLING</sub>  | AC Coupling Capacitor                | 75  | 200  | nF    | 3        |
| T <sub>CDR-SLEW-MAX</sub> | Maximum slew rate                    |     | 10   | ms/s  |          |
| C <sub>TX-PARASITIC</sub> | Tx input capacitance for return loss | -   | 1.25 | pf    | 5        |
|                           | Eye Height                           | 100 | 1200 | mV    | 7,9      |
| Dj                        | Deterministic Jitter                 | -   | 0.43 | UI    | 7,8,9    |
| Rj                        | Random Jitter                        | -   | 0.23 | UI    | 6,7,8,10 |
| Tj                        | Total Jitter                         | -   | 0.66 | UI    | 7,8,9    |

**NOTES:**

1. There is no de-emphasis requirement in this mode. De-emphasis is implementation specific for this mode.
2. Detect voltage transition should be an increase in voltage on the pin looking at the detect signal to avoid a high impedance requirement when an "off" receiver's input goes below output.
3. All transmitters shall be AC coupled. The AC coupling is required either within the media or within the transmitting component itself.
4. The specified UI is equivalent to a tolerance of +-300 ppm for each device. period does not account for SSC induced variations.
5. parasitic capacitance to ground.
6. Measured over 10<sup>6</sup> consecutive UI and extrapolated to 10<sup>-12</sup> BER.
7. Measured after receiver equalization function.
8. Measured at the end of reference channel and cables at TP1.
9. The eye height is measured at the maximum opening.
10. The Rj spec is calculated at 14.069 times the RMS random jitter for 10<sup>-12</sup> BER.

**Table 148. USB 3.0 DC LFPS specifications**

| Symbol                          | Parameter                                  | Min | Max  | Units | Notes |
|---------------------------------|--|-----|------|-------|-------|
| T <sub>PERIOD</sub>             |  | 20  | 100  | ns    |       |
| V <sub>CM-AC-LFPS</sub>         |  | -   | 10   | mV    |       |
| V <sub>CM-AC-LFPS-ACTIVE</sub>  |  | -   | 10   | mV    |       |
| V <sub>TX-DIFF-PP-LFPS</sub>    | peak-peak Differential amplitude           | 0.8 | 1.2  | V     |       |
| V <sub>TX-DIFF-PP-LFPS-LP</sub> | Low power peak-peak Differential amplitude | 0.4 | 0.6  | V     |       |
| T <sub>RISEFALL2080</sub>       |  | -   | 4    | ns    |       |
| Duty cycle                      |  | 40  | 60   | %     |       |
| C <sub>TX-PARASITIC</sub>       | Tx input capacitance for return loss       | -   | 1.25 | pf    |       |



Table 149. USB 3.0 DC Receiver specifications

| Symbol                          | Parameter  | Min    | Max    | Units  | Notes |
|---------------------------------|--|--------|--------|--------|-------|
| UI                              | Unit Interval  | 199.94 | 200.06 | ps     | 1     |
| R <sub>RX-DC</sub>              | Receiver DC common mode impedance                    | 18     | 30     | Ω      | 2     |
| R <sub>RX-DIFF-DC</sub>         | DC differential impedance                            | 72     | 120    | Ω      | 3     |
| Z <sub>RX-HIGH-IMP-DCPOS</sub>  | DC input CM input for V>0 during reset or power down | 25     | -      | kΩ     | 4     |
| V <sub>RX-LFPS-DETDIFFp-p</sub> | LFPS detect threshold                                | 100    | 300    | mV     |       |
| f <sub>1</sub>                  | tolerance corner                                     | -      | 4.9    | MHz    |       |
| J <sub>RJ</sub>                 | Random Jitter  | -      | 0.0121 | UI rms | 1     |
| J <sub>RJP-P</sub>              | Random Jitter peak-peak at 10 <sup>-12</sup>         | -      | 0.17   | UI p-p | 1,4   |
| S <sub>j @0.5MHz</sub>          | Sinusoidal Jitter                                    | -      | 2      | UI p-p | 1,2,3 |
| S <sub>j @1MHz</sub>            | Sinusoidal Jitter                                    | -      | 1      | UI p-p | 1,2,3 |
| S <sub>j @2MHz</sub>            | Sinusoidal Jitter                                    | -      | 0.5    | UI p-p | 1,2,3 |
| S <sub>j @f1MHz</sub>           | Sinusoidal Jitter                                    | -      | 0.2    | UI p-p | 1,2,3 |
| S <sub>j @50MHz</sub>           | Sinusoidal Jitter                                    | -      | 0.2    | UI p-p | 1,2,3 |
| V <sub>full_swing</sub>         | transition bit differential voltage swing            | -      | 0.75   | V p-p  | 1     |
| V <sub>EQ_level</sub>           | Non transition bit voltage (equalization)            | -      | -3     | db     | 1     |

**NOTES:**

1. All parameters are measured at TP1.
2. Due to time limitations at compliance testing, only a subset of frequencies can be tested. however, the Rx is required to tolerate Pj at all frequencies between the compliance test points.
3. During the Rx tolerance test, SSC is generated by test equipment and present all the time.
4. Random jitter is also present during the Rx tolerance test.



### 19.6.12 SSIC DC Specification

Table 150. SSIC DC Specification

| Symbol                     | Parameter  | Min. | Nom. | Max. | Unit      |
|----------------------------|--|------|------|------|-----------|
| $R_{REF\_RT}$              | Reference load for when the Transmitter is terminated.   |      | 100  |      | $\Omega$  |
| $R_{REF\_NT}$              | Reference load for when the Transmitter is not terminated.   | 10   |      |      | $k\Omega$ |
| $Z_R$                      | Reference impedance.   |      | 100  |      | $\Omega$  |
| $V_{DIFF\_DC\_LA\_RT\_TX}$ | Large Amplitude differential TX DC voltage when the Transmitter is terminated. Defined for $R_{REF\_RT}^1$ and test pattern <sup>2</sup>     | 160  |      | 240  | mV        |
| $V_{DIFF\_DC\_LA\_NT\_TX}$ | Large Amplitude differential TX DC voltage when the Transmitter is not terminated. Defined for $R_{REF\_NT}^3$ and test pattern <sup>2</sup> | 320  |      | 480  | mV        |
| $V_{DIFF\_DC\_SA\_RT\_TX}$ | Small Amplitude differential TX DC voltage when the Transmitter is terminated. Defined for $R_{REF\_RT}^1$ and test pattern <sup>2</sup>     | 100  |      | 130  | mV        |
| $V_{DIFF\_DC\_SA\_NT\_TX}$ | Small Amplitude differential TX DC voltage when the Transmitter is not terminated. Defined for $R_{REF\_NT}^3$ and test pattern <sup>2</sup> | 200  |      | 260  | mV        |





Table 150. SSIC DC Specification

| Symbol           | Parameter   | Min. | Nom. | Max. | Unit |
|------------------|---|------|------|------|------|
| $V_{CM\_LA\_TX}$ | Large Amplitude common-mode TX voltage. Defined $R_{REF\_RT}^1$ and test pattern <sup>2</sup> | 160  |      | 260  | mV   |
| $V_{CM\_SA\_TX}$ | Small Amplitude common-mode TX voltage. Defined $R_{REF\_RT}^1$ and test pattern <sup>2</sup> | 80   |      | 190  | mV   |
| $C_{PIN\_RX}$    | PIN Capacitance   | -    |      | 1.5  | pF   |

**NOTES:**

1. External reference load  $R_{REF\_RT}$  and a reference impedance  $Z_{REF\_RT}$  that conform to  $SRL_{REF\_RT}$  (return loss of  $Z_{REF\_RT}$ ).
2. Defined when driving both a DIF-N and a DIF-P LINE state.
3. External reference load  $R_{REF\_NT}$  and capacitances at TXDP and at TXDN within the limit of  $C_{PIN\_RX}$ .

### 19.6.13 LPC DC Specification

Table 151. LPC 1.8V Signal Group DC Specification

| Symbol     | Parameter             | Min       | Typ  | Max       | Units   | Notes |
|------------|-----------------------|-----------|------|-----------|---------|-------|
| $V_{IH}$   | Input High Voltage    | 1.5       | 1.8  | 1.8 +0.5  | V       |       |
| $V_{IL}$   | Input Low Voltage     | -0.5      | 0    | 0.8       | V       |       |
| $V_{OH}$   | Output High Voltage   | 0.9 x 1.8 |      |           | V       |       |
| $V_{OL}$   | Output Low Voltage    |           |      | 0.1 x 1.8 | V       |       |
| $I_{OH}$   | Output High Current   |           | 0.5  |           | mA      |       |
| $I_{OL}$   | Output Low Current    |           | -1.5 |           | mA      |       |
| $I_{LEAK}$ | Input Leakage Current | -10       |      | 10        | $\mu$ A |       |
| $C_{IN}$   | Input Capacitance     |           |      | 10        | pF      |       |

Table 152. LPC 3.3V Signal Group DC Specification (Sheet 1 of 2)

| Symbol   | Parameter           | Min  | Typ | Max      | Units | Notes |
|----------|---------------------|------|-----|----------|-------|-------|
| $V_{IH}$ | Input High Voltage  | 2.0  | 3.3 | 3.3 +0.5 | V     | 1     |
| $V_{IL}$ | Input Low Voltage   | -0.5 | 0   | 0.8      | V     | 2     |
| $V_{OH}$ | Output High Voltage | 2.5  |     |          | V     | 3     |

**Table 152. LPC 3.3V Signal Group DC Specification (Sheet 2 of 2)**

| Symbol            | Parameter             | Min | Typ  | Max | Units | Notes |
|-------------------|-----------------------|-----|------|-----|-------|-------|
| V <sub>OL</sub>   | Output Low Voltage    |     |      | 0.4 | V     | 3     |
| I <sub>OH</sub>   | Output High Current   |     | 0.5  |     | mA    | 3     |
| I <sub>OL</sub>   | Output Low Current    |     | -1.5 |     | mA    | 3     |
| I <sub>LEAK</sub> | Input Leakage Current | -10 |      | 10  | μA    |       |
| C <sub>IN</sub>   | Input Capacitance     |     |      | 10  | pF    |       |

**NOTES:**

1. V<sub>IH</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value, Applies to LPC\_AD[3:0], LPC\_CLKRUN\_N.
2. V<sub>IL</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value. Applies to LPC\_AD[3:0], ILB\_LPC\_CLKRUN\_N.
3. V<sub>OH</sub> is tested with I<sub>out</sub>=500uA, V<sub>OL</sub> is tested with I<sub>out</sub>=1500uA.
4. Applies to LPC\_AD[3:0],LPC\_CLKRUN\_N and LPC\_FRAME\_N.
5. LPC\_SERIRQ is always a 1.8V I/O irrespective of the value of LPC\_V1P8V3P3\_S4.

### 19.6.14 SPI and FST\_SPI DC Specification

**Table 153. SPI and FST\_SPI Signal Group DC Specification**

| Symbol           | Parameter           | Min                     | Typ | Max                     | Units | Notes |
|------------------|---------------------|-------------------------|-----|-------------------------|-------|-------|
| V <sub>REF</sub> | I/O Voltage         | GPIOSE_1P8A_G3          |     |                         | V     | 3     |
| V <sub>IH</sub>  | Input High Voltage  | 0.65 * V <sub>REF</sub> |     |                         | V     | 2     |
| V <sub>IL</sub>  | Input Low Voltage   | -0.5                    |     | 0.35 * V <sub>REF</sub> | V     | 2     |
| V <sub>OH</sub>  | Output High Voltage | V <sub>REF</sub> - 0.45 |     | 1.8V                    | V     | 1     |
| V <sub>OL</sub>  | Output Low Voltage  |                         |     | 0.45                    | V     | 1     |
| I <sub>OH</sub>  | Output High Current |                         |     | 2                       | mA    | 1     |
| I <sub>OL</sub>  | Output Low Current  | -2                      |     |                         | mA    | 1     |

**NOTES:**

1. Applies to SPI1\_CS[1:0], SPI1\_CLK, SPI1\_MOSI.
2. Applies to SPI1\_MISO and SPI1\_MOSI.
3. The I/O buffer supply voltage is measured at the SoC package pins. The tolerances shown are inclusive of all noise from DC up to 20 MHz. In testing, the voltage rails should be measured with a bandwidth limited oscilloscope that has a rolloff of 3 dB/decade above 20 MHz.
4. This buffer reaches VOH/VOL with 3mA load.



## 19.6.15 Power Management/Thermal (PMC) and RTC DC Specification

**Table 154. Power Management Signal Group DC Specification**

| Symbol           | Parameter           | Min                     | Typ | Max                     | Units | Notes |
|------------------|---------------------|-------------------------|-----|-------------------------|-------|-------|
| V <sub>REF</sub> | I/O Voltage         | GPIOSE_1P8A_G3          |     |                         | V     |       |
| V <sub>IH</sub>  | Input High Voltage  | 0.65 * V <sub>REF</sub> |     |                         | V     | 2     |
| V <sub>IL</sub>  | Input Low Voltage   | -0.5                    |     | 0.35 * V <sub>REF</sub> | V     | 2,3   |
| V <sub>OH</sub>  | Output High Voltage | V <sub>REF</sub> - 0.45 |     | 1.8V                    | V     | 1     |
| V <sub>OL</sub>  | Output Low Voltage  |                         |     | 0.45                    | V     | 1     |
| I <sub>OH</sub>  | Output High Current |                         |     | 2                       | mA    | 1     |
| I <sub>OL</sub>  | Output Low Current  | -2                      |     |                         | mA    | 1     |

**NOTES:**

- The data in this table apply to signals - PMC\_ACPRESENT, PMC\_BATLOW\_N, PMC\_PLTRST\_N, PMC\_PWRBTN\_N, PMC\_SLP\_S4\_N, PMC\_SUS\_STAT\_N, PMC\_SUSCLK[3:0], PMC\_SUSPWRDNACK
- V<sub>IH</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value
- V<sub>IL</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value.
- This buffer reaches VOH/VOL with 3mA load.

**Table 155. PMC\_RSTBTN# 1.8V Core Well Signal Group DC Specification**

| Symbol           | Parameter          | Min                    | Typ | Max                    | Units | Notes |
|------------------|--------------------|------------------------|-----|------------------------|-------|-------|
| V <sub>REF</sub> | I/O Voltage        | UNCORE_V1P8_G3         |     |                        | V     |       |
| V <sub>IH</sub>  | Input High Voltage | 0.65* V <sub>REF</sub> |     |                        | V     | 1     |
| V <sub>IL</sub>  | Input Low Voltage  |                        |     | 0.35* V <sub>REF</sub> | V     | 2     |

**NOTES:**

- V<sub>IH</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value.
- V<sub>IL</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value.

**Table 156. Power Management and RTC Well Signal Group DC Specification**

| Symbol           | Parameter          | Min            | Typ | Max  | Units | Notes |
|------------------|--------------------|----------------|-----|------|-------|-------|
| V <sub>REF</sub> | I/O Voltage        | RTC_V3P3RTC_G5 |     |      |       |       |
| V <sub>IH</sub>  | Input High Voltage | 2.0            | -   | -    | V     | 1     |
| V <sub>IL</sub>  | Input Low Voltage  | -              | -   | 0.78 | V     | 2     |

**NOTES:**

- V<sub>IH</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value.
- V<sub>IL</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value.



**Table 157. RTC Well DC Specification**

| Symbol          | Parameter          | Min | Typ | Max  | Units | Notes |
|-----------------|--------------------|-----|-----|------|-------|-------|
| V <sub>IH</sub> | Input High Voltage | 2.3 | -   | -    | V     | 1     |
| V <sub>IL</sub> | Input Low Voltage  | -   | -   | 0.78 | V     | 2     |

**NOTES:**

1. V<sub>IH</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value.
2. V<sub>IL</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value.

**Table 158. PROCHOT# Signal Group DC Specification**

| Symbol           | Parameter          | Min                   | Type | Max                     | Units | Notes |
|------------------|--------------------|-----------------------|------|-------------------------|-------|-------|
| V <sub>REF</sub> | I/O Voltage        | GPION_V1P8A_G3        |      |                         |       |       |
| V <sub>IH</sub>  | Input High Voltage | 0.75*V <sub>REF</sub> |      | V <sub>REF</sub>        | V     | 1     |
| V <sub>IL</sub>  | Input Low Voltage  |                       |      | 0.45*V <sub>REF</sub>   | V     | 2     |
| V <sub>OL</sub>  | Output Low Voltage |                       |      | 0.35 * V <sub>REF</sub> | V     |       |
| I <sub>OL</sub>  | Output Low Current |                       |      | -5                      | mA    |       |

**NOTES:**

1. V<sub>IH</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical high value
2. V<sub>IL</sub> is defined as the minimum voltage level at a receiving agent that will be interpreted as a logical low value.
3. This buffer reaches VOH/VOL with 3mA load.

### 19.6.16 SVID DC Specification

**Table 159. SVID Signal Group DC Specification (SVID\_DATA, SVID\_CLK, SVID\_ALERT\_N)**

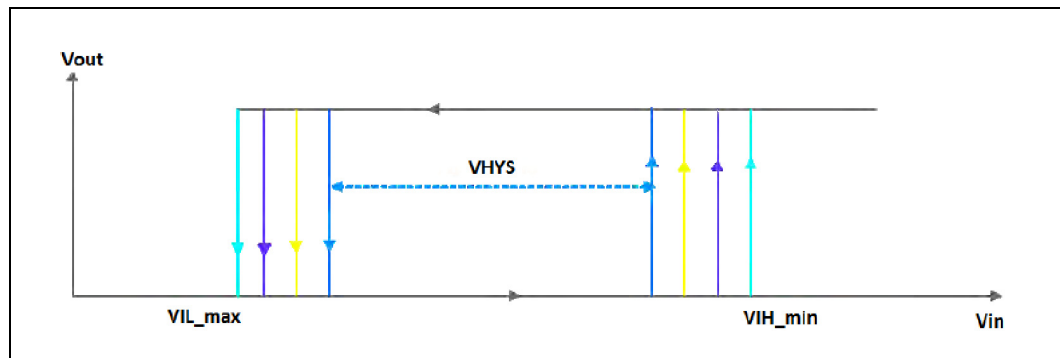
| Symbol           | Parameter            | Min                     | Typ | Max                   | Units | Notes |
|------------------|----------------------|-------------------------|-----|-----------------------|-------|-------|
| V <sub>REF</sub> | I/O Voltage          | GPION_V1P8A_G3          |     |                       |       |       |
| V <sub>IH</sub>  | Input High Voltage   | 0.65*V <sub>REF</sub>   |     |                       | V     | 1     |
| V <sub>IL</sub>  | Input Low Voltage    |                         |     | 0.35*V <sub>REF</sub> | V     | 1     |
| V <sub>OH</sub>  | Output High Voltage  | V <sub>REF</sub> - 0.45 |     | V <sub>REF</sub>      | V     | 1     |
| V <sub>OL</sub>  | Output Low Voltage   |                         |     | 0.45                  | V     | 4     |
| V <sub>HYS</sub> | Hysteresis Voltage   | 0.1                     |     |                       | V     |       |
| R <sub>ON</sub>  | Buffer on Resistance | 40                      |     | 60                    | Ω     | 2     |
| I <sub>L</sub>   | Leakage Current      | -10                     |     | 10                    | μA    | 3     |
| C <sub>PAD</sub> | Pad Capacitance      |                         |     | 9                     | pF    | 4     |
| V <sub>PIN</sub> | Pin Capacitance      |                         |     | 10                    | pF    |       |
| Z <sub>pd</sub>  | Pull down Impedance  | 35                      | 50  | 70                    | Ω     |       |



**NOTES:**

1. GPIO\_V1P8A\_G3 refers to instantaneous voltage VSS\_SENSE.
2. Measured at  $0.31 * \text{GPIO\_V1P8A\_G3}$ .
3.  $V_{IN}$  between 0V and GPIO\_V1P8A\_G3.
4. CPAD includes die capacitance only. No package parasitic included.
5. This buffer reaches VOH/VOL with 3mA load.

**Figure 38. Definition of VHYS**



### 19.6.17 GPIO DC Specification

GPIO Buffer DC specifications.

**Table 160. GPIO 1.8V Core Well Signal Group DC Specification**

| Symbol     | Parameter           | Min                              | Typ | Max              | Units | Notes |
|------------|---------------------|----------------------------------|-----|------------------|-------|-------|
| $V_{REF}$  | I/O Voltage         | GPIO_V1P8A_G3<br>GPIOSE_V1P8A_G3 |     |                  |       |       |
| $V_{IH}$   | Input High Voltage  | $0.65 * V_{REF}$                 |     |                  | V     |       |
| $V_{IL}$   | Input Low Voltage   |                                  |     | $0.35 * V_{REF}$ | V     |       |
| $V_{OH}$   | Output High Voltage | $V_{REF} - 0.45$                 |     | $V_{REF}$        | V     |       |
| $V_{OL}$   | Output Low Voltage  |                                  |     | 0.45             | V     |       |
| $V_{Hys}$  | Input Hysteresis    | 0.1                              |     |                  | V     |       |
| $I_L$      | Leakage Current     | -10                              |     | 10               | mA    |       |
| $C_{LOAD}$ | Load Capacitance    | 2                                |     | 75               | pF    |       |

**NOTE:** This buffer reaches VOH/VOL with 3mA load



### 19.6.18 SIO - I<sup>2</sup>C DC Specification

Table 161. I<sup>2</sup>C Signal Electrical Specifications

| Symbol           | Parameter          | Min                    | Typ | Max                    | Units | Notes |
|------------------|--------------------|------------------------|-----|------------------------|-------|-------|
| V <sub>REF</sub> | I/O Voltage        | GPIOSE_V1P8A_G3        |     |                        | V     |       |
| V <sub>IH</sub>  | Input High Voltage | 0.7 * V <sub>REF</sub> |     |                        | V     |       |
| V <sub>IL</sub>  | Input Low Voltage  |                        |     | 0.3 * V <sub>REF</sub> | V     |       |
| V <sub>OL</sub>  | Output Low Voltage |                        |     | 0.2 * V <sub>REF</sub> | V     |       |
| V <sub>Hys</sub> | Input Hysteresis   | 0.1                    |     |                        | V     |       |
| C <sub>PIN</sub> | Pin Capacitance    | 2                      |     | 5                      | pF    |       |

**NOTE:** This buffer reaches VOH/VOL with 3mA load.

### 19.6.19 SIO - UART DC Specification

Refer to GPIO Buffer (1.8V) DC Specification, mentioned [Section 19.6.17, "GPIO DC Specification"](#)

### 19.6.20 I<sup>2</sup>S (Audio) DC Specification

Refer to the GPIO Buffer (1.8V) DC Specification, mentioned [Section 19.6.17, "GPIO DC Specification"](#)

### 19.6.21 PCI Express DC Specification

Table 162. PCI Express DC Receive Signal Characteristics

| Symbol                   | Parameter                    | Min | Type | Max  | Unit | Notes |
|--------------------------|------------------------------|-----|------|------|------|-------|
| V <sub>RXDIFF</sub> Gen1 | Differential RX Peak to Peak | 175 |      | 1200 | mV   | 1     |
| V <sub>RXDIFF</sub> Gen2 | Differential RX Peak to Peak | 100 |      | 1200 | mV   | 1     |

**NOTE:**

1. PCI Express differential peak to peak = 2\*|RXp[x] - RXn[x]|

Table 163. PCI Express DC Transmit Characteristics (Sheet 1 of 3)

| Symbol                  | Parameter                                     | Gen 1  |        | Gen 2  |        | Unit | Notes |
|-------------------------|---|--------|--------|--------|--------|------|-------|
|                         |   | Min    | Max    | Min    | Max    |      |       |
| UI                      | Unit Interval                                 | 399.88 | 400.12 | 199.94 | 200.06 | ps   | 1     |
| V <sub>TX-DIFF-PP</sub> | Differential p-p Tx voltage swing             | 800    | 1200   | 800    | 1200   | mV   |       |
| V <sub>TX-DIFF-LP</sub> | Differential TX Peak to Peak (low power mode) | 400    | 1200   | 400    | 1200   | mV   |       |



Table 163. PCI Express DC Transmit Characteristics (Sheet 2 of 3)

| Symbol                            | Parameter  | Gen 1 |       | Gen 2 |      | Unit     | Notes |
|-----------------------------------|--|-------|-------|-------|------|----------|-------|
|                                   |  | Min   | Max   | Min   | Max  |          |       |
| $V_{TX-DE-RATIO-3.5DB}$           | Tx de-emphasis level   | 3     | 4     | 3     | 4    | db       |       |
| $V_{TX-DE-RATIO-6DB}$             | Tx de-emphasis level   | -     | -     | 5.5   | 6.5  | db       |       |
| $T_{MIN-PULSE}$                   | Instantaneous pulse width  | -     | -     | 0.9   | -    | UI       |       |
| $T_{TX-EYE}$                      | Transmitter Eye including all jitter sources                             | 0.75  | -     | 0.75  | -    | UI       |       |
| $T_{TX-EYE-MEDIAN-to-MAX-JITTER}$ | Maximum time between the jitter median and max deviation from the median | -     | 0.125 | -     | -    | UI       | 2     |
| $T_{TX-HF-DJ-DD}$                 | Tx deterministic jitter > 1.5 MHz  | -     | -     | -     | 0.15 | UI       | 3     |
| $T_{RF-MISMATCH}$                 | Tx rise/fall mismatch  | -     | -     | -     | 0.1  | UI       |       |
| $T_{TX-RISE-FALL}$                | Transmitter rise and fall time   | -     | -     | 0.15  | -    | UI       |       |
| $V_{TX-CM-AC-PP}$                 | Tx AC peak-peak common mode voltage                                      | -     | -     | -     | 150  | mVp<br>p |       |
| $V_{TX-DC-CM}$                    | Transmitter DC common-mode voltage                                       | 0     | 3.6   | 0     | 3.6  | V        | 4     |
| $V_{TX-CM-DC-LINEDELTA}$          | Absolute Delta of DC Common Mode Voltage between D+ and D-               | 0     | 25    | 0     | 25   | mV       |       |
| $Z_{TX-DIFF-DC}$                  | DC differential Tx impedance   | 80    | 120   | -     | 120  | $\Omega$ |       |
| $I_{TX-SHORT}$                    | Transmitter short-circuit current limit                                  | -     | 90    | -     | 90   | mA       | 5     |



**Table 163. PCI Express DC Transmit Characteristics (Sheet 3 of 3)**

| Symbol                                 | Parameter   | Gen 1 |     | Gen 2 |      | Unit | Notes |
|--|---|-------|-----|-------|------|------|-------|
|  |   | Min   | Max | Min   | Max  |      |       |
| V <sub>TX-CM-DC-ACTIVEIDLE-DELTA</sub> | Absolute Delta of DC Common Mode Voltage during L0 and Electrical Idle. | 0     | 100 | 0     | 100  | mV   |       |
| V <sub>TX-IDLE-DIFF-AC-p</sub>         | Electrical Idle Differential Peak Output Voltage                        | 0     | 20  | 0     | 20   | mV   |       |
| V <sub>TX-IDLE-DIFF-DC</sub>           | DC Electrical Idle Differential Output Voltage                          | -     | -   | 0     | 5    | mV   |       |
| T <sub>TX-DJ</sub>                     | Tx deterministic jitter   | -     | -   | -     | 57   | ps   |       |
| T <sub>TX-RJ</sub>                     | Tx Random jitter  | -     | -   | -     | 3.41 | ps   |       |
| T <sub>TX-MEDIAN-to-MAX-JITTER</sub>   | Maximum Transmitter Medium-to-max jitter                                | -     | 77  | -     | -    | ps   |       |
| T <sub>TX-TJ</sub>                     | Total Jitter @ BER 1E-12  | -     | -   | -     | 105  | ps   |       |

**NOTES:**

1. The specified UI is equivalent to a tolerance of +-300 ppm for each RefClk source. period does not account for SSC induced variations. SSC permits a +0, - 5000 ppm modulation of the clock frequency at a modulation rate not to exceed 33 kHz.
2. Measured differentially at zero crossing points after applying the 2.5 GT/s clock recovery function
3. Deterministic jitter only
4. The allowed DC common-mode voltage at a transmitter pin under any conditions.
5. The total single-ended current a transmitter can supply when shorted to ground.

**Table 164. PCI Express DC Clock Request Input Signal Characteristics**

| Symbol           | Parameter          | Min                   | Type | Max                  | Unit | Notes |
|------------------|--------------------|-----------------------|------|----------------------|------|-------|
| V <sub>REF</sub> | I/O Voltage        | UNCORE_V1P8_S4        |      |                      |      |       |
| V <sub>IL</sub>  | Input Low Voltage  |                       |      | 0.3*V <sub>REF</sub> | V    | 1     |
| V <sub>IH</sub>  | Input High Voltage | 0.65*V <sub>REF</sub> |      |                      | V    | 1     |

**NOTE:**

1. 3.3 V refers to UNCORE\_3P3\_S0 for signals in the core well. Refer [Chapter 2, "Physical Interfaces"](#) for signal and power well association.

§







# 20 Ballout and Ball Map

## 20.1 Ballout

Figure 39. Ballout - DDR3L-RS (T3) Top View Part A

|    |                    |                    |                    |                     |                     |                     |                       |  |   |                                       |                      |                                      |                         |
|----|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|-----------------------|--|---|---------------------------------------|----------------------|--------------------------------------|-------------------------|
|    | 25                 | 24                 | 23                 | 22                  | 21                  | 20                  | 19                    | 18   | 17  | 16                                    | 15                   | 14                                   | 13                      |
| AE | PWR_RSVD_0<br>BS   | PWR_RSVD_0<br>BS   | DDR3_M0_DQ3<br>5   | DDR3_M0_DQ3<br>VREF | DDR3_M0_OCA<br>VREF | DDR3_M0_RCO<br>MPPD | ---                   | UART0_DATAI<br>N   | I2C5_DATA                                     | I2C6_CLK/NMIL<br>N                    | ---                  | SD3_RCOMP                            | UART1_RTS_N             |
| AD | VSS                | DDR3_M0_DQ3<br>2   | DDR3_M0_DQ3<br>8   | VSS                 | DDR3_M0_DQ5<br>1    | ---                 | ---                   | MMC1_RESET_<br>N   | VSS   | I2C6_DATA/SD<br>3_WP                  | ---                  | UART1_DATAI<br>N/UART0_DATAI<br>N    | VSS                     |
| AC | DDR3_M0_DQS<br>4_P | DDR3_M0_DM4        | DDR3_M0_DQ3<br>7   | DDR3_M0_DQ4<br>9    | RESERVED            | GPIO_SW93           | LPE_I2S2_FRM          | GPIO_SW78  | I2C2_DATA                                     | NFC_I2C_CLK                           | NFC_I2C_DATA         | UART1_DATAO<br>UT/UART0_DATA<br>AOUT | UART1_CTS_N             |
| AB | DDR3_M0_DQ3<br>3   | DDR3_M0_DQS<br>4_N | DDR3_M0_DQS<br>6_P | DDR3_M0_DQ4<br>8    | RESERVED            | PCIE_CLKREQ0<br>_N  | LPE_I2S2_CLK          | I2C4_DATA/DDI<br>1_DDC_CLK/DDI<br>2_DDC_CLK/MD<br>I2C2_CLK | I2C4_CLK/DDI1<br>_DDC_CLK/DDI<br>2_DDC_CLK/MD | I2C5_CLK                              | LPE_I2S0_DAT<br>AIN  | LPE_I2S1_CLK                         | UART2_DATAO<br>UT       |
| AA | DDR3_M0_DQ3<br>6   | VSS                | DDR3_M0_DQS<br>6_N | DDR3_M0_DQ5<br>2    | VSS                 | DDR3_CORE_P<br>WROK | DDR3_DRAM_P<br>WROK   | VSS  | I2C2_CLK                                      | LPE_I2S0_CLK                          | LPE_I2S0_DAT<br>AOUT | LPE_I2S1_FRM                         | GPIO_SE79               |
| Y  | DDR3_M0_DQ3<br>9   | DDR3_M0_DQ3<br>4   | DDR3_M0_DQ5<br>3   | DDR3_M0_DM6<br>5    | DDR3_M0_DQ5<br>5    | DDR3_M0_DQ5<br>0    | DDR3_M0_DQ5<br>0      | I2C0_DATA  | I2C0_CLK                                      | LPE_I2S0_FRM                          | DDL_VGG_S00X         | LPE_I2S1_DAT<br>AOUT                 | LPE_I2S1_DAT<br>AIN     |
| W  | ---                | ---                | DDR3_M0_DQ4<br>3   | DDR3_M0_DQ4<br>2    | DDR3_M0_DQ6<br>1    | DDR3_M0_DQ5<br>8    | VSS                   | VSS  | VSS   | I2C1_CLK                              | I2C1_DATA            | DDL_VGG_S00X                         | SDIO_V3P3A_<br>V1P8A_G3 |
| V  | DDR3_M0_DQS<br>5_P | DDR3_M0_DM5        | DDR3_M0_DQ4<br>0   | DDR3_M0_DQ4<br>6    | VSS                 | DDR3_M0_DQ5<br>9    | DDR_VDDQG_<br>S4      | LPE_I2S2_DAT<br>AOUT                                       | DDL_VGG_S00X                                  | UNCORE_V1P8<br>A_G3                   | UNCORE_V1P8<br>A_G3  | DDL_VGG_S00X                         | UART0_DATAI<br>N        |
| U  | DDR3_M0_DQS<br>5_N | VSS                | DDR3_M0_DQS<br>7_N | DDR3_M0_DQS<br>7_P  | DDR3_M0_DQ6<br>0    | DDR3_M0_DQ6<br>2    | DDR3_M0_DRA<br>MRST_N | DDR_V1P05A_<br>G3  | LPE_I2S2_DAT<br>AIN                           | DDL_VGG_S00X                          | DDL_VGG_S00X         | DDL_VGG_S00X                         | DDL_VGG_S00X            |
| T  | DDR3_M0_DQ4<br>7   | DDR3_M0_DQ4<br>1   | DDR3_M0_DM7<br>6   | DDR3_M0_DQ5<br>3    | DDR3_M0_DQ6<br>3    | DDR3_M0_DQ5<br>7    | DDR_VDDQG_<br>S4      | VSS  | DDL_VGG_S00X                                  | DDL_VGG_S00X                          | DDL_VGG_S00X         | DDL_VGG_S00X                         | DDL_VGG_S00X            |
| R  | ---                | ---                | DDR3_M0_DQ4<br>4   | DDR3_M0_DQ4<br>5    | VSS                 | VSS                 | VSS                   | DDR_V1P05A_<br>G3  | DDL_V1p05A_<br>S00X                           | DDL_V1p05A_<br>S00X                   | VSS                  | DDL_VGG_S00X                         | DDL_VGG_S00X            |
| P  | DDR3_M0_ODT<br>1   | DDR3_M0_ODT<br>0   | DDR3_M0_CS1<br>_N  | DDR3_M0_CS0<br>_N   | DDR3_M0_WE_<br>N    | DDR3_M0_CAS<br>_N   | DDRSFR_VDDQ<br>G_S4   | VSS  | VSS   | VSS                                   | VSS                  | VSS                                  | RESERVED                |
| N  | DDR3_M0_MA7        | VSS                | DDR3_M0_MA2        | DDR3_M0_RAS<br>_N   | VSS                 | DDR3_M0_MA1<br>0    | DDR3_M0_BS1           | VSS  | VSS   | VSS                                   | CORE_VCC_S0<br>X     | CORE_VCC_S0<br>X                     | VSS                     |
| M  | DDR3_M0_MA1<br>2   | DDR3_M0_MA0        | DDR3_M0_MA1<br>3   | DDR3_M0_MA4         | DDR3_M0_BS0         | DDR3_M0_MA3         | VSS                   | DDR_VDDQG_<br>S4   | VSS   | VSS                                   | CORE_VCC_S0<br>X     | CORE_VCC_S0<br>X                     | VSS                     |
| L  | ---                | ---                | DDR3_M0_MA1        | DDR3_M0_MA5         | VSS                 | DDR_VDDQG_<br>S4    | DDR_VDDQG_<br>S4      | DDR_VDDQG_<br>S4   | CORE_V1p05A<br>_S00X                          | F_V1p05A_S0<br>X                      | CORE_VCC_S0<br>X     | CORE_VCC_S0<br>X                     | UNCORE2_V1P<br>05A_G3   |
| K  | DDR3_M0_MA1<br>1   | DDR3_M0_MA6        | DDR3_M0_MA1<br>5   | DDR3_M0_BS2         | DDR3_M0_CK1<br>_N   | DDR3_M0_CK1<br>_P   | VSS                   | DDR_VDDQG_<br>S4   | CORE_V1p05A<br>_S00X                          | F_V1p05A_S0<br>X                      | CORE_VCC_S0<br>X     | VSS                                  | VSS                     |
| J  | DDR3_M0_MA8        | VSS                | DDR3_M0_CK0<br>_P  | DDR3_M0_CK0<br>_N   | DDR3_M0_DQ2<br>9    | DDR3_M0_DQ3<br>0    | VSS                   | VSS  | VSS   | VSS                                   | CORE_VCC_S0<br>X     | CORE_VCC_S0<br>X                     | VSS                     |
| H  | DDR3_M0_MA1<br>4   | DDR3_M0_MA0<br>9   | DDR3_M0_DQ2<br>7   | DDR3_M0_DQ3<br>1    | VSS                 | DDR3_M0_DQS<br>3_P  | DDR3_M0_DQS<br>3_N    | DDR_V1P05A_<br>G3  | VSS   | VSS                                   | CORE_VCC_S0<br>X     | CORE0_VSFR_<br>G3                    | UNCORE_V1p0<br>5A_S00X  |
| G  | ---                | ---                | DDR3_M0_CKE<br>1   | DDR3_M0_CKE<br>0    | DDR3_M0_DQ2<br>8    | DDR3_M0_DQ2<br>6    | DDR_V1P05A_<br>G3     | CORE_V1p05A<br>_S00X                                       | CORE_V1p05A<br>_S00X                          | VSS                                   | CORE_VCC_S0<br>X     | CORE_VCC_S0<br>X                     | UNCORE_V1p0<br>5A_S00X  |
| F  | DDR3_M0_DQ1<br>9   | DDR3_M0_DQ2<br>3   | DDR3_M0_CKE<br>2   | DDR3_M0_CKE<br>3    | DDR3_M0_DQ2<br>5    | DDR3_M0_DQ2<br>4    | DDR3_M0_DM3           | GPIO_DFX4  | GPIO_N1/C0_B<br>PM3_TX/C1_BP<br>M3_TX         | GPIO_N2/C0_B<br>PM2_TX/C1_BP<br>M2_TX | VSS                  | JTAG_TMS                             | JTAG_TDO                |
| E  | DDR3_M0_DQ1<br>6   | VSS                | DDR3_M0_DQ1<br>1   | DDR3_M0_DQ1<br>3    | VSS                 | DDR3_M0_DQ1<br>0    | DDR3_M0_DQ1<br>0      | VSS  | GPIO_N0/C0_B<br>PM0_TX/C1_BP<br>M0_TX         | GPIO_N4/C0_B<br>PM4_TX/C1_BP<br>M4_TX | VSS                  | JTAG_TCK                             | JTAG_TRST_N             |
| D  | DDR3_M0_DM2        | DDR3_M0_DQ2<br>1   | DDR3_M0_DQ9        | DDR3_M0_DQ1<br>2    | DDR3_M0_DM1         | DDR3_M0_DQ1<br>5    | DDR3_M0_DQS<br>0_P    | DDR3_M0_DQ0  | ISH_GPIO13/C<br>0_BPM2_TX/C1<br>BP            | GPIO_N8/C0_B<br>PM1_TX/C1_BP<br>M1_TX | JTAG2_TMS            | JTAG2_TDO                            | JTAG_PRDY_N             |
| C  | DDR3_M0_DQS<br>2_N | DDR3_M0_DQS<br>2_P | DDR3_M0_DQ1<br>8   | DDR3_M0_DQS<br>1_P  | DDR3_M0_DQS<br>1_N  | DDR3_M0_DQ8         | DDR3_M0_DQS<br>0_N    | DDR3_M0_DQ3  | GPIO_N3/C0_B<br>PM3_TX/C1_BP<br>M3_TX         | GPIO_N6/C0_B<br>PM6_TX/C1_BP<br>M6_TX | JTAG2_TCK            | PMC_SUSCLK2<br>J                     | GPIO_SUS8               |
| B  | PWR_RSVD_0<br>BS   | DDR3_M0_DQ2<br>0   | DDR3_M0_DQ2<br>2   | DDR3_M0_DQ7         | VSS                 | DDR3_M0_DQ5         | ---                   | DDR3_M0_DQ1  | VSS   | GPIO0_RCOMP                           | ---                  | JTAG2_TDI                            | VSS                     |
| A  | PWR_RSVD_0<br>BS   | VSS                | DDR3_M0_DQ1<br>7   | DDR3_M0_DQ4         | DDR3_M0_DQ2         | DDR3_M0_DM0         | ---                   | DDR3_M0_DQ6  | DDR_VDDQG_<br>S4                              | CORE_V1p05A<br>_S00X                  | ---                  | GPIO_SUS0                            | GPIO_SUS9               |

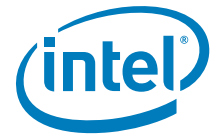


**Ballout and Ball Map**

**Figure 40. Ballout - DDR3L-RS (T3) Top View Part B**

|    | 12              | 11               | 10   | 9                                      | 8                               | 7                 | 6                | 5                                      | 4                                    | 3                                    | 2                                    | 1                       |
|----|-----------------|------------------|--|--|---------------------------------|-------------------|------------------|--|--------------------------------------|--------------------------------------|--------------------------------------|-------------------------|
| AE | UART2_DATAIN    | ---              | MMC1_RCOMP   | SD3_CD_N                               | MMC1_RCLK/MC1_RESET_N           | ---               | DDI_VGG_S0X      | SD2_D[2]                               | SD2_D[1]                             | PMC_PLT_CLK[5]/ISH_GPIO[15]          | RESERVED                             | RESERVED                |
| AD | UART2_CTS_N     | ---              | SD3_D[3]   | VSS                                    | MMC1_CLK                        | ---               | SD2_D[3]_CD_N    | SD2_CLK                                | SD2_D[0]                             | PWM[0]                               | PWM[1]/ISH_GPIO[10]/ISH_UART_DATAOUT | RESERVED                |
| AC | UART2_RTS_N     | FST_SPI_D[1]     | SD3_D[0]   | SD3_CLK                                | MMC1_D[5]                       | MMC1_D[4]         | MMC1_D[3]        | VSS                                    | PMC_PLT_CLK[2]/ISH_GPIO[12]          | PMC_PLT_CLK[4]/ISH_GPIO[14]          | ISH_GPIO[4]/I2S4_CLK                 | ISH_GPIO[7]/I2S4_DATAIN |
| AB | FST_SPI_CLK     | FST_SPI_D[0]     | SD3_D[2]   | SD3_D[1]                               | SD3_1P8_EN                      | MMC1_D[6]         | MMC1_D[2]        | SD2_CMD                                | PMC_PLT_CLK[3]/ISH_GPIO[13]          | ISH_GPIO[2]/I2S3_DATAOUT             | ISH_GPIO[0]/I2S3_CLK                 | ICLK_ICOMP              |
| AA | FST_SPI_CS[0]_N | VSS              | SD3_CMD  | SD3_PWREN_N                            | MMC1_D[0]                       | MMC1_D[7]         | MMC1_CMD         | ISH_I2C1_DATA/ISH_SPI_MOSI/ISE_DATAOUT | ISH_GPIO[9]/ISH_SPI_MISO/I2S5_DATAIN | ISH_I2C1_CLK/ISH_SPI_CLK/I2S6_DATAIN | VSS                                  | ICLK_RCOMP              |
| Y  | UART0_DATAOUT   | VSS              | RESERVED   | USB_OC[0]_N                            | MMC1_D[1]                       | VSS               | VSSA             | PMC_PLTRST_N                           | PMC_SUSCLK[0]                        | PMC_WAKE_N                           | ISH_GPIO[1]/I2S3_FS                  | ISH_GPIO[3]/I2S3_DATAIN |
| W  | VSS             | VSS              | RESERVED   | UNCORE_V1P8A_G3                        | VSS                             | ICLK_OSCIN        | ICLK_OSCOUT      | VSS                                    | PMC_SLP_S0X_N                        | PMC_PWRBTN_N                         | ---                                  | ---                     |
| V  | PMC_SUSPWRDNACK | PMC_RSTBTN_N     | UNCORE_V1P8A_G3                                      | VSS                                    | RTC_V3P3RTCA_G5                 | VSS               | VSS              | PMC_SUS_STAT_N                         | RESERVED                             | PCIE_REFCLK0_P                       | PCIE_REFCLK0_N                       | UNCORE_VNN_S4           |
| U  | DDI_VGG_S0X     | DDI_VGG_S0X      | DDI_VGG_S0X  | F_V1P8A_G3                             | RTC_V3P3A_G5                    | F_V3P3A_G3        | RTC_TEST_N       | RTC_RST_N                              | RTC_X2                               | RTC_X1                               | VSS                                  | RTC_EXTPAD              |
| T  | DDI_VGG_S0X     | DDI_VGG_S0X      | UNCORE_V1P8A_G3                                      | F_V1P05A_G3                            | VSS                             | F_V1P05A_G3       | PMC_CORE_PWR_ROK | PMC_RSMRST_N                           | PCIE_RCOMP_N                         | PCIE_RCOMP_P                         | PCIE_RXN0                            | PCIE_RXP0               |
| R  | VSS             | DDI_VGG_S0X      | VSS  | VSS                                    | ICLK_VSFR_G3                    | F_V1P05A_G3       | VSS              | VSS                                    | PCIE_TXP0                            | PCIE_TXN0                            | ---                                  | ---                     |
| P  | VSS             | DDI_VGG_S0X      | DDI_VGG_S0X  | UNCORE_VNN_S4                          | VSS                             | PCIECLK_V1P05A_G3 | USB_DN0          | USB3_RXN0                              | USB3_RCOMP_N                         | USB3_RCOMP_P                         | USB3_TXN0                            | USB3_TXP0               |
| N  | DDI_VGG_S0X     | DDI_VGG_S0X      | UNCORE_VNN_S4  | VSS                                    | MPHY_1P05A_G3                   | MPHY_1P05A_G3     | USB_DP0          | USB3_RXP0                              | USB_HSIC_1_DATA                      | USB_HSIC_1_STROBE                    | VSS                                  | USB_HSIC_ROMP           |
| M  | UNCORE_VSFR_G3  | UNCORE_VNN_S4    | UNCORE_VNN_S4  | UNCORE_VNN_S4                          | VSS                             | USBSSIC_V1P05A_G3 | USB_DN2          | USB_DP2                                | USB_DP3                              | USB_DN3                              | USB_HSIC_0_DATA                      | USB_HSIC_0_STROBE       |
| L  | UNCORE_VNN_S4   | UNCORE_VNN_S4    | UNCORE_VNN_S4  | UNCORE_VNN_S4                          | USB_V3P3A_G3                    | VSS               | UNCORE_VSFR_G3   | VSS                                    | USB_DP1                              | USB_DN1                              | ---                                  | ---                     |
| K  | UNCORE_VNN_S4   | UNCORE_VNN_S4    | UNCORE_VNN_S4  | UNCORE_VNN_S4                          | USBSSIC_V1P2A_G3                | DDI_USB_VDDQ_G3   | DDI2_TXN3        | DDI2_TXP3                              | DDI2_TXP1                            | DDI2_TXN1                            | USB_VBUSSNS                          | USB_OTG_ID              |
| J  | VSS             | VSS              | UNCORE_VNN_S4  | UNCORE_VNN_S4                          | USBHSIC_V1P2A_G3                | DDI_USB_VDDQ_G3   | DDI0_TXN1        | DDI2_AUXN                              | DDI2_TXN0                            | DDI2_TXP0                            | VSS                                  | USB_RCOMP               |
| H  | USB_V1P8A_G3    | USB_V1P8A_G3     | VSS  | MIPI_V1P2A_G3                          | DDI_USB_VDDQ_G3                 | USB_VDDQ_G3       | DDI0_TXP1        | DDI2_AUXP                              | DDI0_RCOMP_N                         | DDI0_RCOMP_P                         | DDI2_TXP2                            | DDI2_TXN2               |
| G  | RESERVED        | VSS              | VSS  | MIPI_V1P2A_G3                          | UNCORE_VSFR_G3                  | MCSI_1_CLKN       | VSS              | VSS                                    | DDI0_TXN0                            | DDI0_TXP0                            | ---                                  | ---                     |
| F  | SVID_DATA       | SVID_CLK         | RESERVED   | PROCHOT_N                              | MCSI_1_DN0                      | MCSI_1_CLKP       | DDI0_TXN2        | DDI0_TXP2                              | RESERVED                             | DDI0_TXP3                            | DDI0_TXN3                            | DDI0_AUXN               |
| E  | SVID_ALERT_N    | VSS              | DDI2_DDC_CLK/DDI1_DDC_CLK/UART0_DATA                 | DDI2_HPD                               | MCSI_1_DP0                      | VSS               | VSS              | MDSI_A_DN3                             | MDSI_A_DP3                           | MDSI_A_DN2                           | VSS                                  | DDI0_AUXP               |
| D  | VSS             | GPIO_CAMERA_SB08 | GPIO_CAMERA_SB09                                     | DDI0_HPD                               | DDI1_BKLTCTL/MDSI_A_TE/MDSLC_TF | MCSI_1_DN2        | MCSI_1_DP3       | MCSI_2_CLKP                            | MDSI_A_CLKN                          | MDSI_A_DP2                           | DDI1_RCOMP_P                         | DDI1_RCOMP_N            |
| C  | JTAG_TDI        | GPIO_CAMERA_SB11 | DDI0_DDC_DATA/DDI1_DDC_DATA/MDSI_DDC_DATA/UART0_DATA | DDI2_DDC_DATA/DDI1_DDC_DATA/UART0_DATA | DDI0_BKLTEN                     | MCSI_1_DP2        | MCSI_1_DN3       | MCSI_2_CLKN                            | MDSI_A_CLKP                          | MDSI_A_DP0                           | MDSI_A_DP1                           | MDSI_A_DN1              |
| B  | PMC_SUSCLK[3]   | ---              | GPIO_CAMERA_SB10                                     | VSS                                    | DDI0_BKLTCTL                    | ---               | MCSI_1_DN1       | VSS                                    | MCSI_2_DN0                           | MCSI_2_DN1                           | MDSI_A_DN0                           | RESERVED                |
| A  | CORE_VCC_S0X    | ---              | DDI0_DDC_CLK/DDI1_DDC_CLK/MDSI_DDC_C                 | DDI0_VDDEN                             | MCSI_RCOMP                      | ---               | MCSI_1_DP1       | MDSI_RCOMP                             | MCSI_2_DP0                           | MCSI_2_DP1                           | RESERVED                             | ---                     |





# Ballout and Ball Map

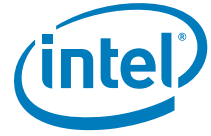
Figure 42. Ballout LPPDR3 (T4) Top View Part B

|    |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
|----|---------------|-----------|---------------|-----------------|----|----|-----------------|----|----|----|----|----|----|----|----|----|----|----|----|--|
| 40 | 39            | 38        | 37            | 36              | 35 | 34 | 33              | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 |  |
| BV | DDR_V1P05A_G3 |           | MMIO1_RESET_N | DDI_V1P15_5_OIX |    |    | UNCORE_V1P8A_G3 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BU |               | GPIO_SW78 |               | I2C0_CLK        |    |    | UNCORE_V1P8A_G3 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BT | SD3_WP        |           |               | I2C0_CLK        |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BR |               |           |               | I2C1_CLK        |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BP |               |           |               | I2C1_CLK        |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BN |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BM |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BL |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BK |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BJ |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BH |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BG |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BF |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BE |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BD |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BC |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BB |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| BA |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AV |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AW |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AV |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AU |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AT |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AR |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AP |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AN |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AM |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AL |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AK |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AJ |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AH |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AG |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AF |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AE |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AD |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AC |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AB |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| AA |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| Y  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| W  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| V  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| U  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| T  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| R  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| P  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| N  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| M  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| L  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| K  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| J  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| H  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| G  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| F  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| E  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| D  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| C  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| B  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |
| A  |               |           |               |                 |    |    |                 |    |    |    |    |    |    |    |    |    |    |    |    |  |



Figure 43. Ballout LPPDR3 (T4) Top View Part C

|    | 20  | 19                                      | 18           | 17                 | 16  | 15                     | 14            | 13            | 12  | 11            | 10                                     | 9                                      | 8                                      | 7                                      | 6                                      | 5                                      | 4             | 3             | 2             | 1             |
|----|-----|---|--------------|--------------------|-----|------------------------|---------------|---------------|-----|---------------|--|--|--|--|--|--|---------------|---------------|---------------|---------------|
| BW | VSS | VSS                                     | VSS          | LPC_V3P3A_V1P6A_S4 | VSS | SDIO_V3P3A_V1P6A_G3    | DDI_VGG_50_IK | DDI_VGG_50_IK | VSS | DDI_VGG_50_IK | DDI_VGG_50_IK                          | VSS                                    | VSS                                    | VSS                                    | VSS                                    | VSS                                    | VSS           | VSS           | VSS           | VSS           |
| BU | VSS | LPC_AD[0:7]/H_GPI0[0:7]/SH_UART_C       | SD3_CD_N     | MMCI_D[5]          | VSS | MMCI_RCLK/MMCI_RESET_N | SD2_D[3]      | MMCI_D[4]     | VSS | SD2_D[0]      | PMCI_PLT_CLK[0]/ISH_GPI0[12]/ISH_UA    | PMCI_PLT_CLK[1]/ISH_GPI0[13]/ISH_UA    | PMCI_PLT_CLK[2]/ISH_GPI0[14]/ISH_UA    | PMCI_PLT_CLK[3]/ISH_GPI0[15]/ISH_UA    | PMCI_PLT_CLK[4]/ISH_GPI0[16]/ISH_UA    | PMCI_PLT_CLK[5]/ISH_GPI0[17]/ISH_UA    | PWM[0]        | VSS           | VSS           | VSS           |
| BT | VSS | LPC_AD[8:15]/H_GPI0[8:15]/SH_UART_RT    | SPI1_CS[1]_N | SD3_CMD            | VSS | MMCI_D[6]              | SD2_D[1]      | MMCI_D[5]     | VSS | SD2_D[0]      | PMCI_PLT_CLK[6]/ISH_GPI0[18]/ISH_UA    | PMCI_PLT_CLK[7]/ISH_GPI0[19]/ISH_UA    | PMCI_PLT_CLK[8]/ISH_GPI0[20]/ISH_UA    | PMCI_PLT_CLK[9]/ISH_GPI0[21]/ISH_UA    | PMCI_PLT_CLK[10]/ISH_GPI0[22]/ISH_UA   | PMCI_PLT_CLK[11]/ISH_GPI0[23]/ISH_UA   | ISH_GPI0[24]  | ISH_GPI0[25]  | ISH_GPI0[26]  | ISH_GPI0[27]  |
| BR | VSS | LPC_AD[16:31]/H_GPI0[16:31]/SH_I2C0_DAT | SPI1_MISO    | SD3_CLK            | VSS | MMCI_D[7]              | SD2_D[2]      | MMCI_D[6]     | VSS | SD2_CMD       | PMCI_PLT_CLK[12]/ISH_GPI0[24]/ISH_UA   | PMCI_PLT_CLK[13]/ISH_GPI0[25]/ISH_UA   | PMCI_PLT_CLK[14]/ISH_GPI0[26]/ISH_UA   | PMCI_PLT_CLK[15]/ISH_GPI0[27]/ISH_UA   | PMCI_PLT_CLK[16]/ISH_GPI0[28]/ISH_UA   | PMCI_PLT_CLK[17]/ISH_GPI0[29]/ISH_UA   | ISH_GPI0[30]  | ISH_GPI0[31]  | ISH_GPI0[32]  | ISH_GPI0[33]  |
| BP | VSS | LPC_CLKOUT[11]/ISH_GPI0[34]/ISH_UART    | SPI1_MOSI    | SD3_CMD            | VSS | MMCI_D[8]              | SD2_D[3]      | MMCI_D[7]     | VSS | SD2_CMD       | PMCI_PLT_CLK[18]/ISH_GPI0[30]/ISH_UA   | PMCI_PLT_CLK[19]/ISH_GPI0[31]/ISH_UA   | PMCI_PLT_CLK[20]/ISH_GPI0[32]/ISH_UA   | PMCI_PLT_CLK[21]/ISH_GPI0[33]/ISH_UA   | PMCI_PLT_CLK[22]/ISH_GPI0[34]/ISH_UA   | PMCI_PLT_CLK[23]/ISH_GPI0[35]/ISH_UA   | ISH_GPI0[36]  | ISH_GPI0[37]  | ISH_GPI0[38]  | ISH_GPI0[39]  |
| BN | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[0]    | SD3_CMD            | VSS | MMCI_D[9]              | SD2_D[4]      | MMCI_D[8]     | VSS | SD2_CMD       | PMCI_PLT_CLK[24]/ISH_GPI0[36]/ISH_UA   | PMCI_PLT_CLK[25]/ISH_GPI0[37]/ISH_UA   | PMCI_PLT_CLK[26]/ISH_GPI0[38]/ISH_UA   | PMCI_PLT_CLK[27]/ISH_GPI0[39]/ISH_UA   | PMCI_PLT_CLK[28]/ISH_GPI0[40]/ISH_UA   | PMCI_PLT_CLK[29]/ISH_GPI0[41]/ISH_UA   | ISH_GPI0[42]  | ISH_GPI0[43]  | ISH_GPI0[44]  | ISH_GPI0[45]  |
| BM | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[1]    | SD3_CMD            | VSS | MMCI_D[10]             | SD2_D[5]      | MMCI_D[9]     | VSS | SD2_CMD       | PMCI_PLT_CLK[30]/ISH_GPI0[42]/ISH_UA   | PMCI_PLT_CLK[31]/ISH_GPI0[43]/ISH_UA   | PMCI_PLT_CLK[32]/ISH_GPI0[44]/ISH_UA   | PMCI_PLT_CLK[33]/ISH_GPI0[45]/ISH_UA   | PMCI_PLT_CLK[34]/ISH_GPI0[46]/ISH_UA   | PMCI_PLT_CLK[35]/ISH_GPI0[47]/ISH_UA   | ISH_GPI0[48]  | ISH_GPI0[49]  | ISH_GPI0[50]  | ISH_GPI0[51]  |
| BL | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[2]    | SD3_CMD            | VSS | MMCI_D[11]             | SD2_D[6]      | MMCI_D[10]    | VSS | SD2_CMD       | PMCI_PLT_CLK[36]/ISH_GPI0[48]/ISH_UA   | PMCI_PLT_CLK[37]/ISH_GPI0[49]/ISH_UA   | PMCI_PLT_CLK[38]/ISH_GPI0[50]/ISH_UA   | PMCI_PLT_CLK[39]/ISH_GPI0[51]/ISH_UA   | PMCI_PLT_CLK[40]/ISH_GPI0[52]/ISH_UA   | PMCI_PLT_CLK[41]/ISH_GPI0[53]/ISH_UA   | ISH_GPI0[54]  | ISH_GPI0[55]  | ISH_GPI0[56]  | ISH_GPI0[57]  |
| BK | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[3]    | SD3_CMD            | VSS | MMCI_D[12]             | SD2_D[7]      | MMCI_D[11]    | VSS | SD2_CMD       | PMCI_PLT_CLK[42]/ISH_GPI0[54]/ISH_UA   | PMCI_PLT_CLK[43]/ISH_GPI0[55]/ISH_UA   | PMCI_PLT_CLK[44]/ISH_GPI0[56]/ISH_UA   | PMCI_PLT_CLK[45]/ISH_GPI0[57]/ISH_UA   | PMCI_PLT_CLK[46]/ISH_GPI0[58]/ISH_UA   | PMCI_PLT_CLK[47]/ISH_GPI0[59]/ISH_UA   | ISH_GPI0[60]  | ISH_GPI0[61]  | ISH_GPI0[62]  | ISH_GPI0[63]  |
| BH | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[4]    | SD3_CMD            | VSS | MMCI_D[13]             | SD2_D[8]      | MMCI_D[12]    | VSS | SD2_CMD       | PMCI_PLT_CLK[48]/ISH_GPI0[60]/ISH_UA   | PMCI_PLT_CLK[49]/ISH_GPI0[61]/ISH_UA   | PMCI_PLT_CLK[50]/ISH_GPI0[62]/ISH_UA   | PMCI_PLT_CLK[51]/ISH_GPI0[63]/ISH_UA   | PMCI_PLT_CLK[52]/ISH_GPI0[64]/ISH_UA   | PMCI_PLT_CLK[53]/ISH_GPI0[65]/ISH_UA   | ISH_GPI0[66]  | ISH_GPI0[67]  | ISH_GPI0[68]  | ISH_GPI0[69]  |
| BG | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[5]    | SD3_CMD            | VSS | MMCI_D[14]             | SD2_D[9]      | MMCI_D[13]    | VSS | SD2_CMD       | PMCI_PLT_CLK[54]/ISH_GPI0[66]/ISH_UA   | PMCI_PLT_CLK[55]/ISH_GPI0[67]/ISH_UA   | PMCI_PLT_CLK[56]/ISH_GPI0[68]/ISH_UA   | PMCI_PLT_CLK[57]/ISH_GPI0[69]/ISH_UA   | PMCI_PLT_CLK[58]/ISH_GPI0[70]/ISH_UA   | PMCI_PLT_CLK[59]/ISH_GPI0[71]/ISH_UA   | ISH_GPI0[72]  | ISH_GPI0[73]  | ISH_GPI0[74]  | ISH_GPI0[75]  |
| BF | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[6]    | SD3_CMD            | VSS | MMCI_D[15]             | SD2_D[10]     | MMCI_D[14]    | VSS | SD2_CMD       | PMCI_PLT_CLK[60]/ISH_GPI0[72]/ISH_UA   | PMCI_PLT_CLK[61]/ISH_GPI0[73]/ISH_UA   | PMCI_PLT_CLK[62]/ISH_GPI0[74]/ISH_UA   | PMCI_PLT_CLK[63]/ISH_GPI0[75]/ISH_UA   | PMCI_PLT_CLK[64]/ISH_GPI0[76]/ISH_UA   | PMCI_PLT_CLK[65]/ISH_GPI0[77]/ISH_UA   | ISH_GPI0[78]  | ISH_GPI0[79]  | ISH_GPI0[80]  | ISH_GPI0[81]  |
| BD | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[7]    | SD3_CMD            | VSS | MMCI_D[16]             | SD2_D[11]     | MMCI_D[15]    | VSS | SD2_CMD       | PMCI_PLT_CLK[66]/ISH_GPI0[78]/ISH_UA   | PMCI_PLT_CLK[67]/ISH_GPI0[79]/ISH_UA   | PMCI_PLT_CLK[68]/ISH_GPI0[80]/ISH_UA   | PMCI_PLT_CLK[69]/ISH_GPI0[81]/ISH_UA   | PMCI_PLT_CLK[70]/ISH_GPI0[82]/ISH_UA   | PMCI_PLT_CLK[71]/ISH_GPI0[83]/ISH_UA   | ISH_GPI0[84]  | ISH_GPI0[85]  | ISH_GPI0[86]  | ISH_GPI0[87]  |
| BC | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[8]    | SD3_CMD            | VSS | MMCI_D[17]             | SD2_D[12]     | MMCI_D[16]    | VSS | SD2_CMD       | PMCI_PLT_CLK[72]/ISH_GPI0[84]/ISH_UA   | PMCI_PLT_CLK[73]/ISH_GPI0[85]/ISH_UA   | PMCI_PLT_CLK[74]/ISH_GPI0[86]/ISH_UA   | PMCI_PLT_CLK[75]/ISH_GPI0[87]/ISH_UA   | PMCI_PLT_CLK[76]/ISH_GPI0[88]/ISH_UA   | PMCI_PLT_CLK[77]/ISH_GPI0[89]/ISH_UA   | ISH_GPI0[90]  | ISH_GPI0[91]  | ISH_GPI0[92]  | ISH_GPI0[93]  |
| BB | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[9]    | SD3_CMD            | VSS | MMCI_D[18]             | SD2_D[13]     | MMCI_D[17]    | VSS | SD2_CMD       | PMCI_PLT_CLK[78]/ISH_GPI0[90]/ISH_UA   | PMCI_PLT_CLK[79]/ISH_GPI0[91]/ISH_UA   | PMCI_PLT_CLK[80]/ISH_GPI0[92]/ISH_UA   | PMCI_PLT_CLK[81]/ISH_GPI0[93]/ISH_UA   | PMCI_PLT_CLK[82]/ISH_GPI0[94]/ISH_UA   | PMCI_PLT_CLK[83]/ISH_GPI0[95]/ISH_UA   | ISH_GPI0[96]  | ISH_GPI0[97]  | ISH_GPI0[98]  | ISH_GPI0[99]  |
| BA | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[10]   | SD3_CMD            | VSS | MMCI_D[19]             | SD2_D[14]     | MMCI_D[18]    | VSS | SD2_CMD       | PMCI_PLT_CLK[84]/ISH_GPI0[96]/ISH_UA   | PMCI_PLT_CLK[85]/ISH_GPI0[97]/ISH_UA   | PMCI_PLT_CLK[86]/ISH_GPI0[98]/ISH_UA   | PMCI_PLT_CLK[87]/ISH_GPI0[99]/ISH_UA   | PMCI_PLT_CLK[88]/ISH_GPI0[100]/ISH_UA  | PMCI_PLT_CLK[89]/ISH_GPI0[101]/ISH_UA  | ISH_GPI0[102] | ISH_GPI0[103] | ISH_GPI0[104] | ISH_GPI0[105] |
| AV | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[11]   | SD3_CMD            | VSS | MMCI_D[20]             | SD2_D[15]     | MMCI_D[19]    | VSS | SD2_CMD       | PMCI_PLT_CLK[90]/ISH_GPI0[102]/ISH_UA  | PMCI_PLT_CLK[91]/ISH_GPI0[103]/ISH_UA  | PMCI_PLT_CLK[92]/ISH_GPI0[104]/ISH_UA  | PMCI_PLT_CLK[93]/ISH_GPI0[105]/ISH_UA  | PMCI_PLT_CLK[94]/ISH_GPI0[106]/ISH_UA  | PMCI_PLT_CLK[95]/ISH_GPI0[107]/ISH_UA  | ISH_GPI0[108] | ISH_GPI0[109] | ISH_GPI0[110] | ISH_GPI0[111] |
| AW | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[12]   | SD3_CMD            | VSS | MMCI_D[21]             | SD2_D[16]     | MMCI_D[20]    | VSS | SD2_CMD       | PMCI_PLT_CLK[96]/ISH_GPI0[108]/ISH_UA  | PMCI_PLT_CLK[97]/ISH_GPI0[109]/ISH_UA  | PMCI_PLT_CLK[98]/ISH_GPI0[110]/ISH_UA  | PMCI_PLT_CLK[99]/ISH_GPI0[111]/ISH_UA  | PMCI_PLT_CLK[100]/ISH_GPI0[112]/ISH_UA | PMCI_PLT_CLK[101]/ISH_GPI0[113]/ISH_UA | ISH_GPI0[114] | ISH_GPI0[115] | ISH_GPI0[116] | ISH_GPI0[117] |
| AU | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[13]   | SD3_CMD            | VSS | MMCI_D[22]             | SD2_D[17]     | MMCI_D[21]    | VSS | SD2_CMD       | PMCI_PLT_CLK[102]/ISH_GPI0[114]/ISH_UA | PMCI_PLT_CLK[103]/ISH_GPI0[115]/ISH_UA | PMCI_PLT_CLK[104]/ISH_GPI0[116]/ISH_UA | PMCI_PLT_CLK[105]/ISH_GPI0[117]/ISH_UA | PMCI_PLT_CLK[106]/ISH_GPI0[118]/ISH_UA | PMCI_PLT_CLK[107]/ISH_GPI0[119]/ISH_UA | ISH_GPI0[120] | ISH_GPI0[121] | ISH_GPI0[122] | ISH_GPI0[123] |
| AT | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[14]   | SD3_CMD            | VSS | MMCI_D[23]             | SD2_D[18]     | MMCI_D[22]    | VSS | SD2_CMD       | PMCI_PLT_CLK[108]/ISH_GPI0[120]/ISH_UA | PMCI_PLT_CLK[109]/ISH_GPI0[121]/ISH_UA | PMCI_PLT_CLK[110]/ISH_GPI0[122]/ISH_UA | PMCI_PLT_CLK[111]/ISH_GPI0[123]/ISH_UA | PMCI_PLT_CLK[112]/ISH_GPI0[124]/ISH_UA | PMCI_PLT_CLK[113]/ISH_GPI0[125]/ISH_UA | ISH_GPI0[126] | ISH_GPI0[127] | ISH_GPI0[128] | ISH_GPI0[129] |
| AR | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[15]   | SD3_CMD            | VSS | MMCI_D[24]             | SD2_D[19]     | MMCI_D[23]    | VSS | SD2_CMD       | PMCI_PLT_CLK[114]/ISH_GPI0[126]/ISH_UA | PMCI_PLT_CLK[115]/ISH_GPI0[127]/ISH_UA | PMCI_PLT_CLK[116]/ISH_GPI0[128]/ISH_UA | PMCI_PLT_CLK[117]/ISH_GPI0[129]/ISH_UA | PMCI_PLT_CLK[118]/ISH_GPI0[130]/ISH_UA | PMCI_PLT_CLK[119]/ISH_GPI0[131]/ISH_UA | ISH_GPI0[132] | ISH_GPI0[133] | ISH_GPI0[134] | ISH_GPI0[135] |
| AP | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[16]   | SD3_CMD            | VSS | MMCI_D[25]             | SD2_D[20]     | MMCI_D[24]    | VSS | SD2_CMD       | PMCI_PLT_CLK[120]/ISH_GPI0[132]/ISH_UA | PMCI_PLT_CLK[121]/ISH_GPI0[133]/ISH_UA | PMCI_PLT_CLK[122]/ISH_GPI0[134]/ISH_UA | PMCI_PLT_CLK[123]/ISH_GPI0[135]/ISH_UA | PMCI_PLT_CLK[124]/ISH_GPI0[136]/ISH_UA | PMCI_PLT_CLK[125]/ISH_GPI0[137]/ISH_UA | ISH_GPI0[138] | ISH_GPI0[139] | ISH_GPI0[140] | ISH_GPI0[141] |
| AN | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[17]   | SD3_CMD            | VSS | MMCI_D[26]             | SD2_D[21]     | MMCI_D[25]    | VSS | SD2_CMD       | PMCI_PLT_CLK[126]/ISH_GPI0[138]/ISH_UA | PMCI_PLT_CLK[127]/ISH_GPI0[139]/ISH_UA | PMCI_PLT_CLK[128]/ISH_GPI0[140]/ISH_UA | PMCI_PLT_CLK[129]/ISH_GPI0[141]/ISH_UA | PMCI_PLT_CLK[130]/ISH_GPI0[142]/ISH_UA | PMCI_PLT_CLK[131]/ISH_GPI0[143]/ISH_UA | ISH_GPI0[144] | ISH_GPI0[145] | ISH_GPI0[146] | ISH_GPI0[147] |
| AM | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[18]   | SD3_CMD            | VSS | MMCI_D[27]             | SD2_D[22]     | MMCI_D[26]    | VSS | SD2_CMD       | PMCI_PLT_CLK[132]/ISH_GPI0[144]/ISH_UA | PMCI_PLT_CLK[133]/ISH_GPI0[145]/ISH_UA | PMCI_PLT_CLK[134]/ISH_GPI0[146]/ISH_UA | PMCI_PLT_CLK[135]/ISH_GPI0[147]/ISH_UA | PMCI_PLT_CLK[136]/ISH_GPI0[148]/ISH_UA | PMCI_PLT_CLK[137]/ISH_GPI0[149]/ISH_UA | ISH_GPI0[150] | ISH_GPI0[151] | ISH_GPI0[152] | ISH_GPI0[153] |
| AL | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[19]   | SD3_CMD            | VSS | MMCI_D[28]             | SD2_D[23]     | MMCI_D[27]    | VSS | SD2_CMD       | PMCI_PLT_CLK[138]/ISH_GPI0[150]/ISH_UA | PMCI_PLT_CLK[139]/ISH_GPI0[151]/ISH_UA | PMCI_PLT_CLK[140]/ISH_GPI0[152]/ISH_UA | PMCI_PLT_CLK[141]/ISH_GPI0[153]/ISH_UA | PMCI_PLT_CLK[142]/ISH_GPI0[154]/ISH_UA | PMCI_PLT_CLK[143]/ISH_GPI0[155]/ISH_UA | ISH_GPI0[156] | ISH_GPI0[157] | ISH_GPI0[158] | ISH_GPI0[159] |
| AJ | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[20]   | SD3_CMD            | VSS | MMCI_D[29]             | SD2_D[24]     | MMCI_D[28]    | VSS | SD2_CMD       | PMCI_PLT_CLK[144]/ISH_GPI0[156]/ISH_UA | PMCI_PLT_CLK[145]/ISH_GPI0[157]/ISH_UA | PMCI_PLT_CLK[146]/ISH_GPI0[158]/ISH_UA | PMCI_PLT_CLK[147]/ISH_GPI0[159]/ISH_UA | PMCI_PLT_CLK[148]/ISH_GPI0[160]/ISH_UA | PMCI_PLT_CLK[149]/ISH_GPI0[161]/ISH_UA | ISH_GPI0[162] | ISH_GPI0[163] | ISH_GPI0[164] | ISH_GPI0[165] |
| AH | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[21]   | SD3_CMD            | VSS | MMCI_D[30]             | SD2_D[25]     | MMCI_D[29]    | VSS | SD2_CMD       | PMCI_PLT_CLK[150]/ISH_GPI0[162]/ISH_UA | PMCI_PLT_CLK[151]/ISH_GPI0[163]/ISH_UA | PMCI_PLT_CLK[152]/ISH_GPI0[164]/ISH_UA | PMCI_PLT_CLK[153]/ISH_GPI0[165]/ISH_UA | PMCI_PLT_CLK[154]/ISH_GPI0[166]/ISH_UA | PMCI_PLT_CLK[155]/ISH_GPI0[167]/ISH_UA | ISH_GPI0[168] | ISH_GPI0[169] | ISH_GPI0[170] | ISH_GPI0[171] |
| AG | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[22]   | SD3_CMD            | VSS | MMCI_D[31]             | SD2_D[26]     | MMCI_D[30]    | VSS | SD2_CMD       | PMCI_PLT_CLK[156]/ISH_GPI0[168]/ISH_UA | PMCI_PLT_CLK[157]/ISH_GPI0[169]/ISH_UA | PMCI_PLT_CLK[158]/ISH_GPI0[170]/ISH_UA | PMCI_PLT_CLK[159]/ISH_GPI0[171]/ISH_UA | PMCI_PLT_CLK[160]/ISH_GPI0[172]/ISH_UA | PMCI_PLT_CLK[161]/ISH_GPI0[173]/ISH_UA | ISH_GPI0[174] | ISH_GPI0[175] | ISH_GPI0[176] | ISH_GPI0[177] |
| AF | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[23]   | SD3_CMD            | VSS | MMCI_D[32]             | SD2_D[27]     | MMCI_D[31]    | VSS | SD2_CMD       | PMCI_PLT_CLK[162]/ISH_GPI0[174]/ISH_UA | PMCI_PLT_CLK[163]/ISH_GPI0[175]/ISH_UA | PMCI_PLT_CLK[164]/ISH_GPI0[176]/ISH_UA | PMCI_PLT_CLK[165]/ISH_GPI0[177]/ISH_UA | PMCI_PLT_CLK[166]/ISH_GPI0[178]/ISH_UA | PMCI_PLT_CLK[167]/ISH_GPI0[179]/ISH_UA | ISH_GPI0[180] | ISH_GPI0[181] | ISH_GPI0[182] | ISH_GPI0[183] |
| AE | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[24]   | SD3_CMD            | VSS | MMCI_D[33]             | SD2_D[28]     | MMCI_D[32]    | VSS | SD2_CMD       | PMCI_PLT_CLK[168]/ISH_GPI0[180]/ISH_UA | PMCI_PLT_CLK[169]/ISH_GPI0[181]/ISH_UA | PMCI_PLT_CLK[170]/ISH_GPI0[182]/ISH_UA | PMCI_PLT_CLK[171]/ISH_GPI0[183]/ISH_UA | PMCI_PLT_CLK[172]/ISH_GPI0[184]/ISH_UA | PMCI_PLT_CLK[173]/ISH_GPI0[185]/ISH_UA | ISH_GPI0[186] | ISH_GPI0[187] | ISH_GPI0[188] | ISH_GPI0[189] |
| AD | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[25]   | SD3_CMD            | VSS | MMCI_D[34]             | SD2_D[29]     | MMCI_D[33]    | VSS | SD2_CMD       | PMCI_PLT_CLK[174]/ISH_GPI0[186]/ISH_UA | PMCI_PLT_CLK[175]/ISH_GPI0[187]/ISH_UA | PMCI_PLT_CLK[176]/ISH_GPI0[188]/ISH_UA | PMCI_PLT_CLK[177]/ISH_GPI0[189]/ISH_UA | PMCI_PLT_CLK[178]/ISH_GPI0[190]/ISH_UA | PMCI_PLT_CLK[179]/ISH_GPI0[191]/ISH_UA | ISH_GPI0[192] | ISH_GPI0[193] | ISH_GPI0[194] | ISH_GPI0[195] |
| AC | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[26]   | SD3_CMD            | VSS | MMCI_D[35]             | SD2_D[30]     | MMCI_D[34]    | VSS | SD2_CMD       | PMCI_PLT_CLK[180]/ISH_GPI0[192]/ISH_UA | PMCI_PLT_CLK[181]/ISH_GPI0[193]/ISH_UA | PMCI_PLT_CLK[182]/ISH_GPI0[194]/ISH_UA | PMCI_PLT_CLK[183]/ISH_GPI0[195]/ISH_UA | PMCI_PLT_CLK[184]/ISH_GPI0[196]/ISH_UA | PMCI_PLT_CLK[185]/ISH_GPI0[197]/ISH_UA | ISH_GPI0[198] | ISH_GPI0[199] | ISH_GPI0[200] | ISH_GPI0[201] |
| AB | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[27]   | SD3_CMD            | VSS | MMCI_D[36]             | SD2_D[31]     | MMCI_D[35]    | VSS | SD2_CMD       | PMCI_PLT_CLK[186]/ISH_GPI0[198]/ISH_UA | PMCI_PLT_CLK[187]/ISH_GPI0[199]/ISH_UA | PMCI_PLT_CLK[188]/ISH_GPI0[200]/ISH_UA | PMCI_PLT_CLK[189]/ISH_GPI0[201]/ISH_UA | PMCI_PLT_CLK[190]/ISH_GPI0[202]/ISH_UA | PMCI_PLT_CLK[191]/ISH_GPI0[203]/ISH_UA | ISH_GPI0[204] | ISH_GPI0[205] | ISH_GPI0[206] | ISH_GPI0[207] |
| AA | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[28]   | SD3_CMD            | VSS | MMCI_D[37]             | SD2_D[32]     | MMCI_D[36]    | VSS | SD2_CMD       | PMCI_PLT_CLK[192]/ISH_GPI0[204]/ISH_UA | PMCI_PLT_CLK[193]/ISH_GPI0[205]/ISH_UA | PMCI_PLT_CLK[194]/ISH_GPI0[206]/ISH_UA | PMCI_PLT_CLK[195]/ISH_GPI0[207]/ISH_UA | PMCI_PLT_CLK[196]/ISH_GPI0[208]/ISH_UA | PMCI_PLT_CLK[197]/ISH_GPI0[209]/ISH_UA | ISH_GPI0[210] | ISH_GPI0[211] | ISH_GPI0[212] | ISH_GPI0[213] |
| AY | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[29]   | SD3_CMD            | VSS | MMCI_D[38]             | SD2_D[33]     | MMCI_D[37]    | VSS | SD2_CMD       | PMCI_PLT_CLK[198]/ISH_GPI0[210]/ISH_UA | PMCI_PLT_CLK[199]/ISH_GPI0[211]/ISH_UA | PMCI_PLT_CLK[200]/ISH_GPI0[212]/ISH_UA | PMCI_PLT_CLK[201]/ISH_GPI0[213]/ISH_UA | PMCI_PLT_CLK[202]/ISH_GPI0[214]/ISH_UA | PMCI_PLT_CLK[203]/ISH_GPI0[215]/ISH_UA | ISH_GPI0[216] | ISH_GPI0[217] | ISH_GPI0[218] | ISH_GPI0[219] |
| AW | VSS | LPC_FRAME_N/UART2_DATA/TAIN/SP12_M      | SD3_CS[30]   | SD3_CMD            | VSS | MMCI_D[39]             | SD2_D[34]     | MMCI_D[38]    | VSS | SD2_CMD       | PMCI_PLT_CLK[204]/ISH_GPI0[216]/ISH_UA | PMCI_PLT_CLK[205]/ISH_GPI0[217]/ISH_UA | PMCI_PLT_CLK[206]/ISH_GPI0[218]/ISH_UA | PMCI_PLT_CLK[207]/ISH_GPI0[219]/ISH_UA | PMCI_PLT_CLK[208]/ISH_GPI0[220]/ISH_UA | PMCI_PLT_CLK[209]/ISH_GPI0[221]/ISH_UA | ISH_GPI0[222] | ISH_GPI0[223] | ISH_GPI0[224] | ISH_GPI0[225] |
| AU | VSS | LPC_FRAME_N/UART2_DATA/T                |              |                    |     |                        |               |               |     |               |  |  |  |  |  |  |               |               |               |               |



## 20.2 SoC T3 Pin List Location

| Ball # | DDR3L-RS Customer Pin List                     |
|--------|--|
| A10    | DDI0_DDC_CLK/<br>DDI1_DDC_CLK/<br>MDSI_DDC_CLK |
| A12    | CORE_VCC_S0iX                                  |
| A13    | GPIO_SUS9                                      |
| A14    | GPIO_SUS0                                      |
| A16    | CORE_V1p05A_S0iX                               |
| A17    | DDR_VDDQG_S4                                   |
| A18    | DDR3_M0_DQ6                                    |
| A2     | RESERVED                                       |
| A20    | DDR3_M0_DM0                                    |
| A21    | DDR3_M0_DQ2                                    |
| A22    | DDR3_M0_DQ4                                    |
| A23    | DDR3_M0_DQ17                                   |
| A24    | VSS  |
| A25    | PWR_RSVD_OBS                                   |
| A3     | MCSI_2_DP1                                     |
| A4     | MCSI_2_DP0                                     |
| A5     | MDSI_RCOMP                                     |
| A6     | MCSI_1_DP1                                     |
| A8     | MCSI_RCOMP                                     |
| A9     | DDI0_VDDEN                                     |
| AA1    | ICLK_RCOMP                                     |
| AA10   | SD3_CMD  |
| AA11   | VSS  |
| AA12   | FST_SPI_CS0_N                                  |
| AA13   | GPIO_SE79                                      |
| AA14   | LPE_I2S1_FRM                                   |
| AA15   | LPE_I2S0_DATAOUT                               |
| AA16   | LPE_I2S0_CLK                                   |
| AA17   | I2C2_CLK                                       |
| AA18   | VSS  |
| AA19   | DDR3_DRAM_PWROK                                |
| AA2    | VSS  |
| AA20   | DDR3_CORE_PWROK                                |

| Ball # | DDR3L-RS Customer Pin List                                      |
|--------|---|
| AA21   | VSS   |
| AA22   | DDR3_M0_DQ52  |
| AA23   | DDR3_M0_DQS6_N  |
| AA24   | VSS   |
| AA25   | DDR3_M0_DQ36  |
| AA3    | ISH_I2C1_CLK/ISH_SPI_CLK/<br>I2S5_DATAIN                        |
| AA4    | ISH_GPIO9/ISH_SPI_MISO/<br>I2S5_FS                              |
| AA5    | ISH_I2C1_DATA/<br>ISH_SPI_MOSI/<br>I2S5_DATAOUT                 |
| AA6    | MMC1_CMD  |
| AA7    | MMC1_D7   |
| AA8    | MMC1_D0   |
| AA9    | SD3_PWREN_N   |
| AB1    | ICLK_ICOMP  |
| AB10   | SD3_D2  |
| AB11   | FST_SPI_D0  |
| AB12   | FST_SPI_CLK   |
| AB13   | UART2_DATAOUT   |
| AB14   | LPE_I2S1_CLK  |
| AB15   | LPE_I2S0_DATAIN   |
| AB16   | I2C5_CLK  |
| AB17   | I2C4_CLK/DDI1_DDC_CLK/<br>DDI2_DDC_CLK/<br>MDSI_DDC_CLK         |
| AB18   | I2C4_DATA/<br>DDI1_DDC_DATA/<br>DDI2_DDC_DATA/<br>MDSI_DDC_DATA |
| AB19   | LPE_I2S2_CLK  |
| AB2    | ISH_GPIO0/I2S3_CLK  |
| AB20   | PCIE_CLKREQ0_N  |
| AB21   | RESERVED  |
| AB22   | DDR3_M0_DQ48  |
| AB23   | DDR3_M0_DQS6_P  |
| AB24   | DDR3_M0_DQS4_N  |



**Ballout and Ball Map**

| Ball # | DDR3L-RS Customer Pin List                                |
|--------|---|
| AB25   | DDR3_M0_DQ33  |
| AB3    | ISH_GPIO2/I2S3_DATAOUT                                    |
| AB4    | PMC_PLT_CLK3/ISH_GPIO13/<br>ISH_UART_RTS_N/SPI2_CLK       |
| AB5    | SD2_CMD   |
| AB6    | MMC1_D2   |
| AB7    | MMC1_D6   |
| AB8    | SD3_1P8_EN  |
| AB9    | SD3_D1  |
| AC1    | ISH_GPIO7/I2S4_DATAIN                                     |
| AC10   | SD3_D0  |
| AC11   | FST_SPI_D1  |
| AC12   | UART2_RTS_N   |
| AC13   | UART1_CTS_N   |
| AC14   | UART1_DATAOUT/<br>UART0_DATAOUT                           |
| AC15   | NFC_I2C_DATA  |
| AC16   | NFC_I2C_CLK   |
| AC17   | I2C2_DATA   |
| AC18   | GPIO_SW78   |
| AC19   | LPE_I2S2_FRM  |
| AC2    | ISH_GPIO4/I2S4_CLK  |
| AC20   | GPIO_SW93   |
| AC21   | RESERVED  |
| AC22   | DDR3_M0_DQ49  |
| AC23   | DDR3_M0_DQ37  |
| AC24   | DDR3_M0_DM4   |
| AC25   | DDR3_M0_DQS4_P  |
| AC3    | PMC_PLT_CLK4/ISH_GPIO14/<br>ISH_I2C0_DATA/SPI2_MISO       |
| AC4    | PMC_PLT_CLK2/ISH_GPIO12/<br>ISH_UART_CTS_N/<br>SPI2_CS0_N |
| AC5    | VSS   |
| AC6    | MMC1_D3   |
| AC7    | MMC1_D4   |
| AC8    | MMC1_D5   |
| AC9    | SD3_CLK   |

| Ball # | DDR3L-RS Customer Pin List           |
|--------|--------------------------------------|
| AD1    | RESERVED                             |
| AD10   | SD3_D3                               |
| AD12   | UART2_CTS_N                          |
| AD13   | VSS                                  |
| AD14   | UART1_DATAIN/<br>UART0_DATAIN        |
| AD16   | I2C6_DATA/SD3_WP                     |
| AD17   | VSS                                  |
| AD18   | MMC1_RESET_N                         |
| AD2    | PWM1/ISH_GPIO10/<br>ISH_UART_DATAOUT |
| AD20   | SD3_WP                               |
| AD21   | DDR3_M0_DQ51                         |
| AD22   | VSS                                  |
| AD23   | DDR3_M0_DQ38                         |
| AD24   | DDR3_M0_DQ32                         |
| AD25   | VSS                                  |
| AD3    | PWM0                                 |
| AD4    | SD2_D0                               |
| AD5    | SD2_CLK                              |
| AD6    | SD2_D3_CD_N                          |
| AD8    | MMC1_CLK                             |
| AD9    | VSS                                  |
| AE1    | RESERVED                             |
| AE10   | MMC1_RCOMP                           |
| AE12   | UART2_DATAIN                         |
| AE13   | UART1_RTS_N                          |
| AE14   | SD3_RCOMP                            |
| AE16   | I2C6_CLK/NMI_N                       |
| AE17   | I2C5_DATA                            |
| AE18   | UART0_DATAIN                         |
| AE2    | RESERVED                             |
| AE20   | DDR3_M0_RCOMP                        |
| AE21   | DDR3_M0_OCAVREF                      |
| AE22   | DDR3_M0_ODQVREF                      |
| AE23   | DDR3_M0_DQ35                         |
| AE24   | PWR_RSVD_OBS                         |





**Ballout and Ball Map**

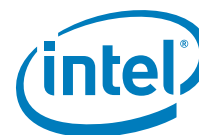
| Ball # | DDR3L-RS Customer Pin List                         |
|--------|--|
| AE25   | PWR_RSVD_OBS                                       |
| AE3    | PMC_PLT_CLK5/ISH_GPIO15/<br>ISH_I2C0_CLK/SPI2_MOSI |
| AE4    | SD2_D1   |
| AE5    | SD2_D2   |
| AE6    | DDI_VGG_S0iX                                       |
| AE8    | MMC1_RCLK/MMC1_RESET_N                             |
| AE9    | SD3_CD_N   |
| B1     | RESERVED   |
| B10    | GPIO_CAMERASB10                                    |
| B12    | PMC_SUSCLK3  |
| B13    | VSS  |
| B14    | JTAG2_TDI  |
| B16    | GPIO0_RCOMP  |
| B17    | VSS  |
| B18    | DDR3_M0_DQ1  |
| B2     | MDSI_A_DN0   |
| B20    | DDR3_M0_DQ5  |
| B21    | VSS  |
| B22    | DDR3_M0_DQ7  |
| B23    | DDR3_M0_DQ22                                       |
| B24    | DDR3_M0_DQ20                                       |
| B25    | PWR_RSVD_OBS                                       |
| B3     | MCSI_2_DN1   |
| B4     | MCSI_2_DN0   |
| B5     | VSS  |
| B6     | MCSI_1_DN1   |
| B8     | DDIO_BKLTCTL                                       |
| B9     | VSS  |
| C1     | MDSI_A_DN1   |
| C10    | DDIO_DDC_DATA/<br>DDI1_DDC_DATA/<br>MDSI_DDC_DATA  |
| C11    | GPIO_CAMERASB11                                    |
| C12    | JTAG_TDI   |
| C13    | GPIO_SUS8  |
| C14    | PMC_SUSCLK2  |
| C15    | JTAG2_TCK  |

| Ball # | DDR3L-RS Customer Pin List   |
|--------|--|
| C16    | GPIO_N6/C0_BPM3_TX/<br>C1_BPM3_TX  |
| C17    | GPIO_N3/C0_BPM1_TX/<br>C1_BPM1_TX  |
| C18    | DDR3_M0_DQ3  |
| C19    | DDR3_M0_DQS0_N   |
| C2     | MDSI_A_DP1   |
| C20    | DDR3_M0_DQ8  |
| C21    | DDR3_M0_DQS1_N   |
| C22    | DDR3_M0_DQS1_P   |
| C23    | DDR3_M0_DQ18   |
| C24    | DDR3_M0_DQS2_P   |
| C25    | DDR3_M0_DQS2_N   |
| C3     | MDSI_A_DP0   |
| C4     | MDSI_A_CLKP  |
| C5     | MCSI_2_CLKN  |
| C6     | MCSI_1_DN3   |
| C7     | MCSI_1_DP2   |
| C8     | DDIO_BKLTEN  |
| C9     | DDI2_DDC_DATA/<br>DDI1_DDC_DATA/<br>UART0_DATAIN/<br>MDSI_DDC_DATA/MDSI_C_TE |
| D1     | DDI1_RCOMP_N   |
| D10    | GPIO_CAMERASB09  |
| D11    | GPIO_CAMERASB08  |
| D12    | VSS  |
| D13    | JTAG_PRDY_N  |
| D14    | JTAG2_TDO  |
| D15    | JTAG2_TMS  |
| D16    | GPIO_N8/C0_BPM1_TX/<br>C1_BPM1_TX  |
| D17    | ISH_GPIO13/C0_BPM2_TX/<br>C1_BPM2_TX   |
| D18    | DDR3_M0_DQ0  |
| D19    | DDR3_M0_DQS0_P   |
| D2     | DDI1_RCOMP_P   |
| D20    | DDR3_M0_DQ15   |
| D21    | DDR3_M0_DM1  |



| Ball # | DDR3L-RS Customer Pin List   |
|--------|--|
| D22    | DDR3_M0_DQ12   |
| D23    | DDR3_M0_DQ9  |
| D24    | DDR3_M0_DQ21   |
| D25    | DDR3_M0_DM2  |
| D3     | MDSI_A_DP2   |
| D4     | MDSI_A_CLKN  |
| D5     | MCSI_2_CLKP  |
| D6     | MCSI_1_DP3   |
| D7     | MCSI_1_DN2   |
| D8     | DDI1_BKLTCTL/MDSI_A_TE/<br>MDSI_C_TE                                       |
| D9     | DDIO_HPD   |
| E1     | DDIO_AUXP  |
| E10    | DDI2_DDC_CLK/<br>DDI1_DDC_CLK/<br>UART0_DATAOUT/<br>MDSI_DDC_CLK/MDSI_A_TE |
| E11    | VSS  |
| E12    | SVID_ALERT_N   |
| E13    | JTAG_TRST_N  |
| E14    | JTAG_TCK   |
| E15    | VSS  |
| E16    | GPIO_N4/C0_BPM0_TX/<br>C1_BPM0_TX  |
| E17    | GPIO_N0/C0_BPM0_TX/<br>C1_BPM0_TX  |
| E18    | VSS  |
| E19    | DDR3_M0_DQ10   |
| E2     | VSS  |
| E20    | DDR3_M0_DQ14   |
| E21    | VSS  |
| E22    | DDR3_M0_DQ13   |
| E23    | DDR3_M0_DQ11   |
| E24    | VSS  |
| E25    | DDR3_M0_DQ16   |
| E3     | MDSI_A_DN2   |
| E4     | MDSI_A_DP3   |
| E5     | MDSI_A_DN3   |
| E6     | VSS  |

| Ball # | DDR3L-RS Customer Pin List        |
|--------|-----------------------------------|
| E7     | VSS                               |
| E8     | MCSI_1_DP0                        |
| E9     | DDI2_HPD                          |
| F1     | DDIO_AUXN                         |
| F10    | RESERVED                          |
| F11    | SVID_CLK                          |
| F12    | SVID_DATA                         |
| F13    | JTAG_TDO                          |
| F14    | JTAG_TMS                          |
| F15    | VSS                               |
| F16    | GPIO_N2/C0_BPM2_TX/<br>C1_BPM2_TX |
| F17    | GPIO_N1/C0_BPM3_TX/<br>C1_BPM3_TX |
| F18    | GPIO_DFX4                         |
| F19    | DDR3_M0_DM3                       |
| F2     | DDIO_TXN3                         |
| F20    | DDR3_M0_DQ24                      |
| F21    | DDR3_M0_DQ25                      |
| F22    | DDR3_M0_CKE3                      |
| F23    | DDR3_M0_CKE2                      |
| F24    | DDR3_M0_DQ23                      |
| F25    | DDR3_M0_DQ19                      |
| F3     | DDIO_TXP3                         |
| F4     | RESERVED                          |
| F5     | DDIO_TXP2                         |
| F6     | DDIO_TXN2                         |
| F7     | MCSI_1_CLKP                       |
| F8     | MCSI_1_DN0                        |
| F9     | PROCHOT_N                         |
| G10    | VSS                               |
| G11    | VSS                               |
| G12    | RESERVED                          |
| G13    | UNCORE_V1p05A_S0iX                |
| G14    | CORE_VCC_S0iX                     |
| G15    | CORE_VCC_S0iX                     |
| G16    | VSS                               |



**Ballout and Ball Map**

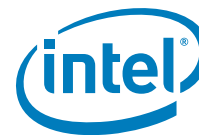
| Ball # | DDR3L-RS Customer Pin List |
|--------|----------------------------|
| G17    | CORE_V1p05A_S0iX           |
| G18    | CORE_V1p05A_S0iX           |
| G19    | DDR_V1P05A_G3              |
| G20    | DDR3_M0_DQ26               |
| G21    | DDR3_M0_DQ28               |
| G22    | DDR3_M0_CKE0               |
| G23    | DDR3_M0_CKE1               |
| G3     | DDI0_TXP0                  |
| G4     | DDI0_TXN0                  |
| G5     | VSS                        |
| G6     | VSS                        |
| G7     | MCSI_1_CLKN                |
| G8     | UNCORE_VSFR_G3             |
| G9     | MIPI_V1P2A_G3              |
| H1     | DDI2_TXN2                  |
| H10    | VSS                        |
| H11    | USB_V1P8A_G3               |
| H12    | USB_V1P8A_G3               |
| H13    | UNCORE_V1p05A_S0iX         |
| H14    | CORE0_VSFR_G3              |
| H15    | CORE_VCC_S0iX              |
| H16    | VSS                        |
| H17    | VSS                        |
| H18    | DDR_V1P05A_G3              |
| H19    | DDR3_M0_DQS3_N             |
| H2     | DDI2_TXP2                  |
| H20    | DDR3_M0_DQS3_P             |
| H21    | VSS                        |
| H22    | DDR3_M0_DQ31               |
| H23    | DDR3_M0_DQ27               |
| H24    | DDR3_M0_MA09               |
| H25    | DDR3_M0_MA14               |
| H3     | DDI0_RCOMP_P               |
| H4     | DDI0_RCOMP_N               |
| H5     | DDI2_AUXP                  |
| H6     | DDI0_TXP1                  |
| H7     | USB_VDDQ_G3                |

| Ball # | DDR3L-RS Customer Pin List |
|--------|----------------------------|
| H8     | DDI_USB_VDDQ_G3            |
| H9     | MIPI_V1P2A_G3              |
| J1     | USB_RCOMP                  |
| J10    | UNCORE_VNN_S4              |
| J11    | VSS                        |
| J12    | VSS                        |
| J13    | VSS                        |
| J14    | CORE_VCC_S0iX              |
| J15    | CORE_VCC_S0iX              |
| J16    | VSS                        |
| J17    | VSS                        |
| J18    | VSS                        |
| J19    | VSS                        |
| J2     | VSS                        |
| J20    | DDR3_M0_DQ30               |
| J21    | DDR3_M0_DQ29               |
| J22    | DDR3_M0_CK0_P              |
| J23    | DDR3_M0_CK0_N              |
| J24    | VSS                        |
| J25    | DDR3_M0_MA8                |
| J3     | DDI2_TXP0                  |
| J4     | DDI2_TXN0                  |
| J5     | DDI2_AUXN                  |
| J6     | DDI0_TXN1                  |
| J7     | DDI_USB_VDDQ_G3            |
| J8     | USBHSIC_V1P2A_G3           |
| J9     | UNCORE_VNN_S4              |
| K1     | USB_OTG_ID                 |
| K10    | UNCORE_VNN_S4              |
| K11    | UNCORE_VNN_S4              |
| K12    | UNCORE_VNN_S4              |
| K13    | VSS                        |
| K14    | VSS                        |
| K15    | CORE_VCC_S0iX              |
| K16    | F_V1p05A_S0iX              |
| K17    | CORE_V1p05A_S0iX           |
| K18    | DDR_VDDQG_S4               |



| Ball # | DDR3L-RS Customer Pin List |
|--------|----------------------------|
| K19    | VSS                        |
| K2     | USB_VBUSSNS                |
| K20    | DDR3_M0_CK1_P              |
| K21    | DDR3_M0_CK1_N              |
| K22    | DDR3_M0_BS2                |
| K23    | DDR3_M0_MA15               |
| K24    | DDR3_M0_MA6                |
| K25    | DDR3_M0_MA11               |
| K3     | DDI2_TXN1                  |
| K4     | DDI2_TXP1                  |
| K5     | DDI2_TXP3                  |
| K6     | DDI2_TXN3                  |
| K7     | DDI_USB_VDDQ_G3            |
| K8     | USBSSIC_V1P2A_G3           |
| K9     | UNCORE_VNN_S4              |
| L10    | UNCORE_VNN_S4              |
| L11    | UNCORE_VNN_S4              |
| L12    | UNCORE_VNN_S4              |
| L13    | UNCORE2_V1P05A_G3          |
| L14    | CORE_VCC_S0iX              |
| L15    | CORE_VCC_S0iX              |
| L16    | F_V1p05A_S0iX              |
| L17    | CORE_V1p05A_S0iX           |
| L18    | DDR_VDDQG_S4               |
| L19    | DDR_VDDQG_S4               |
| L20    | DDR_VDDQG_S4               |
| L21    | VSS                        |
| L22    | DDR3_M0_MA5                |
| L23    | DDR3_M0_MA1                |
| L3     | USB_DN1                    |
| L4     | USB_DP1                    |
| L5     | VSS                        |
| L6     | UNCORE_VSFR_G3             |
| L7     | VSS                        |
| L8     | USB_V3P3A_G3               |
| L9     | UNCORE_VNN_S4              |
| M1     | USB_HSIC_0_STROBE          |

| Ball # | DDR3L-RS Customer Pin List |
|--------|----------------------------|
| M10    | UNCORE_VNN_S4              |
| M11    | UNCORE_VNN_S4              |
| M12    | UNCORE_VSFR_G3             |
| M13    | VSS                        |
| M14    | CORE_VCC_S0iX              |
| M15    | CORE_VCC_S0iX              |
| M16    | VSS                        |
| M17    | VSS                        |
| M18    | DDR_VDDQG_S4               |
| M19    | VSS                        |
| M2     | USB_HSIC_0_DATA            |
| M20    | DDR3_M0_MA3                |
| M21    | DDR3_M0_BS0                |
| M22    | DDR3_M0_MA4                |
| M23    | DDR3_M0_MA13               |
| M24    | DDR3_M0_MA0                |
| M25    | DDR3_M0_MA12               |
| M3     | USB_DN3                    |
| M4     | USB_DP3                    |
| M5     | USB_DP2                    |
| M6     | USB_DN2                    |
| M7     | USBSSIC_V1P05A_G3          |
| M8     | VSS                        |
| M9     | UNCORE_VNN_S4              |
| N1     | USB_HSIC_RCOMP             |
| N10    | UNCORE_VNN_S4              |
| N11    | DDI_VGG_S0iX               |
| N12    | DDI_VGG_S0iX               |
| N13    | VSS                        |
| N14    | CORE_VCC_S0iX              |
| N15    | CORE_VCC_S0iX              |
| N16    | VSS                        |
| N17    | VSS                        |
| N18    | VSS                        |
| N19    | DDR3_M0_BS1                |
| N2     | VSS                        |
| N20    | DDR3_M0_MA10               |



**Ballout and Ball Map**

| Ball # | DDR3L-RS Customer Pin List |
|--------|----------------------------|
| N21    | VSS                        |
| N22    | DDR3_M0_RAS_N              |
| N23    | DDR3_M0_MA2                |
| N24    | VSS                        |
| N25    | DDR3_M0_MA7                |
| N3     | USB_HSIC_1_STROBE          |
| N4     | USB_HSIC_1_DATA            |
| N5     | USB3_RXP0                  |
| N6     | USB_DP0                    |
| N7     | MPHY_1P05A_G3              |
| N8     | MPHY_1P05A_G3              |
| N9     | VSS                        |
| P1     | USB3_TXP0                  |
| P10    | DDI_VGG_S0iX               |
| P11    | DDI_VGG_S0iX               |
| P12    | VSS                        |
| P13    | RESERVED                   |
| P14    | VSS                        |
| P15    | VSS                        |
| P16    | VSS                        |
| P17    | VSS                        |
| P18    | VSS                        |
| P19    | DDRSFR_VDDQG_S4            |
| P2     | USB3_TXN0                  |
| P20    | DDR3_M0_CAS_N              |
| P21    | DDR3_M0_WE_N               |
| P22    | DDR3_M0_CS0_N              |
| P23    | DDR3_M0_CS1_N              |
| P24    | DDR3_M0_ODT0               |
| P25    | DDR3_M0_ODT1               |
| P3     | USB3_RCOMP_P               |
| P4     | USB3_RCOMP_N               |
| P5     | USB3_RXN0                  |
| P6     | USB_DN0                    |
| P7     | PCIeCLK_V1P05A_G3          |
| P8     | VSS                        |
| P9     | UNCORE_VNN_S4              |

| Ball # | DDR3L-RS Customer Pin List |
|--------|----------------------------|
| R10    | VSS                        |
| R11    | DDI_VGG_S0iX               |
| R12    | VSS                        |
| R13    | DDI_VGG_S0iX               |
| R14    | DDI_VGG_S0iX               |
| R15    | VSS                        |
| R16    | DDI_V1p05A_S0iX            |
| R17    | DDI_V1p05A_S0iX            |
| R18    | DDR_V1P05A_G3              |
| R19    | VSS                        |
| R20    | VSS                        |
| R21    | VSS                        |
| R22    | DDR3_M0_DQ45               |
| R23    | DDR3_M0_DQ44               |
| R3     | PCIE_TXN0                  |
| R4     | PCIE_TXP0                  |
| R5     | VSS                        |
| R6     | VSS                        |
| R7     | F_V1P05A_G3                |
| R8     | ICLK_VSFR_G3               |
| R9     | VSS                        |
| T1     | PCIE_RXP0                  |
| T10    | UNCORE1_V1P05A_G3          |
| T11    | DDI_VGG_S0iX               |
| T12    | DDI_VGG_S0iX               |
| T13    | DDI_VGG_S0iX               |
| T14    | DDI_VGG_S0iX               |
| T15    | DDI_VGG_S0iX               |
| T16    | DDI_VGG_S0iX               |
| T17    | DDI_VGG_S0iX               |
| T18    | VSS                        |
| T19    | DDR_VDDQG_S4               |
| T2     | PCIE_RXN0                  |
| T20    | DDR3_M0_DQ57               |
| T21    | DDR3_M0_DQ63               |
| T22    | DDR3_M0_DQ56               |
| T23    | DDR3_M0_DM7                |



| Ball # | DDR3L-RS Customer Pin List |
|--------|----------------------------|
| T24    | DDR3_M0_DQ41               |
| T25    | DDR3_M0_DQ47               |
| T3     | PCIE_RCOMP_P               |
| T4     | PCIE_RCOMP_N               |
| T5     | PMC_RSMRST_N               |
| T6     | PMC_CORE_PWROK             |
| T7     | F_V1P05A_G3                |
| T8     | VSS                        |
| T9     | F_V1P05A_G3                |
| U1     | RTC_EXTPAD                 |
| U10    | DDI_VGG_S0iX               |
| U11    | DDI_VGG_S0iX               |
| U12    | DDI_VGG_S0iX               |
| U13    | DDI_VGG_S0iX               |
| U14    | DDI_VGG_S0iX               |
| U15    | DDI_VGG_S0iX               |
| U16    | DDI_VGG_S0iX               |
| U17    | LPE_I2S2_DATAIN            |
| U18    | DDR_V1P05A_G3              |
| U19    | DDR3_M0_DRAMRST_N          |
| U2     | VSS                        |
| U20    | DDR3_M0_DQ62               |
| U21    | DDR3_M0_DQ60               |
| U22    | DDR3_M0_DQS7_P             |
| U23    | DDR3_M0_DQS7_N             |
| U24    | VSS                        |
| U25    | DDR3_M0_DQS5_N             |
| U3     | RTC_X1                     |
| U4     | RTC_X2                     |
| U5     | RTC_RST_N                  |
| U6     | RTC_TEST_N                 |
| U7     | F_V3P3A_G3                 |
| U8     | RTC_V3P3A_G5               |
| U9     | F_V1P8A_G3                 |
| V1     | UNCORE_VNN_S4              |
| V10    | UNCORE_V1P8A_G3            |
| V11    | PMC_RSTBTN_N               |

| Ball # | DDR3L-RS Customer Pin List |
|--------|----------------------------|
| V12    | PMC_SUSPWRDNACK            |
| V13    | UART0_DATAIN               |
| V14    | DDI_VGG_S0iX               |
| V15    | UNCORE_V1P8A_G3            |
| V16    | UNCORE_V1P8A_G3            |
| V17    | DDI_VGG_S0iX               |
| V18    | LPE_I2S2_DATAOUT           |
| V19    | DDR_VDDQG_S4               |
| V2     | PCIE_REFCLK0_N             |
| V20    | DDR3_M0_DQ59               |
| V21    | VSS                        |
| V22    | DDR3_M0_DQ46               |
| V23    | DDR3_M0_DQ40               |
| V24    | DDR3_M0_DM5                |
| V25    | DDR3_M0_DQS5_P             |
| V3     | PCIE_REFCLK0_P             |
| V4     | RESERVED                   |
| V5     | PMC_SUS_STAT_N             |
| V6     | VSS                        |
| V7     | VSS                        |
| V8     | RTC_V3P3RTC_G5             |
| V9     | VSS                        |
| W10    | RESERVED                   |
| W11    | VSS                        |
| W12    | VSS                        |
| W13    | SDIO_V3P3A_V1P8A_G3        |
| W14    | DDI_VGG_S0iX               |
| W15    | I2C1_DATA                  |
| W16    | I2C1_CLK                   |
| W17    | VSS                        |
| W18    | VSS                        |
| W19    | VSS                        |
| W20    | DDR3_M0_DQ58               |
| W21    | DDR3_M0_DQ61               |
| W22    | DDR3_M0_DQ42               |
| W23    | DDR3_M0_DQ43               |
| W3     | PMC_PWRBTN_N               |



**Ballout and Ball Map**

| Ball # | DDR3L-RS Customer Pin List |
|--------|----------------------------|
| W4     | PMC_SLP_S0IX_N             |
| W5     | VSS                        |
| W6     | ICLK_OSCOUT                |
| W7     | ICLK_OSCIN                 |
| W8     | VSS                        |
| W9     | UNCORE_V1P8A_G3            |
| Y1     | ISH_GPIO3/I2S3_DATAIN      |
| Y10    | RESERVED                   |
| Y11    | VSS                        |
| Y12    | UART0_DATAOUT              |
| Y13    | LPE_I2S1_DATAIN            |
| Y14    | LPE_I2S1_DATAOUT           |
| Y15    | DDI_VGG_S0iX               |
| Y16    | LPE_I2S0_FRM               |
| Y17    | I2C0_CLK                   |
| Y18    | I2C0_DATA                  |
| Y19    | DDR3_M0_DQ50               |

| Ball # | DDR3L-RS Customer Pin List |
|--------|----------------------------|
| Y2     | ISH_GPIO1/I2S3_FS          |
| Y20    | DDR3_M0_DQ54               |
| Y21    | DDR3_M0_DQ55               |
| Y22    | DDR3_M0_DM6                |
| Y23    | DDR3_M0_DQ53               |
| Y24    | DDR3_M0_DQ34               |
| Y25    | DDR3_M0_DQ39               |
| Y3     | PMC_WAKE_N                 |
| Y4     | PMC_SUSCLK0                |
| Y5     | PMC_PLTRST_N               |
| Y6     | VSSA                       |
| Y7     | VSS                        |
| Y8     | MMC1_D1                    |
| Y9     | USB_OC0_N                  |

## 20.3 SoC T4 Pin List Location

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| A1     | --                     |
| A10    | --                     |
| A11    | MIPI_V1P2A_G3          |
| A12    | --                     |
| A13    | VSS                    |
| A14    | --                     |
| A15    | GPION_V1P8A_G3         |
| A16    | --                     |
| A17    | VSS                    |
| A18    | --                     |
| A19    | CORE_VCC0_S0iX         |
| A2     | --                     |
| A20    | --                     |
| A21    | CORE_VCC0_S0iX         |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| A22    | --                     |
| A23    | CORE_VCC1_S0iX         |
| A24    | --                     |
| A25    | CORE_VCC1_S0iX         |
| A26    | --                     |
| A27    | VSS                    |
| A28    | --                     |
| A29    | --                     |
| A3     | VSS                    |
| A30    | CORE_V1P15_S0iX        |
| A31    | --                     |
| A32    | --                     |
| A33    | CORE_V1P15_S0iX        |
| A34    | --                     |

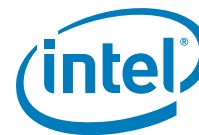


**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| A35    | CORE_V1P15_S0iX        |
| A36    | --                     |
| A37    | CORE_V1P15_S0iX        |
| A38    | --                     |
| A39    | VSS                    |
| A4     | --                     |
| A40    | --                     |
| A41    | DDR_V1P05A_G3          |
| A42    | --                     |
| A43    | DDR_V1P05A_G3          |
| A44    | --                     |
| A45    | VSS                    |
| A46    | --                     |
| A47    | VSS                    |
| A48    | --                     |
| A49    | VSS                    |
| A5     | VSS                    |
| A50    | --                     |
| A51    | VSS                    |
| A52    | --                     |
| A53    | VSS                    |
| A54    | --                     |
| A55    | VSS                    |
| A56    | --                     |
| A57    | VSS                    |
| A58    | --                     |
| A59    | --                     |
| A6     | --                     |
| A7     | VSS                    |
| A8     | --                     |
| A9     | MIPI_V1P2A_G3          |
| AA1    | USBHSIC_V1P2A_G3       |
| AA10   | --                     |
| AA11   | VSS                    |
| AA12   | --                     |
| AA13   | --                     |
| AA14   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AA15   | VSS                    |
| AA16   | --                     |
| AA17   | VSS                    |
| AA18   | --                     |
| AA19   | UNCORE_VNN_S4          |
| AA2    | --                     |
| AA20   | --                     |
| AA21   | UNCORE_VNN_S4          |
| AA22   | --                     |
| AA23   | UNCORE_VNN_S4          |
| AA24   | --                     |
| AA25   | UNCORE_V1P15_S0iX      |
| AA26   | --                     |
| AA27   | UNCORE_VNN_S4          |
| AA28   | --                     |
| AA29   | UNCORE_VNN_S4          |
| AA3    | VSS                    |
| AA30   | --                     |
| AA31   | --                     |
| AA32   | VSS                    |
| AA33   | --                     |
| AA34   | UNCORE_VNN_S4          |
| AA35   | --                     |
| AA36   | UNCORE_VNN_S4          |
| AA37   | --                     |
| AA38   | VSS                    |
| AA39   | --                     |
| AA4    | --                     |
| AA40   | VSS                    |
| AA41   | --                     |
| AA42   | DDR_V1P05A_G3          |
| AA43   | --                     |
| AA44   | VSS                    |
| AA45   | --                     |
| AA46   | VSS                    |
| AA47   | --                     |
| AA48   | --                     |





**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AA49   | VSS                    |
| AA5    | USB_DN[3]              |
| AA50   | --                     |
| AA51   | LPDDR3_M0_DQ[18]_B     |
| AA52   | --                     |
| AA53   | LPDDR3_M0_DQ[21]_B     |
| AA54   | --                     |
| AA55   | LPDDR3_M0_DQ[07]_B     |
| AA56   | --                     |
| AA57   | LPDDR3_M0_DQ[08]_B     |
| AA58   | --                     |
| AA59   | DDR_VDDQG_S4           |
| AA6    | --                     |
| AA7    | USB_HSIC_0_STROBE      |
| AA8    | --                     |
| AA9    | USB_HSIC_0_DATA        |
| AB1    | --                     |
| AB10   | USB_HSIC_1_STROBE      |
| AB11   | --                     |
| AB12   | USB_RCOMP              |
| AB13   | --                     |
| AB14   | --                     |
| AB15   | --                     |
| AB16   | --                     |
| AB17   | --                     |
| AB18   | --                     |
| AB19   | --                     |
| AB2    | USBHSIC_V1P2A_G3       |
| AB20   | --                     |
| AB21   | --                     |
| AB22   | --                     |
| AB23   | --                     |
| AB24   | --                     |
| AB25   | --                     |
| AB26   | --                     |
| AB27   | --                     |
| AB28   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AB29   | --                     |
| AB3    | --                     |
| AB30   | --                     |
| AB31   | --                     |
| AB32   | --                     |
| AB33   | --                     |
| AB34   | --                     |
| AB35   | --                     |
| AB36   | --                     |
| AB37   | --                     |
| AB38   | --                     |
| AB39   | --                     |
| AB4    | USB_SSIC1_RX_P         |
| AB40   | --                     |
| AB41   | --                     |
| AB42   | --                     |
| AB43   | --                     |
| AB44   | --                     |
| AB45   | --                     |
| AB46   | --                     |
| AB47   | --                     |
| AB48   | LPDDR3_M0_DM[03]_B     |
| AB49   | --                     |
| AB5    | --                     |
| AB50   | LPDDR3_M0_DM[02]_B     |
| AB51   | --                     |
| AB52   | LPDDR3_M0_DQ[23]_B     |
| AB53   | --                     |
| AB54   | LPDDR3_M0_DQ[10]_B     |
| AB55   | --                     |
| AB56   | LPDDR3_M0_DQ[09]_B     |
| AB57   | --                     |
| AB58   | VSS                    |
| AB59   | --                     |
| AB6    | VSS                    |
| AB7    | --                     |
| AB8    | USB_HSIC_1_DATA        |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AB9    | --                     |
| AC1    | VSS                    |
| AC10   | --                     |
| AC11   | VSS                    |
| AC12   | --                     |
| AC13   | --                     |
| AC14   | VSS                    |
| AC15   | --                     |
| AC16   | VSS                    |
| AC17   | --                     |
| AC18   | USB_V1P8A_G3           |
| AC19   | --                     |
| AC2    | --                     |
| AC20   | UNCORE_VNN_S4          |
| AC21   | --                     |
| AC22   | VSS                    |
| AC23   | --                     |
| AC24   | UNCORE_VSS_SENSE       |
| AC25   | --                     |
| AC26   | UNCORE_VNN_SENSE       |
| AC27   | --                     |
| AC28   | RESERVED               |
| AC29   | --                     |
| AC3    | USB_SSIC0_RX_P         |
| AC30   | --                     |
| AC31   | UNCORE_VNN_S4          |
| AC32   | --                     |
| AC33   | UNCORE_VNN_S4          |
| AC34   | --                     |
| AC35   | VSS                    |
| AC36   | --                     |
| AC37   | VSS                    |
| AC38   | --                     |
| AC39   | VSS                    |
| AC4    | --                     |
| AC40   | --                     |
| AC41   | DDRSFRCH0_VDDQG_S4     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AC42   | --                     |
| AC43   | VSS                    |
| AC44   | --                     |
| AC45   | VSS                    |
| AC46   | --                     |
| AC47   | --                     |
| AC48   | --                     |
| AC49   | VSS                    |
| AC5    | USB_SSIC1_RX_N         |
| AC50   | --                     |
| AC51   | VSS                    |
| AC52   | --                     |
| AC53   | VSS                    |
| AC54   | --                     |
| AC55   | LPDDR3_M0_DQ[14]_B     |
| AC56   | --                     |
| AC57   | LPDDR3_M0_DQ[13]_B     |
| AC58   | --                     |
| AC59   | DDR_VDDQG_S4           |
| AC6    | --                     |
| AC7    | VSS                    |
| AC8    | --                     |
| AC9    | VSS                    |
| AD1    | --                     |
| AD10   | USB_SSIC1_TX_N         |
| AD11   | --                     |
| AD12   | USB_HSIC_RCOMP         |
| AD13   | --                     |
| AD14   | --                     |
| AD15   | VSS                    |
| AD16   | --                     |
| AD17   | VSS                    |
| AD18   | --                     |
| AD19   | UNCORE_VNN_S4          |
| AD2    | RESERVED               |
| AD20   | --                     |
| AD21   | UNCORE_VNN_S4          |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AD22   | --                     |
| AD23   | VSS                    |
| AD24   | --                     |
| AD25   | UNCORE_VNN_S4          |
| AD26   | --                     |
| AD27   | UNCORE_VNN_S4          |
| AD28   | --                     |
| AD29   | UNCORE_VSFR_G3         |
| AD3    | --                     |
| AD30   | --                     |
| AD31   | --                     |
| AD32   | CORE_VCC1_S0iX         |
| AD33   | --                     |
| AD34   | CORE_VCC1_S0iX         |
| AD35   | --                     |
| AD36   | CORE_VCC1_S0iX         |
| AD37   | --                     |
| AD38   | CORE_VCC1_S0iX         |
| AD39   | --                     |
| AD4    | USB_SSIC0_RX_N         |
| AD40   | F_V1P15_S0iX           |
| AD41   | --                     |
| AD42   | DDRCH0_VDDQG_S4        |
| AD43   | --                     |
| AD44   | LPDDR3_M0_RCOMPDPD     |
| AD45   | --                     |
| AD46   | VSS                    |
| AD47   | --                     |
| AD48   | LPDDR3_M0_DQ[25]_B     |
| AD49   | --                     |
| AD5    | --                     |
| AD50   | LPDDR3_M0_DQ[26]_B     |
| AD51   | --                     |
| AD52   | VSS                    |
| AD53   | --                     |
| AD54   | VSS                    |
| AD55   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AD56   | VSS                    |
| AD57   | --                     |
| AD58   | LPDDR3_M0_DQS[1]_N_B   |
| AD59   | --                     |
| AD6    | VSS                    |
| AD7    | --                     |
| AD8    | VSS                    |
| AD9    | --                     |
| AE1    | USBSSIC_V1P05A_G3      |
| AE10   | --                     |
| AE11   | USB_SSIC1_TX_P         |
| AE12   | --                     |
| AE13   | --                     |
| AE14   | --                     |
| AE15   | --                     |
| AE16   | --                     |
| AE17   | --                     |
| AE18   | --                     |
| AE19   | --                     |
| AE2    | --                     |
| AE20   | --                     |
| AE21   | --                     |
| AE22   | --                     |
| AE23   | --                     |
| AE24   | --                     |
| AE25   | --                     |
| AE26   | --                     |
| AE27   | --                     |
| AE28   | --                     |
| AE29   | --                     |
| AE3    | RESERVED               |
| AE30   | --                     |
| AE31   | --                     |
| AE32   | --                     |
| AE33   | --                     |
| AE34   | --                     |
| AE35   | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AE36   | --                     |
| AE37   | --                     |
| AE38   | --                     |
| AE39   | --                     |
| AE4    | --                     |
| AE40   | --                     |
| AE41   | --                     |
| AE42   | --                     |
| AE43   | --                     |
| AE44   | --                     |
| AE45   | --                     |
| AE46   | --                     |
| AE47   | --                     |
| AE48   | --                     |
| AE49   | LPDDR3_M0_DQ[30]_B     |
| AE5    | USB3_RXP[3]            |
| AE50   | --                     |
| AE51   | LPDDR3_M0_DQS[3]_N_B   |
| AE52   | --                     |
| AE53   | LPDDR3_M0_DQ[27]_B     |
| AE54   | --                     |
| AE55   | LPDDR3_M0_DQ[12]_B     |
| AE56   | --                     |
| AE57   | LPDDR3_M0_DQS[1]_P_B   |
| AE58   | --                     |
| AE59   | DDR_VDDQG_S4           |
| AE6    | --                     |
| AE7    | VSS                    |
| AE8    | --                     |
| AE9    | USB_SSIC0_TX_P         |
| AF1    | --                     |
| AF10   | USB_SSIC0_TX_N         |
| AF11   | --                     |
| AF12   | VSS                    |
| AF13   | --                     |
| AF14   | UNCORE_VSFR_G3         |
| AF15   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AF16   | VSS                    |
| AF17   | --                     |
| AF18   | USBSSIC_V1P2A_G3       |
| AF19   | --                     |
| AF2    | VSS                    |
| AF20   | UNCORE_VNN_S4          |
| AF21   | --                     |
| AF22   | UNCORE_VNN_S4          |
| AF23   | --                     |
| AF24   | UNCORE2_V1P05A_G3      |
| AF25   | --                     |
| AF26   | UNCORE2_V1P05A_G3      |
| AF27   | --                     |
| AF28   | RESERVED               |
| AF29   | --                     |
| AF3    | --                     |
| AF30   | --                     |
| AF31   | VSS                    |
| AF32   | --                     |
| AF33   | CORE_VCC1_S0iX         |
| AF34   | --                     |
| AF35   | CORE_VCC1_S0iX         |
| AF36   | --                     |
| AF37   | CORE_VCC1_S0iX         |
| AF38   | --                     |
| AF39   | CORE_VCC1_SENSE        |
| AF4    | USB3_RXN[3]            |
| AF40   | --                     |
| AF41   | CORE_VSS1_SENSE        |
| AF42   | --                     |
| AF43   | VSS                    |
| AF44   | --                     |
| AF45   | RESERVED               |
| AF46   | --                     |
| AF47   | --                     |
| AF48   | LPDDR3_M0_DQ[29]_B     |
| AF49   | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AF5    | --                     |
| AF50   | LPDDR3_M0_DQS[3]_P_B   |
| AF51   | --                     |
| AF52   | LPDDR3_M0_DQ[31]_B     |
| AF53   | --                     |
| AF54   | VSS                    |
| AF55   | --                     |
| AF56   | LPDDR3_M0_DM[1]_B      |
| AF57   | --                     |
| AF58   | VSS                    |
| AF59   | --                     |
| AF6    | VSS                    |
| AF7    | --                     |
| AF8    | USB_SSIC_RCOMP_P       |
| AF9    | --                     |
| AG1    | USB3_V1P05A_G3         |
| AG10   | --                     |
| AG11   | VSS                    |
| AG12   | --                     |
| AG13   | --                     |
| AG14   | --                     |
| AG15   | --                     |
| AG16   | --                     |
| AG17   | --                     |
| AG18   | --                     |
| AG19   | --                     |
| AG2    | --                     |
| AG20   | --                     |
| AG21   | --                     |
| AG22   | --                     |
| AG23   | --                     |
| AG24   | --                     |
| AG25   | --                     |
| AG26   | --                     |
| AG27   | --                     |
| AG28   | --                     |
| AG29   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AG3    | USB3_RXN[1]            |
| AG30   | --                     |
| AG31   | --                     |
| AG32   | --                     |
| AG33   | --                     |
| AG34   | --                     |
| AG35   | --                     |
| AG36   | --                     |
| AG37   | --                     |
| AG38   | --                     |
| AG39   | --                     |
| AG4    | --                     |
| AG40   | --                     |
| AG41   | --                     |
| AG42   | --                     |
| AG43   | --                     |
| AG44   | --                     |
| AG45   | --                     |
| AG46   | --                     |
| AG47   | --                     |
| AG48   | --                     |
| AG49   | VSS                    |
| AG5    | VSS                    |
| AG50   | --                     |
| AG51   | VSS                    |
| AG52   | --                     |
| AG53   | VSS                    |
| AG54   | --                     |
| AG55   | LPDDR3_M0_DQ[11]_B     |
| AG56   | --                     |
| AG57   | LPDDR3_M0_DQ[15]_B     |
| AG58   | --                     |
| AG59   | VSS                    |
| AG6    | --                     |
| AG7    | VSS                    |
| AG8    | --                     |
| AG9    | USB_SSIC_RCOMP_N       |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AH1    | --                     |
| AH10   | VSS                    |
| AH11   | --                     |
| AH12   | VSS                    |
| AH13   | --                     |
| AH14   | --                     |
| AH15   | VSS                    |
| AH16   | --                     |
| AH17   | VSS                    |
| AH18   | --                     |
| AH19   | UNCORE_VNN_S4          |
| AH2    | USB3_RXP[1]            |
| AH20   | --                     |
| AH21   | UNCORE_VNN_S4          |
| AH22   | --                     |
| AH23   | UNCORE_VNN_S4          |
| AH24   | --                     |
| AH25   | UNCORE_VNN_S4          |
| AH26   | --                     |
| AH27   | RESERVED               |
| AH28   | --                     |
| AH29   | VSS                    |
| AH3    | --                     |
| AH30   | --                     |
| AH31   | --                     |
| AH32   | CORE_VCC1_S0iX         |
| AH33   | --                     |
| AH34   | CORE_VCC1_S0iX         |
| AH35   | --                     |
| AH36   | CORE_VCC1_S0iX         |
| AH37   | --                     |
| AH38   | CORE_VCC1_S0iX         |
| AH39   | --                     |
| AH4    | USB3_RCOMP_N           |
| AH40   | VSS                    |
| AH41   | --                     |
| AH42   | VSS                    |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AH43   | --                     |
| AH44   | VSS                    |
| AH45   | --                     |
| AH46   | RESERVED               |
| AH47   | --                     |
| AH48   | LPDDR3_M0_DQ[28]_B     |
| AH49   | --                     |
| AH5    | --                     |
| AH50   | LPDDR3_M0_DQ[24]_B     |
| AH51   | --                     |
| AH52   | VSS                    |
| AH53   | --                     |
| AH54   | VSS                    |
| AH55   | --                     |
| AH56   | VSS                    |
| AH57   | --                     |
| AH58   | VSS                    |
| AH59   | --                     |
| AH6    | VSS                    |
| AH7    | --                     |
| AH8    | VSS                    |
| AH9    | --                     |
| AJ1    | --                     |
| AJ10   | --                     |
| AJ11   | --                     |
| AJ12   | --                     |
| AJ13   | --                     |
| AJ14   | --                     |
| AJ15   | --                     |
| AJ16   | --                     |
| AJ17   | --                     |
| AJ18   | --                     |
| AJ19   | --                     |
| AJ2    | --                     |
| AJ20   | --                     |
| AJ21   | --                     |
| AJ22   | --                     |

**Ballout and Ball Map**



| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AJ23   | --                     |
| AJ24   | --                     |
| AJ25   | --                     |
| AJ26   | --                     |
| AJ27   | --                     |
| AJ28   | --                     |
| AJ29   | --                     |
| AJ3    | --                     |
| AJ30   | --                     |
| AJ31   | --                     |
| AJ32   | --                     |
| AJ33   | --                     |
| AJ34   | --                     |
| AJ35   | --                     |
| AJ36   | --                     |
| AJ37   | --                     |
| AJ38   | --                     |
| AJ39   | --                     |
| AJ4    | --                     |
| AJ40   | --                     |
| AJ41   | --                     |
| AJ42   | --                     |
| AJ43   | --                     |
| AJ44   | --                     |
| AJ45   | --                     |
| AJ46   | --                     |
| AJ47   | --                     |
| AJ48   | --                     |
| AJ49   | --                     |
| AJ5    | --                     |
| AJ50   | --                     |
| AJ51   | --                     |
| AJ52   | --                     |
| AJ53   | --                     |
| AJ54   | --                     |
| AJ55   | --                     |
| AJ56   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AJ57   | --                     |
| AJ58   | --                     |
| AJ59   | --                     |
| AJ6    | --                     |
| AJ7    | --                     |
| AJ8    | --                     |
| AJ9    | --                     |
| AK1    | USB3_V1P05A_G3         |
| AK10   | --                     |
| AK11   | VSS                    |
| AK12   | --                     |
| AK13   | --                     |
| AK14   | VSS                    |
| AK15   | --                     |
| AK16   | RESERVED               |
| AK17   | --                     |
| AK18   | RESERVED               |
| AK19   | --                     |
| AK2    | --                     |
| AK20   | UNCORE_VNN_S4          |
| AK21   | --                     |
| AK22   | DDI_VGG_S0iX           |
| AK23   | --                     |
| AK24   | DDI_VGG_S0iX           |
| AK25   | --                     |
| AK26   | VSS                    |
| AK27   | --                     |
| AK28   | CORE1_VSFR_G3          |
| AK29   | --                     |
| AK3    | USB3_RCOMP_P           |
| AK30   | --                     |
| AK31   | CORE1_VSFR_G3          |
| AK32   | --                     |
| AK33   | CORE_VCC1_S0iX         |
| AK34   | --                     |
| AK35   | CORE_VCC1_S0iX         |
| AK36   | --                     |

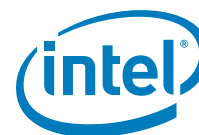


**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AK37   | CORE_VCC1_S0iX         |
| AK38   | --                     |
| AK39   | RESERVED               |
| AK4    | --                     |
| AK40   | --                     |
| AK41   | RESERVED               |
| AK42   | --                     |
| AK43   | VSS                    |
| AK44   | --                     |
| AK45   | VSS                    |
| AK46   | --                     |
| AK47   | --                     |
| AK48   | --                     |
| AK49   | LPDDR3_DRAM_PWROK      |
| AK5    | USB3_RXN[2]            |
| AK50   | --                     |
| AK51   | LPDDR3_CORE_PWROK      |
| AK52   | --                     |
| AK53   | VSS                    |
| AK54   | --                     |
| AK55   | VSS                    |
| AK56   | --                     |
| AK57   | VSS                    |
| AK58   | --                     |
| AK59   | VSS                    |
| AK6    | --                     |
| AK7    | VSS                    |
| AK8    | --                     |
| AK9    | USB3_TXP[2]            |
| AL1    | --                     |
| AL10   | --                     |
| AL11   | --                     |
| AL12   | --                     |
| AL13   | --                     |
| AL14   | --                     |
| AL15   | --                     |
| AL16   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AL17   | --                     |
| AL18   | --                     |
| AL19   | --                     |
| AL2    | --                     |
| AL20   | --                     |
| AL21   | --                     |
| AL22   | --                     |
| AL23   | --                     |
| AL24   | --                     |
| AL25   | --                     |
| AL26   | --                     |
| AL27   | --                     |
| AL28   | --                     |
| AL29   | --                     |
| AL3    | --                     |
| AL30   | --                     |
| AL31   | --                     |
| AL32   | --                     |
| AL33   | --                     |
| AL34   | --                     |
| AL35   | --                     |
| AL36   | --                     |
| AL37   | --                     |
| AL38   | --                     |
| AL39   | --                     |
| AL4    | --                     |
| AL40   | --                     |
| AL41   | --                     |
| AL42   | --                     |
| AL43   | --                     |
| AL44   | --                     |
| AL45   | --                     |
| AL46   | --                     |
| AL47   | --                     |
| AL48   | --                     |
| AL49   | --                     |
| AL5    | --                     |





**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AL50   | --                     |
| AL51   | --                     |
| AL52   | --                     |
| AL53   | --                     |
| AL54   | --                     |
| AL55   | --                     |
| AL56   | --                     |
| AL57   | --                     |
| AL58   | --                     |
| AL59   | --                     |
| AL6    | --                     |
| AL7    | --                     |
| AL8    | --                     |
| AL9    | --                     |
| AM1    | --                     |
| AM10   | USB3_TXN[2]            |
| AM11   | --                     |
| AM12   | VSS                    |
| AM13   | --                     |
| AM14   | --                     |
| AM15   | VSS                    |
| AM16   | --                     |
| AM17   | VSS                    |
| AM18   | --                     |
| AM19   | UNCORE_VNN_S4          |
| AM2    | VSS                    |
| AM20   | --                     |
| AM21   | DDI_VGG_S0iX           |
| AM22   | --                     |
| AM23   | VSS                    |
| AM24   | --                     |
| AM25   | DDI_VGG_S0iX           |
| AM26   | --                     |
| AM27   | DDI_VGG_S0iX           |
| AM28   | --                     |
| AM29   | VSS                    |
| AM3    | --                     |

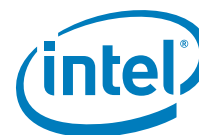
| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AM30   | --                     |
| AM31   | --                     |
| AM32   | VSS                    |
| AM33   | --                     |
| AM34   | PWR_RSVD_OBS           |
| AM35   | --                     |
| AM36   | DDI_VGG_S0iX           |
| AM37   | --                     |
| AM38   | DDI_VGG_S0iX           |
| AM39   | --                     |
| AM4    | USB3_RXP[2]            |
| AM40   | DDI_VGG_S0iX           |
| AM41   | --                     |
| AM42   | VSS                    |
| AM43   | --                     |
| AM44   | VSS                    |
| AM45   | --                     |
| AM46   | RESERVED               |
| AM47   | --                     |
| AM48   | LPDDR3_M1_DQ[19]_A     |
| AM49   | --                     |
| AM5    | --                     |
| AM50   | LPDDR3_M1_DQ[23]_A     |
| AM51   | --                     |
| AM52   | VSS                    |
| AM53   | --                     |
| AM54   | VSS                    |
| AM55   | --                     |
| AM56   | VSS                    |
| AM57   | --                     |
| AM58   | VSS                    |
| AM59   | --                     |
| AM6    | VSS                    |
| AM7    | --                     |
| AM8    | USB3_TXP[3]            |
| AM9    | --                     |
| AN1    | PWR_RSVD_V1P05         |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AN10   | --                     |
| AN11   | USB3_TXP[0]            |
| AN12   | --                     |
| AN13   | --                     |
| AN14   | --                     |
| AN15   | --                     |
| AN16   | --                     |
| AN17   | --                     |
| AN18   | --                     |
| AN19   | --                     |
| AN2    | --                     |
| AN20   | --                     |
| AN21   | --                     |
| AN22   | --                     |
| AN23   | --                     |
| AN24   | --                     |
| AN25   | --                     |
| AN26   | --                     |
| AN27   | --                     |
| AN28   | --                     |
| AN29   | --                     |
| AN3    | VSS                    |
| AN30   | --                     |
| AN31   | --                     |
| AN32   | --                     |
| AN33   | --                     |
| AN34   | --                     |
| AN35   | --                     |
| AN36   | --                     |
| AN37   | --                     |
| AN38   | --                     |
| AN39   | --                     |
| AN4    | --                     |
| AN40   | --                     |
| AN41   | --                     |
| AN42   | --                     |
| AN43   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AN44   | --                     |
| AN45   | --                     |
| AN46   | --                     |
| AN47   | --                     |
| AN48   | --                     |
| AN49   | VSS                    |
| AN5    | USB3_RXP[0]            |
| AN50   | --                     |
| AN51   | VSS                    |
| AN52   | --                     |
| AN53   | VSS                    |
| AN54   | --                     |
| AN55   | LPDDR3_M1_DQ[04]_A     |
| AN56   | --                     |
| AN57   | LPDDR3_M1_DQ[00]_A     |
| AN58   | --                     |
| AN59   | VSS                    |
| AN6    | --                     |
| AN7    | USB3_TXP[1]            |
| AN8    | --                     |
| AN9    | USB3_TXN[3]            |
| AP1    | --                     |
| AP10   | USB3_TXN[0]            |
| AP11   | --                     |
| AP12   | VSS                    |
| AP13   | --                     |
| AP14   | VSS                    |
| AP15   | --                     |
| AP16   | VSS                    |
| AP17   | --                     |
| AP18   | VSS                    |
| AP19   | --                     |
| AP2    | VSS                    |
| AP20   | UNCORE_VNN_S4          |
| AP21   | --                     |
| AP22   | DDI_VGG_S0iX           |
| AP23   | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AP24   | DDI_VGG_S0iX           |
| AP25   | --                     |
| AP26   | DDI_VGG_S0iX           |
| AP27   | --                     |
| AP28   | DDI_VGG_S0iX           |
| AP29   | --                     |
| AP3    | --                     |
| AP30   | --                     |
| AP31   | DDI_VGG_S0iX           |
| AP32   | --                     |
| AP33   | DDI_VGG_S0iX           |
| AP34   | --                     |
| AP35   | DDI_VGG_S0iX           |
| AP36   | --                     |
| AP37   | DDI_VGG_S0iX           |
| AP38   | --                     |
| AP39   | DDI_VGG_S0iX           |
| AP4    | USB3_RXN[0]            |
| AP40   | --                     |
| AP41   | VSS                    |
| AP42   | --                     |
| AP43   | LPDDR3_M1_RCOMPPD      |
| AP44   | --                     |
| AP45   | RESERVED               |
| AP46   | --                     |
| AP47   | --                     |
| AP48   | LPDDR3_M1_DQ[18]_A     |
| AP49   | --                     |
| AP5    | --                     |
| AP50   | LPDDR3_M1_DQS[2]_P_A   |
| AP51   | --                     |
| AP52   | LPDDR3_M1_DQ[16]_A     |
| AP53   | --                     |
| AP54   | VSS                    |
| AP55   | --                     |
| AP56   | LPDDR3_M1_DM[0]_A      |
| AP57   | --                     |

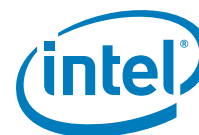
| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AP58   | VSS                    |
| AP59   | --                     |
| AP6    | USB3_TXN[1]            |
| AP7    | --                     |
| AP8    | VSS                    |
| AP9    | --                     |
| AR1    | PWR_RSVD_V1P05         |
| AR10   | --                     |
| AR11   | VSS                    |
| AR12   | --                     |
| AR13   | --                     |
| AR14   | --                     |
| AR15   | --                     |
| AR16   | --                     |
| AR17   | --                     |
| AR18   | --                     |
| AR19   | --                     |
| AR2    | --                     |
| AR20   | --                     |
| AR21   | --                     |
| AR22   | --                     |
| AR23   | --                     |
| AR24   | --                     |
| AR25   | --                     |
| AR26   | --                     |
| AR27   | --                     |
| AR28   | --                     |
| AR29   | --                     |
| AR3    | RESERVED               |
| AR30   | --                     |
| AR31   | --                     |
| AR32   | --                     |
| AR33   | --                     |
| AR34   | --                     |
| AR35   | --                     |
| AR36   | --                     |
| AR37   | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AR38   | --                     |
| AR39   | --                     |
| AR4    | --                     |
| AR40   | --                     |
| AR41   | --                     |
| AR42   | --                     |
| AR43   | --                     |
| AR44   | --                     |
| AR45   | --                     |
| AR46   | --                     |
| AR47   | --                     |
| AR48   | --                     |
| AR49   | LPDDR3_M1_DQ[17]_A     |
| AR5    | VSS                    |
| AR50   | --                     |
| AR51   | LPDDR3_M1_DQS[2]_N_A   |
| AR52   | --                     |
| AR53   | LPDDR3_M1_DQ[20]_A     |
| AR54   | --                     |
| AR55   | LPDDR3_M1_DQ[03]_A     |
| AR56   | --                     |
| AR57   | LPDDR3_M1_DQS[0]_P_A   |
| AR58   | --                     |
| AR59   | DDR_VDDQG_S4           |
| AR6    | --                     |
| AR7    | VSS                    |
| AR8    | --                     |
| AR9    | RESERVED               |
| AT1    | --                     |
| AT10   | PCIE_TXP[1]            |
| AT11   | --                     |
| AT12   | VSS                    |
| AT13   | --                     |
| AT14   | --                     |
| AT15   | VSS                    |
| AT16   | --                     |
| AT17   | VSS                    |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AT18   | --                     |
| AT19   | UNCORE_VNN_S4          |
| AT2    | RESERVED               |
| AT20   | --                     |
| AT21   | UNCORE_VNN_S4          |
| AT22   | --                     |
| AT23   | DDI_VGG_S0iX           |
| AT24   | --                     |
| AT25   | VSS                    |
| AT26   | --                     |
| AT27   | VSS                    |
| AT28   | --                     |
| AT29   | DDI_VGG_S0iX           |
| AT3    | --                     |
| AT30   | --                     |
| AT31   | --                     |
| AT32   | PWR_RSVD_OBS           |
| AT33   | --                     |
| AT34   | VSS                    |
| AT35   | --                     |
| AT36   | VSS                    |
| AT37   | --                     |
| AT38   | DDI_VGG_S0iX           |
| AT39   | --                     |
| AT4    | S_RCOMP_P              |
| AT40   | DDI_VGG_S0iX           |
| AT41   | --                     |
| AT42   | DDRCH1_VDDQG_S4        |
| AT43   | --                     |
| AT44   | VSS                    |
| AT45   | --                     |
| AT46   | VSS                    |
| AT47   | --                     |
| AT48   | LPDDR3_M1_DQ[22]_A     |
| AT49   | --                     |
| AT5    | --                     |
| AT50   | LPDDR3_M1_DQ[21]_A     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AT51   | --                     |
| AT52   | VSS                    |
| AT53   | --                     |
| AT54   | VSS                    |
| AT55   | --                     |
| AT56   | VSS                    |
| AT57   | --                     |
| AT58   | LPDDR3_M1_DQS[0]_N_A   |
| AT59   | --                     |
| AT6    | VSS                    |
| AT7    | --                     |
| AT8    | RESERVED               |
| AT9    | --                     |
| AU1    | PCIE_V1P05_G3          |
| AU10   | --                     |
| AU11   | PCIE_TXP[0]            |
| AU12   | --                     |
| AU13   | --                     |
| AU14   | F_V3P3A_G3             |
| AU15   | --                     |
| AU16   | VSS                    |
| AU17   | --                     |
| AU18   | F_V1P05A_G3            |
| AU19   | --                     |
| AU2    | --                     |
| AU20   | VSS                    |
| AU21   | --                     |
| AU22   | UNCORE_VNN_S4          |
| AU23   | --                     |
| AU24   | DDI_VGG_S0iX           |
| AU25   | --                     |
| AU26   | DDI_VGG_S0iX           |
| AU27   | --                     |
| AU28   | DDI_VGG_S0iX           |
| AU29   | --                     |
| AU3    | S_RCOMP_N              |
| AU30   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AU31   | DDI_VGG_S0iX           |
| AU32   | --                     |
| AU33   | DDI_VGG_S0iX           |
| AU34   | --                     |
| AU35   | DDI_VGG_S0iX           |
| AU36   | --                     |
| AU37   | DDI_VGG_S0iX           |
| AU38   | --                     |
| AU39   | DDI_VGG_S0iX           |
| AU4    | --                     |
| AU40   | --                     |
| AU41   | DDRSFRCH1_VDDQG_S4     |
| AU42   | --                     |
| AU43   | VSS                    |
| AU44   | --                     |
| AU45   | VSS                    |
| AU46   | --                     |
| AU47   | --                     |
| AU48   | --                     |
| AU49   | VSS                    |
| AU5    | PCIE_RXP[1]            |
| AU50   | --                     |
| AU51   | VSS                    |
| AU52   | --                     |
| AU53   | VSS                    |
| AU54   | --                     |
| AU55   | LPDDR3_M1_DQ[01]_A     |
| AU56   | --                     |
| AU57   | LPDDR3_M1_DQ[02]_A     |
| AU58   | --                     |
| AU59   | DDR_VDDQG_S4           |
| AU6    | --                     |
| AU7    | VSS                    |
| AU8    | --                     |
| AU9    | PCIE_TXN[1]            |
| AV1    | --                     |
| AV10   | PCIE_TXN[0]            |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AV11   | --                     |
| AV12   | ICLK_ICOMP             |
| AV13   | --                     |
| AV14   | --                     |
| AV15   | --                     |
| AV16   | --                     |
| AV17   | --                     |
| AV18   | --                     |
| AV19   | --                     |
| AV2    | VSS                    |
| AV20   | --                     |
| AV21   | --                     |
| AV22   | --                     |
| AV23   | --                     |
| AV24   | --                     |
| AV25   | --                     |
| AV26   | --                     |
| AV27   | --                     |
| AV28   | --                     |
| AV29   | --                     |
| AV3    | --                     |
| AV30   | --                     |
| AV31   | --                     |
| AV32   | --                     |
| AV33   | --                     |
| AV34   | --                     |
| AV35   | --                     |
| AV36   | --                     |
| AV37   | --                     |
| AV38   | --                     |
| AV39   | --                     |
| AV4    | PCIE_RXN[1]            |
| AV40   | --                     |
| AV41   | --                     |
| AV42   | --                     |
| AV43   | --                     |
| AV44   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AV45   | --                     |
| AV46   | --                     |
| AV47   | --                     |
| AV48   | LPDDR3_M1_DM[2]_A      |
| AV49   | --                     |
| AV5    | --                     |
| AV50   | LPDDR3_M1_DM[3]_A      |
| AV51   | --                     |
| AV52   | LPDDR3_M1_DQ[24]_A     |
| AV53   | --                     |
| AV54   | LPDDR3_M1_DQ[05]_A     |
| AV55   | --                     |
| AV56   | LPDDR3_M1_DQ[06]_A     |
| AV57   | --                     |
| AV58   | VSS                    |
| AV59   | --                     |
| AV6    | VSS                    |
| AV7    | --                     |
| AV8    | VSS                    |
| AV9    | --                     |
| AW1    | PCIE_V1P05_G3          |
| AW10   | --                     |
| AW11   | VSS                    |
| AW12   | --                     |
| AW13   | --                     |
| AW14   | --                     |
| AW15   | VSS                    |
| AW16   | --                     |
| AW17   | UNCORE1_V1P05A_G3      |
| AW18   | --                     |
| AW19   | UNCORE1_V1P05A_G3      |
| AW2    | --                     |
| AW20   | --                     |
| AW21   | UNCORE_VNN_S4          |
| AW22   | --                     |
| AW23   | DDI_VGG_S0iX           |
| AW24   | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AW25   | DDI_VGG_SENSE          |
| AW26   | --                     |
| AW27   | DDI_VGG_S0iX           |
| AW28   | --                     |
| AW29   | DDI_VGG_S0iX           |
| AW3    | PCIE_RXN[0]            |
| AW30   | --                     |
| AW31   | --                     |
| AW32   | DDI_VGG_S0iX           |
| AW33   | --                     |
| AW34   | DDI_VGG_S0iX           |
| AW35   | --                     |
| AW36   | DDI_VGG_S0iX           |
| AW37   | --                     |
| AW38   | DDI_VGG_S0iX           |
| AW39   | --                     |
| AW4    | --                     |
| AW40   | DDI_VGG_S0iX           |
| AW41   | --                     |
| AW42   | DDR_V1P05A_G3          |
| AW43   | --                     |
| AW44   | VSS                    |
| AW45   | --                     |
| AW46   | VSS                    |
| AW47   | --                     |
| AW48   | --                     |
| AW49   | VSS                    |
| AW5    | VSS                    |
| AW50   | --                     |
| AW51   | LPDDR3_M1_DQ[29]_A     |
| AW52   | --                     |
| AW53   | LPDDR3_M1_DQ[26]_A     |
| AW54   | --                     |
| AW55   | LPDDR3_M1_DQ[08]_A     |
| AW56   | --                     |
| AW57   | LPDDR3_M1_DQ[07]_A     |
| AW58   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AW59   | DDR_VDDQG_S4           |
| AW6    | --                     |
| AW7    | VSS                    |
| AW8    | --                     |
| AW9    | VSS                    |
| AY1    | --                     |
| AY10   | VSS                    |
| AY11   | --                     |
| AY12   | RESERVED               |
| AY13   | --                     |
| AY14   | --                     |
| AY15   | --                     |
| AY16   | --                     |
| AY17   | --                     |
| AY18   | --                     |
| AY19   | --                     |
| AY2    | PCIE_RCOMP_P           |
| AY20   | --                     |
| AY21   | --                     |
| AY22   | --                     |
| AY23   | --                     |
| AY24   | --                     |
| AY25   | --                     |
| AY26   | --                     |
| AY27   | --                     |
| AY28   | --                     |
| AY29   | --                     |
| AY3    | --                     |
| AY30   | --                     |
| AY31   | --                     |
| AY32   | --                     |
| AY33   | --                     |
| AY34   | --                     |
| AY35   | --                     |
| AY36   | --                     |
| AY37   | --                     |
| AY38   | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| AY39   | --                     |
| AY4    | PCIE_RXP[0]            |
| AY40   | --                     |
| AY41   | --                     |
| AY42   | --                     |
| AY43   | --                     |
| AY44   | --                     |
| AY45   | --                     |
| AY46   | --                     |
| AY47   | --                     |
| AY48   | LPDDR3_M1_DQ[27]_A     |
| AY49   | --                     |
| AY5    | --                     |
| AY50   | LPDDR3_M1_DQS[3]_P_A   |
| AY51   | --                     |
| AY52   | LPDDR3_M1_DQ[25]_A     |
| AY53   | --                     |
| AY54   | LPDDR3_M1_DQ[11]_A     |
| AY55   | --                     |
| AY56   | VSS                    |
| AY57   | --                     |
| AY58   | LPDDR3_M1_DQ[09]_A     |
| AY59   | --                     |
| AY6    | VSS                    |
| AY7    | --                     |
| AY8    | ICLK_OSCIN             |
| AY9    | --                     |
| B1     | --                     |
| B10    | MIPI_V1P2A_G3          |
| B11    | --                     |
| B12    | MDSI_A_CLKP            |
| B13    | --                     |
| B14    | GPION_V1P8A_G3         |
| B15    | --                     |
| B16    | MCSI_2_DP[0]           |
| B17    | --                     |
| B18    | CORE_VCC0_S0iX         |

| Ball # | Customer Name - LPDDR3            |
|--------|-----------------------------------|
| B19    | --                                |
| B2     | VSS                               |
| B20    | MCSI_1_DN[1]                      |
| B21    | --                                |
| B22    | CORE_VCC0_S0iX                    |
| B23    | --                                |
| B24    | CORE_VCC1_S0iX                    |
| B25    | --                                |
| B26    | CORE_VCC1_S0iX                    |
| B27    | --                                |
| B28    | GPIO_CAMERASB03                   |
| B29    | --                                |
| B3     | --                                |
| B30    | --                                |
| B31    | --                                |
| B32    | VSS                               |
| B33    | --                                |
| B34    | JTAG_TMS                          |
| B35    | --                                |
| B36    | CORE_V1P15_S0iX                   |
| B37    | --                                |
| B38    | GPIO_N3/C0_BPM1_TX/<br>C1_BPM1_TX |
| B39    | --                                |
| B4     | VSS                               |
| B40    | DDR_V1P05A_G3                     |
| B41    | --                                |
| B42    | LPDDR3_M0_DQ[17]_A                |
| B43    | --                                |
| B44    | VSS                               |
| B45    | --                                |
| B46    | LPDDR3_M0_DQS[2]_P_A              |
| B47    | --                                |
| B48    | VSS                               |
| B49    | --                                |
| B5     | --                                |
| B50    | LPDDR3_M0_DQS[3]_P_A              |
| B51    | --                                |



**Ballout and Ball Map**



| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| B52    | VSS                    |
| B53    | --                     |
| B54    | LPDDR3_M0_ODT_A        |
| B55    | --                     |
| B56    | LPDDR3_M0_CS[1]_N      |
| B57    | --                     |
| B58    | VSS                    |
| B59    | --                     |
| B6     | MDSI_C_CLKP            |
| B7     | --                     |
| B8     | VSS                    |
| B9     | --                     |
| BA1    | VSS                    |
| BA10   | --                     |
| BA11   | VSS                    |
| BA12   | --                     |
| BA13   | --                     |
| BA14   | VSS                    |
| BA15   | --                     |
| BA16   | F_V1P05A_G3            |
| BA17   | --                     |
| BA18   | F_V1P05A_G3            |
| BA19   | --                     |
| BA2    | --                     |
| BA20   | UNCORE_VNN_S4          |
| BA21   | --                     |
| BA22   | DDI_VGG_S0iX           |
| BA23   | --                     |
| BA24   | DDI_VSS_SENSE          |
| BA25   | --                     |
| BA26   | VSS                    |
| BA27   | --                     |
| BA28   | VSS                    |
| BA29   | --                     |
| BA3    | PCIE_RCOMP_N           |
| BA30   | --                     |
| BA31   | DDI_VGG_S0iX           |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BA32   | --                     |
| BA33   | DDI_VGG_S0iX           |
| BA34   | --                     |
| BA35   | VSS                    |
| BA36   | --                     |
| BA37   | VSS                    |
| BA38   | --                     |
| BA39   | DDI_VGG_S0iX           |
| BA4    | --                     |
| BA40   | --                     |
| BA41   | VSS                    |
| BA42   | --                     |
| BA43   | VSS                    |
| BA44   | --                     |
| BA45   | VSS                    |
| BA46   | --                     |
| BA47   | --                     |
| BA48   | --                     |
| BA49   | LPDDR3_M1_DQ[31]_A     |
| BA5    | PCIE_REFCLK[0]_P       |
| BA50   | --                     |
| BA51   | LPDDR3_M1_DQS[3]_N_A   |
| BA52   | --                     |
| BA53   | VSS                    |
| BA54   | --                     |
| BA55   | LPDDR3_M1_DQS[1]_P_A   |
| BA56   | --                     |
| BA57   | LPDDR3_M1_DQ[10]_A     |
| BA58   | --                     |
| BA59   | DDR_VDDQG_S4           |
| BA6    | --                     |
| BA7    | VSS                    |
| BA8    | --                     |
| BA9    | ICLK_OSCOUT            |
| BB1    | --                     |
| BB10   | VSS                    |
| BB11   | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BB12   | ICLK_RCOMP             |
| BB13   | --                     |
| BB14   | --                     |
| BB15   | RTC_V3P3RTC_G5         |
| BB16   | --                     |
| BB17   | F_V1P8A_G3             |
| BB18   | --                     |
| BB19   | VSS                    |
| BB2    | ICLK_VSFR_G3           |
| BB20   | --                     |
| BB21   | UNCORE_VNN_S4          |
| BB22   | --                     |
| BB23   | DDI_VGG_S0iX           |
| BB24   | --                     |
| BB25   | DDI_VGG_S0iX           |
| BB26   | --                     |
| BB27   | DDI_VGG_S0iX           |
| BB28   | --                     |
| BB29   | DDI_VGG_S0iX           |
| BB3    | --                     |
| BB30   | --                     |
| BB31   | --                     |
| BB32   | DDI_VGG_S0iX           |
| BB33   | --                     |
| BB34   | DDI_VGG_S0iX           |
| BB35   | --                     |
| BB36   | DDI_VGG_S0iX           |
| BB37   | --                     |
| BB38   | DDI_VGG_S0iX           |
| BB39   | --                     |
| BB4    | PCIE_REFCLK[0]_N       |
| BB40   | DDI_VGG_S0iX           |
| BB41   | --                     |
| BB42   | VSS                    |
| BB43   | --                     |
| BB44   | VSS                    |
| BB45   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BB46   | VSS                    |
| BB47   | --                     |
| BB48   | LPDDR3_M1_DQ[30]_A     |
| BB49   | --                     |
| BB5    | --                     |
| BB50   | LPDDR3_M1_DQ[28]_A     |
| BB51   | --                     |
| BB52   | VSS                    |
| BB53   | --                     |
| BB54   | VSS                    |
| BB55   | --                     |
| BB56   | LPDDR3_M1_DQS[1]_N_A   |
| BB57   | --                     |
| BB58   | VSS                    |
| BB59   | --                     |
| BB6    | VSS                    |
| BB7    | --                     |
| BB8    | VSSA                   |
| BB9    | --                     |
| BC1    | ICLK_VSFR_G3           |
| BC10   | --                     |
| BC11   | VSS                    |
| BC12   | --                     |
| BC13   | --                     |
| BC14   | --                     |
| BC15   | --                     |
| BC16   | --                     |
| BC17   | --                     |
| BC18   | --                     |
| BC19   | --                     |
| BC2    | --                     |
| BC20   | --                     |
| BC21   | --                     |
| BC22   | --                     |
| BC23   | --                     |
| BC24   | --                     |
| BC25   | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BC26   | --                     |
| BC27   | --                     |
| BC28   | --                     |
| BC29   | --                     |
| BC3    | PCIE_REFCLK[1]_P       |
| BC30   | --                     |
| BC31   | --                     |
| BC32   | --                     |
| BC33   | --                     |
| BC34   | --                     |
| BC35   | --                     |
| BC36   | --                     |
| BC37   | --                     |
| BC38   | --                     |
| BC39   | --                     |
| BC4    | --                     |
| BC40   | --                     |
| BC41   | --                     |
| BC42   | --                     |
| BC43   | --                     |
| BC44   | --                     |
| BC45   | --                     |
| BC46   | --                     |
| BC47   | --                     |
| BC48   | --                     |
| BC49   | VSS                    |
| BC5    | VSS                    |
| BC50   | --                     |
| BC51   | VSS                    |
| BC52   | --                     |
| BC53   | VSS                    |
| BC54   | --                     |
| BC55   | LPDDR3_M1_DM[1]_A      |
| BC56   | --                     |
| BC57   | LPDDR3_M1_DQ[14]_A     |
| BC58   | --                     |
| BC59   | VSS                    |

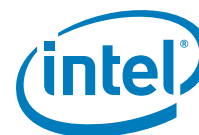
| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BC6    | --                     |
| BC7    | VSS                    |
| BC8    | --                     |
| BC9    | RESERVED               |
| BD1    | --                     |
| BD10   | RESERVED               |
| BD11   | --                     |
| BD12   | VSS                    |
| BD13   | --                     |
| BD14   | RTC_V3P3A_G5           |
| BD15   | --                     |
| BD16   | VSS                    |
| BD17   | --                     |
| BD18   | VSS                    |
| BD19   | --                     |
| BD2    | PCIE_REFCLK[1]_N       |
| BD20   | UNCORE_VNN_S4          |
| BD21   | --                     |
| BD22   | DDI_VGG_S0iX           |
| BD23   | --                     |
| BD24   | VSS                    |
| BD25   | --                     |
| BD26   | DDI_VGG_S0iX           |
| BD27   | --                     |
| BD28   | GPIOSE_V1P8A_G3        |
| BD29   | --                     |
| BD3    | --                     |
| BD30   | --                     |
| BD31   | GPIOSE_V1P8A_G3        |
| BD32   | --                     |
| BD33   | DDI_VGG_S0iX           |
| BD34   | --                     |
| BD35   | DDI_VGG_S0iX           |
| BD36   | --                     |
| BD37   | DDI_VGG_S0iX           |
| BD38   | --                     |
| BD39   | DDI_VGG_S0iX           |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BD4    | RTC_TEST_N             |
| BD40   | --                     |
| BD41   | VSS                    |
| BD42   | --                     |
| BD43   | VSS                    |
| BD44   | --                     |
| BD45   | VSS                    |
| BD46   | --                     |
| BD47   | --                     |
| BD48   | LPDDR3_M1_OCAVREF      |
| BD49   | --                     |
| BD5    | --                     |
| BD50   | LPDDR3_M1_ODQVREF      |
| BD51   | --                     |
| BD52   | LPDDR3_M1_CA[08]       |
| BD53   | --                     |
| BD54   | LPDDR3_M1_DQ[15]_A     |
| BD55   | --                     |
| BD56   | VSS                    |
| BD57   | --                     |
| BD58   | LPDDR3_M1_DQ[12]       |
| BD59   | --                     |
| BD6    | VSS                    |
| BD7    | --                     |
| BD8    | RESERVED               |
| BD9    | --                     |
| BE1    | VSS                    |
| BE10   | --                     |
| BE11   | VSS                    |
| BE12   | --                     |
| BE13   | --                     |
| BE14   | --                     |
| BE15   | --                     |
| BE16   | --                     |
| BE17   | --                     |
| BE18   | --                     |
| BE19   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BE2    | --                     |
| BE20   | --                     |
| BE21   | --                     |
| BE22   | --                     |
| BE23   | --                     |
| BE24   | --                     |
| BE25   | --                     |
| BE26   | --                     |
| BE27   | --                     |
| BE28   | --                     |
| BE29   | --                     |
| BE3    | PMC_RSMRST_N           |
| BE30   | --                     |
| BE31   | --                     |
| BE32   | --                     |
| BE33   | --                     |
| BE34   | --                     |
| BE35   | --                     |
| BE36   | --                     |
| BE37   | --                     |
| BE38   | --                     |
| BE39   | --                     |
| BE4    | --                     |
| BE40   | --                     |
| BE41   | --                     |
| BE42   | --                     |
| BE43   | --                     |
| BE44   | --                     |
| BE45   | --                     |
| BE46   | --                     |
| BE47   | --                     |
| BE48   | --                     |
| BE49   | RESERVED               |
| BE5    | RESERVED               |
| BE50   | --                     |
| BE51   | RESERVED               |
| BE52   | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BE53   | LPDDR3_M1_CA[09]       |
| BE54   | --                     |
| BE55   | LPDDR3_M1_DQ[13]_A     |
| BE56   | --                     |
| BE57   | VSS                    |
| BE58   | --                     |
| BE59   | VSS                    |
| BE6    | --                     |
| BE7    | VSS                    |
| BE8    | --                     |
| BE9    | RESERVED               |
| BF1    | --                     |
| BF10   | RTC_X2                 |
| BF11   | --                     |
| BF12   | VSS                    |
| BF13   | --                     |
| BF14   | --                     |
| BF15   | VSS                    |
| BF16   | --                     |
| BF17   | VSS                    |
| BF18   | --                     |
| BF19   | VSS                    |
| BF2    | PCIeCLK_V1P05A_G3      |
| BF20   | --                     |
| BF21   | VSS                    |
| BF22   | --                     |
| BF23   | SDIO_V3P3A_V1P8A_G3    |
| BF24   | --                     |
| BF25   | LPC_V3P3A_V1P8A_S4     |
| BF26   | --                     |
| BF27   | VSS                    |
| BF28   | --                     |
| BF29   | GPIOSE_V1P8A_G3        |
| BF3    | --                     |
| BF30   | --                     |
| BF31   | --                     |
| BF32   | VSS                    |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BF33   | --                     |
| BF34   | VSS                    |
| BF35   | --                     |
| BF36   | VSS                    |
| BF37   | --                     |
| BF38   | PWR_RSVD_OBS           |
| BF39   | --                     |
| BF4    | RTC_RST_N              |
| BF40   | VSS                    |
| BF41   | --                     |
| BF42   | VSS                    |
| BF43   | --                     |
| BF44   | VSS                    |
| BF45   | --                     |
| BF46   | VSS                    |
| BF47   | --                     |
| BF48   | LPDDR3_M1_CA[02]       |
| BF49   | --                     |
| BF5    | --                     |
| BF50   | RESERVED               |
| BF51   | --                     |
| BF52   | VSS                    |
| BF53   | --                     |
| BF54   | LPDDR3_M1_CK_N_A       |
| BF55   | --                     |
| BF56   | LPDDR3_M1_CK_P_A       |
| BF57   | --                     |
| BF58   | VSS                    |
| BF59   | --                     |
| BF6    | VSS                    |
| BF7    | --                     |
| BF8    | RESERVED               |
| BF9    | --                     |
| BG1    | PCIeCLK_V1P05A_G3      |
| BG10   | --                     |
| BG11   | RTC_EXTPAD             |
| BG12   | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BG13   | --                     |
| BG14   | --                     |
| BG15   | --                     |
| BG16   | --                     |
| BG17   | --                     |
| BG18   | --                     |
| BG19   | --                     |
| BG2    | --                     |
| BG20   | --                     |
| BG21   | --                     |
| BG22   | --                     |
| BG23   | --                     |
| BG24   | --                     |
| BG25   | --                     |
| BG26   | --                     |
| BG27   | --                     |
| BG28   | --                     |
| BG29   | --                     |
| BG3    | PMC_CORE_PWROK         |
| BG30   | --                     |
| BG31   | --                     |
| BG32   | --                     |
| BG33   | --                     |
| BG34   | --                     |
| BG35   | --                     |
| BG36   | --                     |
| BG37   | --                     |
| BG38   | --                     |
| BG39   | --                     |
| BG4    | --                     |
| BG40   | --                     |
| BG41   | --                     |
| BG42   | --                     |
| BG43   | --                     |
| BG44   | --                     |
| BG45   | --                     |
| BG46   | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BG47   | --                     |
| BG48   | --                     |
| BG49   | VSS                    |
| BG5    | VSS                    |
| BG50   | --                     |
| BG51   | LPDDR3_M1_CA[06]       |
| BG52   | --                     |
| BG53   | VSS                    |
| BG54   | --                     |
| BG55   | LPDDR3_M1_CK_N_B       |
| BG56   | --                     |
| BG57   | LPDDR3_M1_CK_P_B       |
| BG58   | --                     |
| BG59   | DDR_VDDQG_S4           |
| BG6    | --                     |
| BG7    | VSS                    |
| BG8    | --                     |
| BG9    | RTC_X1                 |
| BH1    | --                     |
| BH10   | PMC_PWRBTN_N           |
| BH11   | --                     |
| BH12   | VSS                    |
| BH13   | --                     |
| BH14   | MMC1_RCOMP             |
| BH15   | --                     |
| BH16   | SD3_RCOMP              |
| BH17   | --                     |
| BH18   | SD3_D[2]               |
| BH19   | --                     |
| BH2    | VSS                    |
| BH20   | VSS                    |
| BH21   | --                     |
| BH22   | LPC_RCOMP              |
| BH23   | --                     |
| BH24   | PMC_RSTBTN_N           |
| BH25   | --                     |
| BH26   | UART2_RTS_N            |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BH27   | --                     |
| BH28   | UART2_DATAIN           |
| BH29   | --                     |
| BH3    | --                     |
| BH30   | --                     |
| BH31   | --                     |
| BH32   | LPE_I2S0_CLK           |
| BH33   | --                     |
| BH34   | I2C6_CLK/NMI_N         |
| BH35   | --                     |
| BH36   | I2C2_DATA              |
| BH37   | --                     |
| BH38   | VSS                    |
| BH39   | --                     |
| BH4    | PMC_BATLOW_N           |
| BH40   | LPE_I2S2_FRM           |
| BH41   | --                     |
| BH42   | VSS                    |
| BH43   | --                     |
| BH44   | LPDDR3_M1_DQ[09]_B     |
| BH45   | --                     |
| BH46   | LPDDR3_M1_DM[1]_B      |
| BH47   | --                     |
| BH48   | RESERVED               |
| BH49   | --                     |
| BH5    | --                     |
| BH50   | LPDDR3_M1_CA[01]       |
| BH51   | --                     |
| BH52   | VSS                    |
| BH53   | --                     |
| BH54   | LPDDR3_M1_CA[04]       |
| BH55   | --                     |
| BH56   | VSS                    |
| BH57   | --                     |
| BH58   | VSS                    |
| BH59   | --                     |
| BH6    | PMC_SUS_STAT_N         |

| Ball # | Customer Name - LPDDR3                      |
|--------|---|
| BH7    | --  |
| BH8    | VSS   |
| BH9    | --  |
| BJ1    | ICLK_VSFR_G3                                |
| BJ10   | --  |
| BJ11   | VSS   |
| BJ12   | --  |
| BJ13   | VSS   |
| BJ14   | --  |
| BJ15   | MMC1_CMD                                    |
| BJ16   | --  |
| BJ17   | VSS   |
| BJ18   | --  |
| BJ19   | LPC_FRAME_N/UART0_DATAIN/<br>SPI2_MISO      |
| BJ2    | --  |
| BJ20   | --  |
| BJ21   | GPIO_ALERT/ISH_GPIO[11]/<br>ISH_UART_DATAIN |
| BJ22   | --  |
| BJ23   | VSS   |
| BJ24   | --  |
| BJ25   | FST_SPI_D[2]                                |
| BJ26   | --  |
| BJ27   | VSS   |
| BJ28   | --  |
| BJ29   | --  |
| BJ3    | PMC_SLP_S3_N                                |
| BJ30   | LPE_I2S1_DATAIN                             |
| BJ31   | --  |
| BJ32   | --  |
| BJ33   | NFC_I2C_CLK                                 |
| BJ34   | --  |
| BJ35   | VSS   |
| BJ36   | --  |
| BJ37   | UART0_DATAIN                                |
| BJ38   | --  |
| BJ39   | VSS   |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3   |
|--------|--------------------------|
| BJ4    | --                       |
| BJ40   | --                       |
| BJ41   | VSS                      |
| BJ42   | --                       |
| BJ43   | LPDDR3_M1_DQ[14]_B       |
| BJ44   | --                       |
| BJ45   | VSS                      |
| BJ46   | --                       |
| BJ47   | LPDDR3_M1_DQ[07]_B       |
| BJ48   | --                       |
| BJ49   | LPDDR3_M1_CA[00]         |
| BJ5    | PMC_PLTRST_N             |
| BJ50   | --                       |
| BJ51   | LPDDR3_M1_CA[03]         |
| BJ52   | --                       |
| BJ53   | RESERVED                 |
| BJ54   | --                       |
| BJ55   | LPDDR3_M1_CA[05]         |
| BJ56   | --                       |
| BJ57   | LPDDR3_M1_CA[07]         |
| BJ58   | --                       |
| BJ59   | DDR_VDDQG_S4             |
| BJ6    | --                       |
| BJ7    | PMC_WAKE_N               |
| BJ8    | --                       |
| BJ9    | PMC_SLP_S4_N             |
| BK1    | --                       |
| BK10   | ISH_GPIO[6]/I2S4_DATAOUT |
| BK11   | --                       |
| BK12   | MMC1_D[3]                |
| BK13   | --                       |
| BK14   | MMC1_D[1]                |
| BK15   | --                       |
| BK16   | SD3_D[0]                 |
| BK17   | --                       |
| BK18   | SPI1_MOSI                |
| BK19   | --                       |

| Ball # | Customer Name - LPDDR3                          |
|--------|---|
| BK2    | VSS   |
| BK20   | LPC_CLKOUT[0]/ISH_GPIO[10]/<br>ISH_UART_DATAOUT |
| BK21   | --  |
| BK22   | PMC_SUSPWRDNACK                                 |
| BK23   | --  |
| BK24   | VSS   |
| BK25   | --  |
| BK26   | FST_SPI_D[1]                                    |
| BK27   | --  |
| BK28   | UART2_DATAOUT                                   |
| BK29   | --  |
| BK3    | --  |
| BK30   | --  |
| BK31   | --  |
| BK32   | LPE_I2S0_FRM                                    |
| BK33   | --  |
| BK34   | I2C5_CLK  |
| BK35   | --  |
| BK36   | SPI3_MOSI                                       |
| BK37   | --  |
| BK38   | LPE_I2S2_CLK                                    |
| BK39   | --  |
| BK4    | PMC_ACPRESENT                                   |
| BK40   | LPE_I2S2_DATAOUT                                |
| BK41   | --  |
| BK42   | LPDDR3_M1_DQ[15]_B                              |
| BK43   | --  |
| BK44   | LPDDR3_M1_DQ[10]_B                              |
| BK45   | --  |
| BK46   | LPDDR3_M1_DQS[1]_P_B                            |
| BK47   | --  |
| BK48   | VSS   |
| BK49   | --  |
| BK5    | --  |
| BK50   | VSS   |
| BK51   | --  |
| BK52   | LPDDR3_M1_DQ[03]_B                              |





**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3                  |
|--------|---|
| BK53   | --                                      |
| BK54   | VSS                                     |
| BK55   | --                                      |
| BK56   | LPDDR3_M1_CKE[0]_A                      |
| BK57   | --                                      |
| BK58   | VSS                                     |
| BK59   | --                                      |
| BK6    | VSS                                     |
| BK7    | --                                      |
| BK8    | ISH_GPIO[9]/ISH_SPI_MISO/<br>I2S5_FS    |
| BK9    | --                                      |
| BL1    | UNCORE_VNN_S4                           |
| BL10   | --                                      |
| BL11   | SD2_CLK                                 |
| BL12   | --                                      |
| BL13   | VSS                                     |
| BL14   | --                                      |
| BL15   | SD3_D[3]                                |
| BL16   | --                                      |
| BL17   | SD3_CLK                                 |
| BL18   | --                                      |
| BL19   | SPI1_MISO                               |
| BL2    | --                                      |
| BL20   | --                                      |
| BL21   | LPC_CLKRUN_N/<br>UART0_DATAOUT/SPI2_CLK |
| BL22   | --                                      |
| BL23   | VSS                                     |
| BL24   | --                                      |
| BL25   | FST_SPI_D[3]                            |
| BL26   | --                                      |
| BL27   | UART2_CTS_N                             |
| BL28   | --                                      |
| BL29   | --                                      |
| BL3    | PMC_SLP_S0IX_N                          |
| BL30   | VSS                                     |
| BL31   | --                                      |

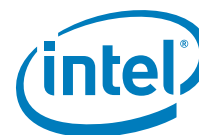
| Ball # | Customer Name - LPDDR3                   |
|--------|--|
| BL32   | --                                       |
| BL33   | I2C6_DATA/SD3_WP                         |
| BL34   | --                                       |
| BL35   | I2C2_CLK                                 |
| BL36   | --                                       |
| BL37   | UART0_DATAOUT/SPI3_CLK                   |
| BL38   | --                                       |
| BL39   | LPE_I2S2_DATAIN                          |
| BL4    | --                                       |
| BL40   | --                                       |
| BL41   | VSS                                      |
| BL42   | --                                       |
| BL43   | LPDDR3_M1_DQ[11]_B                       |
| BL44   | --                                       |
| BL45   | LPDDR3_M1_DQ[08]_B                       |
| BL46   | --                                       |
| BL47   | LPDDR3_M1_DQS[1]_N_B                     |
| BL48   | --                                       |
| BL49   | LPDDR3_M1_DQ[01]_B                       |
| BL5    | VSS                                      |
| BL50   | --                                       |
| BL51   | LPDDR3_M1_DQ[00]_B                       |
| BL52   | --                                       |
| BL53   | LPDDR3_M1_DQ[02]_B                       |
| BL54   | --                                       |
| BL55   | RESERVED                                 |
| BL56   | --                                       |
| BL57   | LPDDR3_M1_CS[0]_N                        |
| BL58   | --                                       |
| BL59   | DDR_VDDQG_S4                             |
| BL6    | --                                       |
| BL7    | VSS                                      |
| BL8    | --                                       |
| BL9    | ISH_GPIO[8]/ISH_SPI_CS[0]_N/<br>I2S5_CLK |
| BM1    | --                                       |
| BM10   | VSS                                      |
| BM11   | --                                       |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3                         |
|--------|--|
| BM12   | MMC1_D[0]                                      |
| BM13   | --   |
| BM14   | MMC1_D[2]                                      |
| BM15   | --   |
| BM16   | VSS  |
| BM17   | --   |
| BM18   | VSS  |
| BM19   | --   |
| BM2    | ISH_GPIO[7]/I2S4_DATAIN                        |
| BM20   | LPC_CLKOUT[1]/ISH_GPIO[11]/<br>ISH_UART_DATAIN |
| BM21   | --   |
| BM22   | VSS  |
| BM23   | --   |
| BM24   | LPC_SERIRQ/SPI2_CS[0]_N                        |
| BM25   | --   |
| BM26   | VSS  |
| BM27   | --   |
| BM28   | VSS  |
| BM29   | --   |
| BM3    | --   |
| BM30   | --   |
| BM31   | --   |
| BM32   | LPE_I2S0_DATAOUT                               |
| BM33   | --   |
| BM34   | VSS  |
| BM35   | --   |
| BM36   | VSS  |
| BM37   | --   |
| BM38   | SPI3_CS[0]_N                                   |
| BM39   | --   |
| BM4    | ISH_GPIO[3]/I2S3_DATAIN                        |
| BM40   | VSS  |
| BM41   | --   |
| BM42   | LPDDR3_M1_DQ[13]_B                             |
| BM43   | --   |
| BM44   | VSS  |
| BM45   | --   |

| Ball # | Customer Name - LPDDR3                      |
|--------|---|
| BM46   | VSS   |
| BM47   | --  |
| BM48   | LPDDR3_M1_DQ[06]_B                          |
| BM49   | --  |
| BM5    | --  |
| BM50   | LPDDR3_M1_DQS[0]_P_B                        |
| BM51   | --  |
| BM52   | LPDDR3_M1_DQ[04]_B                          |
| BM53   | --  |
| BM54   | RESERVED                                    |
| BM55   | --  |
| BM56   | VSS   |
| BM57   | --  |
| BM58   | LPDDR3_M1_CKE[0]_B                          |
| BM59   | --  |
| BM6    | PMC_SUSCLK[0]                               |
| BM7    | --  |
| BM8    | ISH_I2C1_DATA/ISH_SPI_MOSI/<br>I2S5_DATAOUT |
| BM9    | --  |
| BN1    | UNCORE_VNN_S4                               |
| BN10   | --  |
| BN11   | SD2_CMD                                     |
| BN12   | --  |
| BN13   | VSS   |
| BN14   | --  |
| BN15   | MMC1_CLK                                    |
| BN16   | --  |
| BN17   | VSS   |
| BN18   | --  |
| BN19   | SPI1_CLK                                    |
| BN2    | --  |
| BN20   | --  |
| BN21   | VSS   |
| BN22   | --  |
| BN23   | VSS   |
| BN24   | --  |
| BN25   | FST_SPI_D[0]                                |



## Ballout and Ball Map

| Ball # | Customer Name - LPDDR3                   |
|--------|--|
| BN26   | --                                       |
| BN27   | VSS                                      |
| BN28   | --                                       |
| BN29   | --                                       |
| BN3    | ISH_I2C1_CLK/ISH_SPI_CLK/<br>I2S5_DATAIN |
| BN30   | VSS                                      |
| BN31   | --                                       |
| BN32   | --                                       |
| BN33   | NFC_I2C_DATA                             |
| BN34   | --                                       |
| BN35   | VSS                                      |
| BN36   | --                                       |
| BN37   | SPI3_MISO                                |
| BN38   | --                                       |
| BN39   | VSS                                      |
| BN4    | --                                       |
| BN40   | --                                       |
| BN41   | VSS                                      |
| BN42   | --                                       |
| BN43   | LPDDR3_M1_DQ[12]_B                       |
| BN44   | --                                       |
| BN45   | VSS                                      |
| BN46   | --                                       |
| BN47   | LPDDR3_M1_DM[0]_B                        |
| BN48   | --                                       |
| BN49   | LPDDR3_M1_DQ[05]_B                       |
| BN5    | ISH_GPIO[1]/I2S3_FS                      |
| BN50   | --                                       |
| BN51   | LPDDR3_M1_DQS[0]_N_B                     |
| BN52   | --                                       |
| BN53   | VSS                                      |
| BN54   | --                                       |
| BN55   | RESERVED                                 |
| BN56   | --                                       |
| BN57   | RESERVED                                 |
| BN58   | --                                       |
| BN59   | DDR_VDDQG_S4                             |

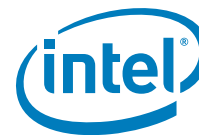
| Ball # | Customer Name - LPDDR3                              |
|--------|---|
| BN6    | --  |
| BN7    | VSS   |
| BN8    | --  |
| BN9    | RESERVED  |
| BP1    | --  |
| BP10   | VSS   |
| BP11   | --  |
| BP12   | SD2_D[3]_CD_N                                       |
| BP13   | --  |
| BP14   | MMC1_D[6]   |
| BP15   | --  |
| BP16   | SD3_D[1]  |
| BP17   | --  |
| BP18   | VSS   |
| BP19   | --  |
| BP2    | UNCORE_VNN_S4                                       |
| BP20   | LPC_AD[2]/ISH_GPIO[14]/<br>ISH_I2C0_DATA            |
| BP21   | --  |
| BP22   | USB_OC[0]_N   |
| BP23   | --  |
| BP24   | FST_SPI_CLK   |
| BP25   | --  |
| BP26   | VSS   |
| BP27   | --  |
| BP28   | LPE_I2S1_DATAOUT                                    |
| BP29   | --  |
| BP3    | --  |
| BP30   | --  |
| BP31   | --  |
| BP32   | VSS   |
| BP33   | --  |
| BP34   | I2C4_CLK/DDI0_DDC_CLK/<br>DDI2_DDC_CLK/MDSI_DDC_CLK |
| BP35   | --  |
| BP36   | I2C1_CLK  |
| BP37   | --  |
| BP38   | GPIO_SW93   |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3                           |
|--------|--|
| BP39   | --   |
| BP4    | ISH_GPIO[5]/I2S4_FS                              |
| BP40   | VSS  |
| BP41   | --   |
| BP42   | LPDDR3_M1_DQ[28]_B                               |
| BP43   | --   |
| BP44   | LPDDR3_M1_DQ[31]_B                               |
| BP45   | --   |
| BP46   | LPDDR3_M1_DM[3]_B                                |
| BP47   | --   |
| BP48   | VSS  |
| BP49   | --   |
| BP5    | --   |
| BP50   | LPDDR3_M1_DQ[19]_B                               |
| BP51   | --   |
| BP52   | LPDDR3_M1_DQ[16]_B                               |
| BP53   | --   |
| BP54   | RESERVED   |
| BP55   | --   |
| BP56   | RESERVED   |
| BP57   | --   |
| BP58   | VSS  |
| BP59   | --   |
| BP6    | VSS  |
| BP7    | --   |
| BP8    | PMC_PLT_CLK[0]/ISH_GPIO[10]/<br>ISH_UART_DATAOUT |
| BP9    | --   |
| BR1    | VSS  |
| BR10   | --   |
| BR11   | SD2_D[1]   |
| BR12   | --   |
| BR13   | MMC1_D[4]  |
| BR14   | --   |
| BR15   | SD3_CMD  |
| BR16   | --   |
| BR17   | SPI1_CS[1]_N                                     |
| BR18   | --   |

| Ball # | Customer Name - LPDDR3                            |
|--------|---|
| BR19   | LPC_AD[1]/ISH_GPIO[13]/<br>ISH_UART_RTS_N         |
| BR2    | --  |
| BR20   | --  |
| BR21   | LPC_AD[3]/ISH_GPIO[15]/<br>ISH_I2C0_CLK/SPI2_MOSI |
| BR22   | --  |
| BR23   | FST_SPI_CS[1]_N                                   |
| BR24   | --  |
| BR25   | UART1_RTS_N                                       |
| BR26   | --  |
| BR27   | UART1_CTS_N                                       |
| BR28   | --  |
| BR29   | --  |
| BR3    | ISH_GPIO[0]/I2S3_CLK                              |
| BR30   | LPE_I2S1_CLK                                      |
| BR31   | --  |
| BR32   | --  |
| BR33   | I2C5_DATA   |
| BR34   | --  |
| BR35   | I2C1_DATA   |
| BR36   | --  |
| BR37   | ISH_GPIO[12]/ISH_UART_CTS_N                       |
| BR38   | --  |
| BR39   | PCIE_CLKREQ[0]_N                                  |
| BR4    | --  |
| BR40   | --  |
| BR41   | VSS   |
| BR42   | --  |
| BR43   | LPDDR3_M1_DQ[29]_B                                |
| BR44   | --  |
| BR45   | LPDDR3_M1_DQ[27]_B                                |
| BR46   | --  |
| BR47   | LPDDR3_M1_DQ[23]_B                                |
| BR48   | --  |
| BR49   | LPDDR3_M1_DM[2]_B                                 |
| BR5    | VSS   |
| BR50   | --  |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3                                       |
|--------|--|
| BR51   | LPDDR3_M1_DQ[18]_B   |
| BR52   | --   |
| BR53   | VSS  |
| BR54   | --   |
| BR55   | RESERVED   |
| BR56   | --   |
| BR57   | RESERVED   |
| BR58   | --   |
| BR59   | VSS  |
| BR6    | --   |
| BR7    | PMC_PLT_CLK[4]/ISH_GPIO[14]/<br>ISH_I2C0_DATA/SPI2_MISO      |
| BR8    | --   |
| BR9    | PMC_PLT_CLK[1]/ISH_GPIO[11]/<br>ISH_UART_DATAIN/SPI2_CS[1]_N |
| BT1    | --   |
| BT10   | SD2_D[0]   |
| BT11   | --   |
| BT12   | VSS  |
| BT13   | --   |
| BT14   | MMC1_D[7]  |
| BT15   | --   |
| BT16   | VSS  |
| BT17   | --   |
| BT18   | SPI1_CS[0]_N   |
| BT19   | --   |
| BT2    | ISH_GPIO[2]/I2S3_DATAOUT                                     |
| BT20   | VSS  |
| BT21   | --   |
| BT22   | SD3_1P8_EN   |
| BT23   | --   |
| BT24   | VSS  |
| BT25   | --   |
| BT26   | UART1_DATAIN/UART0_DATAIN                                    |
| BT27   | --   |
| BT28   | VSS  |
| BT29   | --   |
| BT3    | --   |

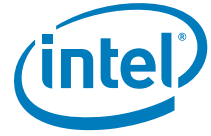
| Ball # | Customer Name - LPDDR3                                      |
|--------|---|
| BT30   | --  |
| BT31   | --  |
| BT32   | I2C4_DATA/DDI2_DDC_DATA/<br>DDI2_DDC_DATA/<br>MDSI_DDC_DATA |
| BT33   | --  |
| BT34   | VSS   |
| BT35   | --  |
| BT36   | I2C0_CLK  |
| BT37   | --  |
| BT38   | VSS   |
| BT39   | --  |
| BT4    | ISH_GPIO[4]/I2S4_CLK  |
| BT40   | SD3_WP  |
| BT41   | --  |
| BT42   | VSS   |
| BT43   | --  |
| BT44   | LPDDR3_M1_DQ[26]_B  |
| BT45   | --  |
| BT46   | VSS   |
| BT47   | --  |
| BT48   | LPDDR3_M1_DQ[21]_B  |
| BT49   | --  |
| BT5    | --  |
| BT50   | VSS   |
| BT51   | --  |
| BT52   | LPDDR3_M1_DQ[20]_B  |
| BT53   | --  |
| BT54   | VSS   |
| BT55   | --  |
| BT56   | VSS   |
| BT57   | --  |
| BT58   | LPDDR3_M1_CKE[1]_A  |
| BT59   | --  |
| BT6    | PMC_PLT_CLK[5]/ISH_GPIO[15]/<br>ISH_I2C0_CLK/SPI2_MOSI      |
| BT7    | --  |
| BT8    | VSS   |



| Ball # | Customer Name - LPDDR3                    |
|--------|---|
| BT9    | --  |
| BU1    | VSS                                       |
| BU10   | --  |
| BU11   | SD2_D[2]                                  |
| BU12   | --  |
| BU13   | MMC1_RCLK/MMC1_RESET_N                    |
| BU14   | --  |
| BU15   | MMC1_D[5]                                 |
| BU16   | --  |
| BU17   | SD3_CD_N                                  |
| BU18   | --  |
| BU19   | LPC_AD[0]/ISH_GPIO[12]/<br>ISH_UART_CTS_N |
| BU2    | --  |
| BU20   | --  |
| BU21   | USB_OC[1]_N                               |
| BU22   | --  |
| BU23   | SD3_PWREN_N                               |
| BU24   | --  |
| BU25   | FST_SPI_CS[0]_N                           |
| BU26   | --  |
| BU27   | UART1_DATAOUT/<br>UART0_DATAOUT           |
| BU28   | --  |
| BU29   | --  |
| BU3    | VSS                                       |
| BU30   | LPE_I2S0_DATAIN                           |
| BU31   | --  |
| BU32   | --  |
| BU33   | I2C3_DATA                                 |
| BU34   | --  |
| BU35   | I2C0_DATA                                 |
| BU36   | --  |
| BU37   | GPIO_SW78                                 |
| BU38   | --  |
| BU39   | PCIE_CLKREQ[1]_N                          |
| BU4    | --  |
| BU40   | --  |

| Ball # | Customer Name - LPDDR3                                      |
|--------|---|
| BU41   | VSS   |
| BU42   | --  |
| BU43   | LPDDR3_M1_DQ[25]_B  |
| BU44   | --  |
| BU45   | LPDDR3_M1_DQ[24]_B  |
| BU46   | --  |
| BU47   | LPDDR3_M1_DQS[3]_N_B  |
| BU48   | --  |
| BU49   | LPDDR3_M1_DQ[22]_B  |
| BU5    | PWM[1]/ISH_GPIO[10]/<br>ISH_UART_DATAOUT                    |
| BU50   | --  |
| BU51   | LPDDR3_M1_DQS[2]_N_B  |
| BU52   | --  |
| BU53   | LPDDR3_M1_DQ[17]_B  |
| BU54   | --  |
| BU55   | LPDDR3_M1_ODT_A   |
| BU56   | --  |
| BU57   | LPDDR3_M1_CKE[1]_B  |
| BU58   | --  |
| BU59   | VSS   |
| BU6    | --  |
| BU7    | PMC_PLT_CLK[2]/ISH_GPIO[12]/<br>ISH_UART_CTS_N/SPI2_CS[0]_N |
| BU8    | --  |
| BU9    | PMC_PLT_CLK[3]/ISH_GPIO[13]/<br>ISH_UART_RTS_N/SPI2_CLK     |
| BV1    | --  |
| BV10   | DDI_VGG_S0iX  |
| BV11   | --  |
| BV12   | VSS   |
| BV13   | --  |
| BV14   | DDI_VGG_S0iX  |
| BV15   | --  |
| BV16   | VSS   |
| BV17   | --  |
| BV18   | LPC_V3P3A_V1P8A_S4  |
| BV19   | --  |

**Ballout and Ball Map**



| Ball # | Customer Name - LPDDR3     |
|--------|----------------------------|
| BV2    | VSS                        |
| BV20   | VSS                        |
| BV21   | --                         |
| BV22   | GPIOSE_V1P8A_G3            |
| BV23   | --                         |
| BV24   | FST_SPI_CS[2]_N            |
| BV25   | --                         |
| BV26   | GPIOSE_V1P8A_G3            |
| BV27   | --                         |
| BV28   | LPE_I2S1_FRM               |
| BV29   | --                         |
| BV3    | --                         |
| BV30   | --                         |
| BV31   | --                         |
| BV32   | UNCORE_V1P8A_G3            |
| BV33   | --                         |
| BV34   | I2C3_CLK                   |
| BV35   | --                         |
| BV36   | DDI_V1P15_S0iX             |
| BV37   | --                         |
| BV38   | MMC1_RESET_N /SPI3_CS[1]_N |
| BV39   | --                         |
| BV4    | PWM[0]                     |
| BV40   | DDR_V1P05A_G3              |
| BV41   | --                         |
| BV42   | LPDDR3_M1_DQ[30]_B         |
| BV43   | --                         |
| BV44   | VSS                        |
| BV45   | --                         |
| BV46   | LPDDR3_M1_DQS[3]_P_B       |
| BV47   | --                         |
| BV48   | VSS                        |
| BV49   | --                         |
| BV5    | --                         |
| BV50   | LPDDR3_M1_DQS[2]_P_B       |
| BV51   | --                         |
| BV52   | VSS                        |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BV53   | --                     |
| BV54   | LPDDR3_M1_ODT_B        |
| BV55   | --                     |
| BV56   | LPDDR3_M1_CS[1]_N      |
| BV57   | --                     |
| BV58   | VSS                    |
| BV59   | --                     |
| BV6    | VSS                    |
| BV7    | --                     |
| BV8    | VSS                    |
| BV9    | --                     |
| BW1    | --                     |
| BW10   | --                     |
| BW11   | DDI_VGG_S0iX           |
| BW12   | --                     |
| BW13   | DDI_VGG_S0iX           |
| BW14   | --                     |
| BW15   | SDIO_V3P3A_V1P8A_G3    |
| BW16   | --                     |
| BW17   | LPC_V3P3A_V1P8A_S4     |
| BW18   | --                     |
| BW19   | VSS                    |
| BW2    | --                     |
| BW20   | --                     |
| BW21   | GPIOSE_V1P8A_G3        |
| BW22   | --                     |
| BW23   | GPIOSE_V1P8A_G3        |
| BW24   | --                     |
| BW25   | GPIOSE_V1P8A_G3        |
| BW26   | --                     |
| BW27   | GPIOSE_V1P8A_G3        |
| BW28   | --                     |
| BW29   | --                     |
| BW3    | VSS                    |
| BW30   | VSS                    |
| BW31   | --                     |
| BW32   | --                     |

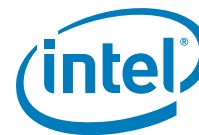


**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| BW33   | UNCORE_V1P8A_G3        |
| BW34   | --                     |
| BW35   | DDI_V1P15_S0iX         |
| BW36   | --                     |
| BW37   | DDI_V1P15_S0iX         |
| BW38   | --                     |
| BW39   | VSS                    |
| BW4    | --                     |
| BW40   | --                     |
| BW41   | DDR_V1P05A_G3          |
| BW42   | --                     |
| BW43   | DDR_V1P05A_G3          |
| BW44   | --                     |
| BW45   | VSS                    |
| BW46   | --                     |
| BW47   | VSS                    |
| BW48   | --                     |
| BW49   | VSS                    |
| BW5    | VSS                    |
| BW50   | --                     |
| BW51   | VSS                    |
| BW52   | --                     |
| BW53   | VSS                    |
| BW54   | --                     |
| BW55   | VSS                    |
| BW56   | --                     |
| BW57   | VSS                    |
| BW58   | --                     |
| BW59   | --                     |
| BW6    | --                     |
| BW7    | VSS                    |
| BW8    | --                     |
| BW9    | DDI_VGG_S0iX           |
| C1     | VSS                    |
| C10    | --                     |
| C11    | MDSI_A_CLKN            |
| C12    | --                     |

| Ball # | Customer Name - LPDDR3                 |
|--------|--|
| C13    | RESERVED                               |
| C14    | --                                     |
| C15    | MCSI_2_DN[0]                           |
| C16    | --                                     |
| C17    | MCSI_1_CLKP                            |
| C18    | --                                     |
| C19    | MCSI_1_DP[1]                           |
| C2     | --                                     |
| C20    | --                                     |
| C21    | DDI2_HPDP                              |
| C22    | --                                     |
| C23    | CORE_VCC1_S0iX                         |
| C24    | --                                     |
| C25    | VSS                                    |
| C26    | --                                     |
| C27    | GPIO_CAMERASB07                        |
| C28    | --                                     |
| C29    | --                                     |
| C3     | DDI1_TXP[3]                            |
| C30    | GPIO_CAMERASB04                        |
| C31    | --                                     |
| C32    | --                                     |
| C33    | SVID_ALERT_N                           |
| C34    | --                                     |
| C35    | GPIO_SUS5/PMC_SUSCLK[1]                |
| C36    | --                                     |
| C37    | GPIO_SUS3/JTAG2_TDI                    |
| C38    | --                                     |
| C39    | ISH_GPIO[13]/C0_BPM2_TX/<br>C1_BPM2_TX |
| C4     | --                                     |
| C40    | --                                     |
| C41    | VSS                                    |
| C42    | --                                     |
| C43    | LPDDR3_M0_DQ[22]_A                     |
| C44    | --                                     |
| C45    | LPDDR3_M0_DQ[23]_A                     |
| C46    | --                                     |





**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| C47    | LPDDR3_M0_DQS[2]_N_A   |
| C48    | --                     |
| C49    | LPDDR3_M0_DQ[25]_A     |
| C5     | MDSI_C_CLKN            |
| C50    | --                     |
| C51    | LPDDR3_M0_DQS[3]_N_A   |
| C52    | --                     |
| C53    | LPDDR3_M0_DQ[30]_A     |
| C54    | --                     |
| C55    | LPDDR3_M0_ODT_B        |
| C56    | --                     |
| C57    | LPDDR3_M0_CKE[1]_A     |
| C58    | --                     |
| C59    | VSS                    |
| C6     | --                     |
| C7     | MDSI_C_DP[2]           |
| C8     | --                     |
| C9     | MDSI_C_DP[0]           |
| D1     | --                     |
| D10    | MDSI_A_DN[1]           |
| D11    | --                     |
| D12    | RESERVED               |
| D13    | --                     |
| D14    | RESERVED               |
| D15    | --                     |
| D16    | MCSI_1_CLKN            |
| D17    | --                     |
| D18    | MCSI_1_DN[2]           |
| D19    | --                     |
| D2     | DDI1_TXP[2]            |
| D20    | VSS                    |
| D21    | --                     |
| D22    | VSS                    |
| D23    | --                     |
| D24    | CORE_VCC1_S0IX         |
| D25    | --                     |
| D26    | GPIO_CAMERASB10        |

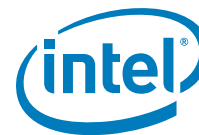
| Ball # | Customer Name - LPDDR3            |
|--------|-----------------------------------|
| D27    | --                                |
| D28    | VSS                               |
| D29    | --                                |
| D3     | --                                |
| D30    | --                                |
| D31    | --                                |
| D32    | SVID_DATA                         |
| D33    | --                                |
| D34    | VSS                               |
| D35    | --                                |
| D36    | GPIO_SUS6/PMC_SUSCLK[2]           |
| D37    | --                                |
| D38    | VSS                               |
| D39    | --                                |
| D4     | DDI1_TXN[3]                       |
| D40    | GPIO_N0/C0_BPM0_TX/<br>C1_BPM0_TX |
| D41    | --                                |
| D42    | VSS                               |
| D43    | --                                |
| D44    | LPDDR3_M0_DQ[21]_A                |
| D45    | --                                |
| D46    | VSS                               |
| D47    | --                                |
| D48    | LPDDR3_M0_DQ[26]_A                |
| D49    | --                                |
| D5     | --                                |
| D50    | VSS                               |
| D51    | --                                |
| D52    | LPDDR3_M0_DQ[27]_A                |
| D53    | --                                |
| D54    | VSS                               |
| D55    | --                                |
| D56    | VSS                               |
| D57    | --                                |
| D58    | LPDDR3_M0_CKE[1]_B                |
| D59    | --                                |
| D6     | MDSI_C_DN[2]                      |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3   |
|--------|--|
| D7     | --   |
| D8     | MDSI_C_DN[0]   |
| D9     | --   |
| E1     | VSS  |
| E10    | --   |
| E11    | VSS  |
| E12    | --   |
| E13    | RESERVED   |
| E14    | --   |
| E15    | VSS  |
| E16    | --   |
| E17    | MCSI_1_DP[2]   |
| E18    | --   |
| E19    | VSS  |
| E2     | --   |
| E20    | --   |
| E21    | DDI2_DDC_CLK/DDI1_DDC_CLK/<br>UART0_DATAOUT/<br>MDSI_DDC_CLK/MDSI_A_TE |
| E22    | --   |
| E23    | CORE_VCC1_S0iX   |
| E24    | --   |
| E25    | DDI1_HPD   |
| E26    | --   |
| E27    | GPIO_CAMERASB06  |
| E28    | --   |
| E29    | --   |
| E3     | DDI1_TXN[2]  |
| E30    | GPIO_CAMERASB02  |
| E31    | --   |
| E32    | --   |
| E33    | JTAG_TDI   |
| E34    | --   |
| E35    | JTAG_TRST_N  |
| E36    | --   |
| E37    | GPIO_SUS0  |
| E38    | --   |

| Ball # | Customer Name - LPDDR3            |
|--------|-----------------------------------|
| E39    | GPIO_N1/C0_BPM3_TX/<br>C1_BPM3_TX |
| E4     | --                                |
| E40    | --                                |
| E41    | VSS                               |
| E42    | --                                |
| E43    | LPDDR3_M0_DQ[18]_A                |
| E44    | --                                |
| E45    | LPDDR3_M0_DQ[20]_A                |
| E46    | --                                |
| E47    | LPDDR3_M0_DQ[24]_A                |
| E48    | --                                |
| E49    | LPDDR3_M0_DM[03]_A                |
| E5     | DDI1_TXN[1]                       |
| E50    | --                                |
| E51    | LPDDR3_M0_DQ[29]_A                |
| E52    | --                                |
| E53    | VSS                               |
| E54    | --                                |
| E55    | RESERVED                          |
| E56    | --                                |
| E57    | RESERVED                          |
| E58    | --                                |
| E59    | VSS                               |
| E6     | --                                |
| E7     | VSS                               |
| E8     | --                                |
| E9     | MDSI_A_DP[1]                      |
| F1     | --                                |
| F10    | VSS                               |
| F11    | --                                |
| F12    | MDSI_A_DP[2]                      |
| F13    | --                                |
| F14    | VSS                               |
| F15    | --                                |
| F16    | VSS                               |
| F17    | --                                |
| F18    | VSS                               |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3   |
|--------|--|
| F19    | --   |
| F2     | VSS  |
| F20    | DDI2_DDC_DATA/<br>DDI1_DDC_DATA/UART0_DATAIN/<br>MDSI_DDC_DATA/MDSI_C_TE |
| F21    | --   |
| F22    | DDIO_VDDEN   |
| F23    | --   |
| F24    | CORE_VCC1_S0iX   |
| F25    | --   |
| F26    | DDIO_DDC_CLK/DDI1_DDC_CLK/<br>MDSI_DDC_CLK                               |
| F27    | --   |
| F28    | GPIO_CAMERASB11  |
| F29    | --   |
| F3     | --   |
| F30    | --   |
| F31    | --   |
| F32    | SVID_CLK   |
| F33    | --   |
| F34    | JTAG_TCK   |
| F35    | --   |
| F36    | GPIO_SUS8  |
| F37    | --   |
| F38    | GPIO_N2/C0_BPM2_TX/<br>C1_BPM2_TX  |
| F39    | --   |
| F4     | DDI1_TXP[1]  |
| F40    | VSS  |
| F41    | --   |
| F42    | LPDDR3_M0_DQ[19]_A   |
| F43    | --   |
| F44    | LPDDR3_M0_DQ[16]_A   |
| F45    | --   |
| F46    | LPDDR3_M0_DM[2]_A  |
| F47    | --   |
| F48    | VSS  |
| F49    | --   |
| F5     | --   |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| F50    | LPDDR3_M0_DQ[28]_A     |
| F51    | --                     |
| F52    | LPDDR3_M0_DQ[31]_A     |
| F53    | --                     |
| F54    | RESERVED               |
| F55    | --                     |
| F56    | RESERVED               |
| F57    | --                     |
| F58    | VSS                    |
| F59    | --                     |
| F6     | VSS                    |
| F7     | --                     |
| F8     | VSS                    |
| F9     | --                     |
| G1     | DDI2_VDDQ_G3           |
| G10    | --                     |
| G11    | MDSI_A_DN[2]           |
| G12    | --                     |
| G13    | VSS                    |
| G14    | --                     |
| G15    | MCSI_2_DP[1]           |
| G16    | --                     |
| G17    | VSS                    |
| G18    | --                     |
| G19    | MCSI_1_DP[3]           |
| G2     | --                     |
| G20    | --                     |
| G21    | VSS                    |
| G22    | --                     |
| G23    | CORE_VCC1_S0iX         |
| G24    | --                     |
| G25    | VSS                    |
| G26    | --                     |
| G27    | GPIO_CAMERASB05        |
| G28    | --                     |
| G29    | --                     |
| G3     | DDI1_TXN[0]            |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3            |
|--------|-----------------------------------|
| G30    | VSS                               |
| G31    | --                                |
| G32    | --                                |
| G33    | JTAG_PRDY_N                       |
| G34    | --                                |
| G35    | VSS                               |
| G36    | --                                |
| G37    | GPIO_SUS4/JTAG2_TDO               |
| G38    | --                                |
| G39    | GPIO_N4/C0_BPM0_TX/<br>C1_BPM0_TX |
| G4     | --                                |
| G40    | --                                |
| G41    | VSS                               |
| G42    | --                                |
| G43    | LPDDR3_M0_DQ[03]_A                |
| G44    | --                                |
| G45    | VSS                               |
| G46    | --                                |
| G47    | LPDDR3_M0_DM[1]_A                 |
| G48    | --                                |
| G49    | LPDDR3_M0_DQ[10]_A                |
| G5     | VSS                               |
| G50    | --                                |
| G51    | LPDDR3_M0_DQS[1]_N_A              |
| G52    | --                                |
| G53    | VSS                               |
| G54    | --                                |
| G55    | RESERVED                          |
| G56    | --                                |
| G57    | RESERVED                          |
| G58    | --                                |
| G59    | DDR_VDDQG_S4                      |
| G6     | --                                |
| G7     | MDSI_C_DP[1]                      |
| G8     | --                                |
| G9     | MDSI_A_DP[3]                      |
| H1     | --                                |

| Ball # | Customer Name - LPDDR3                            |
|--------|---|
| H10    | MDSI_A_DN[3]                                      |
| H11    | --  |
| H12    | VSS   |
| H13    | --  |
| H14    | MCSI_2_DN[1]                                      |
| H15    | --  |
| H16    | MCSI_2_CLKP                                       |
| H17    | --  |
| H18    | MCSI_1_DN[3]                                      |
| H19    | --  |
| H2     | DDI1_AUXP   |
| H20    | MCSI_1_DP[0]                                      |
| H21    | --  |
| H22    | DDI1_VDDEN/MDSI_DDC_DATA                          |
| H23    | --  |
| H24    | CORE_VCC1_S0iX                                    |
| H25    | --  |
| H26    | DDI0_DDC_DATA/<br>DDI1_DDC_DATA/<br>MDSI_DDC_DATA |
| H27    | --  |
| H28    | VSS   |
| H29    | --  |
| H3     | --  |
| H30    | --  |
| H31    | --  |
| H32    | PROCHOT_N   |
| H33    | --  |
| H34    | JTAG_PREQ_N                                       |
| H35    | --  |
| H36    | VSS   |
| H37    | --  |
| H38    | GPIO_N5   |
| H39    | --  |
| H4     | DDI1_TXP[0]                                       |
| H40    | VSS   |
| H41    | --  |
| H42    | LPDDR3_M0_DQ[02]_A                                |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3   |
|--------|--------------------------|
| H43    | --                       |
| H44    | VSS                      |
| H45    | --                       |
| H46    | VSS                      |
| H47    | --                       |
| H48    | LPDDR3_M0_DQ[09]_A       |
| H49    | --                       |
| H5     | --                       |
| H50    | LPDDR3_M0_DQS[1]_P_A     |
| H51    | --                       |
| H52    | LPDDR3_M0_DQ[11]_A       |
| H53    | --                       |
| H54    | RESERVED                 |
| H55    | --                       |
| H56    | VSS                      |
| H57    | --                       |
| H58    | LPDDR3_M0_CKE[0]_A       |
| H59    | --                       |
| H6     | MDSI_C_DN[1]             |
| H7     | --                       |
| H8     | MDSI_C_DN[3]             |
| H9     | --                       |
| J1     | DDI2_VDDQ_G3             |
| J10    | --                       |
| J11    | MDSI_A_DP[0]             |
| J12    | --                       |
| J13    | VSS                      |
| J14    | --                       |
| J15    | MCSI_2_CLKN              |
| J16    | --                       |
| J17    | MCSI_3_CLKP              |
| J18    | --                       |
| J19    | MCSI_1_DN[0]             |
| J2     | --                       |
| J20    | --                       |
| J21    | DDI1_BKLTEN/MDSI_DDC_CLK |
| J22    | --                       |

| Ball # | Customer Name - LPDDR3            |
|--------|-----------------------------------|
| J23    | CORE_VCC1_S0iX                    |
| J24    | --                                |
| J25    | CORE_VCC1_S0iX                    |
| J26    | --                                |
| J27    | GPIO_CAMERASB09                   |
| J28    | --                                |
| J29    | --                                |
| J3     | DDI1_AUXN                         |
| J30    | GPIO_CAMERASB00                   |
| J31    | --                                |
| J32    | --                                |
| J33    | JTAG_TDO                          |
| J34    | --                                |
| J35    | GPIO_SUS9                         |
| J36    | --                                |
| J37    | JTAG2_TMS                         |
| J38    | --                                |
| J39    | GPIO_N6/C0_BPM3_TX/<br>C1_BPM3_TX |
| J4     | --                                |
| J40    | --                                |
| J41    | VSS                               |
| J42    | --                                |
| J43    | LPDDR3_M0_DQ[04]_A                |
| J44    | --                                |
| J45    | LPDDR3_M0_DQ[07]_A                |
| J46    | --                                |
| J47    | LPDDR3_M0_DQS[0]_N_A              |
| J48    | --                                |
| J49    | LPDDR3_M0_DQ[14]_A                |
| J5     | DDI0_TXP[0]                       |
| J50    | --                                |
| J51    | LPDDR3_M0_DQ[15]_A                |
| J52    | --                                |
| J53    | LPDDR3_M0_DQ[13]_A                |
| J54    | --                                |
| J55    | RESERVED                          |
| J56    | --                                |

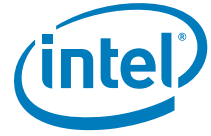


**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3               |
|--------|--------------------------------------|
| J57    | LPDDR3_M0_CS[0]_N                    |
| J58    | --                                   |
| J59    | DDR_VDDQG_S4                         |
| J6     | --                                   |
| J7     | DDI1_RCOMP_N                         |
| J8     | --                                   |
| J9     | MDSI_C_DP[3]                         |
| K1     | --                                   |
| K10    | VSS                                  |
| K11    | --                                   |
| K12    | MDSI_A_DN[0]                         |
| K13    | --                                   |
| K14    | MDSI_RCOMP                           |
| K15    | --                                   |
| K16    | MCSI_3_CLKN                          |
| K17    | --                                   |
| K18    | MCSI_RCOMP                           |
| K19    | --                                   |
| K2     | VSS                                  |
| K20    | DDI1_BKLTCTL/MDSI_A_TE/<br>MDSI_C_TE |
| K21    | --                                   |
| K22    | DDIO_BKLTCTL                         |
| K23    | --                                   |
| K24    | CORE_VCC1_S0iX                       |
| K25    | --                                   |
| K26    | DDIO_HPD                             |
| K27    | --                                   |
| K28    | GPIO_CAMERASB08                      |
| K29    | --                                   |
| K3     | --                                   |
| K30    | --                                   |
| K31    | --                                   |
| K32    | GPIO_CAMERASB01                      |
| K33    | --                                   |
| K34    | GPIO_SUS10                           |
| K35    | --                                   |
| K36    | GPIO_SUS7/PMC_SUSCLK[3]              |

| Ball # | Customer Name - LPDDR3            |
|--------|-----------------------------------|
| K37    | --                                |
| K38    | GPIO_SUS1/JTAG2_TCK               |
| K39    | --                                |
| K4     | DDIO_TXN[0]                       |
| K40    | GPIO_N8/C0_BPM1_TX/<br>C1_BPM1_TX |
| K41    | --                                |
| K42    | LPDDR3_M0_DQ[00]_A                |
| K43    | --                                |
| K44    | LPDDR3_M0_DQ[05]_A                |
| K45    | --                                |
| K46    | LPDDR3_M0_DQS[0]_P_A              |
| K47    | --                                |
| K48    | VSS                               |
| K49    | --                                |
| K5     | --                                |
| K50    | VSS                               |
| K51    | --                                |
| K52    | LPDDR3_M0_DQ[12]_A                |
| K53    | --                                |
| K54    | VSS                               |
| K55    | --                                |
| K56    | LPDDR3_M0_CKE[0]_B                |
| K57    | --                                |
| K58    | VSS                               |
| K59    | --                                |
| K6     | VSS                               |
| K7     | --                                |
| K8     | DDI1_RCOMP_P                      |
| K9     | --                                |
| L1     | DDI1_VDDQ_G3                      |
| L10    | --                                |
| L11    | VSS                               |
| L12    | --                                |
| L13    | VSS                               |
| L14    | --                                |
| L15    | VSS                               |
| L16    | --                                |

**Ballout and Ball Map**



| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| L17    | VSS                    |
| L18    | --                     |
| L19    | VSS                    |
| L2     | --                     |
| L20    | --                     |
| L21    | DDIO_BKLTEN            |
| L22    | --                     |
| L23    | CORE_VCC1_S0iX         |
| L24    | --                     |
| L25    | CORE_VCC1_S0iX         |
| L26    | --                     |
| L27    | VSS                    |
| L28    | --                     |
| L29    | --                     |
| L3     | VSS                    |
| L30    | VSS                    |
| L31    | --                     |
| L32    | --                     |
| L33    | VSS                    |
| L34    | --                     |
| L35    | VSS                    |
| L36    | --                     |
| L37    | PWR_RSVD_OBS           |
| L38    | --                     |
| L39    | VSS                    |
| L4     | --                     |
| L40    | --                     |
| L41    | VSS                    |
| L42    | --                     |
| L43    | LPDDR3_M0_DQ[01]_A     |
| L44    | --                     |
| L45    | VSS                    |
| L46    | --                     |
| L47    | LPDDR3_M0_DQ[08]_A     |
| L48    | --                     |
| L49    | LPDDR3_M0_CA[0]        |
| L5     | DDIO_TXN[1]            |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| L50    | --                     |
| L51    | LPDDR3_M0_CA[3]        |
| L52    | --                     |
| L53    | RESERVED               |
| L54    | --                     |
| L55    | LPDDR3_M0_CA[5]        |
| L56    | --                     |
| L57    | LPDDR3_M0_CA[7]        |
| L58    | --                     |
| L59    | DDR_VDDQG_S4           |
| L6     | --                     |
| L7     | VSS                    |
| L8     | --                     |
| L9     | DDIO_AUXP              |
| M1     | --                     |
| M10    | DDIO_TXN[3]            |
| M11    | --                     |
| M12    | VSS                    |
| M13    | --                     |
| M14    | VSS                    |
| M15    | --                     |
| M16    | VSS                    |
| M17    | --                     |
| M18    | VSS                    |
| M19    | --                     |
| M2     | DDI1_VDDQ_G3           |
| M20    | VSS                    |
| M21    | --                     |
| M22    | VSS                    |
| M23    | --                     |
| M24    | CORE_VCC1_S0iX         |
| M25    | --                     |
| M26    | CORE_VCC1_S0iX         |
| M27    | --                     |
| M28    | CORE_VCC1_S0iX         |
| M29    | --                     |
| M3     | --                     |

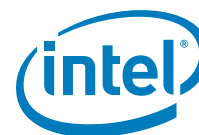


**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| M30    | --                     |
| M31    | --                     |
| M32    | VSS                    |
| M33    | --                     |
| M34    | VSS                    |
| M35    | --                     |
| M36    | VSS                    |
| M37    | --                     |
| M38    | VSS                    |
| M39    | --                     |
| M4     | DDIO_TXP[1]            |
| M40    | GPIO0_RCOMP            |
| M41    | --                     |
| M42    | VSS                    |
| M43    | --                     |
| M44    | LPDDR3_M0_DQ[06]_A     |
| M45    | --                     |
| M46    | LPDDR3_M0_DM[0]_A      |
| M47    | --                     |
| M48    | RESERVED               |
| M49    | --                     |
| M5     | --                     |
| M50    | LPDDR3_M0_CA[1]        |
| M51    | --                     |
| M52    | VSS                    |
| M53    | --                     |
| M54    | LPDDR3_M0_CA[4]        |
| M55    | --                     |
| M56    | VSS                    |
| M57    | --                     |
| M58    | VSS                    |
| M59    | --                     |
| M6     | DDIO_TXP[2]            |
| M7     | --                     |
| M8     | DDIO_AUXN              |
| M9     | --                     |
| N1     | USB_V3P3A_G3           |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| N10    | --                     |
| N11    | DDI2_TXN[0]            |
| N12    | --                     |
| N13    | --                     |
| N14    | --                     |
| N15    | --                     |
| N16    | --                     |
| N17    | --                     |
| N18    | --                     |
| N19    | --                     |
| N2     | --                     |
| N20    | --                     |
| N21    | --                     |
| N22    | --                     |
| N23    | --                     |
| N24    | --                     |
| N25    | --                     |
| N26    | --                     |
| N27    | --                     |
| N28    | --                     |
| N29    | --                     |
| N3     | VSS                    |
| N30    | --                     |
| N31    | --                     |
| N32    | --                     |
| N33    | --                     |
| N34    | --                     |
| N35    | --                     |
| N36    | --                     |
| N37    | --                     |
| N38    | --                     |
| N39    | --                     |
| N4     | --                     |
| N40    | --                     |
| N41    | --                     |
| N42    | --                     |
| N43    | --                     |





**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| N44    | --                     |
| N45    | --                     |
| N46    | --                     |
| N47    | --                     |
| N48    | --                     |
| N49    | VSS                    |
| N5     | DDIO_TXN[2]            |
| N50    | --                     |
| N51    | LPDDR3_M0_CA[6]        |
| N52    | --                     |
| N53    | VSS                    |
| N54    | --                     |
| N55    | LPDDR3_M0_CK_N_A       |
| N56    | --                     |
| N57    | LPDDR3_M0_CK_P_A       |
| N58    | --                     |
| N59    | DDR_VDDQG_S4           |
| N6     | --                     |
| N7     | VSS                    |
| N8     | --                     |
| N9     | DDIO_TXP[3]            |
| P1     | --                     |
| P10    | DDI2_TXP[0]            |
| P11    | --                     |
| P12    | VSS                    |
| P13    | --                     |
| P14    | --                     |
| P15    | VSS                    |
| P16    | --                     |
| P17    | VSS                    |
| P18    | --                     |
| P19    | VSS                    |
| P2     | USB_V3P3A_G3           |
| P20    | --                     |
| P21    | VSS                    |
| P22    | --                     |
| P23    | VSS                    |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| P24    | --                     |
| P25    | CORE_VCC1_S0iX         |
| P26    | --                     |
| P27    | CORE_VCC1_S0iX         |
| P28    | --                     |
| P29    | VSS                    |
| P3     | --                     |
| P30    | --                     |
| P31    | --                     |
| P32    | CORE_VCC0_S0iX         |
| P33    | --                     |
| P34    | CORE_VCC0_S0iX         |
| P35    | --                     |
| P36    | CORE_VCC0_S0iX         |
| P37    | --                     |
| P38    | CORE_VCC0_S0iX         |
| P39    | --                     |
| P4     | DDIO_RCOMP_N           |
| P40    | VSS                    |
| P41    | --                     |
| P42    | VSS                    |
| P43    | --                     |
| P44    | VSS                    |
| P45    | --                     |
| P46    | VSS                    |
| P47    | --                     |
| P48    | LPDDR3_M0_CA[2]        |
| P49    | --                     |
| P5     | --                     |
| P50    | RESERVED               |
| P51    | --                     |
| P52    | VSS                    |
| P53    | --                     |
| P54    | LPDDR3_M0_CK_N_B       |
| P55    | --                     |
| P56    | LPDDR3_M0_CK_P_B       |
| P57    | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| P58    | VSS                    |
| P59    | --                     |
| P6     | VSS                    |
| P7     | --                     |
| P8     | VSS                    |
| P9     | --                     |
| R1     | VSS                    |
| R10    | --                     |
| R11    | VSS                    |
| R12    | --                     |
| R13    | --                     |
| R14    | --                     |
| R15    | --                     |
| R16    | --                     |
| R17    | --                     |
| R18    | --                     |
| R19    | --                     |
| R2     | --                     |
| R20    | --                     |
| R21    | --                     |
| R22    | --                     |
| R23    | --                     |
| R24    | --                     |
| R25    | --                     |
| R26    | --                     |
| R27    | --                     |
| R28    | --                     |
| R29    | --                     |
| R3     | DDI2_AUXN              |
| R30    | --                     |
| R31    | --                     |
| R32    | --                     |
| R33    | --                     |
| R34    | --                     |
| R35    | --                     |
| R36    | --                     |
| R37    | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| R38    | --                     |
| R39    | --                     |
| R4     | --                     |
| R40    | --                     |
| R41    | --                     |
| R42    | --                     |
| R43    | --                     |
| R44    | --                     |
| R45    | --                     |
| R46    | --                     |
| R47    | --                     |
| R48    | --                     |
| R49    | RESERVED               |
| R5     | DDIO_RCOMP_P           |
| R50    | --                     |
| R51    | RESERVED               |
| R52    | --                     |
| R53    | LPDDR3_M0_CA[9]        |
| R54    | --                     |
| R55    | LPDDR3_M0_DQ[02]_B     |
| R56    | --                     |
| R57    | VSS                    |
| R58    | --                     |
| R59    | VSS                    |
| R6     | --                     |
| R7     | VSS                    |
| R8     | --                     |
| R9     | VSS                    |
| T1     | --                     |
| T10    | DDI2_TXN[2]            |
| T11    | --                     |
| T12    | VSS                    |
| T13    | --                     |
| T14    | UNCORE_VSFR_G3         |
| T15    | --                     |
| T16    | VSS                    |
| T17    | --                     |

**Ballout and Ball Map**



| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| T18    | VSS                    |
| T19    | --                     |
| T2     | DDI2_TXP[1]            |
| T20    | VSS                    |
| T21    | --                     |
| T22    | VSS                    |
| T23    | --                     |
| T24    | VSS                    |
| T25    | --                     |
| T26    | VSS                    |
| T27    | --                     |
| T28    | VSS                    |
| T29    | --                     |
| T3     | --                     |
| T30    | --                     |
| T31    | CORE_VCC0_S0iX         |
| T32    | --                     |
| T33    | CORE_VCC0_S0iX         |
| T34    | --                     |
| T35    | CORE_VCC0_S0iX         |
| T36    | --                     |
| T37    | CORE_VCC0_S0iX         |
| T38    | --                     |
| T39    | VSS                    |
| T4     | DDI2_AUXP              |
| T40    | --                     |
| T41    | VSS                    |
| T42    | --                     |
| T43    | VSS                    |
| T44    | --                     |
| T45    | VSS                    |
| T46    | --                     |
| T47    | --                     |
| T48    | LPDDR3_M0_OCAVREF      |
| T49    | --                     |
| T5     | --                     |
| T50    | LPDDR3_M0_ODQVREF      |

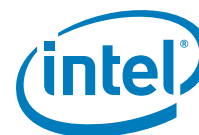
| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| T51    | --                     |
| T52    | LPDDR3_M0_CA[8]        |
| T53    | --                     |
| T54    | LPDDR3_M0_DQ[00]_B     |
| T55    | --                     |
| T56    | VSS                    |
| T57    | --                     |
| T58    | LPDDR3_M0_DQ[03]_B     |
| T59    | --                     |
| T6     | VSS                    |
| T7     | --                     |
| T8     | USB_VBUSSNS            |
| T9     | --                     |
| U1     | USB_VDDQ_G3            |
| U10    | --                     |
| U11    | DDI2_TXP[2]            |
| U12    | --                     |
| U13    | --                     |
| U14    | --                     |
| U15    | --                     |
| U16    | --                     |
| U17    | --                     |
| U18    | --                     |
| U19    | --                     |
| U2     | --                     |
| U20    | --                     |
| U21    | --                     |
| U22    | --                     |
| U23    | --                     |
| U24    | --                     |
| U25    | --                     |
| U26    | --                     |
| U27    | --                     |
| U28    | --                     |
| U29    | --                     |
| U3     | DDI2_TXN[1]            |
| U30    | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| U31    | --                     |
| U32    | --                     |
| U33    | --                     |
| U34    | --                     |
| U35    | --                     |
| U36    | --                     |
| U37    | --                     |
| U38    | --                     |
| U39    | --                     |
| U4     | --                     |
| U40    | --                     |
| U41    | --                     |
| U42    | --                     |
| U43    | --                     |
| U44    | --                     |
| U45    | --                     |
| U46    | --                     |
| U47    | --                     |
| U48    | --                     |
| U49    | VSS                    |
| U5     | VSS                    |
| U50    | --                     |
| U51    | VSS                    |
| U52    | --                     |
| U53    | VSS                    |
| U54    | --                     |
| U55    | LPDDR3_M0_DM[0]_B      |
| U56    | --                     |
| U57    | LPDDR3_M0_DQ[01]_B     |
| U58    | --                     |
| U59    | VSS                    |
| U6     | --                     |
| U7     | USB_OTG_ID             |
| U8     | --                     |
| U9     | RESERVED               |
| V1     | --                     |
| V10    | USB_DN[1]              |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| V11    | --                     |
| V12    | USB_DP[0]              |
| V13    | --                     |
| V14    | --                     |
| V15    | VSS                    |
| V16    | --                     |
| V17    | VSS                    |
| V18    | --                     |
| V19    | VSS                    |
| V2     | USB_VDDQ_G3            |
| V20    | --                     |
| V21    | UNCORE_VNN_S4          |
| V22    | --                     |
| V23    | UNCORE_VNN_S4          |
| V24    | --                     |
| V25    | UNCORE_VNN_S4          |
| V26    | --                     |
| V27    | PWR_RSVD_OBS           |
| V28    | --                     |
| V29    | VSS                    |
| V3     | --                     |
| V30    | --                     |
| V31    | --                     |
| V32    | CORE_VCC0_S0iX         |
| V33    | --                     |
| V34    | CORE_VCC0_S0iX         |
| V35    | --                     |
| V36    | CORE_VCC0_S0iX         |
| V37    | --                     |
| V38    | CORE_VSS0_SENSE        |
| V39    | --                     |
| V4     | DDI2_TXP[3]            |
| V40    | CORE_VCC0_SENSE        |
| V41    | --                     |
| V42    | VSS                    |
| V43    | --                     |
| V44    | VSS                    |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| V45    | --                     |
| V46    | VSS                    |
| V47    | --                     |
| V48    | LPDDR3_M0_DQ[17]_B     |
| V49    | --                     |
| V5     | --                     |
| V50    | LPDDR3_M0_DQ[19]_B     |
| V51    | --                     |
| V52    | VSS                    |
| V53    | --                     |
| V54    | VSS                    |
| V55    | --                     |
| V56    | LPDDR3_M0_DQS[0]_N_B   |
| V57    | --                     |
| V58    | VSS                    |
| V59    | --                     |
| V6     | VSS                    |
| V7     | --                     |
| V8     | VSS                    |
| V9     | --                     |
| W1     | USB_VDDQ_G3            |
| W10    | --                     |
| W11    | USB_DN[0]              |
| W12    | --                     |
| W13    | --                     |
| W14    | VSS                    |
| W15    | --                     |
| W16    | VSS                    |
| W17    | --                     |
| W18    | VSS                    |
| W19    | --                     |
| W2     | --                     |
| W20    | UNCORE_VNN_S4          |
| W21    | --                     |
| W22    | UNCORE_VNN_S4          |
| W23    | --                     |
| W24    | UNCORE_V1P15_S0iX      |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| W25    | --                     |
| W26    | UNCORE_VNN_S4          |
| W27    | --                     |
| W28    | UNCORE_VNN_S4          |
| W29    | --                     |
| W3     | USB_DN[2]              |
| W30    | --                     |
| W31    | CORE0_VSFR_G3          |
| W32    | --                     |
| W33    | CORE_VCC0_S0iX         |
| W34    | --                     |
| W35    | CORE_VCC0_S0iX         |
| W36    | --                     |
| W37    | CORE_VCC0_S0iX         |
| W38    | --                     |
| W39    | F_V1P15_S0iX           |
| W4     | --                     |
| W40    | --                     |
| W41    | VSS                    |
| W42    | --                     |
| W43    | VSS                    |
| W44    | --                     |
| W45    | VSS                    |
| W46    | --                     |
| W47    | --                     |
| W48    | --                     |
| W49    | LPDDR3_M0_DQ[16]_B     |
| W5     | DDI2_TXN[3]            |
| W50    | --                     |
| W51    | LPDDR3_M0_DQS[2]_N_B   |
| W52    | --                     |
| W53    | VSS                    |
| W54    | --                     |
| W55    | LPDDR3_M0_DQS[0]_P_B   |
| W56    | --                     |
| W57    | LPDDR3_M0_DQ[05]_B     |
| W58    | --                     |



**Ballout and Ball Map**

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| W59    | DDR_VDDQG_S4           |
| W6     | --                     |
| W7     | VSS                    |
| W8     | --                     |
| W9     | USB_DP[1]              |
| Y1     | --                     |
| Y10    | VSS                    |
| Y11    | --                     |
| Y12    | VSS                    |
| Y13    | --                     |
| Y14    | --                     |
| Y15    | --                     |
| Y16    | --                     |
| Y17    | --                     |
| Y18    | --                     |
| Y19    | --                     |
| Y2     | VSS                    |
| Y20    | --                     |
| Y21    | --                     |
| Y22    | --                     |
| Y23    | --                     |
| Y24    | --                     |
| Y25    | --                     |
| Y26    | --                     |
| Y27    | --                     |
| Y28    | --                     |
| Y29    | --                     |
| Y3     | --                     |
| Y30    | --                     |
| Y31    | --                     |
| Y32    | --                     |
| Y33    | --                     |
| Y34    | --                     |
| Y35    | --                     |
| Y36    | --                     |
| Y37    | --                     |
| Y38    | --                     |

| Ball # | Customer Name - LPDDR3 |
|--------|------------------------|
| Y39    | --                     |
| Y4     | USB_DP[2]              |
| Y40    | --                     |
| Y41    | --                     |
| Y42    | --                     |
| Y43    | --                     |
| Y44    | --                     |
| Y45    | --                     |
| Y46    | --                     |
| Y47    | --                     |
| Y48    | LPDDR3_M0_DQ[20]_B     |
| Y49    | --                     |
| Y5     | --                     |
| Y50    | LPDDR3_M0_DQS[2]_P_B   |
| Y51    | --                     |
| Y52    | LPDDR3_M0_DQ[22]_B     |
| Y53    | --                     |
| Y54    | LPDDR3_M0_DQ[04]_B     |
| Y55    | --                     |
| Y56    | VSS                    |
| Y57    | --                     |
| Y58    | LPDDR3_M0_DQ[06]_B     |
| Y59    | --                     |
| Y6     | USB_DP[3]              |
| Y7     | --                     |
| Y8     | VSS                    |
| Y9     | --                     |

§



## 21 Package Information

The SoC comes in Flip-Chip Ball Grid Array (FCBGA) package and consists of a silicon die mounted face down on an organic substrate populated with solder balls on the bottom side. Care should be taken to avoid contact with the package inside this area.

### 21.1 SoC Attributes

**Table 165. SoC Attributes**

|         | Category          | T4             | T3             |
|---------|-------------------|----------------|----------------|
| Package | Type              | 17x17mm Type 4 | 17x17mm Type 3 |
|         | IO count          | 628            | 378            |
|         | Core Process (nm) | 14             | 14             |
|         | Ball count        | 1380           | 592            |
|         | Ball pitch        | 0.4mm          | 0.65mm         |
|         | Z-height          | 0.937mm        | 1.002mm        |





Figure 45. Package Mechanical Drawing for T3 (Part 2)

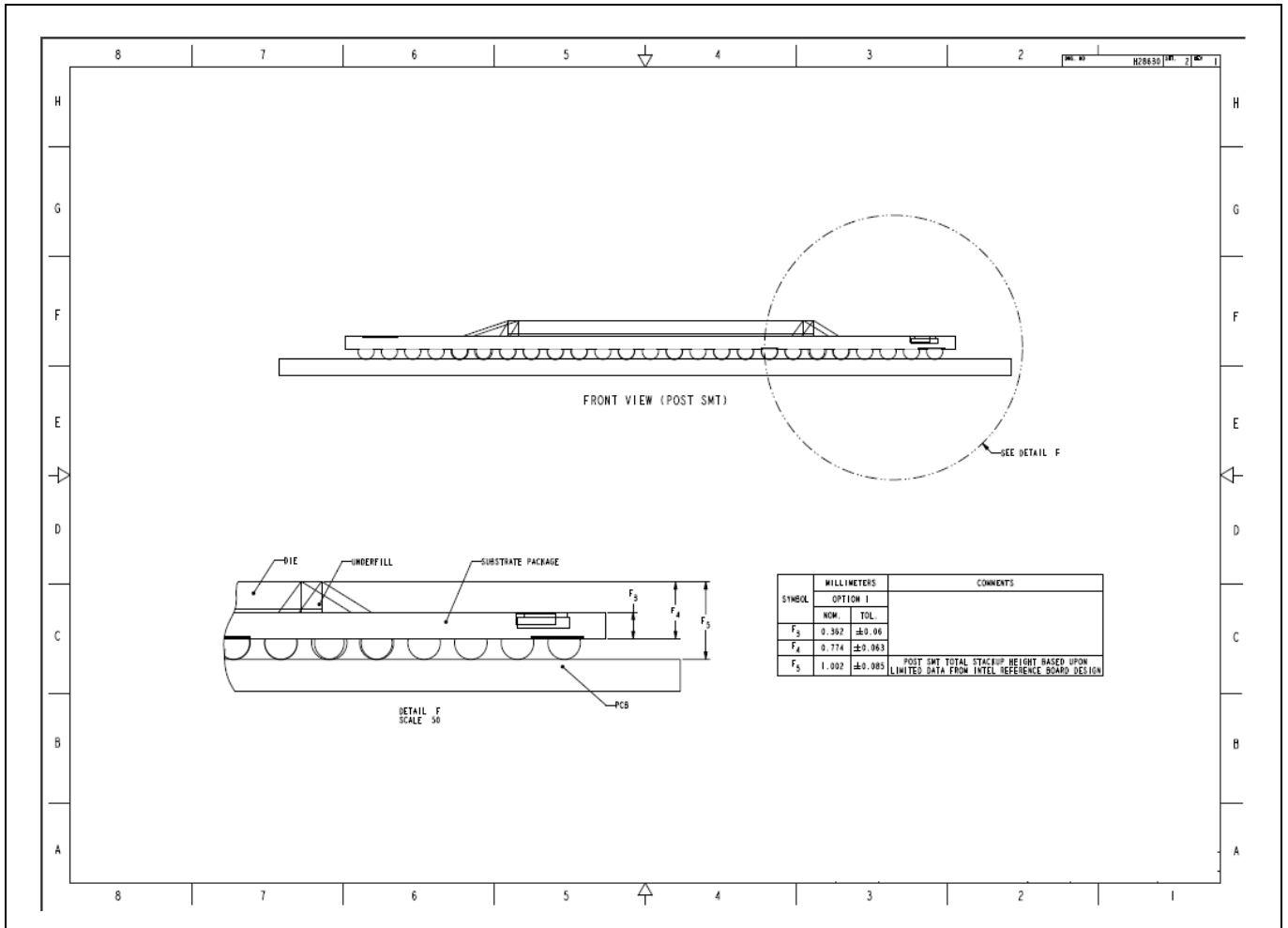


Figure 46. Package Mechanical Drawing for T4 (Part 1)

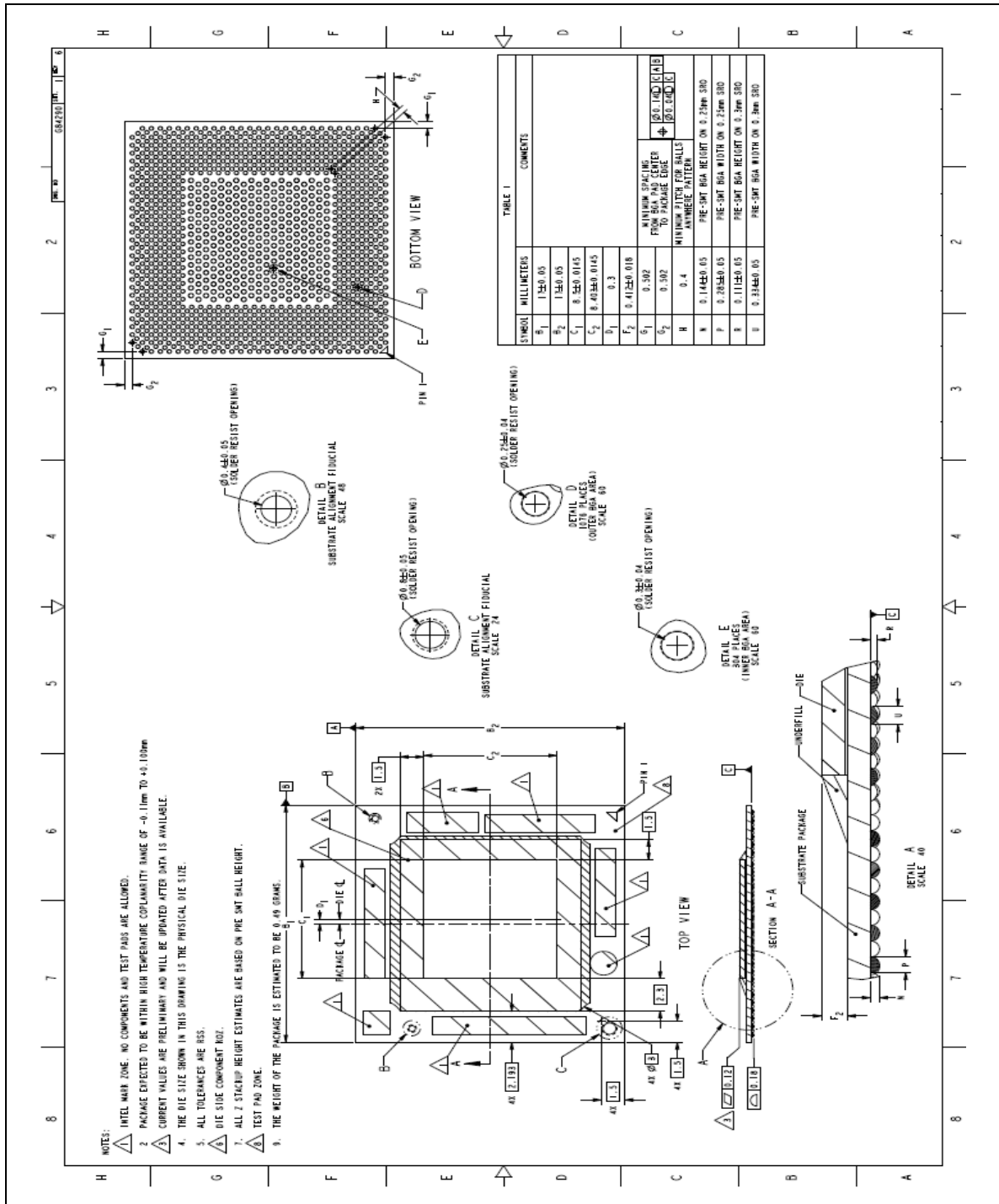
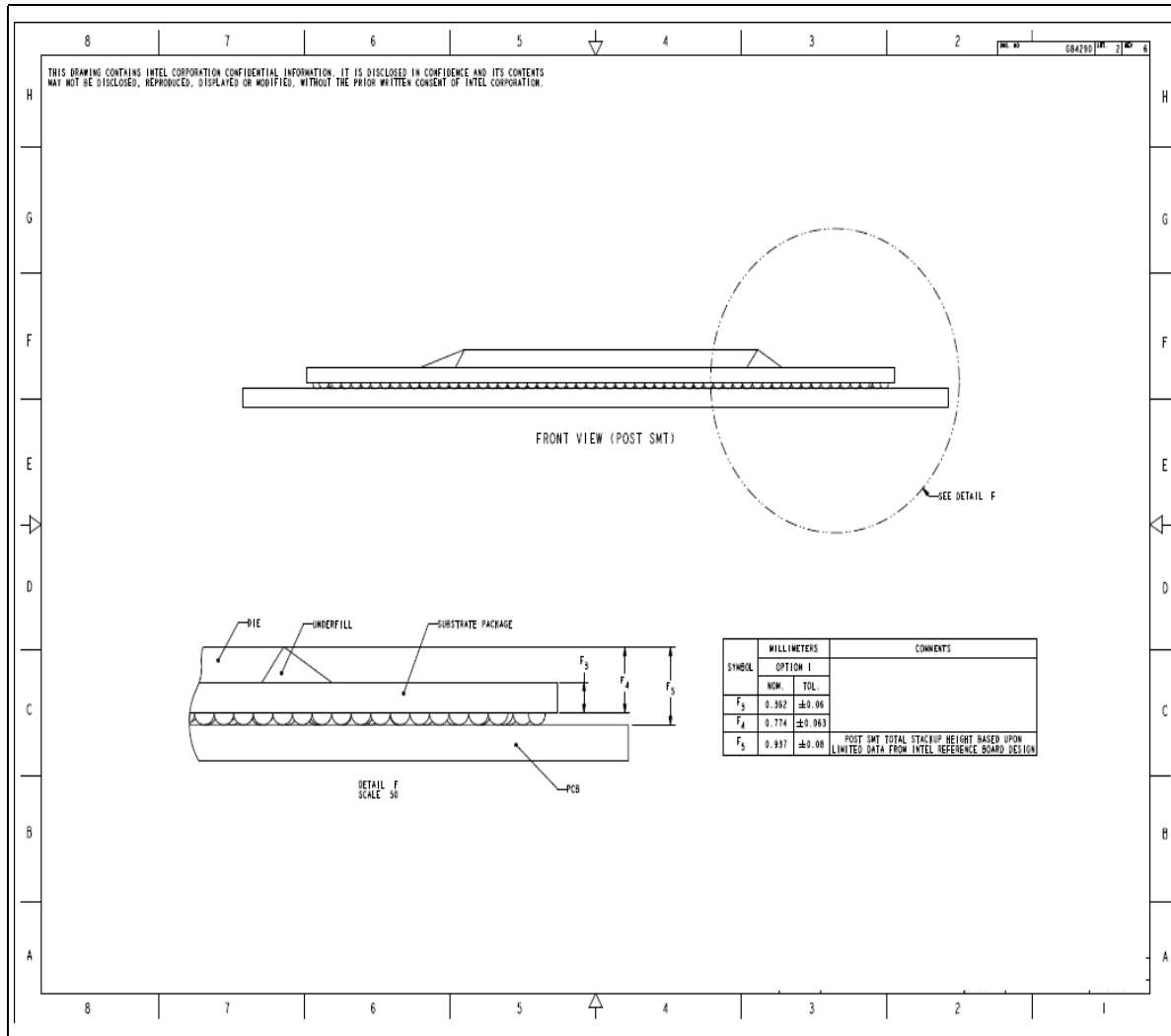


Figure 47. Package Mechanical Drawing for T4 (Part 2)



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